Caption: Climate activists Hilda Nakabuye and Marinel Ubaldo join a climate march in New York in September 2024. ©Karelia Pallan/Oxfam

CARBON INEQUALITY KILLS: METHODOLOGY NOTE

www.oxfam.org

OXFAM

TABLE OF CONTENTS

SECTION 1 OF MAIN REPORT

SUMMARY OF KEY STATISTICS

1. Emissions from the investments, private jets and superyachts from 50 of the world's richest people is more than the consumption emissions of the poorest 2% (155 million) people combined.
2. Billionaires emit more in a just over an hour and a half (96 minutes) through their investments, superyachts and private jets than the average person emits in their lifetime.
3. Billionaires' superyachts and private jets emit more in almost a fortnight than the average person will emit in their lifetime.
4. The average luxury transport emissions (private jets and yachts) of the billionaires in Oxfam's sample is over 7,661 times higher than the carbon footprint of someone in the global poorest 50%.
5. The average investment footprint of the billionaires in Oxfam's sample is 26 million times higher than the investment emissions of someone in the global poorest 50%.
6. If everyone began emitting as much carbon as those in the top 10%, the remaining carbon budget would be gone in less than a year and a half. If everyone began emitting as much carbon as those in the top 1%, the remaining carbon budget would be gone in fewer than five months.
7. If everyone began emitting like 50 of the world's richest billionaires from their superyachts and private jets, the remaining carbon budget would be gone in two days.
8. Oxfam was able to identify the private jets belonging to 23 of 50 of the world's richest billionaires; the others either do not own private jets or have kept them out of public records. On average, these 23 individuals each took 184 flights – spending 425 hours in the air in a single year. That is equivalent to each of them circumnavigating the globe ten times.
9. On average, the private jets of these 23 super-rich individuals emitted 2,074 tonnes of carbon a year. This is equivalent to 300 years' worth of emissions for the average person in the world or over 2000 years' worth for someone in the global poorest 50%.
10. Elon Musk owns (at least) two private jets which combined produced 5,497 tonnes per year of CO_2. This is the equivalent of 834 years' worth of emissions for the average person in the world, or 5,437 years' worth for someone in the global poorest 50%.
11. The two private jets owned by Jeff Bezos collectively spent almost 25 days in the air, emitting 2,908 tonnes of CO_2. It would take the average US Amazon employee 207 years to emit that much.
12. Oxfam was able to identify 23 superyachts owned by 18 of 50 of the world's richest billionaires. Billionaire yachts travelled on average of 12,465 nautical miles a year; this is equivalent to them each crossing the Atlantic almost four times.

12. Oxfam estimates the average annual carbon footprint of each of these yachts to be 5,672 tonnes, which is more than three times the emissions of their private jets. This is equivalent to 860 years of emissions for the average person in the world, and 5,610 times the average of someone in the global poorest 50%.
13. The Walton family, heirs of the Walmart retail chain, own three superyachts worth over US$500m. They travelled 56,000 nautical miles in a year with a combined carbon footprint of around 18,000 tonnes, which is the equivalent to the carbon footprint of around 1,714 Walmart shop workers.
14. Brazilian financer Jorge Paulo Lemann, a member of the Latin America Conservation Council whose goals include protecting oceans, owns a superyacht that travelled 12,000 nautical miles in a year emitting around 2,700 tonnes of carbon.
15. Oxfam's analysis found that investment emissions are the most significant part of a billionaire's carbon footprint. The average investment emissions of 50 of the world's richest billionaires were around 2.6 million tonnes of CO_2e each. This is around 340 times their emissions from private jets and superyachts combined. Each billionaire's investment emissions are equivalent to almost 400,000 years of consumption emissions by the average person, or 2.6 million years of consumption emissions of someone in the poorest 50% of the world.
16. Almost 40% of the investments of 50 of the world's richest billionaires were in highly polluting industries such as oil, mining, shipping, and cement. When fashion and retail is included as a highly polluting sector, the proportion of these billionaire investments that are considered polluting rises to almost two-thirds. Two major billionaire-owned technology companies on Oxfam's list have emissions comparable to major shipping companies. Only one billionaire, Gautam Adani, has significant investments in renewable energy – and even this is just 18% of his overall investment portfolio. A significant proportion of the rest is invested in fossil fuels, including coal.
17. On average, a billionaire's investment portfolio is almost twice as polluting as an investment in the S&P 500.
18. For the data available about the investments of the top 50 billionaires, only 12 companies (24%) have set net-zero targets.
19. The wealth of the world's 2,781 billionaires has soared to US$14.2 trillion. If invested in renewable energy and energy efficiency measures by 2030, this wealth could cover the entire funding gap between what governments have pledged and what is needed to keep global warming below 1.5°C, according to estimates by the International Renewable Energy Agency.
20. For every million US dollars invested by the 50 billionaires in Oxfam's study, 154 tonnes of CO2e are emitted each year. If these same investments were placed in a low-carbon intensity equity fund, their emissions would be 13 times less.

SAMPLE

Oxfam collected information on the emissions associated with the investments and luxury transport use of 50 of the world's richest billionaires and richest five regional billionaires from the following regions: East Asia and Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, North America, South Asia and sub-Saharan Africa.

INVESTMENT EMISSIONS

To identify the investment emissions of Oxfam's sample, the data was filtered by removing cases where:

- The ownership positions of the billionaires could not be identified.
- Unless they are an investor and the CEO or executive chairman, a billionaire had less than a 10% stake in the company. The 10% threshold was chosen based on the definition used by the US Securities and Exchange Commission (SEC) of a principal shareholder, as these shareholders are considered to have a significant influence over a company.
- The company had not publicly disclosed any information on its emissions.

After these exclusions, Oxfam was able to obtain investment emission data for 41 billionaires around the world.

The equity stakes individuals held was calculated using the Bloomberg Billionaires Index.[1] The percentage ownership of each company was determined either by dividing the investment value by the market cap on the day of the analysis or from the narrative description provided by Bloomberg.

Information reported by the company was used for Scope 1 and 2 emissions (direct and indirect emissions), derived either from the company's most recent sustainability report or from CDP disclosures.[2] Where reported, location-based Scope 2 emissions were chosen over market-based emissions. Location-based emissions reflect the grid where the energy is purchased, while market-based emissions take into account the energy the company is purchasing. While both provide important information, location-based emissions were prioritized, as these are the emissions that are physically going into the air.[3]

Using the list of corporations and the equity stakes held by billionaires, the corporations' Scope 1 and 2 CO_2e emissions were proportionally allocated to the owners. For example, if a billionaire owned 50% of a company X, whose Scope 1 and 2 emissions were 1,000 tonnes of CO_2e in total, then 500 tonnes of CO_2e were allocated to the billionaire's carbon footprint.

Table 1. Summary of analysis of the investment emissions of Oxfam's sample of billionaires

	Number	Percentage	Unit
Total billionaire investment	108,143,388		Metric tonnes of

footprint			CO_2e
Average billionaire investment footprint	2,637,644		Metric tonnes of CO_2e
Value of the billionaires' investments	2,080,636,000,000		US$
Number of investments (includes companies counted more than once when held by different billionaires)	51		
Number of billionaires	41		
Number of investments above 50%	20	39%	
Tonnes of CO_2e emitted per US$1m invested	154		Metric tonnes of CO_2e
Number of final sample companies who have science-based targets	12	24%	

CONSUMPTION EMISSIONS

To estimate the luxury emissions linked to billionaire lifestyles, the initial plan was to include emissions from their mansions as well as their luxury transportation methods, such as superyachts and private jets. However, Oxfam chose to focus mainly on transport emissions, as these are significantly higher than those from luxury homes and there was a lack of data available for mansion emissions.

Emissions from private jets

Ownership information of private jets was obtained from public sources such as media reports and photographs, and tail numbers. The tail numbers were then used to determine the model of airplane and the hours flown over a 12-month period; various sources were used to track private jet movement including JetSpy[4], Flightradar24[5] and Cirium[6]. To calculate emissions, the gallons per hour for the plane model was multiplied by 9.75, the Carbon Dioxide Emissions Coefficients for the kilos CO_2 per gallon of jet fuel according to the US Energy Information Administration.[7] That number was then multiplied by hours flown per jet to give total emissions over a 12-month period. Although all other numbers in this section are CO_2e, the IPCC determine that: 'the emission factors of N_2O and CH_4 must be considered to be highly uncertain. However, as the latter pollutants do not contribute much to total emissions in the overall inventory, this is not of a great concern'[8] and therefore no attempt was made to adjust to CO_2 equivalent.

Emissions from superyachts

The SuperYachtFan database[9] and publicly available information on sites such as *Superyacht Times*[10] were used to identify the names and types of yachts owned by the billionaires. Historical travel data of these yachts for the past year was obtained from the MarineTraffic database.[11] This data included the total distance travelled by the yacht (in nautical miles) and its average speed (in knots).

Propulsion emissions

The likely emissions from the yachts while at sea was approximated using publicly available information on the type of yacht (motor/sail), the model and number of engines used for propulsion, and corresponding specific fuel consumption and the engine power, following the formula:

Propulsion emissions = Specific Fuel Consumption of the Engine x Total Hours at Sea x Engine Power x Number of Engines x Adjustment Factor of 0.75 x Emissions Factor

Specific Fuel Consumption (SFC) of the Engine: This is a measure of the fuel efficiency of the engine design, typically used for aircraft or yacht engines. It is defined as the amount of fuel needed to produce a specific amount of power over a given period. Its typical units are g/kWh (grams/kilowatt-hours). This information was obtained from the engine specification documents for the engine used in each yacht.

Total Hours at Sea: This denotes the total hours the yacht is being propelled at sea. This information was found on the MarineTraffic database.

Engine Power: This denotes the specified power of the engine, in kilowatts (kW), which is provided by the manufacturer (in engine-specification documents) and is typically measured under standardized test conditions.

Number of Engines: This describes the total number of engines used in the yacht for propulsion. The data is publicly available on sites such as *Superyacht Times.*

Adjustment Factor: The adjustment factor of 0.75 was used to account for the deduction of any shaft generators. A study by Alwan provided the rationale for this factor.[12]

Emissions Factor: This is the conversion factor that indicates how many grams of CO_2 equivalents are released by burning 1 gram of fuel. This factor was calculated to be 3.256, based on an International Maritime Organization (IMO) report on the intensity of marine fuels.[13]

Auxiliary or ‘hotel load’ emissions

These refer to the greenhouse gas (GHG) emissions generated by the energy used for non-propulsion purposes when the yacht is docked or anchored. These emissions come from the operation of various systems and amenities on board, including lighting, air-conditioning, refrigeration, stabilization, navigation and communication systems, and other luxury services such as spas and entertainment systems.

The auxiliary emissions from the auxiliary load were estimated by assuming that these facilities are run using a diesel-powered generator of about 300 kW for the entire duration that the yacht is stationary – either anchored or docked. Even though there have been some improvements in marina power, where a ship can connect to onshore electricity, these facilities are emerging and not sufficient for the heavy loads run by most superyachts when they are stationery. The auxiliary power when stationery was calculated using the following formula:

Auxiliary power = Total Hours Anchored/Docked x Average Auxiliary Load x SFC of the Auxiliary Engine x Emissions Factor

Total Hours Anchored/Docked: This was calculated by subtracting the total hours of sea from the year.

Average Auxiliary Load: An average of 300 kW was used as the auxiliary load, based on estimates in a paper published in the *Journal of Marine Science and Engineering*.[14]

SFC of the Auxiliary Engine: This was assumed to be around 200g/kWh, based on the commonly used Cummins 300kW genset engine.

Emissions Factor: This was calculated to be 3.256, based on the IMO report.[15]

Propulsion emissions and auxiliary emissions were then added together to calculate the total emissions from the superyachts. Table 2 provides an overview of the findings.

Table 2. Summary of analysis of emissions from luxury transport

	Number	Units
Number of billionaires for whom Oxfam has data for superyacht emissions	18	
Number of billionaires for whom Oxfam has data for private jet emissions	23	
Average emissions of billionaires in Oxfam's sample from superyachts	5,672	Metric tonnes of CO_2e
Average emissions of billionaires in Oxfam's sample from private jets	2,074	Metric tonnes of CO_2e
Total miles travelled by billionaires in Oxfam's sample in superyachts	224,372	Nautical miles
Total number of hours travelled in private jets (in 2022–2023) by billionaires in Oxfam's sample	9,774	Hours
Total number of flights taken in private jets (in 2022–2023) by the billionaires in Oxfam's sample	4,225	

LIMITATIONS OF THE DATA

Lack of availability of data was the principal limitation in calculating billionaires' emissions from their luxury transport usage. Oxfam was able to gather data on 23 superyachts owned by 18 billionaires, and 31 private jets owned by 23 billionaires. No data was available for the remaining billionaires in the list. In some cases, we found that they take additional measures to hide the data from their luxury transport.

While we can track the movements of the yachts and jets, we do not know who was on-board so while we assign the emissions to the individuals as owner or primary user, we cannot be sure that they were travelling on all the journeys. Many of the jets are owned through corporations and shell companies rather than directly by the billionaires and we have used open-source information to identify their de facto owner and primary user. We sought to use the most up-to-date information, but some ownership information may be out of date.

Given the data gaps that have been detailed, to get an average across a total of 50 billionaires we took the average for investments, superyachts and private jets and multiplied by 50.

AVOIDING DOUBLE-COUNTING

As only Scope 1 and 2 emissions were used for investments, this avoids the risk of double-counting consumption emissions within investments (consumption emissions would sit under Scope 3 emissions within corporate reporting). The consumption emissions calculated do not include the emissions caused by the construction of the private jets and superyachts, only those from the fuel that is used to power them.

