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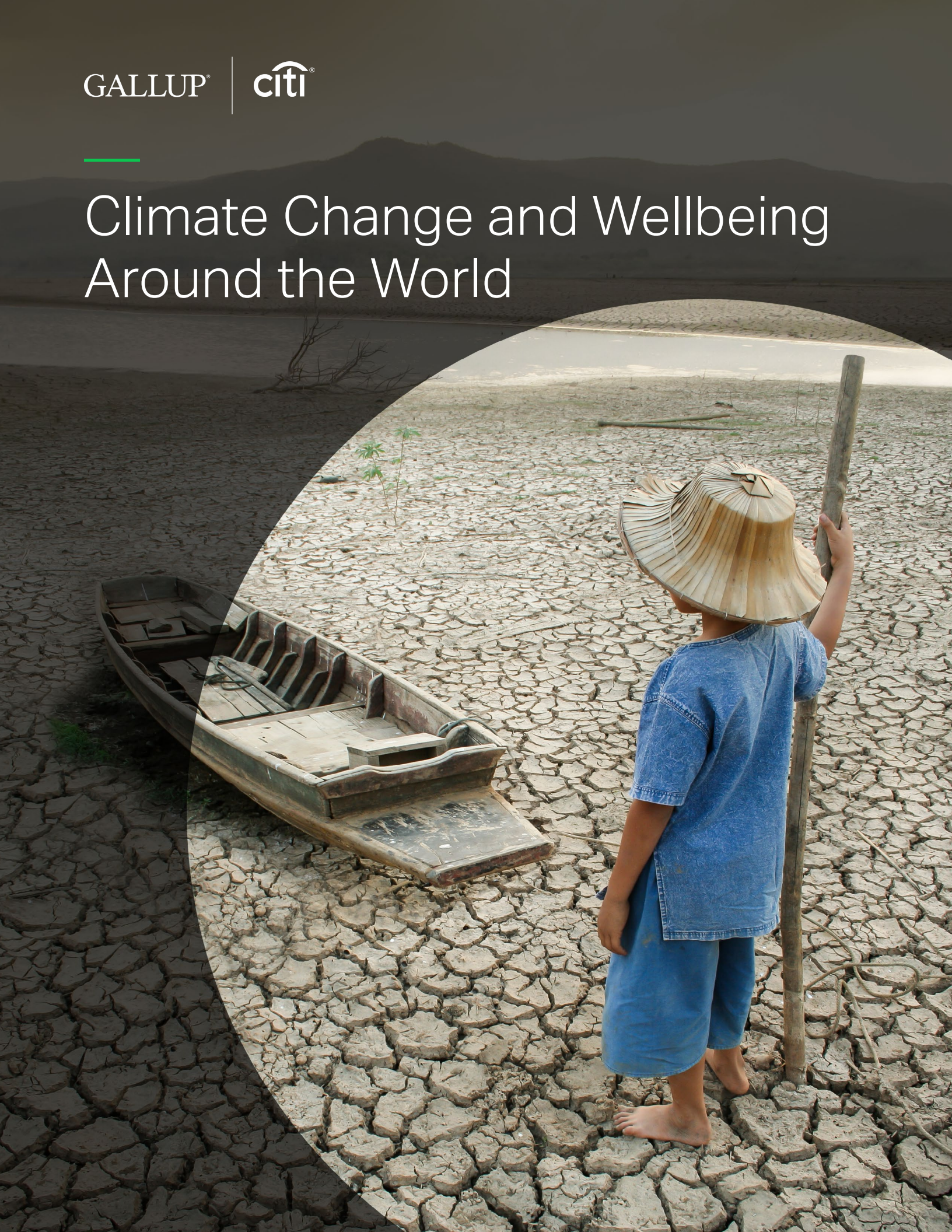
Climate Change and Wellbeing Around the World



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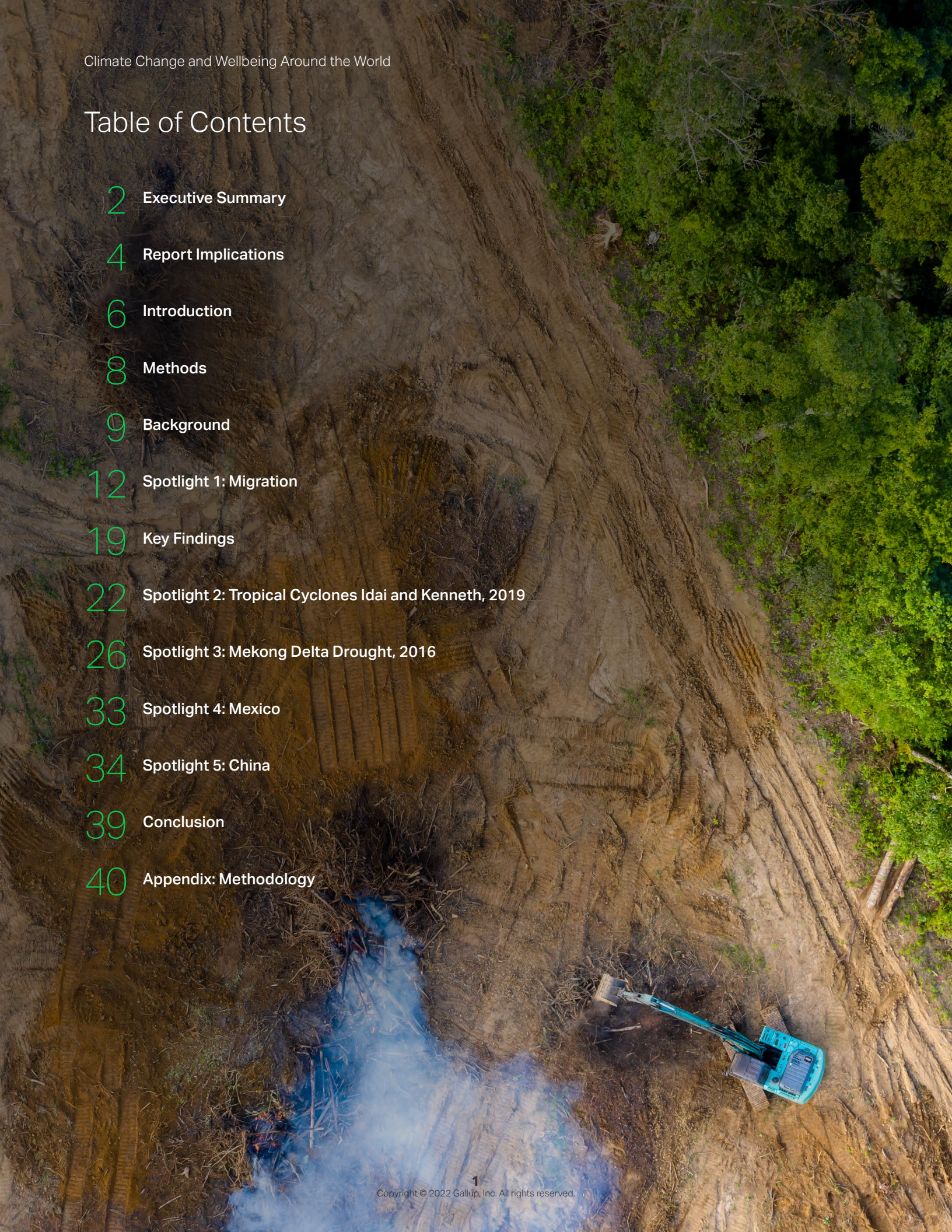


Executive Summary

While much is known about the environmental and economic effects of climate change, there has been less systematic analysis of how rising temperatures affect quality of life around the world. This analysis represents a preliminary effort to quantify and track the impact of rising temperatures on people's lives by using geospatial information on respondent locations to combine Gallup survey results from 1.75 million people in 160 countries with daily, high-resolution temperature data from NASA. The results allow researchers to study in detail how objective weather information relates to subjective data on how people around the world evaluate their lives.

The findings provide new insight into the significant negative impact rising temperatures have on global quality of life. They also quantify the overall human toll, beyond financial impacts, climate change has had on people's lives over the past 10 years. And the data project that by 2030, the number of high-temperature days people experience will double.

When viewed in the context of the stability of life evaluations — even in the face of negative events such as financial and governmental crises — these data provide an important tool for policymakers and leaders more broadly to use to galvanize action, as wellbeing is projected to continue to decline unless efforts are made to mitigate and build resilience to rising temperatures. Quantifying where people are most affected and how much will help policymakers communicate the tangible effects of climate change and develop more targeted strategies for helping people adapt to it.

Key findings include:

1 **Globally, people faced 3x more "high-temperature days" in 2020 than in 2008, and rising temperatures have decreased wellbeing by 6.5%.**

Combining individual-level Gallup World Poll data with NASA's daily temperature data shows that in 2020, people experienced more than 1.0 high-temperature days per month on average, up from 0.36 days in 2008. Gallup World Poll data is sampled on a probability-to-population basis — meaning the locations in which people are interviewed reflect the weather where most humans reside. The current analysis thus provides a more relevant measure of how rising temperatures are experienced by the world's population than global temperature estimates, which include large uninhabited areas.

Each time a person experiences a high-temperature day, their life evaluation drops by an average of 0.56%. In more technical terms, within a 30-day period, one additional day with temperatures at least two standard deviations above the historical average is associated with a drop of 0.037 points on a 0-to-10 life evaluation scale, controlling for the respondent's location and a range of other factors that influence life evaluations. This decrease is substantively meaningful given the stability of the life evaluation metric, even in adverse circumstances. For example, during the 2009 global financial crisis, worldwide life evaluations fell by just 3.7% or 0.20 points on the 10-point ladder scale.

Life ratings also vary modestly among countries with different living standards. For example, in 2019, people in Japan rated their lives at about "6" out of 10 on average, while those in Cambodia gave an average rating of about "5," highlighting that economic conditions do not drastically impact life evaluations.

