

Protecting people from a changing climate: The case for resilience

Our new study lays bare the potential impact of climate risks for people across the globe—and underscores the need to protect the most vulnerable and build resilience.

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The United Nations’ 2021 Intergovernmental Panel on Climate Change (IPCC) report stated—

with higher confidence than ever before—that, without meaningful decarbonization, global temperatures will rise to at least 1.5°C above preindustrial levels within the next two decades.¹ This could have potentially dangerous and irreversible effects. A better understanding of how a changing climate could affect people around the world is a necessary first step toward defining solutions for protecting communities and building resilience.²

As part of our knowledge partnership with Race to Resilience at the UN Climate Change Conference of the Parties (COP26) in Glasgow, we have built a detailed, global assessment of the number of people exposed to four key physical climate hazards, primarily under two different warming scenarios. This paper lays out our methodology and our conclusions from this independent assessment.

Our findings suggest the following conclusions:

- Under a scenario with 1.5°C of warming above preindustrial levels by 2030, almost half of the world’s population could be exposed to a climate hazard related to heat stress, drought, flood, or water stress in the next decade, up from 43 percent today³—and almost a quarter of the world’s population would be exposed to severe

hazards. (For detailed explanations of these hazards and how we define “severe,” see sidebar “A climate risk analysis focused on people: Our methodology in brief.”)

- Indeed, as severe climate events become more common, even in a scenario where the world reaches 1.5°C of warming above preindustrial levels by 2050 rather than 2030, nearly one in four people could be exposed to a severe climate hazard that could affect their lives or livelihoods.
- Climate hazards are unevenly distributed. On average, lower-income countries are more likely to be exposed to certain climate hazards compared with many upper-income countries, primarily due to their geographical location but also to the nature of their economies. (That said, both warming scenarios outlined here are likely to expose a larger share of people in nearly all nations to one of the four modeled climate hazards compared with today.) Those who fall within the most vulnerable categories are also more likely to be exposed to a physical climate hazard.

These human-centric data can help leaders identify the best areas of focus and the scale of response needed to help people—particularly the most vulnerable—build their climate resilience.

¹ *Climate change 2021: The physical science basis*, Intergovernmental Panel on Climate Change (IPCC), August 2021, ipcc.ch.

² For further details on how a changing climate will impact a range of socioeconomic systems, see “Climate risk and response: Physical hazards and socioeconomic impacts,” McKinsey Global Institute, January 16, 2020, on McKinsey.com.

³ Climate science makes extensive use of scenarios; we have chosen Representative Concentration Pathway (RCP) 8.5 and a multimodel ensemble to best model the full inherent risk absent mitigation and adaption. Scenario 1 consists of a mean global temperature rise of 1.5°C above preindustrial levels, which is reached by about 2030 under this RCP; Scenario 2 consists of a mean global temperature rise of 2.0°C above preindustrial levels, reached around 2050 under this RCP. Following standard practice, future estimates for 2030 and 2050 represent average climatic behavior over multidecadal periods: 2030 represents the average of the 2021–2040 period, and 2050 represents the average of the 2041–2060 period. We also compare results with today, also based on multidecadal averages, which differ by hazard. For further details, see technical appendix.

A climate risk analysis focused on people: Our methodology in brief

Our research consists of a global analysis of the exposure of people's lives and livelihoods to multiple hazards related to a changing climate. This analysis identifies people who are potentially vulnerable to four core climate hazards—heat stress, urban water stress, agricultural drought, and riverine and coastal flooding—even if warming is kept within 2.0°C above preindustrial levels.

Our methodology

The study integrates climate and socioeconomic data sources at a granular level to evaluate exposure to climate hazards. We used an ensemble mean of a selection of Coupled Model Intercomparison Project Phase 5 (CMIP5) global climate models under Representative Concentration Pathway (RCP) 8.5—using a Shared Socioeconomic Pathway (SSP2) for urban water stress—with analysis conducted under two potential warming scenarios: global mean temperature increases above preindustrial levels of 1.5°C and 2.0°C. We sometimes use the shorthand of “1.5°C warming scenario” and “2.0°C warming scenario” to describe these scenarios. Our modeling of temperatures in 2030 refers to a multidecadal average between 2021 and 2040. When we say 2050, we refer to a multidecadal average between 2041 and 2060. These are considered relative to a reference period, which is dependent on hazard basis data availability (which we sometimes refer to as “today”).

