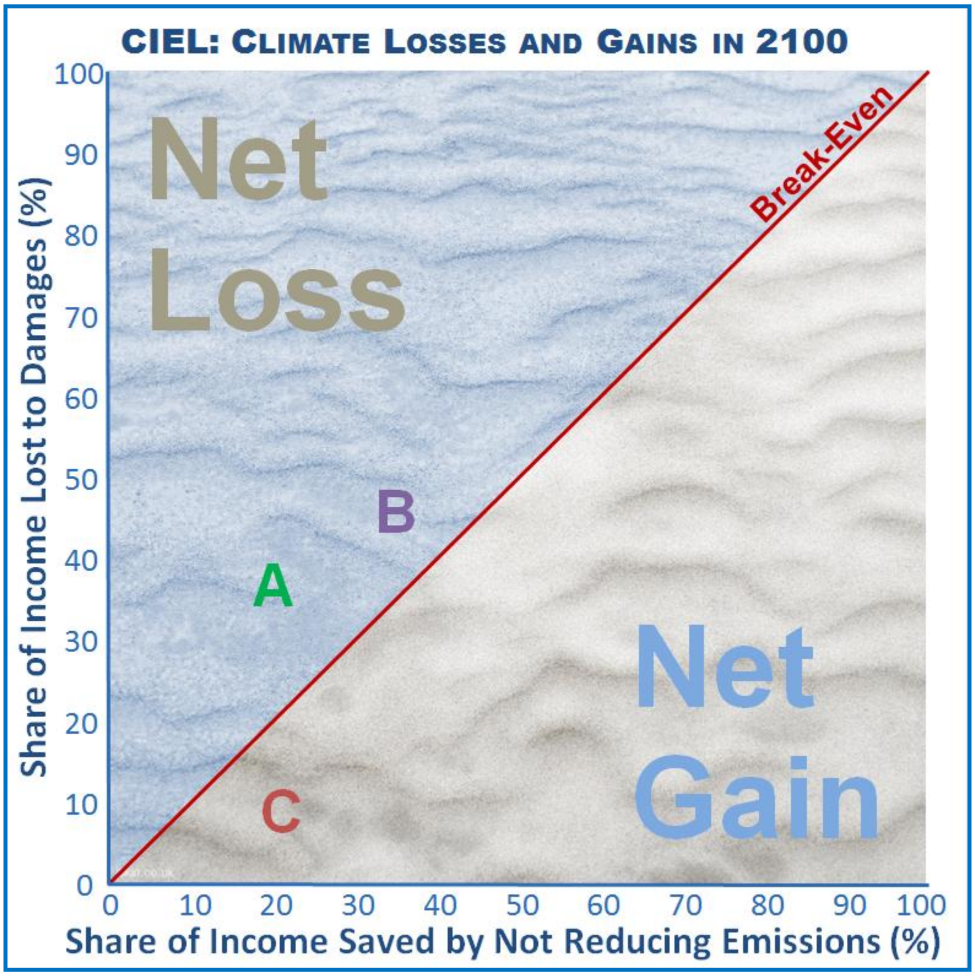
The CIEL Backgrounder:
Understanding the Climate Impact Equity Lens



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Introduction

By failing to greatly reduce greenhouse gas emissions, we save money now by avoiding having to pay for a new, zero-carbon energy system – at the expense of what are likely to be disastrous climate impacts worldwide in the not-too-distant future. For some, the gains from avoided costs may be larger than the damages they will face from climate change, at least in the short run. These individuals will be "net gainers" from emissions for decades to come; a small number will continue to benefit into the next century. For others, climate damages – even today and more so in the future – are far larger than any gains they receive from the fossil fuel economy; these individuals are "net losers" from emissions.

To provide insight into the wide range of outcomes that climate change will have on individuals, the Climate Impact Equity Lens (CIEL, pronounced "see-el") calculates net gains and losses from a global failure to cut greenhouse gas emissions, viewed not as global or national averages, but instead for individuals. The purpose of the tool is to illustrate both the severity and the diversity of expected impacts from climate change.

What is CIEL?

CIEL personalizes the consequences of global warming by showcasing the costs of climate damages and emissions reductions on an individual level. It estimates and compares the individual costs and the individual benefits of climate change. To do this, CIEL imagines two possible futures: one is a world in which nothing is done to combat climate change; the other is a world where maximum efforts are made to reduce emissions.

In the do-nothing future, the failure to reduce greenhouse gas emissions has a negative consequence and a (less obvious) positive consequence:

The Bad News: Hotter temperatures, higher sea levels, and a departure from historical weather patterns result in costly economic damages to many people around the world. By 2100, temperatures are nearly 4°C higher than they were in pre-industrial times, and climate damages are swallowing up about one-sixth of global economic output, and a much greater share of national income in some countries. In this world of continued growth in greenhouse gas emissions, temperature increases top 7°C by 2200, when three-fourths of all global output is lost to damages from climate change.

There is a lot of great information online documenting the latest scientific knowledge about the effects of climate change (see, for example, Ackerman and Stanton's *Climate Economics: The State of the Art* (2011), which includes a detailed review of the latest science; also see U.S. Global Change Research Program and U.S. Climate Change Science Program (2009); Met Office Handley Centre et al. n.d.; Pew Center on Global Climate Change n.d.; UCS n.d.; UCAR n.d.; 350.org n.d.).We won't try to repeat that here. Good research about just how much those physical impacts are likely to cost is much harder to come by. CIEL uses damage estimates provided by the Stockholm Environment Institute's CRED model.[1] In CIEL, each person's damages are the economic losses from climate change that could be prevented by reducing greenhouse gas emissions – or the difference between that person's experiences under the two possible futures. These are the avoidable damages from climate change: the difference between the "business-as-usual" damages from a high-emissions scenario and the (relatively small, no longer avoidable) damages from a very-low-emissions scenario.

[1] For more information on the Climate and Regional Economics of Development (CRED) model, see Ackerman, Stanton and Bueno (2011b; 2011a), Ackerman et al. (2011), and Ackerman and Bueno (2011). A more technical description of CIEL, including its use of CRED results, is provided below in the "Nuts and Bolts" section.

The Good News: On the bright side, not acting to reduce emissions and stop climate change could save most people a lot of money right now. Look at it this way: Cutting down on emissions, in a future where we take climate policy seriously, will mean higher energy and transportation costs for just about everyone. *Not* lowering emissions means that, in comparison, you save money. The money not spent is the savings from failing to reduce emissions.