The results of the current study show that life ratings continue to drop as the number of high-temperature days accumulate, with considerable declines in life evaluations in countries with more frequent high-temperature days.

2 The impact of rising temperatures on quality of life is more pronounced among older generations and people in poorer countries and developing economies with large populations, including China and Brazil.

High-temperature days are more strongly associated with lower life evaluations for some groups than others. Globally, the largest difference is seen between older adults and their younger counterparts. Among people 65 and older, each day of heat in the past 30 days at least two standard deviations above the historical mean is associated with a 1.11% drop in life evaluation, compared to a 0.48% drop among people younger than 65.

The analysis affirms prior research showing people in low- and middle-income countries are more vulnerable to weather extremes than those in high-income countries.[1] The relationship between high temperatures and lower life evaluations is especially strong in 37 countries, among them several of the world's largest populations: China, Mexico, Turkiye, Nigeria and Brazil. Collectively, these 37 countries represent about a third of the global population.

3 Given climate projections, high-temperature days could decrease global wellbeing by an estimated 17% by 2030.

Using observed heat trends from the past 14 years to predict the global rise in high-temperature days over the next decade, the results suggest people will experience on average 3.1 such days in 2030, compared to 1.7 days in 2021. The cumulative effect of such days implies that, holding all else constant, rising temperatures will be associated with a drop in life evaluations three times greater in 2030 than current levels.

1 *UNDESA world social report 2020.* (2020). United Nations Department of Economic and Social Affairs. https://www.un.org/development/desa/dspd/world-social-report/2020-2.html; Sperling, F. (Editor) [World Bank]. (2002). *Poverty and climate change: Reducing the vulnerability of the poor through adaptation.* Retrieved March 10, 2022, from https://www.oecd.org/env/cc/2502872.pdf; U.S. Global Leadership Coalition. (2021, March). C*limate change and the developing world: A disproportionate impact*. https://www.usglc.org/blog/climate-change-and-the-developing-world-a-disproportionate-impact/

Report Implications

What is life evaluation, and why does it matter in the context of climate change?

- Life evaluation is a stable measure of the quality of people's subsistence that allows researchers to make international comparisons of individuals' wellbeing. The life evaluation metric evaluated in this study (the 10-point Cantril scale) is strongly positively correlated with GDP per capita, life expectancy, social support and freedom to make life choices, among other factors.

- Wellbeing metrics are an essential complement to GDP: The United Nations, OECD and many countries already use these metrics to inform policy design — an important shift that will help capture a true picture of the human condition beyond economic stability.

What are the implications of declining life evaluations globally in the last 10 years as a result of rising temperatures?

- Uneven effects of a warming world: Low- and middle-income countries are most at risk and vulnerable populations in particular.
  - Climate change is worsening the wellbeing divide between high-income countries and the rest of the world.
  - High-income countries have more effective ways to mitigate the effects of climate change on their populations.
  - High-income countries will need to take the lead on policy solutions: These countries contribute disproportionately to climate change due to higher emissions and, in effect, rising temperatures.

- The great climate migration:
  - It is predicted that people from poorer and hotter countries will be forced to migrate due to climate pressures, catalyzing refugee crises. Higher-income nations will, in turn, need to absorb displaced populations.
  - Given the projection of rising temperatures over the next decade, the data in this study could indicate that this process will accelerate as wellbeing in the most impacted locations drops.

- Declines in wellbeing can be related to conflict and food insecurity: Gallup life evaluation data saw declines in wellbeing ahead of the Arab Spring and have observed these trends in advance of other instances of conflict.
  - Rising temperatures contribute to declines in agricultural production, leading to rising food insecurity. As these factors work in tandem, food insecurity may be just one factor that can lead to conflict and migration.

- The predictions are only becoming more dire: As the IPCC report explains, climate change will accelerate and may be irreversible unless there is an immediate effort to combat rising temperatures.
  - The data in this report show that as temperatures continue to rise, life evaluations will continue to decline on a global scale.
  - There are no signs of these declines abating: The data have observed consistent declines in the last decade and predict declines to triple by 2030. Future declines are expected to accelerate as temperatures are estimated to rise at a faster rate.
  - This finding is alarming from the perspective of life evaluation ratings: Life evaluation is a stable metric that bounced back even after the global financial crisis. The data in this study do not show signs of bouncing back, given the current trajectory of rising temperatures predicted by climate scientists.

- Education is key: Educational attainment has been shown to be the strongest predictor of climate change awareness. The authors of a 2015 analysis of World Poll data published in *Nature Climate Change* concluded that "improving basic education, climate literacy and public understanding of the local dimensions of climate change are vital to public engagement and support for climate action."
  - Rising temperatures are less associated with negative life evaluations among more educated populations.

Introduction

A key element missing from understanding the impact of climate change is its effect on individuals globally. Scientists have developed a sophisticated understanding of how the warming planet is altering the natural world and ecosystems. However, there is less understanding of how changing weather systems affect the wellbeing of individuals around the world.

To help quantify how much people are affected by climate change, policymakers in the U.S. developed a metric called *the social cost of carbon*, which monetizes the damage caused by one additional ton of greenhouse gas. However, estimates for the social cost of carbon have varied widely in recent years, from $7/ton to around $125/ton or more, reflecting disagreement in how the figure should be calculated and — more fundamentally — a lack of consensus on the true toll of climate change on populations.[2,3,4] In commenting on how to estimate the cost of climate change, UC Berkeley economist Maximilian Auffhammer recently wrote, "… it is shocking how little has been done on the effects of climate change on nonmarket goods other than mortality."[5]

The need for a deeper understanding of the effects of climate change is urgent: Over the past two decades, extreme weather events associated with climate change have become more common. A 2020 report from the UN Office for Disaster Risk Reduction estimates that there were 3,656 climate-related disasters worldwide between 1980 and 1999, rising to 6,681 between 2000 and 2019. That sharp increase meant 3.9 billion people were directly affected by climate-related events in 2000-2019, up from 3.2 billion in 1980-1999.[6] Quantifying where people are most affected and by how much will help policymakers worldwide better understand policy needs and communicate the tangible effects climate change is likely to have on their constituents' daily lives.

2 Plumer, B. (2018, August 23). Trump put a low cost on carbon emissions. Here's why it matters. *The New York Times*. https://www.nytimes.com/2018/08/23/climate/social-cost-carbon.html

3 Interagency Working Group on Social Cost of Greenhouse Gases. (2021, February). *Technical support document: Social cost of carbon, methane, and nitrous oxide interim estimates under Executive Order 13990*. United States Government. https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

4 Carleton, T., & Greenstone, M. (2021). *Updating the United States government's social cost of carbon* (SSRN Scholarly Paper ID 3764255). Social Science Research Network. https://impactlab.org/research/updating-the-united-states-governments-social-cost-of-carbon/

5 Auffhammer, M. (2018). Quantifying economic damages from climate change. *Journal of Economic Perspectives, 32*(4), 33-52. https://www3.nd.edu/~nmark/Climate/Auffhammer_JEP.pdf

6 Centre for Research on Epidemiology of Disasters. (2020). *The human cost of disasters: An overview of the last 20 years (2000-2019)*. United Nations Office for Disaster Risk Reduction. https://www.undrr.org/publication/human-cost-disasters-overview-last-20-years-2000-2019

Global subjective wellbeing measures provide a new lens for assessing the impact of climate change.

To evolve how policymakers and their constituents think about the issue of climate change, stakeholders need clear evidence of where and how weather changes affect people's everyday lives.

In response to this need, Gallup has assembled a large-scale dataset that combines measures of people's life quality and subjective wellbeing (SWB) with climate data from where they live. As the most globally inclusive survey ever administered, the Gallup World Poll includes data on the life evaluations of 1.75 million people worldwide. Combining 15 years of World Poll data with daily geolocated NASA temperature data provides a unique opportunity to study the relationship between exposure to rising heat and people's life ratings.

The need for a deeper understanding of the effects of climate change is urgent.

Methods

In a typical year, the Gallup World Poll covers more than 140 countries and areas and more than 98% of the global population. The World Poll questionnaire includes more than 100 questions spanning many aspects of people's lives, from overall wellbeing measures to specific issues like access to food and shelter, the availability of essential services such as education and healthcare, and confidence in national institutions.

In most countries, Gallup interviews nationally representative samples of about 1,000 adults each year. Gallup uses telephone surveys in countries where telephone coverage represents at least 80% of the population. In more than 100 lower-income countries, including much of Latin America, the former Soviet Union countries, most of Asia, the Middle East and Africa, data are collected face-to-face in randomly selected households. In these countries, Gallup has captured the GPS coordinates of each interview since 2016, providing precise information about respondents' environment and geography. For the current analysis, Gallup used these GPS coordinates to test the extent to which temperature data precision matters when studying the impact of climate change on wellbeing.

The results in this report are based on Gallup World Poll respondent-level data from 2006 to 2020 in 160 countries. This data represents about 1.75 million respondents interviewed over the course of those 15 years. Information about the respondents' location (either country administrative divisions or GPS coordinates) is matched with daily, high-resolution land surface temperatures from NASA's MERRA-2 database. Specifically, the analysis tests for relationships between respondents' life ratings and the number of days in the 30 days prior to the survey with unusually high daytime temperatures where they live.

In this study, Gallup merged NASA MERRA-2 daily temperature data from 1980 to 2020 with the World Poll data. "High-temperature days" are defined as days on which the temperature in a given location is 1.5 or two standard deviations above the location's mean temperature during a historical reference period, which is derived using aggregated NASA MERRA-2 data from 1980-2004. This approach follows previous analyses that examine relationships with heat anomalies relative to baseline levels in investigating the effects of rising heat on wellbeing.[7]

This study is a novel attempt to explore the relationship between rising temperatures and life evaluations. Yet, the relationships and associations mentioned in this report do not imply causality. Human adaptation to and recovery from rising temperatures is a critical question that should be considered in future research. Further research is needed to explore the mechanisms through which climate change impacts individuals' livelihoods.