We built our analysis by applying 2030 and 2050 population-growth projections to our 1.5°C and 2.0°C warming scenarios, respectively. This amount of warming by those time periods is consistent with an RCP 8.5 scenario, relative to the preindustrial average. Climate science makes extensive use of scenarios. We chose a higher emissions scenario of RCP 8.5 to measure the full inherent risk from a changing climate. Research also suggests that cumulative historical emissions, which indicate the actual degree of warming, have been in line with RCP 8.5.¹ In some instances, we have also considered a scenario in which decarbonization actions limit warming and 1.5°C of warming relative to the preindustrial levels is only achieved in 2050,

rather than in 2030. For our analysis we used models which differ to some extent on their exact amount of warming and timing, even across the same emissions scenario (RCP 8.5). Naturally, all forward-looking climate models are subject to uncertainty, and taking such an ensemble approach to our model allows us to account for some of that model uncertainty and error.² However, the mean amount of warming typically seen across our ensemble of models is approximately 1.5°C by 2030 and 2.0°C by 2050.

Our analysis consisted of three major steps (see technical appendix for details on our methodology):

First, we divided the surface of the planet into a grid composed of five-kilometer cells, with climate hazards and socioeconomic data mapped for each cell.

Second, in each of those cells, we combined climate and socioeconomic data to estimate the number and vulnerability of people likely to be exposed to climate hazards. These data were categorized on the basis of severity and classified on the basis of exposure to one or more hazards at the grid-cell level.

Third, taking into account people's vulnerability, we examined the potential impact of our four core hazards on the current and future global population. To do this, we assessed, globally, the number and vulnerability of people affected by different types and severities of hazards. We then aggregated the data from each cell up to the subnational, national, subcontinental, continental, and global levels to allow for comparison across countries.

¹ For further details, see “Climate risk and response,” January 16, 2020, appendix; see also Philip B. Duffy, Spencer Glendon, and Christopher R. Schwalm, “RCP8.5 tracks cumulative CO2 emissions,” *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, August 2020, Volume 117, Number 33, pp. 19656–7, pnas.org.

² For a more detailed discussion of these uncertainties, see chapter 1 of “Climate risk and response: Physical hazards and socioeconomic impacts,” McKinsey Global Institute, January 16, 2020, on [McKinsey.com](https://mckinsey.com).

It's important to note that we carefully selected these four hazards because they capture the bulk of hazards likely to affect populations on a global scale. We did not account for a range of other hazards such as wildfires, extreme cold, and snow events. Further, our analysis accounts only for first-order effects of climate hazards and does not take into account secondary or indirect effects, which can have meaningful impact. Drought, for example, can lead to higher food prices and even migration—none of which are included in our analysis. Thus, the number of people affected by climate hazards is potentially underestimated in this work.

A focus on four main climate hazards

For our study, we used global data sets covering four key hazards: heat stress, urban water stress, agricultural drought, and riverine and coastal flooding. We relied on data from a selection of CMIP5 climate models, unless otherwise specified. For further details, see the technical appendix.

Heat stress

Heat stress can have meaningful impacts on lives and livelihoods as the climate changes. Heat stress is measured using wet-bulb temperature, which combines heat and humidity. We assess heat stress in the form of acute exposure to humid heat-wave occurrence as well as potential chronic loss in effective working hours, both of which depend on daily wet-bulb temperatures. Above a wet-bulb temperature of 35°C, heat stress can be fatal.

Acute humid heat waves are defined by the average wet-bulb temperature of the hottest six-hour period during a rolling three-day period in which the daily maximum wet-bulb temperature exceeds 34°C for three consecutive days.³ Heat-wave occurrence was calculated for each year for both a reference

time period⁴ and our two future time periods and translated into annual probabilities. Exposure was defined as anyone living in either an urban or rural location with at least a 2 percent annual probability of experiencing such a humid heat wave in any given year. Acute humid heat waves of 34°C or higher can be detrimental to health, even for a healthy and well-hydrated human resting in the shade, because the body begins to struggle with core body-temperature regulation and the likelihood of experiencing a heat stroke increases.