CIEL assumes that, if efforts were made to reduce emissions, each person would have to pay her own share of emission reduction costs. (Rich countries would not, for example, contribute funding for emissions cuts in poor countries; and rich people would not subsidize emissions cuts by the poor within their own countries.) Given this assumption, reducing emissions would mean that most people around the world would have to pay higher energy and transportation costs. But if we don't reduce emissions, then everyone "saves" by avoiding those cost increases.

This effect may be somewhat counter-intuitive to many CIEL users at first, but consider this: Emissions reductions require investment in new infrastructure and technology, mostly in the energy and transportation sectors. This investment has two effects: 1) it strengthens the economy (and hopefully makes everyone's income a little bit higher); and 2) it increases consumer prices for energy, transportation, and goods that require a lot of fossil fuels to produce.

Why is there no international aid in CIEL?

The CRED model – on which CIEL bases its temperatures, damages, emissions reduction costs, and incomes – is unique among climate-economics models in its ability to explicitly model the effect of allowing or prohibiting international aid (or in CRED's terms, investment transfers between regions). CIEL uses CRED model results that assume there would be no international aid – both in the high emissions and very-low-emissions scenarios. This "no aid" assumption demonstrates the full impact that climate change would have on low-income countries in the event that high-income countries fail to provide economic assistance for low-carbon development in their poorer neighbors, and fail to live up to the promise of "common but differentiated responsibilities" (United Nations 1997).

If, instead, CIEL were to include international aid for emissions cuts, there would be several important changes in damage costs and savings from not reducing emissions:

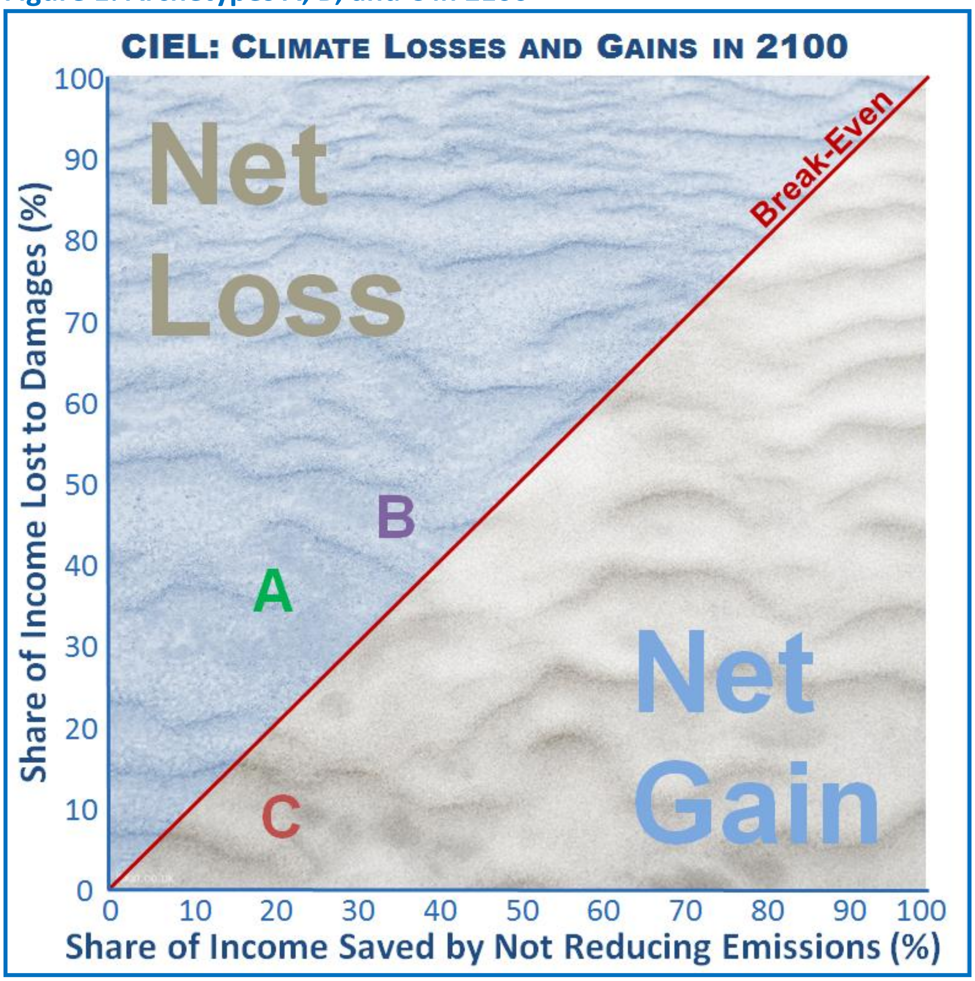
- Temperatures and damages in the very-low-emissions scenario would be even lower. That would mean that the unavoidable part of damages would be smaller, while total business-as-usual damages stay the same. In short, avoidable damages (avoidable = total less unavoidable) as a share of income would be slightly higher for all individuals.
- Individuals from low-income countries would pay less for emissions cuts in the very-low-emissions scenario. That would make their savings from not reducing emissions smaller and their net losses larger.
- Individuals from high-income countries would pay more for emissions cuts in the very-low-emissions scenario. That would make their savings from not reducing emissions larger and their net losses smaller.

All in all, the effect would most likely be to make success in reducing greenhouse gas emissions look like an even better deal for people in poorer countries (as compared to the actual CIEL scenarios, which do not include international aid) and a somewhat worse deal for people in richer countries.

CIEL uses emissions reduction cost estimates from the very-low-missions CRED scenario in which everything that *can* be done to reduce emissions *is* done. In this scenario, emissions cuts have a different price in each world region. Investment in lowering emissions does increase incomes, but it also increases the costs paid by consumers. Each person's savings from not lowering emissions in CIEL are the value of those potential higher costs (if emissions cuts were made) as a share of her new, slightly higher income.

CIEL compares each person's damages from the failure to stop climate change to her savings from not paying for emissions reductions.[2] On the CIEL graph (see Figure 1) for 2100 both damages and savings are shown as a share of each person's income. That's because $500[3] in losses or gains is worth a lot more to someone who makes $5,000 a year than it is to someone who makes $50,000 a year. Each person is represented as a letter marked on a graph. Who are A, B, and C in this example? We look at them next.

Figure 1: Archetypes A, B, and C in 2100



[2] This analysis is inspired by James K. Boyce's writings on the political economy of the environment. See Boyce (2002).