7 Deschênes, O., & Greenstone, M. (2007). *Climate change, mortality, and adaptation: Evidence from annual fluctuations in weather in the US* (No. w13178; p. w13178). National Bureau of Economic Research. https://www.nber.org/system/files/working_papers/w13178/w13178.pdf; Aragón, F. M., Oteiza, F., Rud, & J. P. (2018). *Climate change and agriculture: Farmer responses to extreme heat*. https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2018/11/Climate_Change_and_Agriculture_Farmer_Adaptation_to_Extreme_Heat.pdf

Background

Climate change

The United Nations Climate Change Conference in Glasgow (COP26), held Oct. 21-Nov. 12, 2021, in Scotland, gathered more than 20,000 delegates from nearly 200 countries to align world leaders around specific goals for reducing emissions and addressing other critical issues, such as deforestation.[8] Conference delegates were asked to update the pledges made in the landmark Paris Agreement of 2015, in which participants agreed to pursue efforts to keep the global temperature increase less than 2 degrees Celsius above pre-industrial levels.[9]

COP26 came shortly after the UN's Intergovernmental Panel on Climate Change (IPCC) released the physical science component of its sixth assessment report. The report affirms that human influence has unequivocally warmed the planet, with the likely range of human-caused global surface temperature increase from 1850-1900 to 2010-2019 being between 0.8 degrees and 1.3 degrees Celsius. The report also notes that "human-induced climate change is already affecting many weather and climate extremes in every region across the globe," including "heatwaves, heavy precipitation, droughts and tropical cyclones."[10]

The reality that climate change is no longer a distant possibility, but a direct threat to billions of people, has heightened the importance of discarding increasingly outdated notions, such as the idea that clean-energy regulations are inconsistent with economic growth. A 2021 *Economist* op-ed argues that long-term prosperity is "unachievable if it is based on an economy powered by coal, oil and natural gas. The harms from the cumulative emissions of carbon dioxide would eventually pile up so rapidly that fossil-fuel-fired development would stall."[11]

8 COP26: What was agreed at the Glasgow climate conference? (2021, November 15). *BBC News*. https://www.bbc.com/news/science-environment-56901261

9 Briggs, H. (2021, October 21). Why is the Paris Climate Agreement important for COP26? *BBC News*. https://www.bbc.com/news/science-environment-35073297

10 IPCC. (2021, August). *Climate change 2021: The physical science basis* [Working Group I contribution to the sixth assessment report of the Intergovernmental Panel on Climate Change] (pp. 6-10). https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf

11 Why the COP26 climate summit will be both crucial and disappointing. (2021, October 30). *The Economist*. https://www.economist.com/leaders/2021/10/30/why-the-cop26-climate-summit-will-be-both-crucial-and-disappointing

In recent years, other reports have focused on the most common mechanisms through which climate change affects people's lives:

- **Climate change perpetuates poverty and threatens the livelihoods of many low-income people**, such as shareholder farmers.[12] The UN's *World Social Report 2020* names climate change as one of four "megatrends" exacerbating global economic inequality.[13] In some countries, women may be disproportionately affected, particularly where they have lower average education levels and fewer employment options than men.[14]

- **Climate change reduces access to food and clean water**, especially during extreme weather events such as droughts and floods.

- **Climate change spurs conflict and migration**. Heightened insecurity about basic necessities like food and water can lead to violent conflict between groups over scarce resources and migration away from areas most affected by climate change.[15] Climate-induced migration and displacement can also spur instability and conflict between receiving communities and new arrivals.[16]

- **Climate change has health consequences**, especially in countries with poor healthcare infrastructure and where infectious diseases are less controlled. Higher temperatures and more frequent droughts or floods can affect health outcomes in many ways, including through direct heat exposure, undernutrition and increased proliferation of diseases that affect poor households, like malaria and diarrhea.[17]

12 Shock waves: Managing the impacts of climate change on poverty - background papers. (2015, November 8). *The World Bank*. https://www.worldbank.org/en/topic/climatechange/brief/shock-waves-managing-the-impacts-of-climate-change-on-poverty-background-papers

13 *UNDESA world social report 2020*. (2020). United Nations Department of Economic and Social Affairs. https://www.un.org/development/desa/dspd/world-social-report/2020-2.html

14 Chandra, A., McNamara, K. E., Dargusch, P., Caspe, A. M., & Dalabajan, D. (2017). Gendered vulnerabilities of smallholder farmers to climate change in conflict-prone areas: A case study from Mindanao, Philippines. *Journal of Rural Studies, 50*, 45-59. https://www.sciencedirect.com/science/article/abs/pii/S0743016716307392

15 Sherbinin, A. (2020, October 23). Climate impacts as drivers of migration. *Migration Policy Institute*. https://www.migrationpolicy.org/article/climate-impacts-drivers-migration

16 Blocher, J. M., & Kileli, E. O. (2020, November 13). In relatively peaceful Tanzania, climate change and migration can spur conflict. *Migration Policy Institute*. https://www.migrationpolicy.org/article/tanzania-climate-change-migration-conflict

17 The World Bank *Shock waves* report. (2015, November 8). p. 116.

In recent years, many surveys have measured awareness and views of climate change in specific countries, but international studies are much rarer and generally skewed toward more developed regions. However, a 2015 analysis of Gallup World Poll data examining the predictors of climate change awareness and risk perception around the world resulted in several key findings, primarily:

1. Educational attainment is the strongest predictor of climate change awareness at the global level.
2. Predictors of risk perception vary by region, but in many African and Asian countries — where populations are particularly vulnerable to the effects of climate change — the strongest predictor is residents' perceptions of local temperature change.[18]

18 Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C. Y., & Leiserowitz, A. A. (2015, July 27). Predictors of public climate change awareness and risk perception around the world. *Nature Climate Change, 5*, 1014-1020. http://sciencepolicy.colorado.edu/students/envs3173/lee2015.pdf

Spotlight 1: Migration

One of the most pressing consequences of climate change policymakers face is the rising number of people forced to relocate because of increasingly inhospitable conditions. According to the UN High Commissioner for Refugees, an average of 21.5 million people per year were displaced by extreme weather events between 2008 and 2016, with thousands more relocating due to slow-onset hazards like drought and coastal erosion.[19]

The risk of forced migration is greatest in low-income countries, where many people live in areas that lack the resources and infrastructure to prepare for and endure extreme weather events. Further, many countries that are most vulnerable to climate change have weak governance or are prone to conflict or violence. Climate-induced migration can increase the risk of conflict by shifting power balances or placing new groups in competition for scarce resources.[20]

In 2010, the Gallup World Poll asked adults in 112 countries and areas whether they thought they would need to move because of environmental problems in the next five years. In 16 countries, at least 20% said "yes." All 16 were in three regions with high average temperatures: Sub-Saharan Africa (7), Latin America (6) and the Middle East (3). Most were also low-income countries, where much of the population depends on agriculture or natural resources to survive.

19 UNHCR. (2016, November 6). *Frequently asked questions on climate change and disaster displacement*. https://www.unhcr.org/en-us/news/latest/2016/11/581f52dc4/frequently-asked-questions-climate-change-disaster-displacement.html

20 Campbell, J. (2019, November 15). *What's behind South Africa's recent violence?* Council on Foreign Relations. https://www.cfr.org/in-brief/whats-behind-south-africas-recent-violence; https://www.migrationpolicy.org/article/tanzania-climate-change-migration-conflict

Table 1: Countries highest in the belief that severe environmental problems will force people to move, 2010

In the next five years, do you think you will need to move because of severe environmental problems?

	% Yes		% Yes
Chad	39	Bolivia	23
Sudan	33	Ecuador	22
Saudi Arabia	32	Uganda	22
Liberia	29	Colombia	21
Guatemala	25	Kuwait	21
Tanzania	24	Mauritania	21
Botswana	24	Syria	20
Haiti	23	Dominican Republic	20

Given the relationship between migration and conflict,[21] it is also important to note that several countries where residents were most likely to think they would have to relocate because of environmental problems have also been plagued by violence in recent years.

The two Northern African countries at the top of the list, Chad and Sudan, are subject to chronic instability and conflict amid desolate socioeconomic conditions.[22] Gang-related violence endangers Guatemalan migrants beset by both severe droughts and devastating floods.[23] And Syria's 10-year civil war has created the largest refugee and displacement crisis in the world.[24] The role climate-related displacement plays in perpetuating such conflicts is an issue global leaders will increasingly need to contend with and understand.

21 de Sherbinin, A. (2020, October 23). *Climate impacts as drivers of migration*. Migration Policy Institute. https://www.migrationpolicy.org/article/climate-impacts-drivers-migration

22 *Peace & security report: Chad conflict insights*. (2021, April 26). ReliefWeb. https://reliefweb.int/report/chad/peace-security-report-chad-conflict-insights-april-2021; Sudan: 250 killed, over 100,000 displaced as violence surges in Darfur. (2021, January 22). UN News. https://news.un.org/en/story/2021/01/1082722

23 Chow, D., & Beltran, C. P. (2021, September 22). *Hungry and desperate: Climate change fuels a migration crisis in Guatemala.* NBC News. https://www.nbcnews.com/science/environment/hungry-desperate-climate-change-fuels-migration-crisis-guatemala-rcna2135

24 Syrian refugee crisis: Facts, FAQS, and how to help. (2021, July 13). *World Vision.* https://www.worldvision.org/refugees-news-stories/syrian-refugee-crisis-facts

Subjective wellbeing measures

Measures of subjective wellbeing (SWB) are increasingly being used to complement traditional economic indicators of life quality, such as per-capita GDP. The increased recognition of their importance reflects extensive research over the past 30 years showing that 1) they can be measured using statistically sound and replicable procedures, and 2) they diverge at times from traditional, objective wellbeing metrics in ways that can have significant consequences for people's preferences and behaviors. Specifically, SWB indicators offer a different and complementary perspective on life quality in two critical ways:

- They measure individuals' perceptions of the quality of their experiences and, therefore, do not rely on judgments by researchers or others on the requirements and factors that constitute a "good life."
- They are holistic in that they reflect the combined impact of a multitude of circumstances on people's lives.