Chronic heat stress was assessed for select livelihoods and defined by processing daily mean air temperature and relative humidity data into a heat index and translating that into the fraction of average annual effective working hours lost due to heat exposure. This calculation was conducted following the methods of John P. Dunne et al.,⁵ using empirically corrected International Organization for Standardization (ISO) heat-exposure standards from Josh Foster et al.⁶

We combined groups of people who were exposed to both chronic and acute heat stress to assess the aggregate number of people exposed. Heat stress can affect livelihoods, particularly for those employed in outdoor occupations, most prominently because an increased need for rest and a reduction in the body's efficiency reduce effective working hours. Therefore, our analysis of potential exposure to chronic heat stress was limited to people estimated to be working in agriculture, crafts and trades, elementary, factory-based, and manufacturing occupations likely to experience at least a 5 percent loss of effective working hours on average annually. We excluded managers, professional staff, and others who are more likely to work indoors, in offices, or in other cooled environments from this analysis.

³ Analysis of lethal heat waves in our previous McKinsey Global Institute report (see "Climate risk and response," January 16, 2020) was limited to urban populations, and the temperature threshold was set to 34°C wet-bulb temperature under the assumption that the true wet-bulb temperature would actually be 35°C due to an additional 1°C from the urban heat-island effect.

⁴ The reference period for heat stress refers to the average between 1998 and 2017.

⁵ John P. Dunne, Ronald J. Stouffer, and Jasmin G. John, "Reductions in labour capacity from heat stress under climate warming," *Nature Climate Change*, 2013, Volume 3, Number 6, pp. 563–6, nature.com.

⁶ Josh Foster et al., "A new paradigm to quantify the reduction of physical work capacity in the heat," *Medicine and Science in Sports and Exercise*, 2019, Volume 51, Number 6S, p. 15, journals.lww.com.

Urban water stress

Urban water stress⁷ often occurs in areas in which demand for water from residents, local industries, municipalities, and others exceeds the available supply. This issue can become progressively worse over time as demand for water continues to increase and supply either remains constant, decreases due to a changing climate, or even increases but not quickly enough to match demand. This can reduce urban residents' access to drinking water or slow production in urban industry and agriculture.

Our analysis of water stress is limited to urban areas partially because water stress is primarily a demand-driven issue that is more influenced by socioeconomic factors than by changes in climate. We also wanted to avoid methodological overlap with our agricultural drought analysis, which mostly focused on rural areas.

We define urban water stress as the ratio of water demand to supply for urban areas globally. We used World Resources Institute (WRI) data for baseline water stress today and the SSP2 scenario for future water stress outlooks, where 2030 represents the 1.5°C warming scenario and 2040 represents the 2.0°C warming scenario. We only considered severe water stress, defined as withdrawals of 80 percent or more of the total supply, which WRI classifies as “extremely high” water stress.

We make a distinction for “most severe” urban water stress, defined as withdrawals of more than 100 percent of the total supply, to show how many people could be affected by water running out—a situation that will require meaningful interventions to avoid. However, for the sake of the overall

exposure analysis, people exposed to the most severe category are considered to be exposed to “severe” water stress unless otherwise noted (exhibit).

Agricultural drought

Agricultural drought⁸ is a slow-onset hazard defined by a period of months or years that is dry relative to a region's normal precipitation and soil-moisture conditions, specifically, anomalously dry soils in areas where crops are grown. Drought can inhibit plant growth and reduce plant production, potentially leading to poor yields and crop failures. For more details, see the technical appendix.

Riverine and coastal flooding

We define flooding as the presence of water at least one centimeter deep on normally dry land. We analyze two types of flooding here: riverine flooding from rivers bursting their banks and coastal flooding from storm surges and rising sea levels pushing water onto coastal land. Both coastal and riverine flooding can damage property and infrastructure. In severe cases, they could lead to loss of life.⁹ For more details, see the technical appendix.

Based on a combination of frequency and intensity metrics, we estimated three severity levels of each climate hazard: mild, moderate, and severe (exhibit).

Even when we only look at first-order effects, it is clear that building resilience and protecting people from climate hazards are critical. Our analysis provides data that may be used to identify the areas of highest potential exposure and vulnerability and to help build a case for investing in climate resilience on a global scale.

⁷ The reference period for water stress refers to the average between 1950 and 2010.





⁸ The reference period for agricultural drought refers to the average between 1986 and 2005.

⁹ The reference period for riverine flooding refers to the average between 1960 and 1999; the reference period for coastal flooding refers to the average between 1979 and 2014.

Exhibit

For the purposes of our analysis, we grouped climate hazards by severity levels that account for frequency and intensity.