INCOME-BASED EMISSIONS DATA

The methodology and datasets used to calculate emissions of non-billionaires is based on research by the Stockholm Environmental Institute.[16] The datasets and methodology are publicly available,[17] along with an interactive data tool.[18] We adjusted this data from CO_2 to CO_2e using a factor of 1.375 to align with the data collected for super yachts and investments.

EXPLANATION OF STATISTICS IN THE MAIN REPORT

1. **Emissions from the investments, private jets and superyachts from 50 of the world's richest people is more than the consumption emissions of the poorest 2% (155 million) people combined.**

The average emissions from yachts, jets and investments for our sample multiplied by 50 is 132,269,478 tonnes CO_2e. The emissions of the poorest 2% of the world (154,853,639 million people) is 118,657,710 tonnes CO_2e.

2. **Billionaires emit more in just over an hour and a half (96 minutes) through their investments, superyachts and private jets than the**

average person emits in their lifetime.

Billionaire average emissions for investments, yachts and jets is 2,645,389.55 tonnes CO_2e divided by 525,600 (minutes in a year) equals 5.03. The global average per person emissions are 6.6 tonnes CO_2, multiplied by 73 (the global life expectancy[19]) is 481, which divided by 5.03 is 95.58.

3. **Billionaires' superyachts and private jets emit more in almost a fortnight than the average person will emit in their lifetime.**

The annual average emissions from jets and yachts in our sample is 7,746 tonnes CO_2e, divided by 365, this is 21.22 tonnes CO_2e per day. The global average per person emissions is 6.6 tonnes CO_2 which multiplied by 73 (the global life expectancy[20]) is 481 to give the lifetime emissions. 481 divided by 21.22 (daily billionaire emissions) equals 23.

4. **The average luxury transport emissions (private jets and yachts) of the billionaires in Oxfam's sample is over 7,661 times higher than the carbon footprint of someone in the global poorest 50%.**

The average emissions of someone in the poorest 50% of humanity is 1.01 tonnes of CO_2e annually. This data is taken from work by Oxfam and the Stockholm Environmental Institute.[21] Calculations by Oxfam for this report show average emissions for the top 50 billionaires of 7,746 tonnes of CO_2e through their usage of superyachts and private jets (**Table 2**), 7,661 times the carbon footprint of someone in the global poorest 50%.

5. **The average investment emissions footprint of the billionaires in Oxfam's sample is 26 million times higher than the investment emissions of someone in the global poorest50%.**

The average emissions of someone in the poorest 50% of humanity is 1.01 tonnes of CO_2e annually.[22] The share of investments in the total emissions of the global poorest50% of the population is less than 10%.[23] Thus, the investment-related emissions of the poorest 50% can be estimated to be around 0.10 tonnes of CO_2 annually. The average investment footprint of the top 50 billionaires in Oxfam's sample is around 2,645,389 tonnes of CO_2e – 26 million times higher than that of the poorest50%.

6. **If everyone began emitting as much carbon as those in the top 10%, the remaining carbon budget would be gone in just over one year.**

   If everyone began emitting as much carbon as those in the top 1%, the remaining carbon budget would be gone in fewer than five months.

   If everyone began emitting like 50 of the world's richest billionaires, the remaining carbon budget would be gone in fewer than two days.

The remaining carbon budget that would give a 50% chance of keeping warming to 1.5°C is around 250 $GtCO_2$ (343.75 Gt CO_2e) as of January 2023.[24] According to data from Stockholm Environmental Institute, the average carbon footprint of those in the top 10% is around 24 tonnes of CO_2 (33 tonnes of CO_2e) per year, and that of the top 1% is 77 tonnes of CO_2 (105 tonnes of CO_2e). The average emissions (from luxury transport) of billionaires in this study is 7,746 tonnes of CO_2e (**Table 3**).

Table 3. Calculations for the consumption of the remaining carbon budget at different rates.

	Rate of emissions per year (tonnes of CO_2e /per person/per year)	Total annual emissions at this rate by the entire population (tonnes of CO_2e)	Total number of years needed to reach 250 $GtCO_2$ (343.75 Gt CO_2e)	Total number of months	Total number of days
If everyone began emitting as much carbon as those in the top 10%	33	254,200,546,143	1.35	16.23	493.58
If everyone began emitting as much carbon as those in the top 1%	105	812,950,491,493	0.42	5.07	154.34
If everyone began emitting as much carbon as 50 of the world's richest billionaires	7,746	59,974,277,115,964	0.00573	0.06878	2.09

7. **Oxfam was able to identify the private jets belonging to 23 of 50 of the world's richest billionaires; the others either do not own private jets or have kept them out of public records. On average these 23 individuals each took 184 flights – spending 425 hours in the air –in 2023. That is equivalent to each of them circumnavigating the globe ten times.**

It would take about 42 hours to circumnavigate the globe by plane,[25] thus 425 hours in the air is equivalent to more than ten such trips around the world.

8. **On average, the private jets of these 23 super -rich individuals emitted 2,074 tonnes of carbon a year. This is equivalent to 300 years' worth of emissions for the average person in the world or over 2000 years' worth for someone in the global poorest 50% .**

The average emissions of someone in the poorest 50% of humanity is 1.01 tonnes of CO_2e annually.[26] Global average emissions are around 6.6 tonnes of CO_2e per year. 2,074 divided by 6.6 is 315 and 2,074 divided by 1.01 is 2,051.

9. **Elon Musk owns (at least) two private jets which combined produce 5,497 tonnes per year of CO_2. This is the equivalent of 834 years' worth of emissions for the average person in the world, or 5,437 years' worth for someone in the global poorest 50%.**

We were able to identify the tail numbers of two private jets owned by Elon Musk. The average emissions of someone in the poorest 50% of humanity is 1.01 tonnes of CO_2e annually. Global average emissions are around 6.6 tonnes of CO_2e per year. See page 5for how aviation emissions were calculated.

10. **The two private jets owned by Jeff Bezos collectively spent almost 25 days in the air, emitting 2,908 tonnes of CO_2. It would take the average US Amazon employee 207 years to emit that much.**

Median employee salary in Amazon is close to US$37,000.[27] According to the inequality data developed by the Stockholm Environmental Institute, a person with that income in the US emits around 14.068 tonnes of CO_2e a year: 2,908.22 divided by 14.068 is 207.

11. **Oxfam was able to identify 23 superyachts owned by 18 of 50 of the world's richest billionaires. Billionaires' yachts travelled on average of 12,465 nautical miles a year; this is equivalent to them each crossing the Atlantic over four times.**

The average distance for an Atlantic crossing is assumed to be around 2,800 nautical miles:[28] 12,465 divided by 2,800 is 4.45.

12. **Oxfam estimates the average annual carbon footprint of each of these yachts to be 5,672 tonnes, which is more than three times the emissions of the billionaires' private jets. This is equivalent to 860 years of emissions for the average person in the world, and 5,610 times the average of someone in the global poorest 50%.**

The average emissions of someone in the poorest 50% of humanity is 1.01 tonnes of CO_2e annually. Global average emissions are around 6.6 tonnes of CO_2e per year.

13. **The Walton family, heirs of the Walmart retail chain, own three superyachts worth over US$500m. They travelled 56,000 nautical miles in a year with a combined carbon footprint of around 18,000 tonnes, which is the equivalent to the carbon footprint of around 1,714 Walmart shop workers.**

The three yachts owned by various members of the Walton family are Aquila (US$150m),[29] KAOS (US$300m)[30] and Seanna (US$60m).[31] The median pay of a Walmart employee is around US$27,000 per annum.[32] According to the inequality data developed by the Stockholm Environmental Institute, a person with that income in the US emits around 10.37 tonnes of CO_2e a year.[33] The ratio of 17,769 tonnes to 10.37 tonnes is 1,714.

14. **Brazilian financer Jorge Paulo Lemann, a member of the Latin America Conservation Council whose goals include protecting oceans, owns a superyacht that travelled 12,000 nautical miles in a year emitting around 2,700 tonnes of carbon.**

Lemann is listed on the Latin America Conservation Council's website as a member.[34]

15. **Oxfam's analysis found that investment emissions are the most**

significant part of a billionaire's carbon footprint. The average investment emissions of 50 of the world's richest billionaires were around 2.6 million tonnes of CO_2e each. This is around 340 times their emissions from private jets and superyachts combined. Each billionaire's investment emissions are equivalent to almost 400,000 years of consumption emissions by the average person, or 2.6 million years of consumption emissions of someone in the poorest 50% of the world.

Oxfam's analysis shows the average investment emissions of 50 of the world's richest billionaires to be 2,645,389 metric tonnes of CO_2e. Their average emissions from private jets and superyachts combined are around 7,746 tonnes. The global average for consumption emissions is around 6.6 tonnes of CO_2e per year and that of someone in the poorest 50% in the world is around 1.01 tonnes of CO_2e per year

16. **Almost 40% of the investments of 50 of the world's richest billionaires were in highly polluting industries such as oil, mining, shipping, and cement. When fashion and retail is included as a highly polluting sector, the proportion of these billionaire investments that are considered polluting rises to 63%. Two major billionaire-owned technology companies on Oxfam's list have emissions comparable to major shipping companies. Only one billionaire, Gautam Adani, has significant investments in renewable energy – and even this is just 18% of his overall investment portfolio. A significant proportion of the rest is invested in fossil fuels, including coal.**

The number of billionaires on Oxfam's list with significant investments in various sectors is as follows: 13 in fashion and retail, eight in metals and mining, seven in energy and petrochemicals, three in shipping and logistics, one in an airline and one in cement.

Amazon's Scope 1 emissions were over 17 million metric tonnes of CO_2e[35] and Google's Scope 1 and 2 emissions were over 8 million metric tonnes in 2022,[36] so together they cause emissions over 25 million tonnes in a year. Shipping company Hapag Lloyd's reported emissions for the year 2023 are over 12 million tonnes of CO2e.[37]

Bloomberg Billionaires Index (on 26 June 2024) shows that Gautam Adani owns a 56% stake in Adani Green Energy whose market cap on the same day was US$33.92bn; thus the value of his stake in Adani Green Energy is around US$19bn.[38] Gautam Adani's total investments are around US$101bn, meaning his stake in Adani Green Energy is around 18% of his total portfolio.

17. **On average, a billionaire's investment portfolio is almost twice as polluting as an investment in the S&P 500.**

For every US$1 million invested by billionaires, 154 tonnes of CO_2e were produced. For the S&P 500, the 87 tonnes of CO_2e are produced for every US$1m invested.[39]

18. **For the data available about the investments of the top 50 billionaires, only 12 companies (24%) have set net-zero targets.**

The Science Based Targets initiative's company dashboard[40] was used to find out which of these corporations that the top 50 billionaires invested in had either set or committed to a near-term or a net-zero target.

19. **The wealth of the world's 2,781 billionaires has soared to US$14.2 trillion. If invested in renewable energy and energy efficiency measures by 2030, this wealth could cover the entire funding gap between what governments have pledged and what is needed to keep global warming below 1.5°C, according to estimates by the International Renewable Energy Agency.**

Forbes estimates the cumulative wealth of all the world's billionaires at US$14.2 trillion.[41] International Renewable Energy Agency's report on energy transition released just before COP29 advocates for additional investment in energy transition over and above what has already been planned for by governments and the private sector.[42] The report argues that in order to remain below 1.5°C, cumulative investments of US$45 trillion are needed between 2023 and 2030. Total cumulative energy sector investments already planned for account for US$29 trillion, US$16 trillion short of the required funds.

For every million US dollars invested by the 50 billionaires in Oxfam's study, 154 tonnes of CO_2e are emitted each year. If these same investments were placed in a low-carbon intensity equity fund, their emissions would be 13 times less.

For every US$1 million invested by billionaires, 154 tonnes of CO_2e were produced. An example of a low-carbon US equity fund produces just 12 tonnes CO_2e per US$1 million invested.[43]

SECTION 2 OF MAIN REPORT

SUMMARY OF KEY STATISTICS

1. Three decades of consumption emissions by the world's super-rich 1% (1990–2019), have already caused global economic output to fall by $2.9 trillion between 1990 and 2023. By 2050, the economic damage of only four decades of emissions (1990–2030) rises to $52.6 trillion, equivalent to a loss of 0.5% of global cumulative GDP between 1990 and 2050.

2. The consumption emissions of the world's richest 10% (1990–2019) have already caused global economic output to fall by $8.6 trillion between 1990 and 2023. About as much damage was caused by the COVID-19 pandemic in 2020, which led to massive economic and social disruption and caused global poverty levels and inequality to surge. By 2050, four decades of consumption emissions (1990–2030) by the world's richest 10% will cause economic damage totalling $150 trillion, equivalent to a loss of 1.5% of global cumulative GDP between 1990 and 2050.

3. Oxfam calculates that about one decade of 50 of the world's richest billionaires' investment emissions alone (between 2018 and 2028) will cause $250bn of economic damage by 2050. This is equivalent to the current economic output of countries such as Ecuador and Bulgaria.

4. Between 1990 and 2050, low- and lower-middle-income countries will accrue economic damage totalling $44 trillion. By contrast, high-income countries will benefit, accruing economic gains totalling $5.8 trillion.

5. As a result of the economic damage they accrue, low- and lower-middle-income countries will lose 2.6% and 2.5% of their cumulative GDP between 1990 and 2050, respectively. The most affected regions – Southern Asia, South-East Asia and sub-Saharan Africa – will lose 3.0%, 2.4% and 2.4%, respectively, of their cumulative GDP by 2050. By contrast, high-income countries are least affected or are even benefiting economically.