Furthermore, SWB measures are a leading indicator of a country's living conditions compared to traditional, lagging economic indicators such as GDP.

> Many international organizations and government agencies have incorporated SWB measures into their benchmarks for progress, including:
>
> - The United Nations Development Programme Human Development Report
> - The OECD Better Life Index
> - The Legatum Prosperity Index
> - The World Happiness Report
> - The U.K. Office for National Statistics
> - The U.S. Bureau of Labor Statistics – American Time Use Survey
> - The French National Institute of Statistics and Economic Studies
> - The New Zealand General Social Survey

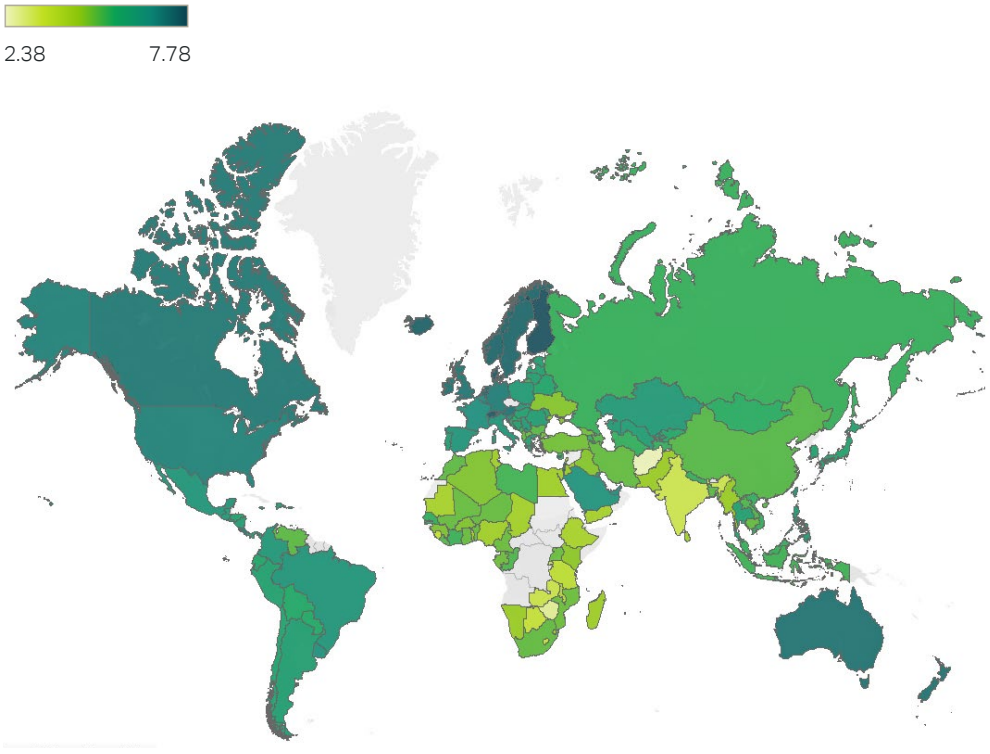
Gallup World Poll life evaluations

The Gallup World Poll includes several measures of evaluative and experiential wellbeing. Among those most used by researchers is a question that asks people to rate their lives on a 0-to-10 "ladder" scale, with the lowest rung (0) representing the worst possible life they could imagine and the highest (10) representing the best possible life.

Global results for 2019 show residents in high-income countries tend to rate their life as a "6" or "7" on average, and residents in low-income countries tend to rate their life around "3" or "4."

Chart 1: Average life evaluations by country, 2019

Please imagine a ladder with steps numbered from 0 at the bottom to 10 at the top. Suppose we say that the top of the ladder represents the best possible life for you, and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time, assuming that the higher the step the better you feel about your life, and the lower the step the worse you feel about it? Which step comes closest to the way you feel?



The average response to this question is stable when aggregated across many countries or regions. In the World Poll's 15-year history, the global average has varied by no more than 0.36 points — the highest figure recorded was 5.45 in 2007, and the lowest 5.09 in 2019.[25] However, even seemingly minor variations represent meaningful changes in wellbeing among the global population. Two shifts are worth highlighting:

The worldwide average dropped from 5.40 to 5.20 in 2009 — **representing a 3.7% decline** at the onset of the global recession — **but largely recovered to 5.38 the following year**.

The **global average tapered steadily downward** from 5.40 in 2011 to its lowest point of 5.09 in 2019, **a drop of 5.7%**.

Life ratings may also vary modestly among countries with different living standards; for example, people in Japan rate their lives at about "6" out of 10, on average, while those in Cambodia give an average rating of about "5." Thus, small differences associated with adverse conditions are substantively meaningful.

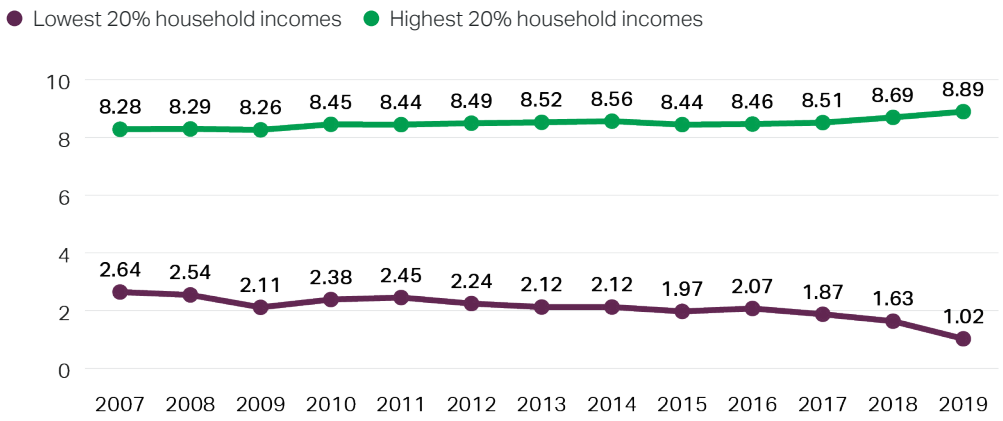
25 In 2020, the COVID-19 pandemic precluded in-person interviewing; therefore, Gallup was unable to include a number of low-income countries in the World Poll where telephone coverage was insufficient to reach a representative national sample. Thus, while the average life evaluation among all countries was higher in 2020, this was largely because fewer low-income countries were included in the calculation.

Life evaluations have become more unequal as global income inequality has risen.

Not surprisingly, income is one of the strongest predictors of life ratings. In a 2008 analysis, Nobel Laureate Sir Angus Deaton found that the relationship is logarithmic: Each doubling of per-capita GDP (for example, from a country where people make $10,000 annually on average to one where they make $20,000) was associated with a constant increase (about 0.84 of a scale point) in life satisfaction.[26] That relationship has remained consistent over time, suggesting that one of the primary mechanisms through which climate change may be expected to influence life evaluations is its effect on people's livelihoods. The results of the current study suggest that some of the global declines in wellbeing are associated with rising temperatures.

Just as income inequality has risen for most of the global population,[27] life evaluations have also grown more unequal over the past decade. The difference in average life evaluations between those in the bottom one-fifth of the ratings distribution and those in the top one-fifth was 5.64 points (2.64 vs. 8.28) in 2007 versus 7.87 points in 2019 (1.02 vs. 8.89). As discussed on page 10, the UN identifies climate change as a primary driver of global economic inequality, which is almost certainly reflected in these diverging life ratings.

Chart 2: Average life evaluation ratings, top income quintile vs. bottom income quintile worldwide



26 Deaton, A. (2008). Income, health, and wellbeing around the world: Evidence from the Gallup World Poll. *Journal of Economic Perspectives, 22*(2): 53-72.

27 *Rising inequality affecting more than two-thirds of the globe, but it's not inevitable: New UN report.* (2020, January 21). UN News. https://news.un.org/en/story/2020/01/1055681

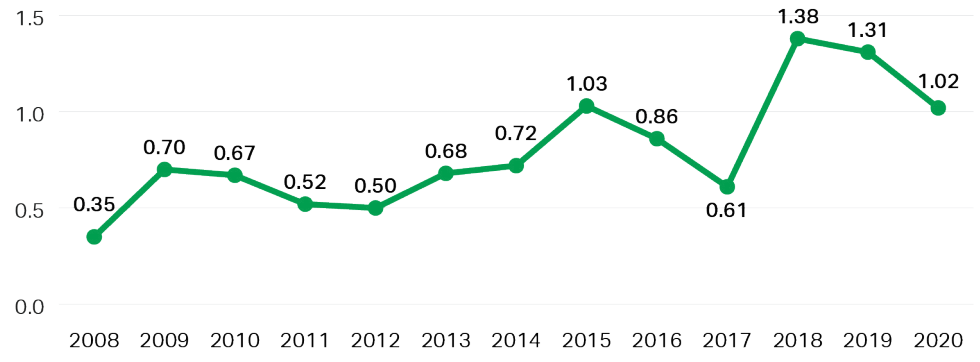
Key Findings

FINDING 1: Globally, people faced 3x more "high-temperature days" in 2020 than in 2008, and rising temperatures have decreased wellbeing by 6.5%.

In 2008, people experienced 0.36 "high-temperature days" (days with temperatures at least two standard deviations above the historical average) on average per month. By 2020, that number had risen to more than 1.0 high-temperature days per month. One standard deviation equates to about 7 degrees Celsius, with variation across latitudes and climates. For example, in New York City, the average temperature in late May is 15-21 degrees Celsius. Therefore, a "two-standard deviation high-temperature day" equates to about 32 degrees in NYC in late May.