Climate hazard severity level

Hazards			Level of severity		
			Mild	Moderate	Severe
	Heat stress	Working hours lost ¹	5%	10%	25%
		Annual probability of humid heat wave ²	2% or 1 in 50 years	5% or 1 in 20 years	10% or 1 in 10 years
	Urban water stress ³	Withdrawals of water as a proportion of supply	Only severe water stress considered		
	Agricultural drought	Probability of a drought year ⁴	5% or 1 year in a 20-year period	20% or 4 years in a 20-year period	75% or at least 15 years in a 20-year period
	Flooding ⁵	Depth	>1 cm	>30 cm	>30 cm and increase of >10 cm compared with baseline
		Return period	1 in 100 years	1 in 25 years	1 in 25 years

¹ Working hours lost defined as the average annual percent of effective working hours lost (chronic heat stress).

² Annual probability of humid heat wave defined as three consecutive days in which the hottest 6-hour portion of the day exceeds 34°C (acute heat stress).

³ Urban water stress measured by ratio of demand-driven water withdrawals to water supply (only assessed for withdrawals of 80% or more of total supply).

⁴ Probability of a drought year defined as total accumulation of droughts over a 20-year period based on annual cumulative monthly values of Standardized Precipitation Evapotranspiration Index (SPEI) over region-specific growing seasons.

⁵ Riverine and coastal flooding defined by average flood depth, in meters, for 3 different annual exceedance probabilities: 1%, 2%, and 4%.

Source: Woodwell Climate Research Center; World Resources Institute (WRI); McKinsey analysis

A larger proportion of the global population could be exposed to a severe climate hazard compared with today

Under a scenario with 1.5°C of warming above preindustrial levels by 2030, almost half of the world's population—approximately 5.0 billion people—could be exposed to a climate hazard related to heat stress, drought, flood, or water stress in the next decade, up from 43 percent (3.3 billion people) today.

In much of the discussion below, we focus on *severe* climate hazards to highlight the most significant effects from a changing climate. We find that regardless of whether warming is limited to 1.5°C or

reaches 2.0°C above preindustrial levels by 2050, severe hazard occurrence is likely to increase, and a much larger proportion of the global population could be exposed compared with today (Exhibit 1).

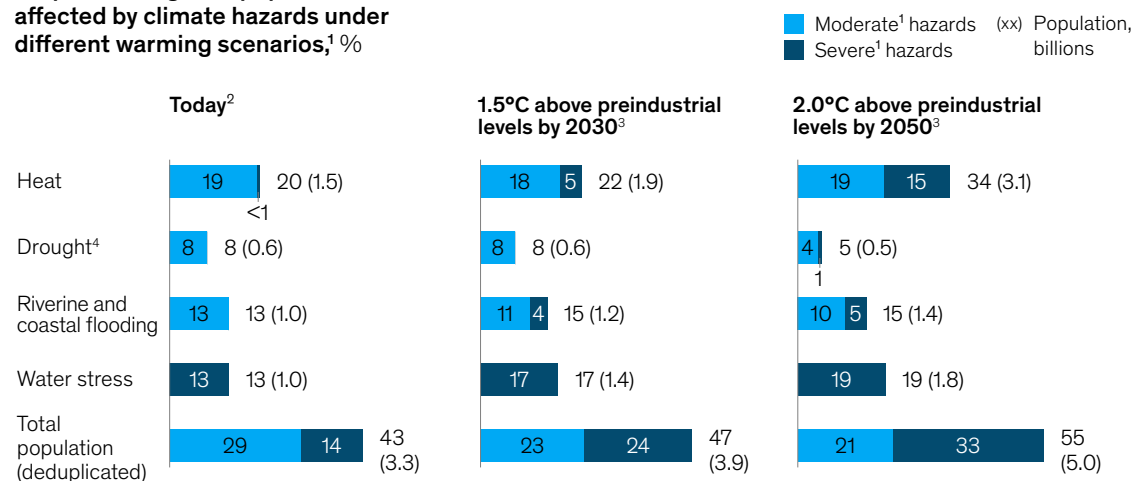
This proportion could more than double, with approximately one in three people likely to be exposed to a severe hazard under a 2.0°C warming scenario by 2050, compared with an estimated one in six exposed today. This amounts to about 2.0 billion additional people likely to be exposed by 2050. Even in a scenario where aggressive decarbonization results in just 1.5°C of warming above preindustrial levels by 2050, the number of people exposed to severe climate hazards could still increase to nearly one in four of the total projected global population, compared with one in six today.

Exhibit 1

Even in moderate warming scenarios, severe climate hazards are likely to become much more common.