6. The economic damage that low- and lower-middle-income countries have already accrued between 1990 and 2023 because of three decades of consumption emissions of the world's super-rich 1% (1990–2019), is about three times the total officially recorded climate finance developed countries have given to poorer countries.

7. The economic damage between 1990 and 2050 caused by four decades of emissions of the world's super-rich 1% (1990–2030) is equivalent to 3% GDP loss in Somalia.

8. Three decades of consumption emissions (1990–2019) of the world's super-rich 1% have already caused crop losses that could have

provided enough calories to feed 14.5 million people a year between 1990 and 2023 (for maize, wheat and soy combined). This will rise to 46 million people a year between 2023 and 2050 due to four decades of consumption emissions (1990–2030) by the world's super-rich 1% only (for maize, wheat and soy combined).

9. The crop losses caused by the consumption emissions (1990–2019) of the world's richest 10% could have provided enough calories to feed a staggering 48.2 million people a year between 1990 and 2023. To put this number into perspective, recent multiple crises, from the COVID-19 pandemic to the war in Ukraine, pushed around 40.7 million additional people into hunger each year between 2019 and 2022. Between 2023 and 2050, the crop losses induced by four decades of consumption emissions of the world's richest 10% (1990–2030) could provide enough calories to feed a 148.8 million people a year.

10. About one decade (2018–2028) of investment emissions by 50 of the world's richest billionaires alone will cause crop losses that could provide enough calories to feed 120,000 people a year between 2028 and 2050 (Table 13).

11. Northern America and Europe have already accrued crop losses that could have provided enough calories to feed 3.6 million and 3.4 million people a year, respectively, between 1990 and 2023 (wheat, maize and soy combined). These numbers will rise to 10.3 million and 10.5 million people a year, respectively, between 2023 and 2050.

12. Latin America and the Caribbean has already accrued crop losses that could have provided enough calories to feed 2.4 million people a year between 1990 and 2023 (wheat, maize and soy combined). This will rise to nine million people a year between 2023 and 2050.

13. Just four years (2015–2019) of consumption emissions of the world's super-rich 1% are enough to cause 1.5 million excess deaths between 2020 and 2120. This equates to just over 15,000 excess deaths per year over the subsequent century, which is higher than the current annual death toll due to natural disasters.

14. The impact of the consumption emissions of the world's richest 10% for the same period is a staggering 4.8 million excess deaths, or 47,600 per year, to 2120.

15. Just four years (2021–2025) of investment emissions of 50 of the world's richest billionaires are enough to cause around 34,000 excess deaths between 2026 and 2126.

16. If the world's super-rich 1% had halved their emissions between 2015 and 2019, 756,000 people would live.

17. If instead 50 of the world's richest billionaires had placed their investments in a low-carbon intensity equity fund between 2021 and 2025, the emissions reductions would have saved about 12,000 lives.

18. If countries will remain as ill-equipped to protect their populations from

heat as they are today, the estimated number of deaths is much higher.

19. Of the 1.5 million excess deaths caused by the emissions of the world's super-rich 1%, Oxfam's analysis finds that 1.18 million or 78% of excess deaths due to heat will occur in low- and lower middle-income countries while the number of deaths in high-income countries will be negligible.

20. Most people who will die are in Southern Asia, followed by sub-Saharan Africa. Around 40% of excess deaths will occur in Southern Asia, with India accounting for most of these excess deaths (70%). Around 29% of excess deaths will occur in sub-Saharan Africa, with Nigeria accounting for most of these excess deaths (19%).

21. Around 430,000 Indian citizens will die until 2120 because of just four years (2015–2019) of emissions by the world's super-rich 1% – about 4,300 excess deaths a year.

ECONOMIC DAMAGE

Economic damages (or benefits) from changes in average annual temperature can be modelled empirically using macroeconometric statistics.[44] This method has been used to attribute economic damages from historical emissions of countries to other countries[45] and can also be used to attribute damages to countries, regions or the world from past and future emissions to emissions from any actor, including wealthy individuals.[46] This study quantified economic damages from the world's wealthiest people by income and by wealth, building on established methods in climate science and economics literature to streamline economic damage calculations. There are two main components of the workflow: estimating temperature change by country from actors and background scenario carbon dioxide emissions (CO_2); and estimating climate damages (or benefits) by country from these temperature changes.

EMISSIONS

Actor emissions

The annual CO_2 emissions of the global top 1% and global top 10% by income given in Stockholm Environmental Institute's Emissions Inequality Dashboard was used.[47] Historical emissions from 1990 to 2019 are publicly available from the dashboard, and projected emissions under a nationally determined contributions (NDCs) scenario were provided by the Stockholm Environment Institute. To approximate an emissions trajectory matching SSP2-4.5 (see section Scenario emissions), the mean of the SSP2-1.9 and SSP-6.0 scenarios was taken, as SSP2-4.5 was not calculated. An annual emissions trajectory was obtained by interpolating linearly between 2019 and the NDC target emissions. Emissions should be lower during the pandemic period, and could be adjusted downwards for these years; however, emissions are now tracking pre-pandemic levels, so this interpolation is deemed to be an acceptable estimate.

The CO_2 emissions estimates of a case study of 50 billionaires' investment emissions are outlined in Section 1. Investment emissions are proportional to shares of companies owned by these billionaires. Investment emissions are for 2023 only. A time series of these emissions of 11 years centred around 2023 (2018–2028) was created. This is roughly indicative of past and current trends, as emissions prior to 2023 may be somewhat lower while emissions are expected to grow after 2023. In lieu of recorded and modelled data, this method provides a reliable first-order approximation of a decadal trend.

Scenario emissions

The emissions scenario created for the Shared Socioeconomic Pathway 2 (SSP2), which represents the 'middle of the road' (medium challenges to mitigation and adaptation) narrative was used, specifically SSP2-4.5, which is seen as the most likely scenario given current policies, and economic and geopolitical trends.[48] SSP2-4.5 is an intermediate GHG emissions pathway, where CO_2 emissions remain around current levels until 2050, then begin to fall but do not reach net zero by 2100.[49] Global temperatures reach 2°C by 2050 and 2.7°C by 2100. National emissions were downloaded from the SSP database.[50] Annual emissions were obtained by interpolating between decadal emissions using a cubic spline.

OBTAINING TEMPERATURE TIME SERIES FOR BASELINE AND LEAVE-ONE-OUT SCENARIOS

Earlier research, such as that of Callahan and Mankin (2022),[51] has used a simplified complexity climate model, like the Finite Amplitude Impulse Response (FaIR) simple climate model, to quantify the global mean temperature response to emissions and then spatially scale this global mean temperature to grid cells using a constant factor for the proportion of local to global temperature change (a process known as 'pattern scaling'). It has been shown that global heating is proportional to cumulative emissions.[52] Rather than replicate the approach taken by Callahan and Mankin, and in other similar studies, this study formulated a method of deriving local temperature change as a function of emissions using the proportionality of heating to cumulative CO_2 emissions, known as the transient climate response to cumulative emissions of CO_2 (TCRE). One can also estimate the localized transient climate response to cumulative emissions of CO_2, referred to as the regional TCRE (RTCRE).[53] The RTCRE estimates were updated using the latest climate data from the Coupled Model Intercomparison Project Phase 6 (CMIP6) ensemble. Given that global heating occurs on the order of a year for small marginal increases in CO_2 emissions[54] and that heating from CO_2 persists for hundreds of years to millennia,[55] the method approximates that annual emissions increase temperatures locally by the product of the RTCRE and annual emissions that year, and persist indefinitely, since it is concerned with time horizons of fewer than 100 years.

Updating the regional transient climate response to cumulative emissions (RTCRE)

Work by Leduc et al. (2016)[56] was updated using the latest climate projection data from CMIP6. PAVICS[57] was used to process the data and CMIP6 data was obtained from Pangeo (2024).[58]

The following query was used to isolate the 16 models used in Oxfam's analysis, which includes models for the 1% increase in CO_2 per year, with a member id (r1i1p1f1) that has an active Earth System Climate Model (ESCM) with outputs of soil carbon (cSoil), vegetation carbon (cVeg), litter carbon (cLitter), ocean downward carbon flux (fgco2) and surface air temperature (tas):

```
= dict(experiment_id=['1pctCO2'],

variable_id=['areacella', 'areacello',
'cSoil','cVeg','cLitter','tas','fgco2'],

member_id=['r1i1p1f1']
```

The list of models that are found in the query above include: ACCESS-ESM1-5, BCC-ESM1, CESM2, CESM2-WACCM, CESM2-WACCM-FV2, CanESM5, EC-Earth3-CC, GFDL-ESM4, IPSL-CM5A2-INCA, IPSL-CM6A-LR, MPI-ESM-1-2-HAM, MPI-ESM1-2-LR, NorCPM1, NorESM2-LM and NorESM2-MM. BCC-ESM1 was removed as the ocean downward flux was significantly negative, compared to all other models, which were positive. $RTCRE = \Delta TAS / E_{tot}$ was then calculated over the temperature change period, where ΔTAS is the change in surface air temperature and E_{tot} is the cumulative CO_2 emissions over that period.

To obtain ΔTAS, a 20-year average window was used. The 70-year change in surface air temperature for each model was averaged at year 10 (year 0–20) and year 80 (year 70–90). This represents the 70-year temperature response to the cumulative CO_2 emission over 70 years.

To obtain the cumulative CO_2 emissions over the same 70 years, the carbon flux changes over those 70 years were calculated to represent the emissions, which is equal to the sum of atmospheric CO_2, the change in land carbon and the change in ocean carbon. Hence:

$$E_{tot} = CO_2atm(year\ 80 - year\ 10) + Land\ carbon\ flux(year\ 80 - year\ 10) + ocean\ carbon\ flux\ (sum\ year\ 10\ to\ year\ 80)$$

where

$$Land\ carbon\ flux(year\ 80 - year\ 10) = cLitter(year\ 80 - year\ 10) + cVeg(year\ 80 - year\ 10) + cSoil(year\ 80 - year\ 10)$$

These values were calculated for every model and re-gridded to the resolution of CanESM5. These were then used to calculate the average, 10th percentile and 90th percentile RTCRE over these 15 models.

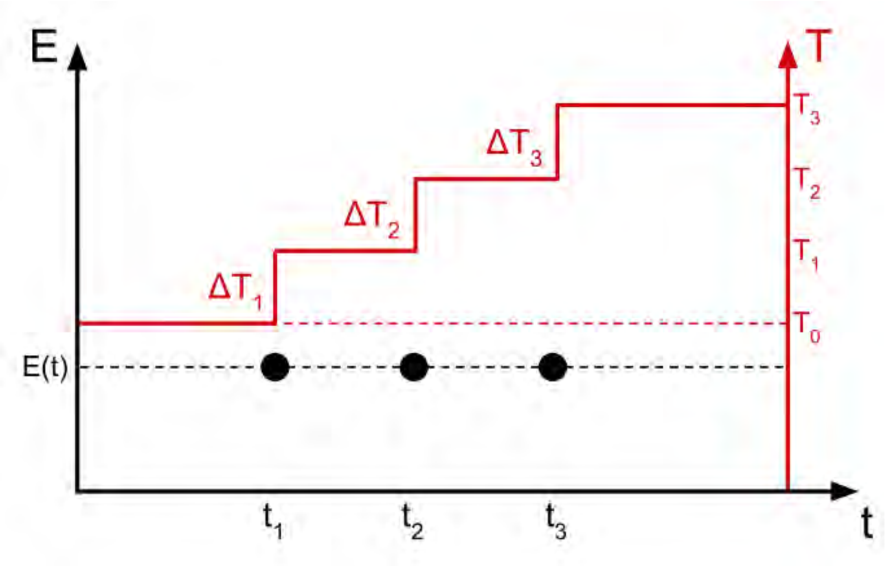
Aggregating RTCRE and historical temperature to national values

Rather than work at the grid-cell level, the RTCRE was aggregated to the country level weighted by population, so that local temperatures are weighted in proportion to population density, emphasizing parts of countries with higher population concentrations. This is the approach used in the cited climate economics literature, and population-weighted national temperatures are used throughout the analysis to also aggregate historical temperatures and to parametrize damage functions used to calculate economic damages caused by heating. Multiplying CO_2 emissions by a population-weighted country-level RTCRE in effect produces temperature increases that are also population weighted. The *xagg* python package (Schwarzwald, 2024)[59] was used to population-weight and aggregate historical temperature and RTCRE data.

Calculating future country temperatures using RTCRE and emissions

Figure 1 provides a schematic of how temperature is calculated using the RTCRE approach. Emissions in year *t* will warm a country by the product of the country's population-weighted RTCRE and the amount of CO_2 emissions.

Figure 1. Schematic of temperature increases from annual emissions using regional transient climate response to cumulative emissions of carbon dioxide (RTCRE)



Each $\Delta T(t)=E(t)\times RTCRE$, where RTCRE is a constant value for the population-weighted RTCRE of a country. In practice, this results in a linear increase in temperature if E(t) is constant, and is nonlinear otherwise.

The temperature $T(t)$ at any future year $t > t_0$ will be the initial temperature T_0 plus the product of this RTCRE and the cumulative emissions up that year (Equation 1).

$$T(t) = T_0 + RTCRE \times \sum_t E(t) \qquad (1)$$

This method was used to simply and reliably estimate future temperatures as they increase with cumulative CO_2 emissions. T_0 was set to the mean population-weighted temperature of the last five years for each country. The mean of the last five years was used, as opposed to the final year of recorded data, to help remove bias due to interannual variability.