> Unlike other global warming measures, Gallup World Poll data is sampled from where people live on a probability-to-population basis — meaning the locations where people are interviewed reflect the weather where most humans live. It does not include unpopulated areas like the Arctic or the vast swaths of uninhabited areas included in general global warming statistics. Thus, the results provide a more relevant measure of how people worldwide experience rising temperatures.

Chart 3: Average number of high-temperature days in a 30-day period, 2008-2020*



* Among regions inhabited by Gallup World Poll respondents

Precipitation

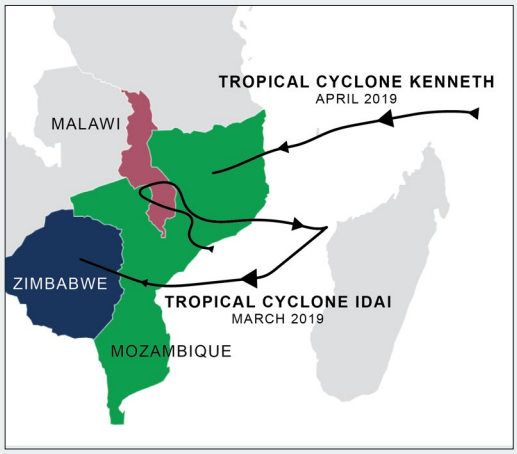
As the planet warms, the earth's hydrological systems are expected to be altered, as warmer air can hold more moisture than cooler air. These changes can lead to greater variation and precipitation extremes. The IPCC's sixth assessment report projects with medium to high levels of confidence that:

- Rising temperatures have and will continue to lead to increases in "the frequency, intensity and/or amount of heavy precipitation in several [world] regions (high confidence)."
- Increases in high-temperature days will lead to an "increase in intensity or frequency of droughts in some regions (medium confidence)."
- Heavy precipitation associated with tropical cyclones is likely to be "higher at 2°C compared to 1.5°C global warming (medium confidence)."[28]

28 IPCC. (2021, August). *Climate change 2021: The physical science basis* [Working Group I contribution to the sixth assessment report of the Intergovernmental Panel on Climate Change] (pp. 177-178). https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf

Spotlight 2: Tropical Cyclones Idai and Kenneth, 2019

There is broad scientific consensus that climate change is increasing the intensity and frequency of tropical cyclones by warming the oceans' surface.[29] In March 2019, Cyclone Idai struck southeastern Africa as one of the most devastating weather events ever in the region. The cyclone's path cut across regions in Mozambique, Zimbabwe and Madagascar, killing hundreds and causing catastrophic damage with strong winds and severe flooding.[30] The following month, Mozambique was struck again by Cyclone Kenneth, which killed an additional 45 people and displaced thousands.[31]



World Poll surveys conducted months later in Mozambique (November-December 2019), Zimbabwe (June-August) and Madagascar (June-July) found that life evaluations had dropped significantly among residents of provinces that had been in the cyclones' paths (0.39 scale points, or 9.5%) while declining more modestly among other residents of the three countries (0.10 scale points, or 2.4%).

Chart 4: Average life evaluations among residents of provinces in the path of Cyclones Idai or Kenneth vs. those living elsewhere in Mozambique, Zimbabwe or Madagascar

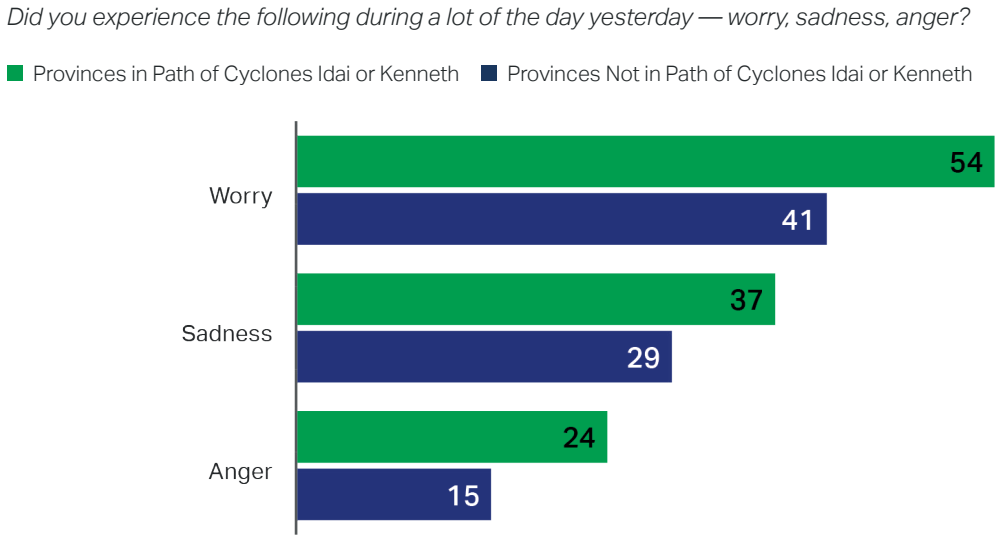
29 Knutson, T. R., Chung, M. V., Vecchi, G., Sun, J., Hsieh, T. L., & Smith, A. J. P. (2021, March 26). *Climate change is probably increasing the intensity of tropical cyclones*. ScienceBrief. https://news.sciencebrief.org/cyclones-mar2021/

30 Warren, M. (2019, March 26). Why Cyclone Idai is one of the Southern Hemisphere's most devastating storms. *Nature*. https://www.nature.com/articles/d41586-019-00981-6

31 *Southern Africa: Tropical Cyclone Kenneth flash update no. 12 (12 May 2019) - Mozambique.* (2019, May 13). ReliefWeb. Retrieved January 12, 2022, from https://reliefweb.int/report/mozambique/southern-africa-tropical-cyclone-kenneth-flash-update-no-12-12-may-2019

Residents of provinces directly affected by the cyclones also appeared worse off in another aspect of subjective wellbeing: day-to-day emotional health. They were significantly more likely than other residents of the three countries to say they experienced worry, sadness and anger the day before the survey.

Chart 5: Percentage who experienced worry, sadness or anger 'a lot of the day yesterday,' among residents of Mozambique, Zimbabwe and Madagascar, 2019



Such findings demonstrate the value of considering different aspects of subjective wellbeing in assessing the effects of climate change. In the case of isolated extreme weather events, it may be just as relevant to gauge the impact on more specific indicators of people's emotional health as on their broader overall life ratings.

Life ratings drop as the number of high-temperature days accumulates, with considerable declines in life evaluations in countries with more frequent high-temperature days.

One additional day with temperatures at least two standard deviations above the historical average is associated with a drop of 0.037 points on the 0-to-10 life evaluation scale, controlling for a range of other factors that would be expected to influence life evaluations (such as respondents' demographic characteristics, the country they live in and the time of year when they were interviewed). That scale-point difference translates to a significant drop of about 0.56% in life evaluations for each high-temperature day in the respondent's administrative region (such as province or state).

One additional day with temperatures at least two standard deviations above their region's historical average is associated with a **drop in respondents' life ratings** of

0.037 scale points, or 0.56%.

While the 0.56% decrease may seem modest, it is substantively meaningful given the stability of the life evaluation metric, even in adverse circumstances. The 2009 global financial crisis, for example, saw a decrease of just 3.7% in life evaluations globally, a drop of 0.20 points on the 10-point scale. Further, life ratings continue to decline as the number of high-temperature days accumulates, so the effect on wellbeing is considerably stronger in countries where such days are more frequent.

Notably, the magnitude of a standard deviation difference from the average historical temperature varies widely across latitudes, from about 2 degrees to about 10 degrees Celsius. Climate models consistently predict increases in temperature variability in tropical regions such as the Amazon, the Sahel and Southeast Asia — regions where predominantly low-income populations are ill-equipped to handle the economic consequences of climate change — in the coming decades.[32] Those living in the southernmost regions of many other countries are also particularly vulnerable; for example, some residents of the U.S. and China experienced at least 10 high-temperature days in the month prior to being interviewed.

32 Bathiany, S., Vasilis, D., Scheffer, M., & Lenton, T. M. (2018, May 2). Climate models predict increasing temperature variability in poor countries. *Science Advances, 4*(5), eaar5809. https://www.science.org/doi/10.1126/sciadv.aar5809

Deeper analysis of how the relationship between life evaluations and high-temperature days may change over time shows that, from 2008 to 2020, life evaluations dropped by roughly the same 0.56% for each additional high-temperature day. This finding indicates that while the size of the effect of each high-temperature day has stayed relatively the same over the last decade or so, the sheer number of high-temperature days has increased (as noted in the previous section) — driving the growing decreases in life evaluation scores.

The occurrence of high-temperature days has increased so much that Gallup estimates that from 2010 to 2020, global life evaluation dropped by 6.5% because of rising temperatures. This broad estimate is based on simplifying assumptions, as the exact figure undoubtedly varies across geography, time and population. For example, this estimate does not consider cumulative effects that may occur from having many high-temperature days in a short period. It also does not assume any adaptation, although the size of the effect of high-temperature days has remained fairly consistent over time.

Nonetheless, life evaluations declining because of rising temperatures on the scale of anything near 6.5% represents a dramatic drop in global wellbeing that is even more significant than the decreases seen during adverse circumstances such as the financial crisis — to which politicians responded swiftly and substantially.

Precision of Temperature Data

As noted on page 8, Gallup records World Poll respondents' specific GPS coordinates in the 110 lower- and middle-income countries where interviewers conduct surveys face-to-face. In these countries and territories, Gallup used those coordinates to generate more precise temperature data for each respondent than the temperature data from respondents' administrative regions used in the global analysis above.