Proportion of global population affected by climate hazards under different warming scenarios,¹ %

Based on RCP 8.5



Note: All projections based on Representative Concentration Pathway (RCP) 8.5 and a multimodel ensemble. This analysis assesses the incremental changes in exposure to hazards relative to today. Figures may not sum, because of rounding.

¹ For definition of "moderate" and "severe," see exhibit in sidebar "A climate risk analysis focused on people: Our methodology in brief" and technical appendix.

² Climate today is defined as the average of a reference period, which differs by hazard: heat, 1998–2017; agricultural drought, 1986–2005; riverine flooding, 1960–1999; coastal flooding, 1979–2014; and urban water stress, 1950–2010. This is applied to 2020 population numbers to identify the number of people affected.

³ Following standard practice, future estimates for 2030 and 2050 represent average climatic behavior over multidecadal periods: 2030 represents the average of the 2021–2040 period, and 2050 represents the average of the 2041–2060 period.

⁴ Only agricultural workers were analyzed for exposure to drought. While land area affected by drought is likely to increase in future warming the number of agricultural workers exposed to drought is likely to decrease due to occupational shifts away from agriculture in the future.

Source: IHS Markit; International Labour Organization; National Center for Atmospheric Research (NCAR) Integrated Assessment Modeling (IAM) group; Socioeconomic Data and Applications Center (SEDAC); Woodwell Climate Research Center; World Resources Institute (WRI); McKinsey analysis

Heat stress

One-sixth of the total projected global population, or about 1.4 billion people, could be exposed to severe heat stress, either acute (humid heat waves) or chronic (lost effective working hours), under a 2.0°C warming scenario above preindustrial levels by 2050, compared with less than 1 percent, or about 0.1 billion people, likely to be exposed today (Exhibit 2).

Our results suggest that both the severity and the geographic reach of severe heat stress may increase to affect more people globally, despite modeled projections of population growth, population shifts from rural to urban areas, and economic migration. Our analysis does not attempt to account for climate-change-related migration or resilience interventions, which could decrease exposure by either forcing people to move away from hot spots or mitigating impacts from severe heat stress.

For those with livelihoods affected by severe chronic heat stress, it could become too hot to

work outside during at least 25 percent of effective working hours in any given year. This would likely affect incomes and might even require certain industries to rethink their operations and the nature of workers' roles. For outdoor workers, extreme heat exposure could also result in chronic exhaustion and other long-term health issues. Heat stress can cause reductions in worker productivity and hours worked due to physiological limits on the human body, as well as an increased need for rest.

We have already seen some of the impacts of acute heat stress in recent years. In the summer of 2010 in Russia, tens of thousands of people died of respiratory illness or heat stress during a large heat-wave event in which temperatures rose to more than 10°C (50°F) higher than average temperatures for those dates. One academic study claims "an approximate 80 percent probability" that the new record high temperature "would not have occurred without climate warming."⁴ To date these impacts have been isolated events, but the potential impact of heat stress on a much broader scale is

Exhibit 2

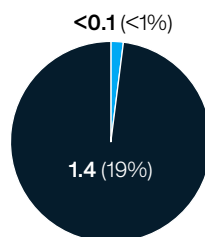
In a 2.0°C warming scenario, an additional 1.6 billion people could be exposed to heat stress by 2050.

Number of people, billions

Based on RCP 8.5

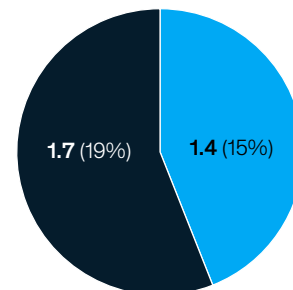
- People exposed to mild and moderate heat stress
- People exposed to severe heat stress

Today
1.5 billion
(20%)



2.0°C warming above preindustrial levels
by 2050, based on 2050 population

3.1 billion
(34%)



Note: All projections based on Representative Concentration Pathway (RCP) 8.5 and a multimodel ensemble. For definition of "mild," "moderate," and "severe" heat stress, see exhibit in sidebar "A climate risk analysis focused on people: Our methodology in brief" and technical appendix. Following standard practice, 2050 estimates represent the average climatic behavior between 2041 and 2060. Climate today is defined as the average between 1998–2017. This is applied to 2020 population numbers to identify the number of people affected.