All Pacific Island countries (except Papua New Guinea) were smaller than a grid cell, and so temperatures for these countries were approximated as the temperature of the grid cell they fall into. This should be a valid approximation since local temperatures are highly influenced by surrounding sea surface air temperatures. Likewise, the method does not population weight these temperatures (or RTCREs, which are also taken as the encompassing grid cell's RTCRE).

Temperatures with and without an actor's emissions

Two temperature time series are required to calculate economic damages, a baseline with all emissions and one excluding an actor's emissions ('leave-one-out' scenario). To obtain temperatures with all emissions, Equation 1 with total global CO_2 emissions was used. The leave-one-out time series for each actor was then obtained by subtracting their emissions at each time step. Heating contributions are held constant after actor emissions stop. For emissions of the top 1% and top 10% by income, this was done for both historical emissions only (1990–2019) and with projected emissions under an NDC pathway (1990–2030). This allows for differentiation between damages from recorded emissions and forecasted emissions. The extrapolated time series described above was used for billionaires' investment emissions.

CALCULATING ECONOMIC DAMAGES

The damage function by Burke et al. (2015)[60] was used, using updated regression parameters from Callahan and Mankin (2023).[61] The mean of bootstrapped parameters is used to obtain a central estimate. The damage function measures the change in GDP per capita growth of a country as a function of temperature change, while controlling for other physical variables (precipitation) and economic variables (economic shocks and trends common to all countries, country-specific fixed effects and trends, and other economic differences).[62]

Similarly to Burke et al. (2018, 2023)[63] and Callahan and Mankin (2022, 2023),[64] this study isolated the effect of temperature by taking the difference of change in GDP per capita growth rates. This allows the marginal effect of an actor's emissions in a given year to be calculated. The simplified damage function is given in Equation 2, where g is the change in GDP per capita growth, β_1 and β_2 are the parameters and T is the annual population-weighted temperature of a country.[65] The damage function has an inverted parabolic shape (inverted 'u-shaped') form such that economic productivity is enhanced when temperatures are increasing up to an optimal point, and then is harmed once this optimal temperature is exceeded, and declines more steeply the further the temperature is above this point.

$$g = \beta_1 T + \beta_2 T^2 \qquad (2)$$

The change in g was obtained as follows:

$$\Delta g = g(T) - g(T_{no\ actor}) \qquad (3)$$

Where T is the annual temperature under SSP2-4.5, and $T_{no\ actor}$ is the same temperature without the actor's emissions. Note that $\Delta g < 0$ when warming harms economic productivity and $\Delta g > 0$ when it improves economic productivity.

To obtain GDP per capita, Δg was added to observed (for historical damages) and projected growth rates, where GDP per capita (GPC) in year t is as follows:

$$GPC(t) = GPC(t-1) \times (1 + g_{baseline}(t) + \Delta g(t)) \quad (4)$$

Recorded GPC was used for the initial year t_0, and then iterated over this for subsequent years, using new estimates of GPC so that economic losses or gains permanently alter the growth trajectory of a country.[66] This GPC value was then subtracted from the historical or projected value (GPC_{SSP}) to obtain the damage:

$$\Delta GPC(t) = GPC_{SSP}(t) - GPC(t) \qquad (5)$$

Change in annual GDP ($\Delta GDP(t)$) was obtained by multiplying $\Delta GPC(t)$ by annual population. The result is the GDP lost or gained each year due to global heating.

These annual GDP damages were then discounted using a fixed rate of 2% per year, centred around the present year (t_p=2024), as suggested by Burke et al. (2023)[67] as a way of quantifying loss and damage (Equation 6). This amplifies the impact of emissions exponentially prior to t_p and discounts them in the conventional manner post t_p. The reasoning behind amplifying historical damages is that damages incurred from historical emissions today are compounded by the forgone economic growth that would have occurred in absence of these damages. These discounted annual damages were summed over all years up to a final year set by a time horizon (t_h), which determines the cumulative discounted damage at t_h. t_h was set to 2023 for damages from emissions to date, 2030 and 2050 for mid-term damages, and 2100 for longer-term estimates that align with existing literature.

$$\sum_{t=t_0}^{t_h} (1+r)^{-(t-t_p)} \times \Delta GPC(t) \qquad (6)$$

CAVEATS AND LIMITATIONS

Damage function

The method used to estimate climate change-related economic damages captures broad trends and does not explicitly account for extreme events, such as climate-related disasters (e.g. hurricanes, floods and heatwaves), geopolitical unrest and global economic effects, such as recession in countries caused by the collapse of another country's economy. Also, the damage function is parameterized according to historical data, which does not capture damages from unprecedented warming; however, some countries entering higher warming regimes already experienced historically by other countries should follow a similar damage response. Further, lagged effects from warming, while increasing uncertainty, tend to remove benefits to countries that experience benefits in the unlagged model. This calls into question whether any countries will benefit from warming in the long run, as economic impacts accumulate over time. The estimates provided in the study should therefore be considered non-exhaustive and relatively conservative in these respects.

CO_2-only focus

This analysis for the global richest 1% and 10% only accounts for warming and impacts related to CO_2 emissions, as there is only CO_2 data available for actors' emissions. If non-CO_2 emissions were included, global and regional heating would be higher and the impacts more pronounced. However, the analysis controlled for this by only increasing temperatures by CO2 related heating, neglecting future non-CO_2 warming. The analysis does, however, use observed temperatures up to 2019, and so the damage contribution from historical actor emissions will be slightly understated relative to the full GHG-related anthropogenic heating. This is not expected to qualitatively alter Oxfam's results. It may only lead to the estimates given being more conservative.

DATA AND CODE

GDP and population data

Population projections were taken from the SSP database, and harmonized GDP and GDP per capita (2005 International $) from Geiger and Frieler (2017).[68] Countries not in this dataset were added from World Bank, International Monetary Fund (IMF) and Organisation for Economic Co-operation and Development (OECD) data. Quadratic interpolation was used to fill missing years to obtain annual GDP and population values. Historical population values were inferred from the harmonised dataset by dividing GDP by GDP per capita values. GDP was converted from 2005 Int$ to 2022 Int$ using the GDP unit-converter (GDPuc) R package, which has built-in purchasing power parity (PPP) conversion factors and deflators.[69]

Temperature data

Gridded observed monthly mean atmospheric temperatures from the Berkeley Earth dataset were used for historical temperatures.[70] Historical temperatures and RTCRE values were population-weighted and aggregated to the country level using the *xagg* python package.[71] Gridded population data from the year 2000 from Population of the World[72] was used to calculate population-weighted country level means. As in earlier research by Callahan and Mankin (2022, 2023),[73] population weighting was used to spatially aggregate in a way that reflects where temperature increases have the most profound effects, since these usually occur where most capital and likewise people are concentrated.

Damage function parameters

The analysis used damage function parameters from Callahan and Mankin

(2023),[74] which are derived from a regression of changes in economic growth on population-weighted country-level mean temperature, precipitation and other transient and fixed economic effects, using the approach developed by Burke et al. (2015).[75] The python script was based on Callahan and Mankin (2022, 2023)[76] and is available upon request.

A note: In this section, economic damages are expressed in International Dollars ($), which adjusts for Purchasing Power Parity (PPP). Doing so enables us to make a fairer comparison of climate damages since International Dollars ($) better accounts for differences in the cost of living between countries. Using United States dollars (US$) – as done commonly in early climate economic literature – would downplay harms caused to lower income countries. Recently, International Dollars has become a more accepted method in climate economics literature. Emerging research is exploring more sophisticated methods of equity-weighting climate damages to reflect the uneven impacts of climate change. For instance, a recent study suggests using the diminishing marginal value of income to weight damages across countries.[77]

EXPLANATION OF STATISTICS IN THE MAIN REPORT

The report outlines key net economic damages (or net gains), which is the net sum of economic losses and gains.

1. **Three decades of consumption emissions by the world's super-rich 1% (1990–2019), have already caused global economic output to fall by $2.9 trillion between 1990 and 2023. By 2050, the economic damage of only four decades of emissions (1990–2030) rises to $52.6 trillion, equivalent to a loss of 0.5% of global cumulative GDP between 1990 and 2050.**

By 2023, the cumulative economic damage of the cumulative consumption emissions of the world's richest 1% between 1990 and 2019 was $2.92 trillion (in $ 2022).

By 2050, the cumulative economic damage of the cumulative consumption emissions of the world's super-rich 1% between 1990 and 2030 will be $52.57 trillion (in $ 2022). Table 4 summarizes the GDP change calculations.

Table 4. Cumulative damage attributable to the emissions of the world's super-rich 1%

Cumulative damage 1990–2050 (in $bn 2022) attributable to the emissions of the world's super-rich 1% (1990–2030)	Cumulative GDP 1990–2050 (in $bn 2022)	GDP change (in %)
-52,571	9,994,924	0.53

2. **The consumption emissions of the world's richest 10% (1990–2019) have already caused global economic output to fall by $8.6 trillion between 1990 and 2023. About as much damage was caused by the COVID-19 pandemic in 2020, which led to massive economic and social disruption and caused global poverty levels and inequality to surge. By 2050, four decades of consumption emissions (1990–2030) by the world's richest 10% will cause economic damage totalling $150 trillion,**

equivalent to a loss of 1.5% of global cumulative GDP between 1990 and 2050.

By 2023, the cumulative economic damage of the consumption emissions of the world's richest 10% between 1990 and 2019 was $8.62 trillion (in $ 2022).

The economic damage caused by the COVID-19 pandemic in 2020 was US$4,741bn (in US$ 2015) according to the World Bank[78] which is $8,610 (in $ 2022) (Table 5).

Table 5. Global economic damage caused by the COVID-19 pandemic

Year	Economic damage (in US$bn 2015)	Economic damage (in $bn 2022)
2019	0.00	0.00
2020	-4,741	-8,610

Source: World Bank Group (n.d).[79]

$8.62 trillion (in $ 2022) is about as much as $8.61 trillion (in $ 2022).

By 2050, the cumulative economic damage of the consumption emissions of the world's richest 10% between 1990 and 2030 is $149.7 trillion (in $ 2022). Table 6 summarizes the GDP change calculations.

Table 6. Cumulative damage attributable to the emissions of the world's richest 10%

Cumulative damage 1990–2050 (in $bn 2022) attributable to the emissions of the world's richest 10% (1990–2030)	Cumulative GDP 1990–2050 (in $bn 2022)	GDP change (in %)
-149,712	9,994,924	1.50

3. **Oxfam calculates that about one decade of 50 of the world's richest billionaires' investment emissions alone (between 2018 and 2028) will cause $250bn of economic damage by 2050. This is equivalent to the current economic output of countries such as Ecuador and Bulgaria.**

The cumulative economic damage of 11 years (2018–2028 inclusive) of investment emissions of 50 of the world's richest billionaires in 2050 is $250.1bn (in 2022 $). In 2023, the economic output of Ecuador was $248.3bn, while that of Bulgaria $249.9 bn (in 2022 $).

4. **Between 1990 and 2050, low- and lower-middle-income countries will accrue economic damage totalling $44 trillion. By contrast, high-income countries will benefit, accruing economic gains totalling $5.8 trillion (Table 7).**

Table 7. Cumulative economic net damages or gains attributable to the emissions of the world's super-rich 1%

	Cumulative economic net damage 1990–2050 (in $bn	Cumulative economic net gain 1990–2050 (in $bn 2022)

	2022) attributable to the emissions of the world's super-rich 1% (1990–2030)	attributable to the emissions of the world's super-rich 1% (1990–2030)
High-income countries	0	5,769
Low-income countries	-3,527	0
Lower-middle-income countries	- 40,464	0
Not classified	-1,788	0
Upper-middle-income countries	-12,562	0

Note: The only country covered in the 'not classified' income level is Venezuela.

5. **As a result of the economic damage they accrue, low- and lower-middle-income countries will lose 2.6% and 2.5% of their cumulative GDP between 1990 and 2050, respectively. The most affected regions – Southern Asia, South-East Asia and sub-Saharan Africa – will lose 3.0%, 2.4% and 2.4%, respectively, of their cumulative GDP by 2050. By contrast, high-income countries are least affected or are even benefiting economically (Table 8).**

Table 8. Changes in GDP attributable to the emissions of the worlds' super-rich 1%

	Cumulative damage 1990–2050 (in $bn 2022) attributable to the emissions of the world's super-rich 1% (1990–2030)	Cumulative GDP 1990–2050 (in $bn 2022)	GDP change (in %)
Regions			
Southern Asia	-27,910	945,779	-3.0
South-East Asia	-12,638	517,520	-2.4
sub-Saharan Africa	-9,572	395,597	-2.4
Middle East and North Africa	-10,818	479,355	-2.3
Pacific Islands	-9,572	7,134	-1.7
Latin America and the Caribbean	-12,385	892,181	-1.4
Australia and New Zealand	-391	132,558	-0.3
Eastern Asia	-5,926	2,317,556	-0.2
Western Asia	-285	182,906	-0.2
Northern America	3,026	1,692,791	0.2
Europe	23,828	2,369,922	1.0
Central Asia	621	61,624	1.0
World Bank income classification (2023)			
Low income	-3,527	135,282	-2.6
Lower-middle income	-40,464	1,648,262	-2.5
Upper-middle income	-12,562	3,644,828	-0.3
High income	5,769	4,499,323	0.1
Not classified	-1,788	67,288	-2.7
World	52,571	9,994,924	-0.5

Notes: The only country covered in the 'not classified' income level is Venezuela. The regional classification is based on the seven world regions defined by the World Bank. Some world regions are further disaggregated to gain more detailed insights into regional differences. Annex 1 lists the regional classifications of all countries.