[3] All money values in the CIEL model and throughout this report are 2005 real (inflation-adjusted) U.S. dollars.

Graphing archetypes in CIEL

Climate damages and emissions reduction costs are compared on the CIEL graph. Note that annual damages in CIEL are averaged, or smoothed out, over a decade, so they never reach the level of any one terrible event that can take away most or all of one's income in single year. Any damage that resulted in more than a few percentage points' loss to a person's income would have a noticeable effect on her quality of life. A 20-percent loss of income would represent a really big challenge to most households. And, unless you have a lot of savings or other assets, a 50-percent loss of income would be devastating.

Different people in one year

This example graph compares climate damage costs to the savings from not reducing emissions for Persons A, B, and C in the year 2100. All markers above and to the left of the red line represent people who, in a particular year, suffer net losses from climate change, while all markers below and to the right of the red "break-even" line represent people with net gains.

Person A loses 37 percent of her income to climate damages in 2100 but saves an amount equal to 20 percent of her income by not having to pay for emissions cuts. Her net losses amount to 17 percent of her income. (If Person A made $10,000 in 2100, she would lose about $3,700 but save $2,000. Her net losses would be $1,700.)

Person B loses 46 percent of her income to damages but saves 35 percent in avoided costs. Her net losses are 11 percent of her income.

Person C loses 9 percent of his income to damages but saves 21 percent in avoided costs. His net gains are12 percent of his income.

Persons A, B, and C will experience climate change very differently. For A and B, damages outweigh savings in that year, but for C savings outweigh damages.

Different years for one person

CIEL can also be used to track climate damages and savings from not reducing emissions for a single person over many years. Figure 2 shows losses and gains for Person B in 2050, 2100, and 2150. (Perhaps Person B has discovered the secret of longevity, allowing her to earn income over a 100-year span. For a more believable story, assume that we are talking about very similar people – with the same income, location, and vulnerability – living in successive generations. To avoid introducing extra names, we'll call them all Person B.)

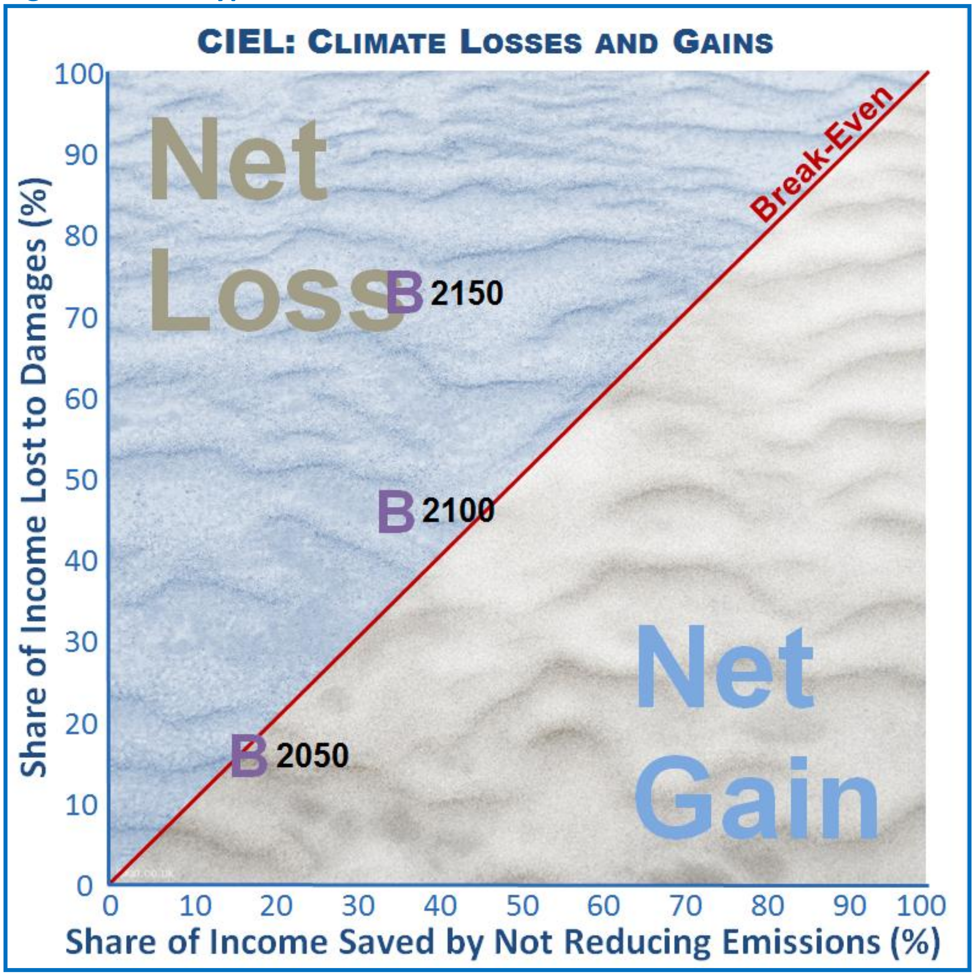
In 2050, Person B loses 16 percent of her income to climate damages but saves 17 percent in avoided costs. Her net gains are 1 percent of her income. (If Person B made $10,000 in 2050, she would lose $1,600 but save $1,700. Her net gains would be $100.)

In 2100, she loses 46 percent of her income to climate damages but saves 35 percent in avoided costs. Her net losses are 11 percent of her income.

In 2150, she loses 73 percent of her income to climate damages but saves 37 percent in avoided costs. Her net losses are 36 percent of her income.

Person B starts out with net gains – more savings than damages – but by 2100 is suffering net losses – more damages than savings – from climate change. These net losses only grow worse after 2100.

Figure 2: Archetype B in 2050, 2100, and 2150



Who are the 'people' shown in CIEL?