Source: IHS Markit; International Labour Organization; National Center for Atmospheric Research (NCAR) Integrated Assessment Modeling (IAM) group; Socioeconomic Data and Applications Center (SEDAC); Woodwell Climate Research Center; McKinsey analysis

⁴ Dim Coumou and Stefan Rahmstorf, "Increase of extreme events in a warming world," *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, November 2011, Volume 108, Number 44, pp. 17905–9, pnas.org.

possible in a 1.5°C or 2.0°C warming scenario in the coming decades.

While we did not assess second-order impacts, they could also be meaningful. Secondary impacts from heat stress may include loss of power, and therefore air conditioning, due to greater stress on electrical grids during acute heat waves,⁵ increased stress on hospitals due to increased emergency room visits and admission rates primarily during acute heat-stress events,⁶ and migration driven primarily by impacts from chronic heat stress.⁷

Urban water stress

The rate of growth in global urban water demand is highly likely to outpace that of urban water supply under future warming and socioeconomic

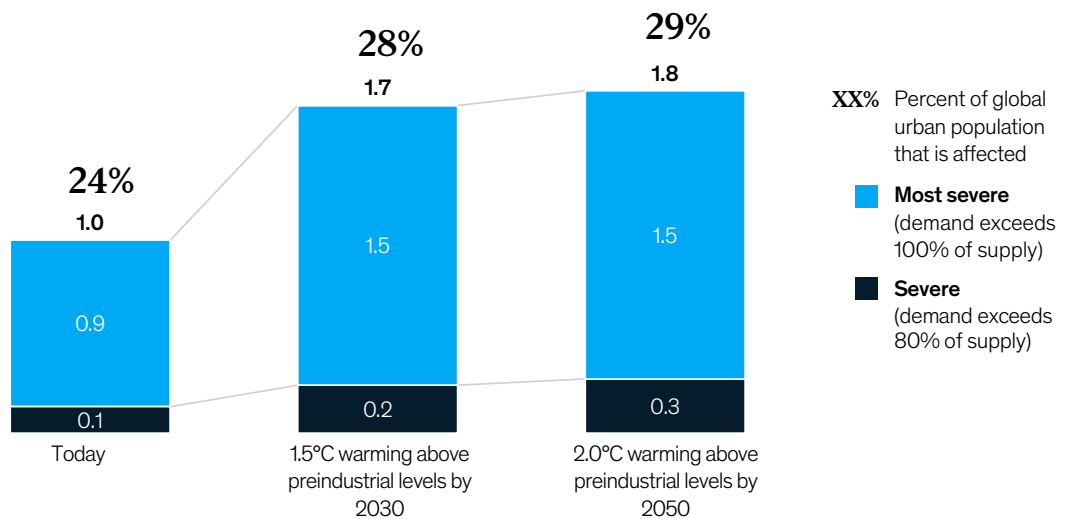
pathway scenarios, compared with the overall historical baseline period (1950–2010). In most geographies, this problem is primarily caused not by climate change but by population growth and a corresponding growth in demand for water. However, in some geographies, urban water stress can be exacerbated by the impact of climate change on water supply. In a 2.0°C warming scenario above preindustrial levels by 2050, about 800 million additional people could be living in urban areas under severe water stress compared with today (Exhibit 3). This could result in lack of access to water supplies for drinking, washing and cleaning, and maintaining industrial operations. In some areas, this could make a case for investment in infrastructure such as pipes and desalination plants to make up for the deficit.

Exhibit 3

By 2050, water stress is projected to increase as demand will outpace supply.

Global urban water stress, billions of people

Based on RCP 8.5



Note: All projections based on Representative Concentration Pathway (RCP) 8.5 and a multimodel ensemble. Urban water stress increases due to increased demand from population growth and urbanization as well as due to decreased supply from climate change. However, increased demand, rather than climate change, is the driving factor in increased water stress exposure. Following standard practice, future estimates for 2030 and 2050 represent average climatic behavior over multidecadal periods: 2030 represents the average of the 2021–2040 period, and 2050 represents the average of the 2041–2060 period. Climate today is defined as the average between 1950 and 2010. This is applied to 2020 population numbers to identify the number of people affected. For the definition of “severe” and “most severe” urban water stress, see sidebar “A climate risk analysis focused on people: A focus on four main climate hazards” and technical appendix.