6. **The economic damage that low- and lower-middle-income countries have already accrued between 1990 and 2023 because of three decades of consumption emissions of the world's super-rich 1% (1990–2019), is about three times the total officially recorded climate finance developed countries have given to poorer countries.**

The economic damage low- and lower-middle-income countries accrued between 1990 and 2023 amounted to $3.73 trillion.

Monitoring the flows of climate finance is difficult, as there is no agreed definition of what constitutes climate finance or consistent accounting rules.[80] At the request of donor countries, the OECD has tracked climate finance given by developed countries for climate action in developing countries.[81] Data is available for 2013 through to 2022 (Table 9).

Table 9. Climate finance provided and mobilized by donor countries

Year	Climate finance provided and mobilized (US$bn, current year)	Climate finance provided and mobilised ($bn 2022)
2013	52.4	86.4
2014	61.8	102.6
2015	44.6	81.0
2016	58.5	107.9
2017	71.6	128.6
2018	79.9	140.8
2019	80.4	142.8
2020	83.3	147.8
2021	89.6	148.4
2022	115.9	190.9
Total	**738.0**	**1,276.4**

Source: OECD (2024).[82]

Notes: The OECD notes that the gap in time series in 2015 for mobilized private finance results from the implementation of enhanced measurement methods. As a result, the grand totals in 2016–2022 and 2013–2014 are not directly comparable.

$3,730bn divided by $1,276.4bn is 2.9.

However, it should be noted that Oxfam analysis has shown that generous accounting practices have allowed developed countries[83] to overstate the level of support they have actually provided.[84]

Even if developed countries reach the pledged US$100bn in 2023, the economic damage that low- and lower-middle-income countries accrued between 1990 and 2023 is still more than two times the climate finance given by developed countries.

7. **The economic damage between 1990 and 2050 caused by four decades of emissions of the world's super-rich 1% (1990–2030) is equivalent to**

3% GDP loss in Somalia.

Table 10 summarizes the data and calculations.

Table 10. GDP change in Somalia due to the cumulative economic damage attributable to the world's super-rich 1%

	GDP cumulative 1990–2050 (in $bn 2022)	Cumulative damage 1990–2050 attributable to the emissions of the world's super-rich 1% (1990–2030) (in $bn 2022)	GDP change in %
Somalia	7.76	-0.25	-3.2

IMPACTS OF EMISSIONS ON CROP YIELD

The calculations in this section are based on the following research. To attribute agricultural impacts of climate change to actors, the study first adapted the statistical crop yield model of Proctor et al. (2022),[85] which links historical variability in the yields of maize, soybean and wheat to variability in growing season daily maximum temperature and soil moisture across the globe. The crop yield data for maize, soybean and wheat is from the UN Food and Agriculture Organization (FAOSTAT)[86] and is based on national reporting with quality control. The temperature data is from the US National Center for Environmental Prediction Climate Prediction Center (CPC) Global Unified Temperature product,[87] which is based on station observations gridded to half-degree resolution. The soil moisture data is from the European Space Agency Climate Change Initiative[88] and is derived from active and passive satellite sensors. All the climate data was re-gridded to half-degree resolution, and only the local growing season for each crop was considered, using crop calendars from Sacks et al. (2010).[89]

The statistical model estimates crop yield for a given grid point *i* and year *t* in terms of the cubic expansion *f(.)* of daily maximum temperature and soil moisture:

$$Y_{it} = \beta_T f_T(T_{itg}) + \beta_S f_S(S_{itg}) + \lambda_i + \alpha_{it} + \epsilon_{it} \qquad (1)$$

The model includes fixed effects for time-invariant spatial heterogeneity, λ_i, and for long-term time trends, α_{it}. Errors are denoted by ϵ_{it}.[90] Subscripts *g* on the climate variables indicated that the cubic expansions *f(.)* are performed on the growing season daily time series of climate variables, which were then averaged over the growing season to harmonize timescales between daily climate variables and annual yield data. This step captures the nonlinear impacts of temperature and soil moisture on crop yield. The model is calibrated on the period 2007–2019, for which data availability is optimal, and generates separate response functions for the three crops. The use of temperature and soil moisture as key climate drivers of crop yield reflects the current best understanding of the mechanism of climate impacts on crop yields.

The model generates global response curves inferred from the non-linear β coefficients in Equation 1. These responses were then used to estimated yield impacts of warming induced by emissions from groups of emitters. This warming (in annual mean temperature) is in turn estimated via the regional transient climate response to cumulative emissions (*rTCRE*) derived from an ensemble of climate models from CMIP6 (see description under subsection 'Obtaining temperature time series for baseline and leave-one-out scenarios'). Scaling factors (Φ_i) relating local warming in annual mean temperatures (ΔT_i) to local growing season mean daily maximum temperature warming (ΔT_{ig}) are also estimated as a ratio from an ensemble of CMIP6 models. Thus, the crop-relevant warming due to emissions of a given actor, E_e, at a given grid point *i*, is given by:

$$\Delta Tmax_{ie} = E_e \cdot \Phi_i rTCRE_i$$

$$\Phi_i = \frac{\Delta Tmax_{ig}}{\Delta T_i}$$

The yield impact (ΔY_{ite}) due to this emitter-attributable maximum temperature warming ($\Delta Tmax_{ie}$) was then estimated using coefficients from Equation 1 as the difference between estimated yields under baseline temperatures and under temperatures incremented by $\Delta Tmax_{ie}$:

$$\Delta \mathrm{Y}_{ite} = \beta_T \mathrm{f}_T(\mathrm{T}_{it} + \Delta Tmax_{ie}) - \beta_T \mathrm{f}_T(\mathrm{T}_{it})$$

Soil moisture changes were excluded in the yield change attribution because soil moisture changes under warming are both smaller and more uncertain than changes in temperature. However, including soil moisture in the estimation of yield responses to temperature in Equation 1 is necessary to isolate temperature effects given their correlation with soil moisture state (i.e. to avoid conflating and double-counting temperature and moisture impacts on crop yield). To translate yield impacts to production impacts, grid-point yield impacts were first aggregated to the national scale (denoted subscript *c*) via national harvested area (*HA*) fraction weighting. This step ensures that national attributable yield changes account for the subnational spatial distribution of croplands:

$$\Delta \mathrm{Y}_{cte} = \sum_{i \in c} \Delta \mathrm{Y}_{ite} \frac{HA_i}{\sum_{i \in c} HA_i}$$

This step matches attributable yield impact estimates to the limiting spatial scale of the FAOSTAT national crop data, giving national yield impacts as percentages. National attributable production impacts (ΔP_{cte}) for maize, wheat and soybean were then estimated for each year *t* based on annual harvested area, yield and yield impact:

$$\Delta P_{cte} = \Delta \mathrm{Y}_{cte} \mathrm{Y}_{cte} \mathrm{HA}_{cte}$$

TOTAL PRODUCTION IMPACTS

Total production impacts for countries and regions were integrated over 1990 to the accounting year of 2023 for impacts-to-date, and through 2050 as an estimate of persistent impacts of warming. Future national yields harvested areas were kept constant, in line with SSP2-4.5, which most closely agrees with NDC scenarios used to project the emissions of actors through until 2030.

PRODUCTION IMPACTS IN PERSON-YEAR EQUIVALENTS

The production impacts in person-year equivalents were estimated assuming base caloric requirements of 2,000kcal/person/day and caloric crop yields of 3,500kcal/kg.[91]

The daily caloric need for a person depends on many factors, including gender, age, activity and weather. The UK National Health Service (NHS) recommends 2,000 kcal per day for a woman and 2,500 for a man.[92] The Dietary Guidelines for Americans also use 2,000 kcal per day as a reference value for a healthy adult diet.[93]

These numbers are illustrative as consuming wheat, maize and soy alone would not provide the complete nutrition required to sustain a healthy diet. These estimates do not account for food system complexity and thus do not truly reflect the food security consequences of production impacts. They merely help contextualize the scale of attributable production impacts in terms of people potentially fed.

EXPLANATION OF STATISTICS IN THE MAIN REPORT

The report outlines key net crop losses.

8. **Three decades of consumption emissions (1990–2019) of the world's super-rich 1% have already caused crop losses that could have provided enough calories to feed 14.5 million people a year between 1990 and 2023 (for maize, wheat and soy combined). This will rise to 46 million people a year between 2023 and 2050 due to four decades of consumption emissions (1990–2030) by the world's super-rich 1% only (for maize, wheat and soy combined).**

Table 11 summarizes the calculations.

Table 11. Cumulative crop losses caused by the emissions of the world's super-rich 1%

Crop	Cumulative crop loss 1990–2023 (in tonnes) caused by the past emissions of the world's super-rich 1%	Cumulative crop loss in person-year equivalents (1990–2023)	Cumulative crop loss in person-year equivalents per year 1990–2023 (33 years)

	(1990–2019)		
Maize, wheat and soy combined	-99,871,181	-478,834,440	-14,510,135
	Cumulative crop loss 2023-2050 (in tonnes) caused by the emissions of the world's super-rich 1% (1990–2030)	**Cumulative crop loss in person-year equivalents (2023–2050)**	**Cumulative crop loss in person-year equivalents per year 2023–2050 (27 years)**
Maize, wheat and soy combined	-259,080,451	-1,242,166,580	46,006,170

9. **The crop losses caused by the consumption emissions (1990–2019) of the world's richest 10% could have provided enough calories to feed a staggering 48.2 million people a year between 1990 and 2023. To put this number into perspective, recent multiple crises, from the COVID-19 pandemic to the war in Ukraine, pushed around 40.7 million additional people into hunger each year between 2019 and 2022. Between 2023 and 2050, the crop losses induced by four decades of consumption emissions of the world's richest 10% (1990–2030) could provide enough calories to feed a 148.8 million people a year.**

Table 12 summarizes the calculations.

Table 12. Cumulative crop losses caused by the emissions of the world's richest 10%

Crop	Cumulative crop loss 1990–2023 (in tonnes) caused by the past emissions of the world's richest 10% (1990–2019)	Cumulative crop loss in person-year equivalents (1990–2023)	Cumulative crop loss in person-year equivalents per year 1990–2023 (33 years)
Maize, wheat and soy combined	-331,913,965	-1,591,368,368	-48,223,284
	Cumulative crop loss 2023–2050 (in tonnes) caused by the emissions of the world's richest 10% (1990–2030)	**Cumulative crop loss in person-year equivalents (2023–2050)**	**Cumulative crop loss in person-year equivalents per year 2023–2050 (27 years)**
Maize, wheat and soy combined	-838,195,385	-4,018,745,104	-148,842,411

According to the World Health Organization (WHO),[94] 120 million people were pushed into hunger between 2019 and 2022, an average of 40,666,667 in each of the three years.

About one decade (2018–2028) of investment emissions by 50 of the world's richest billionaires alone will cause crop losses that could provide enough calories to feed 120,000 people a year between 2028 and 2050 (Table 13).

Table 13. Cumulative crop losses due to investment emissions by 50 of the world's richest billionaires.

	Cumulative crop loss in person-year equivalents	Cumulative crop loss in person-year equivalents per year (22 years)
Maize, wheat and soy combined	-2,631,956	-119,634

11. **Northern America and Europe have already accrued crop losses that could have provided enough calories to feed 3.6 million and 3.4 million people a year, respectively, between 1990 and 2023 (wheat, maize and soy combined). These numbers will rise to 10.3 million and 10.5 million people a year, respectively, between 2023 and 2050.**

12. **Latin America and the Caribbean has already accrued crop losses that could have provided enough calories to feed 2.4 million people a year between 1990 and 2023 (wheat, maize and soy combined). This will rise to nine million people a year between 2023 and 2050.**

Table 14 a and b summarize the calculations and data.

Table 14a. Cumulative crop losses 1990–2023 caused by the emissions of the world's super-rich 1% (1990–2019)

Maize, wheat and soy combined	Cumulative crop loss 1990–2023 (in tonnes) caused by the past emissions of the world's super-rich 1% (1990–2019)	Cumulative crop loss in person-year equivalents (1990–2023)	Cumulative crop loss in person-year equivalents per year 1990–2023 (33 years)
Northern America	- 24,689,435	-118,374,007	-3,587,091
Europe	- 23,360,314	-112,001,509	-3,393,985
Latin America and the Caribbean	- 16,787,303	-80,487,070	-2,439,002

Table 14b. Cumulative crop losses 2023–2050 caused by the emissions of the world's super-rich 1% (1990–2030)

Maize, wheat and soy combined	Cumulative crop loss 2023–2050 (in tonnes) caused by the emissions of the world's super-rich 1% (1990–2030)	Cumulative crop loss in person-year equivalents (2023–2050)	Cumulative crop loss in person-year equivalents per year 2023–2050 (27 years)
Northern	-57,979,984	-277,986,234	-10,295,786

America			
Europe	-59,214,991	-283,907,499	-10,515,093
Latin America and the Caribbean	-50,895,218	-244,018,174	-9,037,710

HEAT-RELATED EXCESS DEATHS

The calculations below use a concept called the mortality cost of carbon, which assesses excess deaths due to temperature changes caused by climate change. It is one of the metrics used to calculate the social cost of carbon (SC-CO_2). The SC-CO_2 is widely used, for instance, by the US Environmental Protection Agency to evaluate the impact of mitigation policies. The concept is used to calculate the cost–benefit analysis required when agencies propose environmental rules.

Oxfam's study chose to use the mortality cost of carbon as it shows the impact on human lives of excess heat.