The "people" shown on the CIEL graph are archetypes (that is, model or example people) defined by a few critical characteristics:

- Income per capita – household income divided by the number of people in the household.
- Economic vulnerability – share of household income derived from industries and economic sectors that are especially vulnerable to climate change, such as agriculture, fishing and tourism.
- Sea-level rise vulnerability – vulnerability of home to sea-level rise and storm surges (based on home elevation in meters above sea level, distance from the coast, and other factors affecting vulnerability to coastal flooding).
- Water shortage vulnerability – vulnerability of local water supply: areas where less than 1,000 cubic meters are available per person per year are "water scarce"; areas with between 1,000 and 1,700 cubic meters are "water stressed"; and areas with more than 1,700 cubic meters are "water abundant."[4]

[4] Water scarcity occurs when a large number of people in an area lack affordable access to sufficient safe water to meet demands for drinking, washing, and livelihood for a significant period of time (Rijsberman 2006). This definition is open to some interpretation, however, based on how one defines both a sufficient level, and the spatial

- Region – one of nine world regions[5]

Each person shown on the CIEL graph is assigned a set of these defining characteristics. Income per capita, economic vulnerability, sea-level rise vulnerability, and water shortage vulnerability are used to estimate what share of total world damages from climate change each person will suffer. Income per capita and region are used to estimate what share of global emissions reduction costs each person will be spared from paying. In Figure 1 (above), for example:

Person A lives in the Developing Asia/Pacific region. Her household of three adults and two children makes about US$7,500 each year, for an average income of $1,500 per person; 90 percent of this income comes from the tourism industry. Her home is in a village not far from the Indian Ocean, at about 4 meters of elevation above sea level. Fresh water is abundant.

Person B lives in Africa. Her household of one adult and three children makes about US$2,000 each year, for an average income of $500 per person; all of this income comes from agriculture. Her home is inland, many meters above sea level, in an area where fresh water is very scarce.

Person C lives in the United States. His household of two adults and one child makes about US$90,000 each year, for an average income of $30,000 per person, none of which is derived from an industry that is especially vulnerable to climate change. His home is inland, away from the ocean and river deltas, and well above sea level. Water is abundant in his local area.

In 2100, Person A experiences a net loss from climate change equal to 17 percent of her income, Person B experiences a 11 percent loss, but Person C experiences a net gain equal to 12 percent of his income. A, B, and C have very different incomes, and vulnerabilities to climate change. And they live in different regions with different patterns of energy use. As a result, their net impacts from climate change are not the same.

How does CIEL work?

CIEL compares the damages from preventable climate change to the savings from not reducing emissions, using a scenario of the future climate and economy in which no greenhouse gas emissions cuts occur and another scenario in which maximum efforts are made (though without international aid) to reduce emissions. CIEL uses temperatures, incomes, damages and emissions reduction cost estimates from CRED model scenarios.[6] CIEL was built in Excel 2007 and is available for download at http://SEI-CIEL.org. (For a detailed description of the CIEL methodology, see the "Nuts and Bolts" section of this report.)

Like many other models of the climate and economy, CIEL weighs the costs of climate change against the benefits of avoiding emissions reduction costs. But unlike other models, CIEL looks at costs and benefits

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and temporal aspects of scarcity. The most commonly cited standard for water scarcity is the Falkenmark indicator, according to which a region is water stressed when water resources per capita per year fall below 1,700 m^3; a region is water scarce when water resources per capita per year are less than 1,000 m^3; and when water resources fall below 500 m^3 per capita per year, the region experiences absolute scarcity (Falkenmark et al. 1989; Rijsberman 2006). These definitions for water stress and water scarcity have been used by a multitude of global environmental and development agencies; including the United Nations (n.d.), the United Nations Development Programme (Watkins 2006), the United Nations Environment Programme (UNEP 2008), the Food and Agriculture Organization (FAO 2007), the World Bank (Xie 2009), the World Resources Institute (Revenga 2000), and the Institute for Global Environmental Strategies (2003).

[5] CIEL uses the same regions as the CRED model. See the "Nuts and Bolts" section for a detailed description of these regions.

[6] All data taken from CRED have been entered into the CIEL Excel model. It is not necessary to have or run the CRED model in order to run CIEL.

for each person individually, instead of the average costs and benefits for large regions. CIEL also views costs and benefits one decade at a time and leaves policy recommendations up to each reader, while other models often recommend a "best" emissions reduction policy based on the sum of "discounted" costs over several hundred years.

How is CIEL different from other models?

Policymakers rely on the results of climate-economics models to help answer questions such as: How much money should be invested in reducing greenhouse gas emissions? Can we wait a few decades (or centuries) before spending that money? And, how much of the bill should each country have to pay?

Economic models weigh the costs of suffering the impacts of climate change (damaged property, lost income, lower economic productivity) against the savings from not paying for emissions reductions (lower electricity and fuel costs, less money spent on insulating homes and building electric cars). If the savings from not reducing emissions are greater than the damage costs, the best policy is to do nothing at all – to ignore climate change, at least until its damages seem more urgent.

Two problems arise from the common practice of ignoring individual differences in this kind of model. First, when people in a country or region are aggregated (lumped together), each person's different experience is lost. Second, when policy recommendations are "discounted" – summing up two or three hundred years of costs and savings, but giving less weight to impacts the further out in the future they fall – models assume that people today care only (or at least most) about themselves, and less about their children or grandchildren.