Notably, the results from the two models were similar: The size of the relationship between extreme temperature and life evaluation was nearly identical regardless of whether GPS-based or region-based temperature data was used. This finding indicates that the effect of climate change on wellbeing is more regional in nature and not highly localized.

Spotlight 3: Mekong Delta Drought, 2016

The increasing frequency and intensity of agricultural and ecological droughts in recent years have disproportionately affected the world's poorest populations, who are more likely to rely on productive agricultural land for survival.[33] The IPCC's 2021 report estimates that droughts occurring once every 10 years in drying regions now occur 1.7 times in that period, with that frequency projected to increase as surface temperatures continue to rise.[34]

The Mekong Delta is a rural area in the southernmost part of Vietnam, where most residents are poorly educated and have limited options for alternative sources of income. Gallup's 2019 survey found that 72% of the region's residents had no more than primary education (vs. 41% among all other Vietnamese).[35]

In the spring of 2016, Vietnam suffered the worst drought in the Mekong River Delta region in 90 years. Rising sea levels compounded the impact, as saltwater intrusion destroyed countless acres of paddy rice and other crops, increasing food insecurity and affecting the livelihoods of many of the region's 20 million residents.[36]

The event appeared to significantly affect average life evaluations in the region, which dropped from 5.40 to 4.81 (a 10.9% decline) between the surveys administered in April 2015 and June 2016. By contrast, average life ratings did not change significantly among Vietnamese living elsewhere in the country during this time.

33 *GAR special report on drought 2021.* (2021). United Nations Office for Disaster Risk Reduction. https://www.undrr.org/publication/gar-special-report-drought-2021

34 IPCC *Climate change* report. (2021, August). p. SPM-23.

35 Provinces grouped as part of the Mekong Delta region include Long An, Đồng Tháp, Tiền Giang, An Giang, Bến Tre, Vĩnh Long, Trà Vinh, Hậu Giang, Kiên Giang, Sóc Trăng, Bạc Liêu, and Cà Mau, and the province-level municipality of Cần Thơ.

36 Gerin, R. (2015, October 27). *Vietnam: Experts warn Mekong Delta agriculture, livelihoods face serious threats*. Radio Free Asia. https://www.refworld.org/docid/584811b1e.html

Chart 6: Average life evaluations among Vietnamese living in the Mekong Delta region vs. the rest of the country

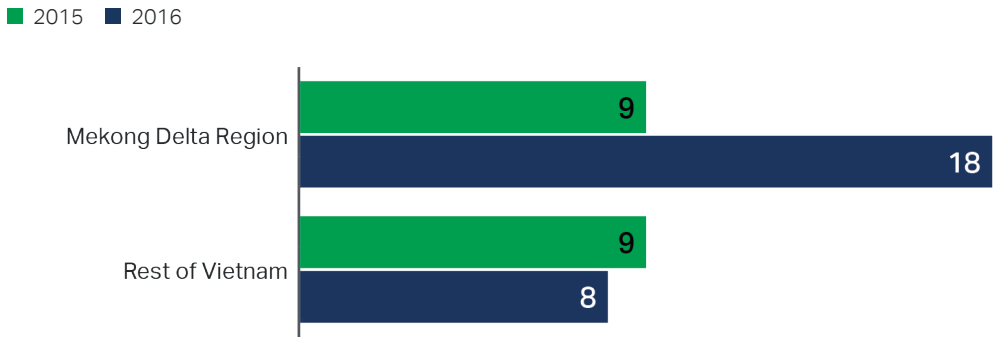
The crisis was also reflected in other life quality measures, including two commonly discussed effects of climate change: food insecurity and migration. Delta residents' likelihood to say there were times in the past year when they could not afford to buy food rose significantly between 2015 (23%) and 2016 (29%), though it fell among all other Vietnamese. And those living in the Delta region were twice as likely in 2016 (18%) as in 2015 (9%) to say they were likely to move away from the area in the next 12 months.

Chart 7: Percentage with enough money for food among Vietnamese living in the Mekong Delta region vs. the rest of the country

Were there times in the past 12 months when you did not have enough money for food?

Chart 8: Percentage "likely" to move among Vietnamese living in the Mekong Delta region vs. the rest of the country

In the next 12 months, are you likely or unlikely to move away from the city or area where you live?



FINDING 2: The impact of rising temperatures on quality of life is more pronounced among older generations and people in poorer countries and developing economies with large populations, including China and Brazil.

Consistent with literature on the groups most impacted by climate change, this global analysis finds that high temperatures are more predictive of lower life evaluations among some vulnerable demographic groups — including older people and those with less education, as shown in Table 2.

Results did not differ significantly by gender at the global level, though prior research suggests that climate change affects women and men differently.[37] And while the overall effect size is similar, more targeted research on causal mechanisms may reveal that the specific ways climate change affects life evaluations differ somewhat by gender.

Table 2: Life evaluation differences associated with one additional high-temperature day, global results by demographic group*

		Scale-point difference	Percentage difference
Age	Under 65 years old	- 0.033 pts.	-0.48%
	65 and older	- 0.065 pts.	-1.11%
Education	Primary education	- 0.041 pts.	-0.78%
	Secondary education	- 0.036 pts.	-0.47%
	Tertiary education	- 0.032 pts.	-0.38%
Gender	Men	- 0.040 pts.	-0.57%
	Women	- 0.034 pts.	-0.52%

* All relationships are statistically significant at the p<.05 level.

37 Pearse, R. (2017). Gender and climate change. *WIREs Climate Change , 8*(2). https://wires.onlinelibrary.wiley.com/doi/epdf/10.1002/wcc.451

Elderly people

The largest difference is seen among older adults worldwide compared to their younger counterparts. Among people aged 65 and older, each day of temperature exposure at least two standard deviations above the historical mean in the 30 days prior to the survey is associated with a 1.11% drop in life evaluation, versus a 0.48% drop among people younger than 65.

This finding reflects widespread concern about temperature-related health effects among older adults, particularly during heatwaves and in countries where in-home air conditioning is less prevalent.[38] However, even in some OECD countries, high-temperature days predict lower life evaluations among residents 65 and older.

People with lower levels of education

The strength of the relationship between high-temperature days and life evaluation ratings also varies by a key marker of socioeconomic status: educational attainment. This global analysis finds that among people with primary education or less, each high-temperature day is associated with a 0.78% drop in life evaluations, compared to a 0.38% drop among those with tertiary education or more.

The relationship between high-temperature days and life evaluations is weaker in OECD countries.

Among the 110 low- and middle-income countries where Gallup conducts interviewing face-to-face, the decline in life evaluations associated with one additional high-temperature day is 0.050 scale points, or 0.74% — a larger effect size than in the global analysis. This finding affirms previous research showing people in developing regions are more vulnerable to weather extremes than those in high-income countries and territories.[39]

When OECD countries were analyzed separately as a group, a significant negative relationship between extreme heat and life evaluation was not present. However, significant negative relationships were seen individually in several of the world's most populated countries, including China, Turkiye, Brazil, Nigeria and Mexico.

38 O'Neill, M. S., Carter, R., Kish, J. K., Gronlund, C. J., White-Newsome, J. L., Manarolla, X., Zanobetti, A., & Schwartz, J. D. (2009). Preventing heat-related morbidity and mortality: New approaches in a changing climate. *Maturitas, 64*(2), 98-103. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2793324/

39 U.S. Global Leadership Coalition. (2021). *Climate change and the developing world: A disproportionate impact*. https://www.usglc.org/media/2021/03/USGLC-Fact-Sheet-Climate-Change.pdf

Table 3: Life evaluation differences associated with additional high-temperature days in select countries

	Scale-point difference	Percent difference
Mexico	- 0.092 pts.	-1.24%
China	- 0.078 pts.	-1.14%
Turkiye	- 0.060 pts.	-1.78%
Nigeria	- 0.039 pts.	-0.52%
Brazil	- 0.033 pts.	-0.24%

* All relationships are statistically significant at the p<.05 level.

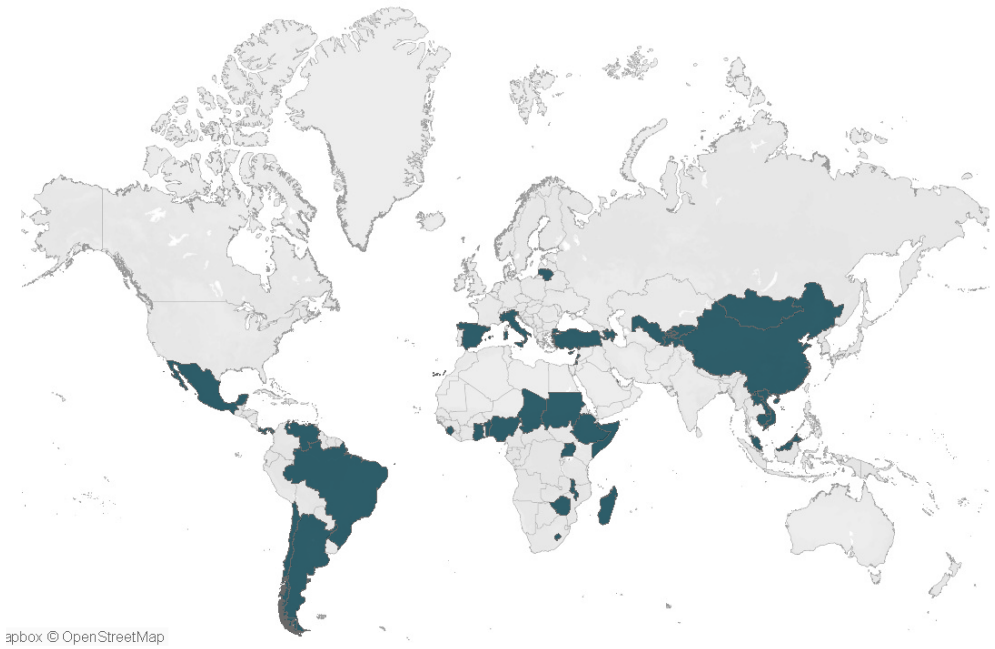
In 110 low- and middle-income countries, one additional day with temperatures at least two standard deviations above that region's historical average is associated with a drop in respondents' life ratings of

0.050 scale points, or 0.74%.