The estimated mortality cost of carbon per metric ton of 2020 emissions is 6.49 x 10^ – 5 (0.0000649).[95] This assumes income-based adaptation (that countries will become richer) and that additional income is available and used to invest in adaptation measures – such as air conditioning – to reduce the risk of deaths due to heat.

The mortality-cost-of-carbon results were calculated in the RFF-SP emissions scenarios[96] now being used by the US government,[97] in which global average temperatures are expected to rise just above 2°C above preindustrial levels by 2100.

The deaths calculated span the 100-year period between 2020 and 2120.

EXPLANATION OF STATISTICS IN THE MAIN REPORT

13. Just four years (2015–2019) of consumption emissions of the world's super-rich 1% are enough to cause 1.5 million excess deaths between 2020 and 2120. This equates to just over 15,000 excess deaths per year over the subsequent century, which is higher than the current annual death toll due to natural disasters.

14. The impact of the consumption emissions of the world's richest 10%for the same period is a staggering 4.8 million excess deaths, or 47,600 per year, to 2120.

15. Just four years (2021–2025) of investment emissions of 50 of the world's richest billionaires are enough to cause around 34,000 excess deaths between 2026 and 2126.

The total cumulative consumption emissions of the world's super-rich 1% between 2015 and 2019 was 23.3 GtCO2: 23,300,000,000 tonnes multiplied by 6.49 x 10^ – 5 (0.0000649) is 1,512,170.

The deaths calculated span a 100-year period, so 1,512,170 divided by 100 years is an average of 15,121.70 excess deaths a year.

The estimated number of annual deaths caused by natural disasters in 2021 (the latest year for which data is available) was 9,427. The estimated average of annual deaths caused by natural disasters between 2011 and 2021 is 13,915.98

The total cumulative consumption emissions of the world's richest 10% between 2015 and 2019 was 73.3 GtCO2: 73,300,000,000 tonnes multiplied by 6.49 x 10^ – 5 (0.0000649) is 4,757,170, while 4,757,170 divided by 100 years is 47,571.70.

The estimated total cumulative investment emissions of 50 of the world's richest billionaires between 2015 and 2019 was 527,528,724 tonnes: 527,528,724 multiplied by 6.49 x 10^ – 5 (0.0000649) is 34,237.

16. If the world's super-rich 1% had halved their emissions between 2015 and 2019, 756,000 people would live.

The total cumulative consumption emissions of the world's super-rich 1% between 2015 and 2019 was 23.3 $GtCO_2$: 23,300,000,000 tonnes divided by 2 is 11,650,000,000; 11,650,000,000 multiplied by 6.49 x 10^ – 5 (0.0000649) is 756,085.

17. If instead 50 of the world's richest billionaires had placed their investments in a low-carbon intensity equity fund between 2021 and 2025, the emissions reductions would have saved about 12,000 lives.

The total cumulative investment emissions of 50 of the world's richest billionaires between 2015 and 2019 was 527,528,724 tonnes. If the 50 billionaires had placed their investments in a low-carbon intensity equity fund between 2021 and 2025, the total investment emissions would have been reduced by 35% (see Section 1).

Thirty-five percent of 527,528,724 tonnes is 342,893,671 tonnes: 342,893,671 multiplied by 6.49 x 10^ – 5 (0.0000649) is 22,254, 11,983 fewer excess deaths than 34,237 (see calculation 15).

18. If countries will remain as ill-equipped to protect their populations from heat as they are today, the estimated number of deaths is much higher.

The estimated mortality cost of carbon per metric ton of 2020 emissions, assuming no income-based adaptation of countries, is 1.15 x 10^ – 4 (0.000115).[99]

The total cumulative consumption emissions of the world's super-rich 1% between 2015 and 2019 was 23.3 $GtCO_2$: 23,300,000,000 tonnes multiplied by 1.15 x 10^ – 4 (0.000115) is 2,679,500.

The total cumulative consumption emissions of the world's richest 10% between 2015 and 2019 was 73.3 $GtCO_2$: 73,300,000,000 tonnes multiplied by 1.15 x 10^ – 4 (0.000115) is 8,429,500.

The total cumulative investment emissions of 50 of the world's richest billionaires between 2015 and 2019 was 551,790,104 tonnes: 551,790,104 multiplied by 1.15 x 10^ – 4 (0.000115) is 63,456.

19. Of the 1.5 million excess deaths caused by the emissions of the world's super-rich 1%, Oxfam's analysis finds that 1.18 million or 78% of excess deaths due to heat will occur in low- and lower middle-income countries while the number of deaths in high-income countries will be negligible.

Seventy-eight percent of excess deaths will occur in low- and lower-middle-income countries (using World Bank categorizations from 2020).[100] The 1,512,170 excess deaths in total multiplied by 0.78 is 1,179,492.60.

20. Most people who will die are in Southern Asia, followed by sub-Saharan Africa. Around 40% of excess deaths will occur in Southern Asia, with India accounting for most of these excess deaths (70%). Around 29% of excess deaths will occur in sub-Saharan Africa, with Nigeria accounting for most of these excess deaths (19%).

Bressler (2024)[101] provides the estimated mortality cost of carbon per metric ton of 2020 emissions by country (see Annex 1). The estimated mortality cost of carbon per country was then multiplied by 23,300,000,000 tonnes (the total cumulative consumption emissions of the world's super-rich 1% between 2015 and 2019) to get the excess deaths per country. The total number of excess deaths per region was then calculated based on the country groupings used (Table 15).

Table 15. Excess deaths per region

Regions	Number of excess deaths	Share of global total (%)	Country most affected	Number of excess deaths	Share of regional total (%)

All other regions	3,421	0	n/a	n/a	n/a
Europe	12,882	1	Ukraine	8,318	65
Central Asia	21,601	1	Uzbekistan	13,234	61
Latin America and the Caribbean	37,397	2	Brazil	12,745	34
South-East Asia	82,489	5	Indonesia	2,531	27
Middle East and North Africa	87,445	6	Egypt	19,991	23
Eastern Asia	226,081	15	China	221,350	98
Sub-Saharan Africa	432,025	29	Nigeria	81,084	19
Southern Asia	608,234	40	India	428,720	70
Total	**1,511,576**				

Notes: The regional classification is based on the seven world regions defined by the World Bank. Some world regions are further disaggregated to gain more detailed insights into regional differences. Annex 1 lists the regional classifications of all countries.

21. Around 430,000 Indian citizens will die until 2120 because of just four years (2015–2019) of emissions by the world's super-rich 1% – about 4,300 excess deaths a year.

For India, the estimated mortality cost of carbon per metric ton of 2020 emissions assuming income-based adaptation is 0.0000184,[102] while 23,300,000,000 tonnes multiplied by 0.0000184 is 428,720: 428,720 divided by 100 years is 4287.2.

ANNEX 1. REGIONAL GROUPINGS OF COUNTRIES AND MORTALITY COST OF CARBON USED IN SECTION 2

Country code	Country	Region	Expected mortality cost of carbon
IND	India	Southern Asia	0.000018400
CHN	China	Eastern Asia	0.000009500
PAK	Pakistan	Southern Asia	0.000004620
NGA	Nigeria	Sub-Saharan Africa	0.000003480
COD	Democratic Republic of Congo	Sub-Saharan Africa	0.000001880
BGD	Bangladesh	Southern Asia	0.000001480
AFG	Afghanistan	Southern Asia	0.000001120
ETH	Ethiopia	Sub-Saharan Africa	0.000001120
IDN	Indonesia	South-East Asia	0.000000967
NER	Niger	Sub-Saharan Africa	0.000000966
SDN	Sudan	Sub-Saharan Africa	0.000000917
EGY	Egypt	Middle East and North Africa	0.000000858
VNM	Vietnam	South-East Asia	0.000000763
SOM	Somalia	Sub-Saharan Africa	0.000000715
BFA	Burkina Faso	Sub-Saharan Africa	0.000000704
MLI	Mali	Sub-Saharan Africa	0.000000671
MOZ	Mozambique	Sub-Saharan Africa	0.000000662
TZA	United Republic of Tanzania	Sub-Saharan Africa	0.000000631
IRQ	Iraq	Middle East and North Africa	0.000000582
PHL	Philippines	South-East Asia	0.000000577
UGA	Uganda	Sub-Saharan Africa	0.000000576
TCD	Chad	Sub-Saharan Africa	0.000000573
UZB	Uzbekistan	Central Asia	0.000000568
MMR	Myanmar	South-East Asia	0.000000562
BRA	Brazil	Latin America and the Caribbean	0.000000547
CIV	Côte d'Ivoire	Sub-Saharan Africa	0.000000537
IRN	Iran (Islamic Republic of)	Middle East and North Africa	0.000000518
KEN	Kenya	Sub-Saharan Africa	0.000000456
CMR	Cameroon	Sub-Saharan Africa	0.000000444
YEM	Yemen	Middle East and North Africa	0.000000416
NPL	Nepal	Southern Asia	0.000000404
AGO	Angola	Sub-Saharan Africa	0.000000388

THA	Thailand	South-East Asia	0.000000377
GHA	Ghana	Sub-Saharan Africa	0.000000367
MWI	Malawi	Sub-Saharan Africa	0.000000360
UKR	Ukraine	Europe	0.000000357
RUS	Russian Federation	Europe	0.000000356
MDG	Madagascar	Sub-Saharan Africa	0.000000340
SYR	Syrian Arab Republic	Middle East and North Africa	0.000000274
DZA	Algeria	Middle East and North Africa	0.000000268
ZAF	South Africa	Sub-Saharan Africa	0.000000266
ZMB	Zambia	Sub-Saharan Africa	0.000000265
BEN	Benin	Sub-Saharan Africa	0.000000264
GIN	Guinea	Sub-Saharan Africa	0.000000244
SEN	Senegal	Sub-Saharan Africa	0.000000239
TUR	Türkiye	Western Asia	0.000000232
MAR	Morocco	Middle East and North Africa	0.000000230
MEX	Mexico	Latin America and the Caribbean	0.000000202
ZWE	Zimbabwe	Sub-Saharan Africa	0.000000201
BDI	Burundi	Sub-Saharan Africa	0.000000196
TGO	Togo	Sub-Saharan Africa	0.000000196
KHM	Cambodia	South-East Asia	0.000000187
TJK	Tajikistan	Central Asia	0.000000147
CAF	Central African Republic	Sub-Saharan Africa	0.000000144
HTI	Haiti	Latin America and the Caribbean	0.000000144
SAU	Saudi Arabia	Middle East and North Africa	0.000000135
SLE	Sierra Leone	Sub-Saharan Africa	0.000000135
RWA	Rwanda	Sub-Saharan Africa	0.000000131
JPN	Japan	Eastern Asia	0.000000125
MRT	Mauritania	Sub-Saharan Africa	0.000000096
VEN	Venezuela (Bolivarian Republic of)	Latin America and the Caribbean	0.000000096
GTM	Guatemala	Latin America and the Caribbean	0.000000093
HND	Honduras	Latin America and the Caribbean	0.000000084
JOR	Jordan	Middle East and North Africa	0.000000082
LBR	Liberia	Sub-Saharan Africa	0.000000082
TUN	Tunisia	Middle East and North Africa	0.000000082
KGZ	Kyrgyzstan	Central Asia	0.000000080
ARG	Argentina	Latin America and the Caribbean	0.000000079
ARE	United Arab Emirates	Middle East and North Africa	0.000000075
KOR	Republic of Korea	Eastern Asia	0.000000075
LKA	Sri Lanka	Southern Asia	0.000000074
KAZ	Kazakhstan	Central Asia	0.000000070
ERI	Eritrea	Sub-Saharan Africa	0.000000066
COL	Colombia	Latin America and the Caribbean	0.000000064
COG	Congo	Sub-Saharan Africa	0.000000062
TKM	Turkmenistan	Central Asia	0.000000062

GMB	Gambia	Sub-Saharan Africa	0.000000058
PSE	Occupied Palestinian Territory	Middle East and North Africa	0.000000055
LAO	Lao PDR	South-East Asia	0.000000055
KWT	Kuwait	Middle East and North Africa	0.000000053
NIC	Nicaragua	Latin America and the Caribbean	0.000000051
PRY	Paraguay	Latin America and the Caribbean	0.000000050
ROU	Romania	Europe	0.000000050
MYS	Malaysia	South-East Asia	0.000000050
AZE	Azerbaijan	Western Asia	0.000000050
LBY	Libya	Middle East and North Africa	0.000000050
BOL	Bolivia (Plurinational State of)	Latin America and the Caribbean	0.000000042
ITA	Italy	Europe	0.000000040
SRB	Serbia	Europe	0.000000039
PNG	Papua New Guinea	Pacific Islands	0.000000038
ESP	Spain	Europe	0.000000037
BLR	Belarus	Europe	0.000000036
DOM	Dominican Republic	Latin America and the Caribbean	0.000000035
SLV	El Salvador	Latin America and the Caribbean	0.000000032
GRC	Greece	Europe	0.000000032
MDA	Republic of Moldova	Europe	0.000000031
GNB	Guinea-Bissau	Sub-Saharan Africa	0.000000029
CUB	Cuba	Latin America and the Caribbean	0.000000028
CAN	Canada	Northern America	0.000000027
ECU	Ecuador	Latin America and the Caribbean	0.000000025
GEO	Georgia	Western Asia	0.000000024
BGR	Bulgaria	Europe	0.000000023
LSO	Lesotho	Sub-Saharan Africa	0.000000023
ALB	Albania	Europe	0.000000020
ARM	Armenia	Western Asia	0.000000019
HUN	Hungary	Europe	0.000000018
OMN	Oman	Middle East and North Africa	0.000000017
NAM	Namibia	Sub-Saharan Africa	0.000000016
MNG	Mongolia	Eastern Asia	0.000000015
QAT	Qatar	Middle East and North Africa	0.000000015
BWA	Botswana	Sub-Saharan Africa	0.000000015
LBN	Lebanon	Middle East and North Africa	0.000000014
PER	Peru	Latin America and the Caribbean	0.000000014
BIH	Bosnia and Herzegovina	Europe	0.000000014
JAM	Jamaica	Latin America and the Caribbean	0.000000014
TWN	Taiwan	Eastern Asia	0.000000013
ISR	Israel	Middle East and North Africa	0.000000013
MKD	North Macedonia	Europe	0.000000011
DJI	Djibouti	Middle East and North Africa	0.000000011
HRV	Croatia	Europe	0.000000011