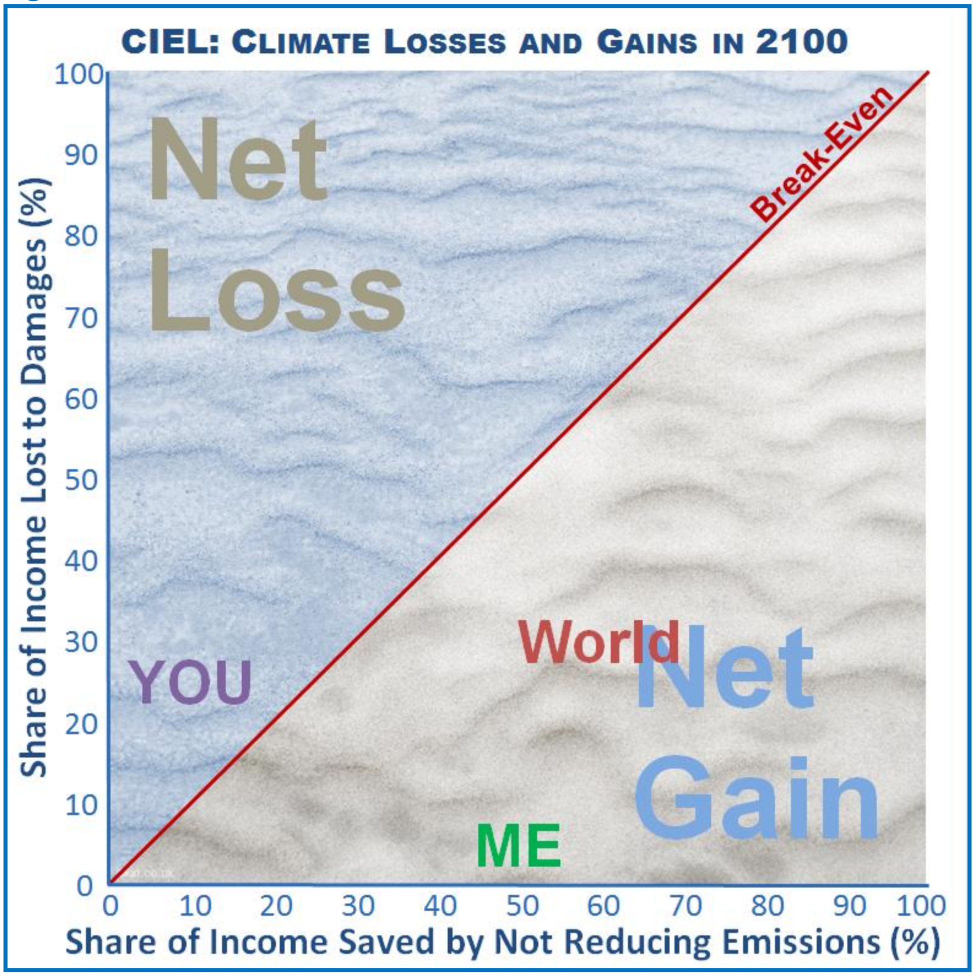
Aggregating across regions

In every public policy issue, there are winners and losers – not everyone is in the same boat. Aggregating all the people in a country or region gives the impression that everyone has the same income, the same vulnerability to climate change, and the same reliance on fossil fuels. Of course, nothing could be farther from the truth.

Climate-economic models add up all of the damage costs suffered by everyone, everywhere in the world (or in some models, everyone in each of five to 20 world regions), and compare them with all of the savings of not reducing the emissions of everyone everywhere (or by region). That is, the models aggregate over very large regions.

An illustration may help to pinpoint the problem: Imagine comparing the costs and benefits of climate change in a world in which just two individuals lived; we'll call them ME and YOU. ME and YOU have the same income ($2,000 a year) but live in different regions (with different patterns of energy use) and have different vulnerabilities to climate change. In 2100, ME suffers $100 in climate damages, but saves $1,000 by not reducing emissions (see Figure 3). YOU suffers $500 in damages and gains just $200 in savings from not reducing emissions. A typical cost-benefit analysis adds the results for ME and YOU to assess the impact on the "World" as a whole – $600 in costs and $1,200 in savings – and recommends that no action be taken to avert climate change.

Figure 3: ME, YOU, and World in 2100



By lumping together everyone in the world, or in a few large world regions, we miss out on a key policy insight: Some people will be winners from climate change (benefits greater than costs) and some will be losers (costs greater than benefits). If you are among those suffering net losses, or care about the people who are, the fact that in a particular year, savings from not reducing emissions may outweigh climate damage costs for the world as a whole isn't going to be of much comfort to you.[7]

CIEL avoids the problem of aggregating across regions by looking at climate damage costs and savings from not reducing emissions for individuals, based on their income, the region in which they live, and their vulnerability to climate damages. Individuals in the same region will not have the same experience of climate change. Some will suffer net losses; others will reap net gains. Decisions about climate policy need to consider the diversity of the human experience. It is quite unlikely that any one person has the average income, the average vulnerability to climate change, *and* the average reliance on fossil fuels. Policy decisions about climate change shouldn't be based on the experience of a mythical "average person."

[7]See Sen (2000).

Aggregating across time

Every public policy problem requires some forecasting (making the best possible projections of what will happen in the future), but climate change is exceptional in how far into the future it is necessary to forecast. While some climate damages have already begun to occur, economic losses are expected to ramp up in 50 to 100 years, and could reach catastrophic levels in 100 to 150 years. How do we add up costs that will take place this year with costs that will take place in 150 years?

In economic analysis, the most common approach is to "discount" costs that take place in the far future – the farther into the future a cost occurs the less weight it is given. For most economists the question is not, should you discount future costs? but rather, how much should you discount them?[8] Conventional models make policy recommendations based on adding up this year's losses from climate change with scaled-down estimates of losses that will occur in each of the next few hundred years; the farther into the future a loss occurs, the more it is "discounted" or scaled down. Some models discount so heavily that losses that will occur 50 or 100 years from now are given a vanishingly small weight in comparison to current losses, and their policy recommendations focus on today's costs and savings ignoring effects on later generations.

Policymakers often rely on climate-economics forecasts without really knowing what makes them tick. Recommended policy actions taken from some of the most prominent climate-economics models –often calling for policymakers to "do nothing, and do it slowly" – are based on the assumption that future damages matter little to today's population. Policy recommendations based on models designed in this way may be taken, mistakenly, as scientific fact, when really they are a result of a moral judgment that is not widely shared.

CIEL avoids making policy recommendation based on discounted aggregations across time by presenting costs and damages for each decade separately from now until 2200– there is no attempt to add together costs from different years, so there is no need for value-laden discounting. Instead, CIEL tracks each individual's impacts over time. Decisions about climate policy require an unobstructed view of the future, free of any judgment regarding how much each generation's losses are worth.

The CRED model

The temperatures, income, damages, and emissions reduction costs used in CIEL are taken from the Stockholm Environment Institute's Climate and Regional Economics of Development (CRED) model.[9] CRED focuses on the global distribution of climate damages and emissions reduction costs. It is designed to estimate both the best pace of investment in emissions reduction, and the best distribution of the cost of that investment to nine regions of the world, with an eye on questions of equity between high- and low-income regions.

CRED stands out from other climate-economics models in its central focus on equity between regions both in terms of who reduces emissions and in who pays for those reductions. CRED finds that climate policies with a good chance of keeping future temperature increases below 2°C require international aid: Rich countries must share their resources to help pay to lower emissions in developing countries. Without aid (or investment transfers between regions), rapid worldwide emissions cuts render global poverty reduction goals unachievable; conversely, the persistence of global poverty makes it doubtful that developing countries can afford the necessary investments in lowering emissions on their own.

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[8] For a more detailed critique of the use of discounted costs and benefits in environmental analysis, see Ackerman and Heinzerling (2004).

[9] For more information on the CRED model, see Ackerman, Stanton and Bueno (2011b; 2011a), Ackerman et al. (2011), and Ackerman and Bueno (2011).