Among lower-income countries, however, there is considerable variation in the strength and direction of the relationship, much of which cannot be explained without considering a multitude of other factors. The effects of climate change on people's lives depend on a complex array of local conditions, such as culture, infrastructure, economic development and geographic latitude.

Nonetheless, a range of statistical models using different parameters and control variables consistently find significant negative relationships between extreme heat and life evaluations in 37 predominantly low- and middle-income countries. In addition to the five listed above, this group includes Argentina, Azerbaijan, Bahrain, Benin, Cambodia, Chad, Chile, Cyprus, Ethiopia, Ghana, Italy, Kyrgyzstan, Laos, Lebanon, Lesotho, Lithuania, Madagascar, Malawi, Malaysia, Mongolia, Palestine, Panama, Sierra Leone, Somalia, Spain, Sudan, Tajikistan, Uganda, Uzbekistan, Venezuela, Vietnam and Zimbabwe. The combined population of these 37 countries represents more than a third of the global population.

Chart 9: Countries with significant negative relationships between extreme heat and life evaluations



Spotlight 4: Mexico

In Mexico, an additional high-temperature day in the past 30 days is associated with a 0.092 scale-point drop in life ratings, or 1.24%, controlling for other factors.

Extreme temperatures and erratic rainfall affect agricultural productivity in Mexico, heightening the risk of food and water insecurity. In 2019, the proportion of Mexicans who said they had trouble paying for food in the past year reached 47% — the highest level in the World Poll's 15-year trend and up from 28% in 2007. Mexico's location between two oceans also increases the population's exposure to extreme weather events, such as tropical cyclones and floods.

Chart 10: Average life evaluations by province in Mexico, aggregated results for 2010-2019

Spotlight 5: China

China's massive population is among 37 countries and areas where high temperature consistently predicts lower life evaluations. In China, an additional day with temperatures at least two standard deviations above the historical mean is associated with a 0.078 scale-point drop in life ratings, or 1.14%, controlling for other factors.

China is easily the world's top greenhouse gas emitter — its skyrocketing economic growth in recent decades having come largely from carbon-intensive industries.[40] Rapid urbanization has created new manufacturing and industrial centers that rely on fossil fuels — particularly coal, which represents more than half of the country's primary energy consumption.[41]

However, millions of Chinese are acutely vulnerable to the effects of climate change. About 24% of the country's workforce is employed in agriculture;[42] that figure rises significantly in the rural Western provinces, where the increased frequency of heatwaves and heavy rainfalls endangers the livelihoods of countless farmers.

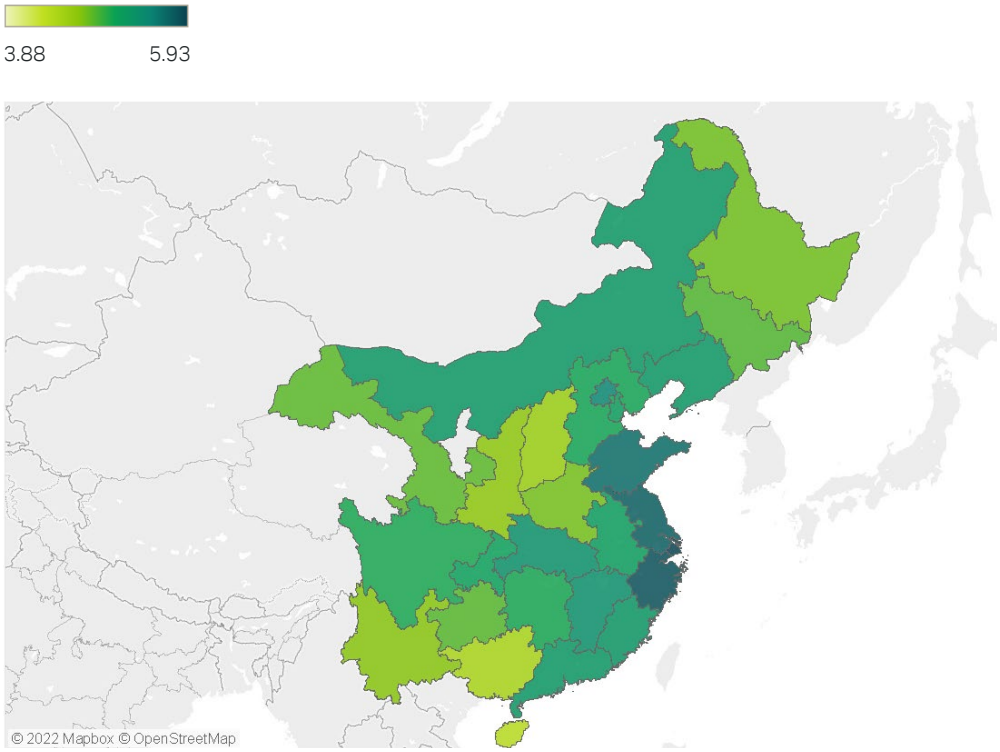
40 Maizland, L. (2021, May 19). *China's fight against climate change and environment degradation*. Council on Foreign Relations. https://www.cfr.org/backgrounder/china-climate-change-policies-environmental-degradation

41 *Independent statistics & analysis: China | Data.* (2020, September 31). U.S. Energy Information Administration. Retrieved January 10, 2022, from https://www.eia.gov/international/analysis/country/CHN

42 *China: Employment by sector*. (2022). Statista. Retrieved January 17, 2022, from https://www.statista.com/statistics/270327/distribution-of-the-workforce-across-economic-sectors-in-china/

As with the world overall, China's wellbeing inequality has increased steadily over the past 15 years. This inequality is reflected in regional patterns that roughly correspond to economic growth and development patterns. In 2019, average life evaluations were significantly lower in China's rural Western regions and the Northeastern provinces of Heilongjiang and Jilin than in the country's East Coast economic centers.

Chart 11: Average life evaluations by province in China, aggregated results for 2010-2019*

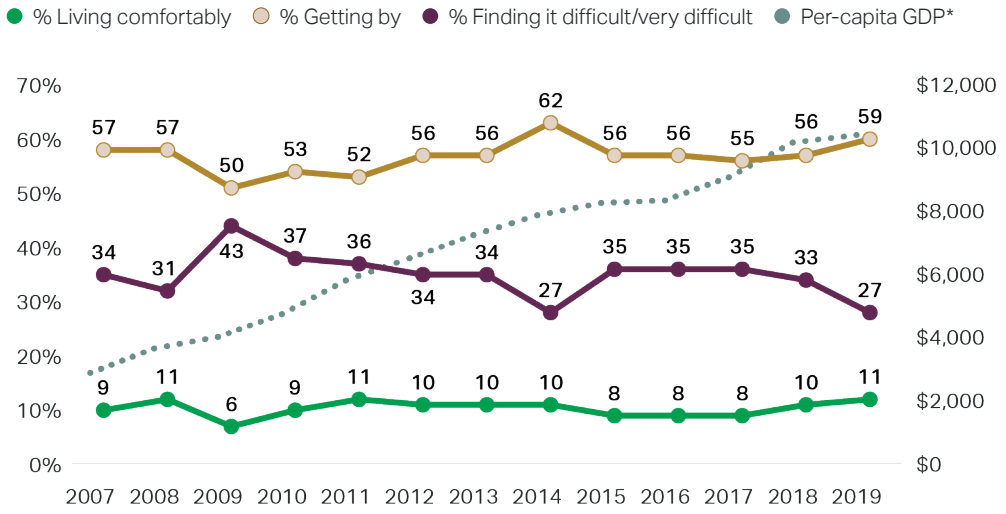


* Results not available for the sparsely populated Western provinces of Xinjiang, Qinghai and Tibet.

Moreover, despite the country's strong economic growth over the past decade, the percentage of Chinese who say they are "living comfortably" on their present income has not changed much, despite GDP per capita increasing over three-fold. In 2019, it stood at just 11% — identical to its 2008 level. The percentage who said they are finding it "difficult" or "very difficult" on their present income declined from 43% in 2009 to 27% in 2019. However, Chinese in the rural Western provinces were more than twice as likely as those on the East Coast to be finding it difficult or very difficult in 2019 — 40% vs. 18%, respectively.

Chart 12: Feelings about household income in China, 2007-2019

Which one of these phrases comes closest to your own feelings about your household's income these days?



* GDP data derived from https://www.macrotrends.net/countries/CHN/china/gdp-per-capita; data retrieved January 17, 2022.

While rural Chinese people are particularly vulnerable to extreme weather events, climate change poses a real threat in Chinese cities as well. Air pollution is a major concern, as rising temperatures have led to increased heatwaves and more periods of stagnant air. Among Chinese people interviewed from 2017 to 2019, 22% said they were dissatisfied with the air quality in their area. However, this figure rises dramatically in some urban areas — including Beijing, where 57% were dissatisfied.

The Chinese government has set ambitious targets for cutting carbon emissions; in 2020, President Xi Jinping declared the country would commit to net-zero emissions by 2060.[43] Analysts note this is a bold target given the country's current reliance on fossil fuels. However, leaders in Beijing have long been sensitive to potential threats to social stability[44] and to the extent that climate change threatens wellbeing in the country, it may indeed represent such a threat.