Source: IHS Markit; International Labour Organization; National Center for Atmospheric Research (NCAR) Integrated Assessment Modeling (IAM) group; Socioeconomic Data and Applications Center (SEDAC); Woodwell Climate Research Center; World Resources Institute (WRI); McKinsey analysis

⁵ Sofia Aivalioti, *Electricity sector adaptation to heat waves*, Sabin Center for Climate Change Law, Columbia University, 2015, academiccommons.columbia.edu.

⁶ *Climate change and extreme heat events*, Centers for Disease Control and Prevention, 2015, [cdc.gov](https://www.cdc.gov).

⁷ Mariam Traore Chazalnoël, Dina Ionesco, and Eva Mach, *Extreme heat and migration*, International Organization for Migration, United Nations, 2017, environmentalmigration.iom.int.

Agricultural drought

Agricultural drought is most likely to directly affect people employed in the agricultural sector: in conditions of anomalously dry soils, plants do not have an adequate water supply, which inhibits plant growth and reduces production. This in turn could have adverse impacts on agricultural livelihoods.

In a scenario with warming 2.0°C above preindustrial levels by 2050, nearly 100 million people—or approximately one in seven of the total global rural population projected to be employed in the agricultural sector by 2050—could be exposed to a severe level of drought, defined as an average of seven to eight drought years per decade. This could severely diminish people's ability to maintain a livelihood in rainfed agriculture. Additional irrigation would be required, placing further strain on water demand, and yields could still be reduced if exposed to other heat-related hazards.

While our analysis focused on the first-order effects of agricultural drought, the real-world impact could be much larger. Meaningful second-order effects of agricultural drought include reduced access to drinking water and widespread malnutrition. In addition, drought in regions with insufficient aid can cause infectious disease to spread.

Further, although our analysis did not cover food security, many other studies have posited that if people are unable to appropriately adapt, this level of warming would raise the risk of breadbasket failures and could lead to higher food prices.⁸

Primarily as a result of surging demand exacerbated by climate change,⁹ Cape Town, South Africa, a semi-arid country, recently experienced a water shortage. From 2015 to 2018, unusually high temperatures contributed to higher rates of evaporation with less refresh due to low rainfall, contributing to decline in water reserves which

fell to the point of emergency¹⁰—by January 2018, about 4.3 million residents of South Africa had endured years of constant restrictions on water use in both urban and agricultural settings. Area farmers recorded losses, and many agricultural workers lost their jobs. In the city, businesses were hit with steep water tariffs, jobs were lost, and residents had to ration water.

Riverine and coastal flooding

Under a scenario with warming 2.0°C above preindustrial levels by 2050, about 400 million people could be exposed to severe riverine or coastal flooding, which may breach existing defenses in place today. As the planet warms, patterns of flooding are likely to shift. This could lead to decreased flood depth in some regions and increases likely beyond the capacity of existing defenses in others.

Riverine floods can disrupt travel and supply chains, damage homes and infrastructure, and even lead to loss of life in extreme cases. The most vulnerable are likely to be disproportionately affected—fragile homes in informal coastal settlements are highly vulnerable to flood-related damages.

This analysis does not account for the secondary impacts of floods that may affect people. In rural areas, floods could cause the salinity of soil to increase, which in turn could damage agricultural productivity. Flooding could also make rural roads impassable, limiting residents' ability to evacuate and their access to emergency response. Major floods sometimes lead to widespread impacts caused by population displacement, healthcare disruptions, food supply disruptions, drinking-water contamination, psychological trauma, and the spread of respiratory and insect-borne disease.¹¹ The severity of these impacts varies meaningfully across geographic and socioeconomic factors.¹²

⁸ For more on how a changing climate might affect global breadbaskets, see "Will the world's breadbaskets become less reliable?," McKinsey Global Institute, May 18, 2020, on McKinsey.com.

⁹ Salvatore Pascale et al., "Increasing risk of another Cape Town 'Day Zero' drought in the 21st century," *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, November 2020, Volume 117, Number 47, pp. 29495–503, pnas.org.

¹⁰ "Cape Town's Water is Running Out," NASA Earth Observatory, January 14, 2018, earthobservatory.nasa.gov.

¹¹ Christopher Ohl and Sue Tapsell, "Flooding and human health: The dangers posed are not always obvious," *British Medical Journal (BMJ)*, 2000, Volume 321, Number 7270, pp. 1167–8, bmj.com; Shuili Du, C.B. Bhattacharya, and Sankar Sen, "Maximizing business returns to corporate social responsibility (CSR): The role of CSR communication," *International Journal of Management Reviews (IJMR)*, 2010, Volume 12, Number 1, pp. 8–19, onlinelibrary.wiley.com.