CRED also uses more up-to-date physical climate, damage impact, and emissions reduction cost information than many other climate-economics models. When forecasting both climate damages and the future costs of emission cuts, past experience can only help so much – no observations from the past can truly prepare us for this uncharted future. An important body of scientific literature now offers a piecemeal, but quite detailed, forecast of the physical impacts of climate change, but there is no equivalent body of economic literature applying monetary costs to the physical effects.

Today's economic estimates of future climate damage costs do not have a solid scientific foundation; many are loosely based on more optimistic scientific projections that are now ten years out of date (Ackerman and Stanton 2011). The most complex models project the cost of future emissions reduction technology based on collected experience regarding past technological change, but in some of the simplest and best-known climate-economic models, emissions reduction costs are assumed to drop a little bit each year automatically, regardless of how much is invested in emissions-reducing technology. CRED's estimates of damages and emissions reduction costs are consistent with the most current scientific and economic literature. Damages reach 50 percent of world output at 6°C temperature increase above pre-industrial, and emissions reduction costs are based on the well-known McKinsey[10] marginal abatement cost curves for each of CRED's nine world regions. CRED treats "green" investments in emissions reduction as contributing to economic growth, though at half the productivity of standard (non-green) investments; many models instead treat these investments as dead-weight losses to the economy.

Climate change gets personal

In CIEL, results are shown for individuals, some of them net losers from climate change and some net gainers. CIEL avoids the ethical dilemma of how to value damages and savings that our great-grandchildren will experience, relative to our own, by reporting results separately for each decade through 2200, and not the discounted sum of future impacts. CIEL damage costs and savings from not reducing emissions are based on results from the CRED model, which uses the best information available regarding physical climate processes, the scale and distribution of damages, and cost of emissions cuts. By zooming in on damages to a particular person in a particular year, CIEL offers a new vantage point on climate-change decision making. CIEL doesn't provide any simple recommendations about the best climate policy. And that's the point.

When climate-economics models simplify they miss the big picture: In the absence of climate policy, some people will suffer devastating damages from climate change in the near future, and by the end of this century, most people will be experiencing very serious climate damages. Aggregating across regions and time obscures the winners and losers from climate change, showing instead an "average person" whose savings may be just a little bit higher than her costs for decades. CIEL replaces impossibly "average people" with real people.

What does CIEL reveal?

CIEL considers a future in which nothing is done to cut greenhouse gas emissions and our climate is profoundly changed, and compares it to a future in which everything possible is done to stop climate change. If that high-emissions future comes to pass, CIEL asks, what climate-related damages will each person in the world suffer? What will each person gain by not paying for emissions reductions? And how do these two values compare?

If a person's damages are greater than her savings in a given year, they are marked on the CIEL graph above and to the left of the red break-even line – that person, in that year, is a net loser from the failure to stop climate change. If a person's damages are less than her savings in a given year, her marker is below

[10] McKinsey & Company (2009).

and to the right of the break-even line – that person, in that year, is a net winner from the failure to stop climate change. Whether we think of ourselves, and those we care about, as "winners" or "losers" from climate change inevitably colors our perception of the urgency of greenhouse gas emissions cuts.

Who are the winners and who are the losers? Not everyone would be affected in the same way by a failure to stop climate change. At first, there are large numbers of people on both sides of the line; some are net gainers and some net losers. But the balance shifts over time. By about 2075, it becomes difficult to specify characteristics in CIEL – income, vulnerability to climate change, region – that result in net gains from climate change. If emissions continue to grow at today's pace, by the end of this century very few people will experience savings from not reducing emissions that are greater than their climate damages.

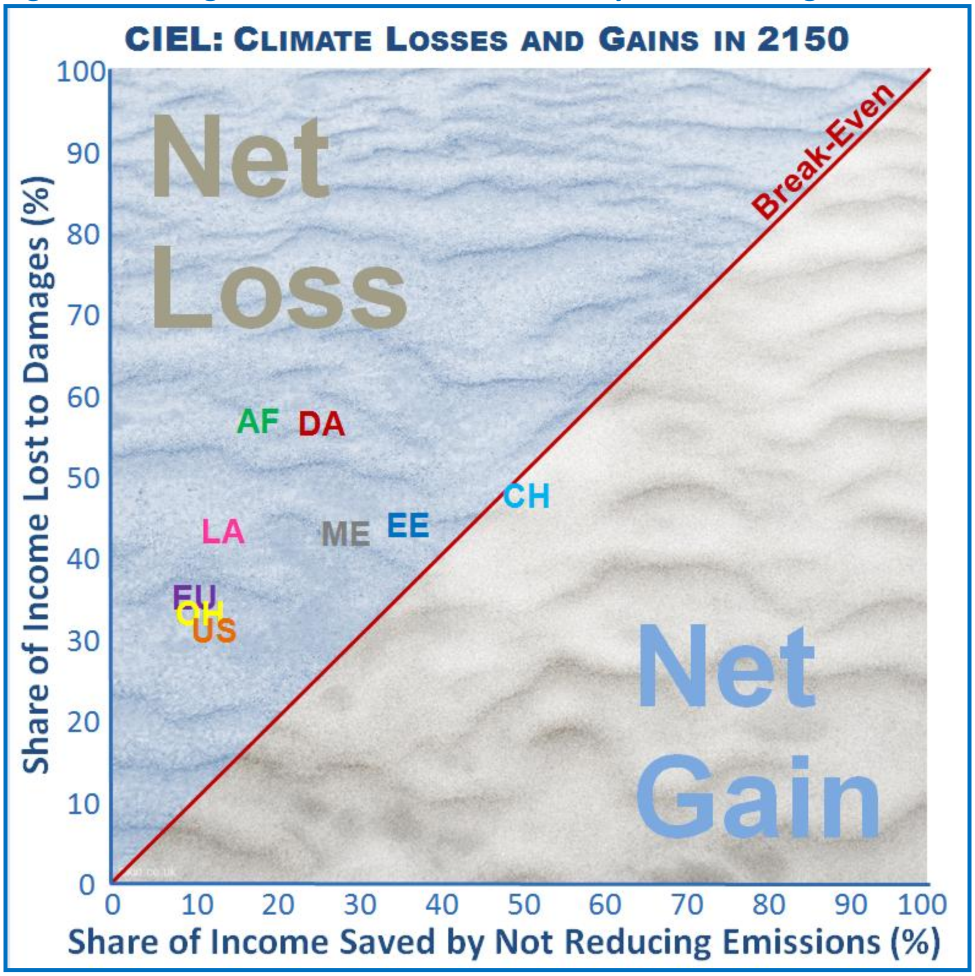
Two main characteristics distinguish net losers from net gainers. First, some people are more vulnerable to climate damages (their income comes from an economic sector that relies heavily on the existing climate, or is sensitive to extreme weather events; they live close to sea level or close to the coastline; water is already a scarce commodity in their region today). Second, the cost of reducing emissions varies by region (due to different patterns of energy use) and by income level (the poorer you are, the more of your income is spent on energy, and the more expensive – as a share of your income – lowering emissions would be).