TLS	Timor-Leste	South-East Asia	0.000000011
COM	Comoros	Sub-Saharan Africa	0.000000009
CRI	Costa Rica	Latin America and the Caribbean	0.000000007
SWZ	Eswatini	Sub-Saharan Africa	0.000000007
GAB	Gabon	Sub-Saharan Africa	0.000000005
BHR	Bahrain	Middle East and North Africa	0.000000005
URY	Uruguay	Latin America and the Caribbean	0.000000005
PRT	Portugal	Europe	0.000000005
SLB	Solomon Islands	Pacific Islands	0.000000004
BTN	Bhutan	Southern Asia	0.000000004
SVK	Slovakia	Europe	0.000000003
BLZ	Belize	Latin America and the Caribbean	0.000000003
GUY	Guyana	Latin America and the Caribbean	0.000000003
MNE	Montenegro	Europe	0.000000003
GNQ	Equatorial Guinea	Sub-Saharan Africa	0.000000002
SUR	Suriname	Latin America and the Caribbean	0.000000002
MDV	Maldives	Southern Asia	0.000000002
FJI	Fiji	Pacific Islands	0.000000002
LTU	Lithuania	Europe	0.000000002
CYP	Cyprus	Western Asia	0.000000002
PRI	Puerto Rico	Latin America and the Caribbean	0.000000002
MUS	Mauritius	Sub-Saharan Africa	0.000000001
CPV	Cabo Verde	Sub-Saharan Africa	0.000000001
STP	São Tomé and Príncipe	Sub-Saharan Africa	0.000000001
LVA	Latvia	Europe	0.000000001
TTO	Trinidad and Tobago	Latin America and the Caribbean	0.000000001
BHS	Bahamas	Latin America and the Caribbean	0.000000001
MLT	Malta	Middle East and North Africa	0.000000001
WSM	Samoa	Pacific Islands	0.000000000
VCT	Saint Vincent and the Grenadines	Latin America and the Caribbean	0.000000000
VUT	Vanuatu	Pacific Islands	0.000000000
SVN	Slovenia	Europe	0.000000000
LCA	Saint Lucia	Latin America and the Caribbean	0.000000000
TON	Tonga	Pacific Islands	0.000000000
POL	Poland	Europe	0.000000000
ABW	Aruba	Latin America and the Caribbean	0.000000000
BRB	Barbados	Latin America and the Caribbean	0.000000000
NCL	New Caledonia	Pacific Islands	0.000000000
PYF	French Polynesia	Pacific Islands	0.000000000
EST	Estonia	Europe	0.000000000
CZE	Czechia	Europe	0.000000000
BRN	Brunei Darussalam	South-East Asia	-0.000000001
ISL	Iceland	Europe	-0.000000001
PAN	Panama	Latin America and the Caribbean	-0.000000001

LUX	Luxembourg	Europe	-0.000000002
MAC	Macao	Eastern Asia	-0.000000003
SGP	Singapore	South-East Asia	-0.000000008
NZL	New Zealand	Australia and New Zealand	-0.000000009
FIN	Finland	Europe	-0.000000011
DNK	Denmark	Europe	-0.000000013
IRL	Ireland	Europe	-0.000000013
AUT	Austria	Europe	-0.000000014
CHL	Chile	Latin America and the Caribbean	-0.000000018
BEL	Belgium	Europe	-0.000000020
NOR	Norway	Europe	-0.000000020
HKG	Hong Kong	Eastern Asia	-0.000000022
SWE	Sweden	Europe	-0.000000024
CHE	Switzerland	Europe	-0.000000025
NLD	Netherlands	Europe	-0.000000038
AUS	Australia	Australia and New Zealand	-0.000000055
FRA	France	Europe	-0.000000070
DEU	Germany	Europe	-0.000000141
GBR	United Kingdom	Europe	-0.000000144
USA	United States of America	Northern America	-0.000000187

Source: Mortality cost of carbon based on Bressler (2024);[103] country groupings by Oxfam. Countries ranked from highest to lowest mortality cost of carbon.

NOTES

1 Bloomberg. (2024). *Bloomberg Billionaires Index*. Accessed 16 August 2024. https://www.bloomberg.com/billionaires

2 CDP is a charity that runs the global disclosure system for investors, companies, cities, states and regions to manage their environmental impacts. See CDP. Accessed 20 August 2024. https://www.cdp.net/en.

3 M.E. Sotos. (20 January 2015). Scope 2: *Changing the way companies think about electricity emissions*. World Resources Institute. Accessed 16 August 2024. https://www.wri.org/insights/scope-2-changing-way-companies-think-about-electricity-emissions

4 JetSpy. Accessed April 2024. https://jetspy.com/

5 FlightRadar 24. Accessed April 2024. https://www.flightradar24.com/

6 Cirium. Cirium Tracked Utilization Data (Aggregated by Flight/Fleet) purchased data. September 2024 https://www.cirium.com/

7 U.S. Energy Information Administration. Carbon Dioxide Emissions Coefficients. Accessed September 2024. https://www.eia.gov/environment/emissions/co2_vol_mass.php

8 IPCC. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_5_Aircraft.pdf

9 SuperYachtFan. Accessed 20 August 2024. https://www.superyachtfan.com

10 Superyacht Times. Accessed 20 August 2024. https://www.superyachttimes.com

11 MarineTraffic. Accessed 20 August 2024. https://www.marinetraffic.com

12 S. Alwan. (2012) *Energy Efficiency Design Index (EEDI) Impact on Superyacht Design*. Master's thesis, University of Liège and Ecole Centrale De Nantes. Accessed 16 August 2024. https://matheo.uliege.be/bitstream/2268.2/6125/1/Sabah%20Alwan%20%28EMSHIP%20Thesis%20Feb%202013%29%20UNIGE-Public%20Version.pdf

13 International Maritime Organization (IMO). (2023). *Annex 14. Resolution MEPC.376(80): Guidelines on Life Cycle GHG Intensity of Marine Fuels*. Accessed 16 August 2024. https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/annex/MEPC%2080/Annex%2014.pdf. Information on marine diesel/gas oil on p. 50 was used for emission factors for CO_2, methane and N_2O. The CO_2 equivalent factor was calculated by using the global warming potential of each of these gases as specified in the *Sixth Assessment Report of the IPCC*. Intergovernmental Panel on Climate Change (IPCC). (2023). *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC*. Accessed 16 July 2024. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf

14 F. Mauro et al. 'Design of Hybrid-Electric Megayachts: The Impact of Operative Profile and Smart Berthing Infrastructures'. *J. Mar. Sci. Eng*. 2021, 9, 186. Accessed 28th August 2024 https://doi.org/10.3390/jmse9020186, https://www.mdpi.com/2077-1312/9/2/186#

15 International Maritime Organization (IMO). (2023). *Annex 14. Resolution MEPC.376(80): Guidelines on Life Cycle GHG Intensity of Marine Fuels*. Accessed 16 August 2024. https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/annex/MEPC%2080/Annex%2014.pdf

16 A. Khalfan, A. Nilsson Lewis, C. Aguilar, M. Lawson, S. Jayoussi, J. Persson, N. Dabi, and S. Acharya. (2023). *Climate Equality: A Planet for the 99%*. Oxfam International. Accessed 16 July 2024. https://policy-practice.oxfam.org/resources/climate-equality-a-planet-for-the-99-621551

17 Ibid.

18 Emissions Inequality Calculator. (n.d.). Global Dashboard. Accessed 16 August 2024. https://emissions-inequality.org

19 World Health Organisation. GHE: Life expectancy and healthy life expectancy. Accessed September 2024. https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-life-expectancy-and-healthy-life-expectancy

20 World Health Organisation. GHE: Life expectancy and healthy life expectancy. Accessed September 2024. https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-life-expectancy-and-healthy-life-expectancy

21 Oxfam and the Stockholm Environment Institute. (2023). https://oxfamilibrary.openrepository.com/bitstream/10546/621551/3/ds1-climate-equality-201123-en.xlsx

22 Ibid.

23 L. Chancel. 'Global carbon inequality over 1990–2019'. *Nat Sustain* 5, 931–938 (2022). Accessed September 9, 2024. https://doi.org/10.1038/s41893-022-00955-z https://www.nature.com/articles/s41893-022-00955-z#citeas

24 R.D. Lamboll, Z.R.J. Nicholls, C.J. Smith, J.S. Kikstra, E. Byers and J. Rogelj. (2023). 'Assessing the Size and Uncertainty of Remaining Carbon Budgets'. *Nature Climate Change*, 13, 1360–7. https://doi.org/10.1038/s41558-023-01848-5

25 A. Arthur. (18 March 2024). *On foot, by car, by plane and by space station! How long does it take to travel around the world?* BBC Sky at Night Magazine. Accessed 16 August 2024. https://www.skyatnightmagazine.com/space-science/how-long-take-travel-around-world

26 Oxfam and the Stockholm Environment Institute. (2023). https://oxfamilibrary.openrepository.com/bitstream/10546/621551/3/ds1-climate-equality-201123-en.xlsx

27 AFL-CIO. (n.d.). *Highest-Paid CEOs*. Accessed 16 August 2024. https://aflcio.org/paywatch/highest-paid-ceos

28 SVB. (n.d.). *ARC – Cross the Atlantic - The Dream of Many Sailors*. Accessed 16 August 2024. https://www.svb24.com/en/guide/arc-cross-the-atlantic-the-dream-of-many-sailors.html

29 SuperYachtFan. (n.d.). *MY Aquila: The Epitome of American Luxury Yachting*. Accessed 16 August 2024. https://www.superyachtfan.com/yacht/aquila

30 SuperYachtFan. (n.d.). *Discover KAOS: The Largest Dutch-Built Superyacht*. Accessed 16 August 2024. https://www.superyachtfan.com/yacht/kaos

31 SuperYachtFan. (n.d.). SEANNA Yacht • Benetti • 2011 • Owner Stan Kroenke. Accessed 16 August 2024. https://www.superyachtfan.com/yacht/seanna

32 AFL-CIO. (2024). Doug McMillon: Walmart Inc. (WMT). Accessed 16 August 2024. https://aflcio.org/paywatch/WMT

33 Oxfam and the Stockholm Environment Institute. (2023). https://oxfamilibrary.openrepository.com/bitstream/10546/621551/3/ds1-climate-equality-201123-en.xlsx

34 The Nature Conservancy. (n.d.). Members: Jorge Paulo Lemann. Accessed 16 August 2024. https://www.nature.org/en-us/about-us/where-we-work/latin-america/latin-america-conservation-council/members/jorge-paulo-lemann

35 Amazon. (2023). *Sustainability Report*. https://sustainability.aboutamazon.com/2023-amazon-sustainability-report.pdf

36 Google. (2023). *Environnemental Report*. https://www.gstatic.com/gumdrop/sustainability/google-2023-environmental-report.pdf

37 Hapag Lloyd. (2023). *Sustainability Report*. https://www.hapag-lloyd.com/content/dam/website/downloads/ir/HLAG_Sustainability_Report_2023.pdf

38 Bloomberg. (2024). *Bloomberg Billionaires Index: #14 Gautam Adani*. Accessed 26 June 2024. https://www.bloomberg.com/billionaires/profiles/gautam-s-adani

39 S&P Dow Jones Indices. Stepping Up to Carbon Transparency. October 2017. https://www.spglobal.com/spdji/en/documents/education/education-stepping-up-to-carbon-transparency.pdf

40 Science Based Targets. (2024). Target Dashboard (Beta). Accessed 20 August 2024. https://sciencebasedtargets.org/target-dashboard

41 Forbes. (2024). *Forbes World's Billionaires List: The Richest in 2024*. Accessed 16 August 2024. https://www.forbes.com/billionaires

42 International Renewable Energy Agency (IRENA). (2023). *World Energy Transitions Outlook 2023: 1.5°C Pathway*. Accessed 16 July 2024. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2023/Jun/IRENA_World_energy_transitions_outlook_2023.pdf?rev=db3ca01ecb4a4ef8accb31d017934e97

43 Fossil Free Funds. Amana Mutual Funds Trust Growth Fund. Accessed September 2024. https://fossilfreefunds.org/fund/amana-mutual-funds-trust-growth-fund/AMIGX/carbon-footprint/FSUSA0028M/F00000Q6Z6

44 M. Burke, S.M. Hsiang, and E. Miguel. (2015). 'Global Non-Linear Effect of Temperature on Economic Production'. *Nature*, 527(7577), 235–9. https://doi.org/10.1038/nature15725

45 C.W. Callahan and J.S. Mankin. (2022). 'National Attribution of Historical Climate Damages'. *Climatic Change*, 172(3), 40. https://doi.org/10.1007/s10584-022-03387-y

46 M. Burke, M. Zahid, N. Diffenbaugh and S.M. Hsiang. (2023). *Quantifying Climate Change Loss and Damage Consistent with a Social Cost of Greenhouse Gases*. Working Paper 31658. National Bureau of Economic Research. Accessed 16 July 2024. https://doi.org/10.3386/w31658

47 Stockholm Environment Institute. (2024). *Emissions Inequality Dashboard: List of APIs*. Accessed 16 August 2024. https://emissions-inequality.org/api

48 Z. Hausfather and G.P. Peters. (2020). 'Emissions – the "Business as Usual" Story is Misleading'. *Nature*, 577(7792), 618–20.