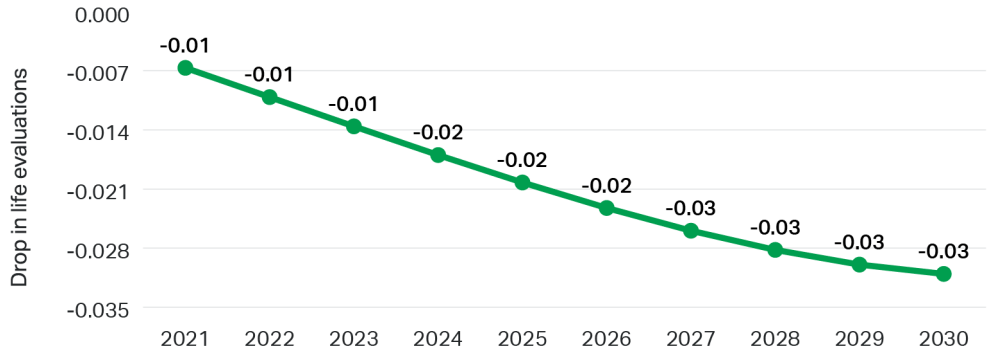
43 Mallapaty, S. (2020, October 19). How China could be carbon neutral by mid-century. *Nature*. https://www.nature.com/articles/d41586-020-02927-9

44 Fen, C. (2013, June). Preserving stability and rights protection: Conflict or coherence? *Journal of Current Chinese Affairs, 42*(2), 21-50. https://journals.sagepub.com/doi/10.1177/186810261304200202

FINDING 3: Given climate projections, high-temperature days could decrease global wellbeing by an estimated 17% by 2030.

Using observed heat trends from the past 14 years to predict the global rise in high-temperature days over the next decade, the results suggest people will experience roughly 1.4 more such days on average in 2030 than they did a decade earlier — 3.1 days are predicted for 2030, compared to 1.7 in 2021. The effect of such days implies that, holding all else constant, rising temperatures will be associated with a drop in life evaluations three times greater in 2030 than in 2020.

Chart 13: Potential effect of high-temperature days on global life evaluations, 2021-2030



The estimated 17% drop in life evaluation by 2030 again does not take adaptability and recovery into account. However, this estimation is based on the increase in the number of high-heat days people will face globally by 2030, and is substantively meaningful.

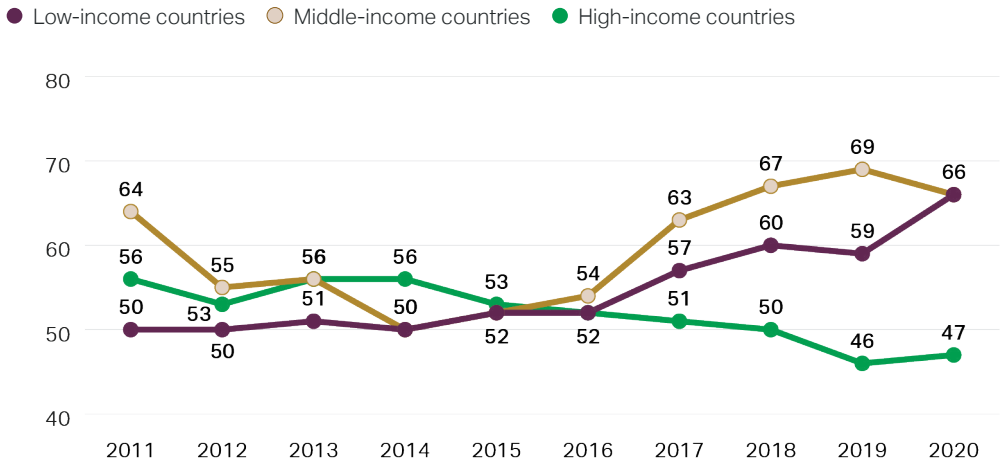
It is important to note that projections differ to the extent that the temperature and life evaluation relationship varies around the world. The rising number of high-temperature days is expected to have the biggest effect on life ratings in lower-income countries and territories and hotter regions and less impact in higher-income countries in more temperate climate zones.

In Gallup's 2020 World Poll, about two-thirds of people in middle-income (66%) and low-income (66%) countries and territories said they are satisfied with efforts to preserve the environment in their countries, compared to less than half (47%) in high-income countries. Further, since 2016, satisfaction with such efforts has generally trended upward in low- and middle-income countries, even as it has declined among high-income populations.

Chart 14: Satisfaction with efforts to preserve the environment, by country income group

In [country], are you satisfied or dissatisfied with efforts to preserve the environment?

Percentage "satisfied"



Such findings represent a growing challenge for curbing emissions in many countries where rising temperatures are most likely to harm residents' wellbeing. For example, though many low-income Asian populations are particularly vulnerable to extreme weather events, there is little public pressure for governments in Asia to act on climate change.[45]

At least some of the difference in satisfaction with environmental efforts is likely due to higher average education levels in high-income countries; a 2015 analysis of World Poll data published in *Nature Climate Change* found that educational attainment was the strongest predictor of climate change awareness. The authors concluded that "improving basic education, climate literacy and public understanding of the local dimensions of climate change are vital to public engagement and support for climate action."[46] Among low-income and middle-income countries, satisfaction with efforts to preserve the environment was higher among those with elementary education or less (72%) than among those with secondary (64%) or tertiary (55%) education. This context is an important consideration as policymakers communicate the effects of climate change to their constituents.

45 How Asia is crucial in the battle against climate change. (2021, October 27). *The Economist*. https://www.economist.com/special-report/2021/10/27/how-asia-is-crucial-in-the-battle-against-climate-change

46 Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C. Y., & Leiserowitz, A. A. (2015). Predictors of public climate change awareness and risk perception around the world. *Nature Climate Change, 5*(11), 1014-1020. https://www.nature.com/articles/nclimate2728

Conclusion

The analysis finds that as people experience more high-temperature days, there is a negative relationship between rising temperatures and life evaluations globally. This relationship varies widely around the world and is particularly noteworthy among certain vulnerable populations, such as older adults and people in low-income countries with weaker infrastructure and greater dependence on agriculture.

This study takes a novel approach to studying the impacts of climate change on people. While it is globally comprehensive — representing countries that make up 98% of the world's population — it is based on local observations from more than 1.75 million individuals. It does not assume that we know all the ways climate change impacts us; rather, it objectively measures the relationship and establishes a valuable research instrument with which we can better understand these effects moving forward.

Future studies might more directly explore the mechanisms through which climate change influences life evaluations around the world by examining the specific ways people think extreme heat and the rising frequency of severe weather events have affected their lives — through employment, food insecurity and basic comfort to name a few. More specific information about possible causal links between rising temperatures and subjective wellbeing may help global leaders develop better adaptation strategies and mobilize constituents to act in ways that help sustain their quality of life.

Appendix: Methodology

For this analysis, Gallup merged daily temperature data with its World Poll dataset using geolocation. Gallup obtained the temperature information from NASA's Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2). This data contains daily temperature information, two meters above land, for the planet's entire surface at a high-resolution pixel size of five kilometers by five kilometers. Gallup incorporated this global temperature information for each day from Jan. 1, 1980, to Dec. 31, 2020.

To merge this information with Gallup World Poll data, Gallup constructed a global digital map that matched the geographic locations recorded with each World Poll survey. Gallup has conducted the World Poll annually since 2006 and covers roughly 140 countries and territories each year. In each of these countries, Gallup collects sub-national location information for every respondent. In most cases, this is the first sub-national administrative configuration in a country — units often referred to as states, provinces or oblasts.

Gallup identified the boundaries of all these sub-national locations so it could record the weather data within each. The temperature was calculated for each administrative unit by aggregating the pixels within. Weighted averages were calculated to ensure that pixel cells only partially included in an administrative unit were down-weighted appropriately during the calculation.

In total, Gallup mapped roughly 3,300 units. The median land area of a unit was 9,600 square kilometers (3,700 square miles), which is slightly smaller than the land area of the Big Island of Hawaii. Therefore, the weather for each respective survey respondent was quite accurate.

Some units cover large surface areas, such as those in Russian Siberia or northern Canada. However, these units contain only a tiny fraction of the global population. In fact, the vast majority of the world's population lives in smaller-than-average administrative units (cities and densely populated areas were often broken into smaller units to make them more manageable). The World Poll sampling is based on each location's relative population size within a given country. Therefore, most of the World Poll sample lives in administrative units with a smaller-than-average area, enabling Gallup to provide accurate weather statistics.

Respondent-level weather variables were calculated according to the day of the interview and the location. The period of 1980 to 2004 was used as the historical reference period respondent weather data was compared against, enabling Gallup to understand how different a respondent's weather was from the historical average. Gallup used the variance in the 1980 to 2004 period to calculate the standard deviation accordingly.

To understand how many high-temperature days a respondent faced in a 30-day period, the temperature for each of the 30 days prior to the interview was recorded and compared against the historical weather from 1980 to 2004 for that location.

To understand the high temperature a respondent faced over the previous year, the monthly average of daily information was used. Each month's temperature average was compared against that month's average from the historical reference period.

Precipitation data was merged with the World Poll data using the same geospatial merging technique as the temperature data. The data was generated by the U.S. National Oceanic and Atmospheric Administration. Gallup used the daily precipitation data, defined at a pixel resolution of 50 kilometers by 50 kilometers across the globe. As with temperature, Gallup used 1980 to 2004 to establish a historical reference period.

In this way, Gallup was able to understand not only the weather individuals faced but also how much it deviated from the mean. This deviation from the mean is an important aspect when studying climate change-related phenomena because studies show that climate change is resulting in greater weather variation.[47]

Gallup would like to thank the following individuals for their feedback on this work: Dr. Max Auffhammer, Dr. Susan Clayton, Dr. John Helliwell, Dr. Diana Hernández, and Dr. Anthony Leiserowitz. Gallup also thanks Dr. Stephan Dietrich and Stafford Nichols for their significant contributions to the research. This report was developed by Gallup thanks to funding provided by Citi. The findings and conclusions are those of Gallup.

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GALLUP®

World Headquarters

The Gallup Building
901 F Street, NW
Washington, D.C. 20004

t +1.877.242.5587
f +1.888.500.8282

www.gallup.com