In several of the poorest regions, people with average incomes and multiple vulnerabilities begin to suffer net losses as early as 2050; people with lower than average income may already have higher costs than savings. By 2120, even people whose income is at or above their region's average and who have just one of the three other vulnerabilities to climate change – high share of income from a vulnerable industry, living very close to sea level, or water scarcity – will be net losers regardless of where they live. By 2150, a person with the average income for her region and none of the other vulnerabilities will suffer net losses (as shown in Figure 4 below, plotting the results for average-income, low-vulnerability individuals in CIEL's nine world regions).

Today, a large share of world population is already vulnerable to climate change in one or more ways: 7 percent of world population lives at an elevation less than 5 meters above sea level and 37 percent live within 100 km of the coast; 5 percent of world GDP comes from tourism and agriculture – but 35 percent of world employment is in agriculture; and 5 percent of world population lives in countries that are classified as "water scarce", with an additional 24 percent considered "water stressed."[11] As temperatures grow warmer, sea levels rise, and historical weather patterns change, the share of world population especially vulnerable to climate change will grow, and more people will suffer net losses. Given that current scientific findings project a strong likelihood of catastrophic damages, it is all but certain that a continued rise in greenhouse gases will result in devastating economic losses for the vast majority.

[11] Based on CRED data for 2005 (Ackerman, Stanton and Bueno 2011a); coastal share of world population for 2005 based on an interpolation of 1995 data and 2025 projections (Hachadoorian et al. 2011); share of world employment in agriculture, 2005, from the World Bank's *World dataBank* (http://databank.worldbank.org).

Figure 4: Average income and low vulnerability in 9 world regions, 2150



Note: AF=Africa; CH=China; DA=Developing Asia/Pacific; EE=Eastern Europe; EU=Europe; LA=Latin American and Caribbean; OH=Other High Income; ME=Middle East; and US=United States.

Once the obscuring veil of aggregation (lumping people together across regions and time) is drawn away, climate-economics analysis demonstrates that some people are already suffering net losses from climate change, and that many more will join this group in the coming decades. It is also true, however, that most people are net gainers from climate change today, and some will continue to gain even after the turn of the next century. The more short-sighted decision-makers are (caring only about immediate impacts or, at best, the next few decades), the more important it is for the net losers from climate change to have a prominent seat at the international negotiating table. If only the voices of net winners are heard, climate policy could fail.

Does CIEL try to predict the future?

It is impossible to accurately predict a person's future, and CIEL doesn't try to. Here's what CIEL can and cannot do:

CIEL can:

- Show expected patterns and trends in individual climate damages and emissions reduction costs.
- Estimate an individual's likely chronic damages in each decade from now until 2200. Chronic damages are the average level of damages over the course of the decade.

- Give a sense of whether damages and savings are big or small, and whether their net value is negative (a net cost) or positive (a net benefit).
- Give a ballpark measurement of the economic damages from climate change.
- Illustrate the idea – so often left out of economic analysis – that every policy action has winners and losers. No one should expect to get the average net cost or benefit.

CIEL cannot:

- Tell any individual what her exact costs and savings will be in a given year.
- Estimate an individual's likely acute damage in each particular year. Acute damages are the damages that occur in the worst year of your life: the year that a storm surge destroys your house, or you lose your entire crop to drought.
- Put an exact dollar figure on climate damages or savings from not reducing emissions.
- Put a price on things that are priceless: your life, your health, the health of your natural environment.
- Tell us how much to spend on emissions reduction. Policymakers can, however, examine results from CIEL to help them decide how much to invest in emissions cuts and when.

CIEL is not a crystal ball. It's a tool designed to help concerned global citizens better imagine a future in which greenhouse gas emissions continue to grow. CIEL starts with the best estimation available of the most likely consequences of climate change. Most models stop there, or stop with dividing those damages up among large world regions. But CIEL uses individuals' relative vulnerability to climate change to assign each person a share of global damages, and regional emissions reduction costs – together with the assumption that poorer people spend more of their budget on energy – to assign each person an (avoided) cost of emissions reduction.

The rest is up to you. What's hidden in the average damage and emissions reduction costs for your region? Who will gain or lose from climate change over the next decades? How many more decades until most people in your local area are on the losing side? And, perhaps most important, when representatives from all of our nations are negotiating over our climate future, are they thinking about averages or about people?

The nuts and bolts

CIEL compares individual climate damages as a share of income (the cost of not lowering greenhouse gas emissions) with individual avoided emissions reduction costs as a share of income (the benefit of not lowering emissions). When costs outweigh benefits, an individual suffers net losses; when benefits outweigh costs, an individual reaps net gains. In the CIEL graphs shown throughout this report, each point represents this comparison of costs to benefits for an individual in a given year. The red diagonal line divides individuals with net losses from those with net gains. CIEL can be used to display both the "average" individual (with the average income, vulnerability to climate change, and emissions) for each of nine world regions,[12] and for archetypal individuals defined by the following characteristics: income,

[12] CIEL uses the same regions as the CRED model (Ackerman, Stanton, and Bueno 2011a): Africa includes Sub-Saharan and North Africa; China includes Hong Kong but not Taiwan or Macau; Eastern Europe includes Russia and non-EU Eastern Europe, i.e., European ex-USSR, ex-Yugoslavia, and Albania; Europe includes EU-27, Norway, Switzerland, Iceland, and Turkey; Latin America and the Caribbean includes Puerto Rico and all Virgin Islands; Middle East excludes North Africa; Other High Income includes Canada, Japan, South Korea, Australia, and New Zealand; Developing Asia/Pacific includes South and Southeast Asia, Taiwan, Asian ex-USSR and Pacific; and United States excludes Puerto Rico and smaller island territories such as Guam and American Samoa.

share of income from industries vulnerable to climate change, sea-level-rise vulnerability, water availability, and region.