49 K. Riahi et al. (2017). 'The Shared Socioeconomic Pathways and their Energy, Land Use, and Greenhouse Gas Emissions Implications: An Overview'. *Global Environmental Change*, 42, 153–68. https://doi.org/10.1016/j.gloenvcha.2016.05.009

50 International Institute for Applied Systems Analysis. (2018). SSP Database (Shared Socioeconomic Pathways) - Version 2.0. Accessed 16 August 2024. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=welcome

51 C.W. Callahan and J.S. Mankin. (2022). 'National Attribution of Historical Climate Damages', op. cit.

52 H.D. Matthews, N.P. Gillett, P.A. Stott, and K. Zickfeld. (2009). 'The Proportionality of Global Warming to Cumulative Carbon Emissions'. *Nature*, 459(7248), 829–32.

53 M. Leduc, H.D. Matthews and R. de Elía. (2016). 'Regional Estimates of the Transient Climate Response to Cumulative CO_2 Emissions'. *Nature Climate Change*, 6(5), 474–8.

54 K.L. Ricke and K. and Caldeira. (2014). 'Maximum Warming Occurs About One Decade After a Carbon Dioxide Emission'. *Environmental Research Letters*, 9(12), 124002. https://doi.org/10.1088/1748-9326/9/12/124002; K. Zickfeld and T. Herrington. (2015). 'The Time Lag Between a Carbon Dioxide Emission and Maximum Warming Increases with the Size of the Emission'. *Environmental Research Letters*, 10(3), 031001. https://doi.org/10.1088/1748-9326/10/3/031001

55 M. Inman. (2008). 'Carbon is Forever'. *Nature Climate Change*, 1(812), 156–8. https://doi.org/10.1038/climate.2008.122

56 M. Leduc et al. (2016). 'Regional Estimates of the Transient Climate Response', op. cit.

57 Ouranos. (2024). *PAVICS: Power Analytics and Visualization for Climate Science*. Accessed 16 August 2024. https://pavics.ouranos.ca

58 Pangeo. (2024). Pangeo CMIP6 data. Accessed 16 August 2024. https://storage.googleapis.com/cmip6/pangeo-cmip6.json

59 K. Schwarzwald. (2024). xagg: Aggregating raster data over polygons (0.3.2.0) [Python; OS Independent]. Accessed 16 August 2024. https://github.com/ks905383/xagg

60 M. Burke et al. (2015). 'Global Non-Linear Effect of Temperature', op. cit.

61 C.W. Callahan and J.S. Mankin. (2023). 'Persistent Effect of El Niño on Global Economic Growth'. *Science*, 380(6649), 1064–9. https://doi.org/10.1126/science.adf2983

62 For a more detailed explanation of how the damage function is derived and parameterized, as well as its original form including all terms, see M. Burke et al. (2015). 'Global Non-Linear Effect of Temperature', op. cit.; M. Burke et al. (2023). *Quantifying Climate Change Loss and Damage*, op. cit.

63 M. Burke et al. (2015). 'Global Non-Linear Effect of Temperature', op. cit.; M. Burke et al. (2023). *Quantifying Climate Change Loss and Damage*, op. cit.

64 C.W. Callahan and J.S. Mankin. (2022). 'National Attribution of Historical Climate Damages', op. cit.; C.W. Callahan and J.S. Mankin. (2023). 'Persistent Effect of El Niño', op. cit.

65 Note that, for simplicity's sake, this damage function does not include temperature independent terms, since they are cancelled out when taking the difference of the growth rates.

66 This is in keeping with the method outlined by M. Burke et al. (2015). 'Global Non-Linear Effect of Temperature', op. cit.

67 M. Burke et al. (2023). Quantifying Climate Change Loss and Damage, op. cit.

68 T. Geiger and K. Frieler. (2017). Continuous National Gross Domestic Product (GDP) Time Series for 195 Countries: Past -Oobservations (1850–2005) Harmonized with Future Projections According the Shared Socio-Economic Pathways (2006–2100) (p. 806905 Bytes, 2 Files) [Application/x-zip-compressed,application/pdf]. Accessed 16 August 2024. https://doi.org/10.5880/PIK.2017.003

[69] Koch. (2024). GDPuc: Easily Convert GDP Data. Accessed 21 August. https://cran.r-project.org/web/packages/GDPuc/index.html

70 R.A. Rohde and Z. Hausfather. (2020). 'The Berkeley Earth Land/Ocean Temperature Record'. *Earth System Science Data*, 12(4), 3469–79. https://doi.org/10.5194/essd-12-3469-2020

71 K. Schwarzwald. (2024). xagg, op. cit.

72 Center for International Earth Science Information Network. (2018). Gridded Population of the World, Version 4 (GPWv4): Population Count, Revision 11. NASA Socioeconomic Data and Applications Center (SEDAC). Accessed 16 August 2024. https://doi.org/10.7927/H4JW8BX5

73 C.W. Callahan and J.S. Mankin. (2022). 'National Attribution of Historical Climate Damages', op. cit.; C.W. Callahan and J.S. Mankin. (2023). 'Persistent Effect of El Niño', op. cit.

74 Ibid.

75 M. Burke et al. (2015). 'Global Non-Linear Effect of Temperature', op. cit.

76 C.W. Callahan and J.S. Mankin. (2022). 'National Attribution of Historical Climate Damages', op. cit.; C.W. Callahan and J.S. Mankin. (2023). 'Persistent Effect of El Niño', op. cit.

77 Prest, B. C., Rennels, L., Errickson, F., & Anthoff, D. (2024). 'Equity weighting increases the social cost of carbon'. *Science*, 385(6710), 715-717.

78 World Bank Group. (n.d.). Rebuilding Economies After COVID-19: Will Countries Recover? Accessed 16 July 2024. https://datatopics.worldbank.org/sdgatlas/goal-8-decent-work-and-economic-growth?lang=en#c12. Original data from World Bank Group. (2024). Global Economic Prospects. Accessed 16 July 2024. https://www.worldbank.org/en/publication/global-economic-prospects

79 World Bank Group. (n.d.). *Rebuilding Economies After COVID-19*, op. cit.

80 C. Watson, L. Schalatek, and A. Evéquoz. (2023). *The Global Climate Finance Architecture. ODI and Heinrich Böll Stiftung*. Accessed 16 August 2024. https://climatefundsupdate.org/wp-content/uploads/2023/03/CFF2-2023-ENG-Global-Architecture.pdf

81 Oxfam is moving away from using terms such as 'developed' or 'developing countries', but since these country groupings are enshrined in the UNFCCC and the Paris Agreement, they are used for clarity when referencing aspects of the international climate regime, including the provision of climate finance.

82 Organisation for Economic Co-operation and Development (OECD). (2024). Climate Finance Provided and Mobilised by Developed Countries in 2013–2022. Accessed 16 August 2024. https://doi.org/10.1787/19150727-en

[83] Oxfam is moving away from using terms such as 'developed' or 'developing countries', but since these country groupings are enshrined in the UNFCCC and the Paris Agreement, we use them for clarity when referencing aspects of the international climate regime, including the provision of climate finance.

84 B. Zagema, J. Kowalzig, L. Walsh, A. Hattle, C. Roy and H.P. Dejgaard. (2023). *Climate Finance Shadow Report 2023: Assessing the Delivery of the $100 Billion Commitment*. Oxfam. Accessed 16 July 2024. https://policy-practice.oxfam.org/resources/climate-finance-shadow-report-2023-621500

85 J. Proctor, A. Rigden, D. Chan, and P. Huybers. (2022). 'More Accurate Specification of Water Supply Shows its Importance for Global Crop Production'. *Nature Food*, 3(9), 753–63.

86 Food and Agriculture Organization of the United Nations (FAO). (n.d.). *FAOSTAT: Crops and Livestock Products*. Accessed 16 August 2024. https://www.fao.org/faostat/en/#data/QCL

87 US National Weather Service Climate Prediction Center. https://www.cpc.ncep.noaa.gov. Accessed 16 August 2024.

88 European Space Agency Climate Office. https://climate.esa.int/en. Accessed 16 August 2024.

89 W.J. Sacks, D. Deryng, J.A. Foley, and N. Ramankutty. (2010). 'Crop Planting Dates: An Analysis of Global Patterns'. Global Ecology and Biogeography, 19(5), 607–20.

90 Further details on model specification and performance are available in J. Proctor et al. (2022). 'More Accurate Specification of Water Supply', op. cit.

91 FAO. (n.d.). *FAOSTAT: Food Composition Tables, Annex I*. Accessed 16 August 2024. https://www.fao.org/3/X9892E/X9892e05.htm

92 National Health Service. (2022). What Should My Daily Intake of Calories Be? Accessed 16 August 2024. https://www.nhs.uk/common-health-questions/food-and-diet/what-should-my-daily-intake-of-calories-be

93 US Department of Agriculture. (2020). Dietary Guidelines for Americans 2020–2025. Accessed 16

August 2024. https://www.dietaryguidelines.gov/sites/default/files/2020-12/Dietary_Guidelines_for_Americans_2020-2025.pdf

94 FAO, IFAD, UNICEF, WFP and WHO. (2023). *The State of Food Security and Nutrition in the World 2023: Urbanization, Agrifood Systems Transformation and Healthy Diets Across the Rural–Urban Continuum*. Accessed 16 July 2024. https://openknowledge.fao.org/server/api/core/bitstreams/8b27c570-2f8b-4350-8d5a-8e82432e6db7/content

95 Bressler. (2024). *The Distributional Mortality and Social Cost of Carbon*. [Unpublished manuscript]

96 K. Rennert, B.C. Prest, W.A. Pizer, R.G. Newell, D. Anthoff, C. Kingdon, … and F. Errickson. (2021). 'The Social Cost of Carbon: Advances in Long-Term Probabilistic Projections of Population, GDP, Emissions, and Discount Rates'. Brookings Papers on Economic Activity, 2021(2), 223–305.

97 National Center for Environmental Economics. (2023). Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, 'Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review'. Accessed 16 August 2024. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf

98 For the original data, see Institute of Health Metrics and Evaluation. (2021). GBD Results. Accessed 16 August 2024. https://vizhub.healthdata.org/gbd-results. See also Our World in Data. (2024). Number of Deaths from Natural Disasters, 2021. Accessed 16 August 2024. https://ourworldindata.org/grapher/natural-disaster-deaths-ihme

99 Bressler. (2024). *The Distributional Mortality and Social Cost of Carbon*. [Unpublished manuscript]

100 Ibid.

101 Ibid.

102 Ibid.

103 Ibid.

This publication was written by Mira Alestig, Daniel Horen Greenfood, Abha Jeurkar, Corey Lesk, and Alex Maitland Oxfam acknowledges the assistance of Adam Houlbrook and Lucy Cowie in its production.

Research and technical input: Daniel Horen Greenford (Concordia University and Universitat de Barcelona) conceived and coordinated the damage calculations, and performed the economic damages calculations. Corey Lesk (Dartmouth College) conceived and performed the agricultural loss calculations and provided additional guidance throughout the process. Donny Seto (Concordia University) conducted the CMIP6 data extraction and RTCRE calculation. Daniel Bressler (Columbia University) provided country-level estimates of the mortality cost of carbon. Chris Callahan (Stanford University) provided extensive guidance on the climate damages methods and calculated population-weighted values for historical temperature and RTCRE values. Damon Matthews (Concordia University) provided guidance on climate science and the RTCRE approach.

For further information on the issues raised in this publication please email Alex.Maitland@oxfam.org

Published by Oxfam GB for Oxfam International in October 2024.

DOI: 10.21201/2024.000039

Oxfam GB, Oxfam House, John Smith Drive, Cowley, Oxford, OX4 2JY, UK.

OXFAM

Oxfam is an international confederation of 21 organizations networked together in 65 countries, as part of a global movement for change, to build a future free from the injustice of poverty. Please write to any of the agencies for further information, or visit www.oxfam.org.

Oxfam America (www.oxfamamerica.org)
Oxfam Aotearoa (www.oxfam.org.nz)
Oxfam Australia (www.oxfam.org.au)
Oxfam-in-Belgium (www.oxfamsol.be)
Oxfam Brasil (www.oxfam.org.br)
Oxfam Canada (www.oxfam.ca)
Oxfam Colombia (www.oxfamcolombia.org)
Oxfam Danmark (www.oxfam.dk)
Oxfam India (www.oxfamindia.org)
Oxfam Intermón (Spain) (www.oxfamintermon.org)
Oxfam Ireland (www.oxfamireland.org)
Oxfam Italy (www.oxfamitalia.org)
Oxfam Mexico (www.oxfammexico.org)
Oxfam Novib (Netherlands) (www.oxfamnovib.nl)

www.oxfam.org

OXFAM

Oxfam France (www.oxfamfrance.org)
Oxfam Germany (www.oxfam.de)
Oxfam GB (www.oxfam.org.uk)
Oxfam Hong Kong (www.oxfam.org.hk)
Oxfam Québec (www.oxfam.qc.ca)
Oxfam South Africa (www.oxfam.org.za)
KEDV (www.kedv.org.tr)

www.oxfam.org

OXFAM