CIEL combines the results of two CRED model scenario runs to determine net losses or gains from climate change: a business-as-usual scenario (CRED-BAU), and a very-low-emissions scenario (CRED-LOW). (See Ackerman, Stanton and Bueno 2011a for a detailed methodology of the CRED v.1.3 model.)

The CRED-BAU used in CIEL assumes that there is no effort to reduce emissions, that decisions are made without any knowledge of damages (damages are "turned off"), climate sensitivity is 3.0°C[13] (the mean value in the current literature (Ackerman and Stanton 2011), and the rate of pure time preference[14] is 1.5 percent (the value used in the well-known DICE model, Nordhaus 2008).[15]Atmospheric concentrations reach 900 ppm CO_2 by 2100, with 3.8°C in average global temperature increase above pre-industrial levels. In CRED, global population rises to 9.2 billion in 2100, gradually decreasing to 8.2 billion over the next century, then remaining constant; this rate of population increase closely approximates the United Nations 2008 long-term projections.[16] (For comparison, the CRED-BAU scenario falls halfway between the IPCC's SRES A2 and A1FI scenarios for year 2100 concentrations and temperatures.[17] Global population reaches 15 billion by 2100 in the A2 scenario, and 7.1billion in the A1FI scenario.[18])

In this high emissions scenario, economic damages rise to 16 percent of world output in 2100; by 2200, temperature increase reaches 7.3°C and damages 76 percent of world output. Because current and future emissions cuts cannot prevent all climate damages, CIEL adjusts the CRED-BAU results by not including the damages that are now inescapable. These "sunk costs" are modeled as the damages that occur even in CRED's very-low-emissions scenario (CRED-LOW , described below). The avoidable portion of CRED-BAU damages – after subtracting sunk costs – is 13 percent of world output in 2100, and 75 percent in 2200.

In the CRED-LOW scenario, the pure rate of time preference is 0.1 percent (as used in the *Stern Review*, 2007), and the only restrictions placed on emissions reduction investments are that no region's average consumption per capita can grow by less than 0.5 percent a year, and that the only funds for investing in emissions cuts come from within each region (investing in other regions is not allowed in this scenario). The CRED model chooses the levels of "green" (low-carbon) and standard investment, for each decade, that maximize the sum of discounted regional per capita consumption in all regions, weighted by regions' populations, and all decades. The model finds that rapid reductions in greenhouse gas emissions lead to the highest consumption levels. (CRED runs that allow cross-regional investment recommend even faster emissions reductions.)

CIEL uses an adapted version of the CRED v.1.3 Vulnerability Index to apportion world damages to individuals. The CIEL Vulnerability Index (CIEL-VI) gives a one-third weight to each of four component indices: income, economic exposure, sea-level rise exposure, water scarcity (such that a value of 1 for

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[13] Climate sensitivity is the equilibrium change in global average temperature caused by a doubling of carbon dioxide in the atmosphere.

[14]The pure rate of time preference is the portion of the discount rate not dependent on income growth. The value assigned to the pure rate of time preference is an indication of how the present generation values changes to the well-being of future generations. A lower rate assigns more weight to future outcomes.

[15]The CRED-BAU scenario used in CIEL differs from the standard CRED-BAU described in Ackerman, Stanton and Bueno (2011a). In the CIEL version, damages are turned off (i.e., the optimizer is unaware of damages). Damages are calculated as a function of temperatures and the CRED damages parameters in the CIEL Excel model.

[16] Long-range extension to the 2008 Revision of the World Population Prospects Database provided by the United Nations, Department of Economic and Social Affairs, Population Division.

[17] See IPCC (2011).

[18] See IPCC (2000a; 2000b).

three component indices and 0 for the fourth results in a value of 1 for the CIEL-VI). The value of each component index ranges from 0 to 1, and the CIEL-VI index value is capped at 1.

In CRED the component indices are measures of aggregate regional vulnerability; in CIEL they are adapted to better reflect the vulnerability of individuals. Income (not included in the CRED Vulnerability Index) is measured by the logarithm of per capita household income.[19] Economic exposure measures the contribution to household income from vulnerable industries such as agriculture, fisheries, forestry and tourism. Sea-level rise exposure is measured as elevation above sea-level, where elevations above 5 meters earn the minimum index value. Water scarcity is the inverse of total renewable water resources per capita in an individual's country or region, where values less than 1,000 cubic meters of water per person earn the maximum index value. The value of each exposure indicator is converted into a component index by normalizing it against world maximum and minimum values (or in the case of income, against $100,000 and $250). Indices are calculated using the same methodology employed in the United Nations Development Programme's Human Development Index (UNDP 2011).

The CIEL-VI, weighted by income to incorporate the importance of income growth over time, determines an individual's share of monetary global damages from climate change:

1) $$Share\ of\ global\ damages_i = {(VI_i * \ Income_i)}\Big/{(VI_{world} * \ GDP_{world})}$$

The CIEL-VI does not vary by year, but income per capita does. Starting with current-day incomes, CIEL projects future incomes using the regional output per capita growth rates implied by the CRED-BAU and CRED-LOW scenarios. Climate damages in CIEL are expressed as dollars of *avoidable* damages (CRED-BAU damages less CRED-LOW damages) suffered by an individual in a given year as a share of individual income (CRED-BAU and CRED-LOW income, respectively) in that same year.

CIEL compares the avoidable damages of failing to lower greenhouse gas emissions to the economic benefits of not lowering emissions. By not reducing carbon emissions, one saves the cost of lowering emissions. CIEL bases its value of total emissions reductions by region and year (the total benefit of not cutting emissions received by the region as a whole) on emissions reduction costs in the CRED very-low-emissions run. CRED, in turn, bases its emissions reduction estimates on marginal abatement curves constructed using McKinsey & Company data.[20]

In the absence of data on individual emissions or energy use, CIEL represents regressivity in emissions reductions costs by assigning individual reduction costs in proportion to the product of two ratios: 1) the regional average of per capita abatement costs; and 2) the ratio of individual income to regional average income, raised to the 0.9 power. This is a very mild representation of regressivity: doubling income from the regional average increases the individual's share of emission reduction costs to 1.86 times their original value; halving average income decreases costs to 0.54 times their original value. The impacts of this assumption are broadly consistent with the overall pattern of energy use: The poorer you are, the higher your per capita emissions reduction costs.

[19] Using the logarithm of per capita income, a doubling of income has same effect on index value points, regardless of the original income level.

[20] Ackerman and Bueno (2011).

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