¹² Roger Few et al., *Floods, health and climate change: A strategic review*, Tyndall Centre working paper, number 63, November 2004, unisdr.org.

People in lower-income countries tend to have higher levels of exposure to hazards

Our analysis suggests that exposure to climate hazards is unevenly distributed. Overall, a greater proportion of people living in lower-income countries are likely to be exposed to one or more climate hazards (Exhibit 4). Under a scenario with warming 2.0°C above preindustrial levels by 2050, more than half the total projected global population

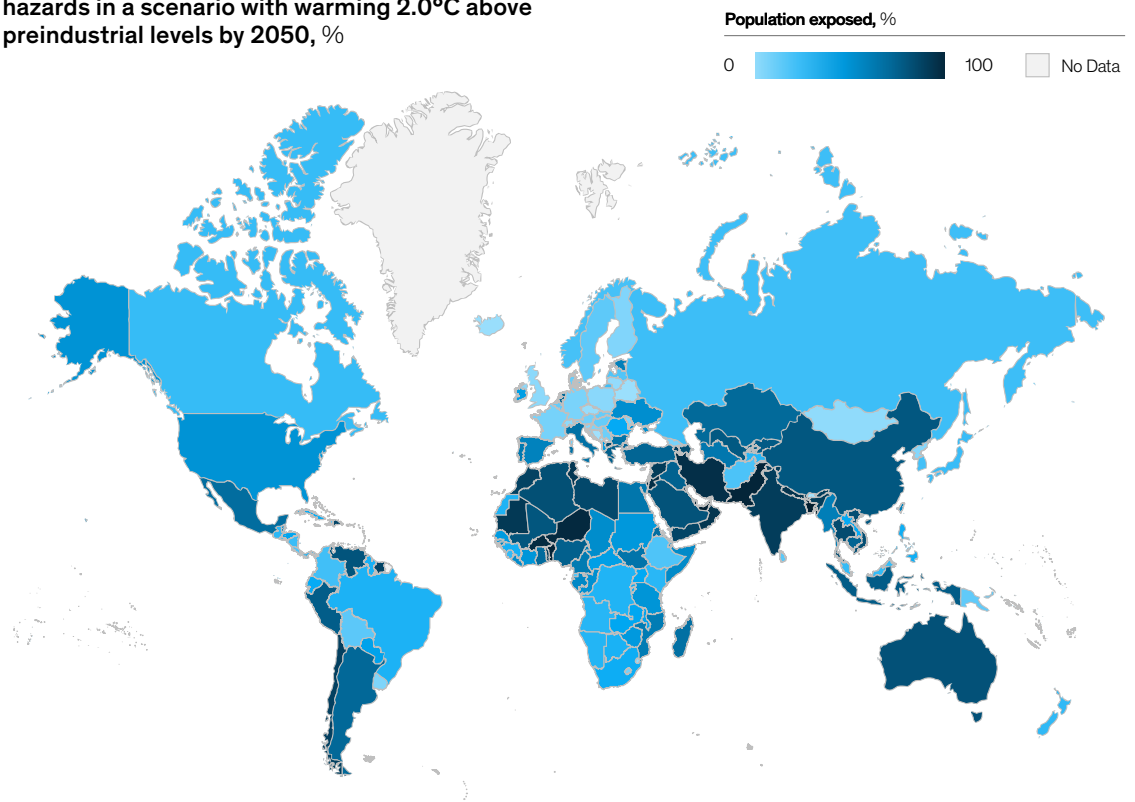
could be affected by a climate hazard. On the other hand, only 10 percent of the total population in high-income countries is likely to be exposed. That said, there could also be meaningful increases in overall exposure in developed nations. For example, based on 2050 population projections, about 160 million people in the United States—almost forty percent of the US population—could be exposed to at least one of the four climate hazards in a 2.0°C warming scenario by 2050.

Exhibit 4

In a 2.0°C warming scenario, more than half of the global population could be exposed to a climate hazard, with a high variance in share by country likely to be affected.

Share of country population exposed to climate hazards in a scenario with warming 2.0°C above preindustrial levels by 2050, %

Based on RCP 8.5



Note: The boundaries shown on this map do not imply official endorsement or acceptance by McKinsey & Company. All projections based on Representative Concentration Pathway (RCP) 8.5 and a multimodel ensemble. Following standard practice, 2050 estimates represent the average climatic behavior between 2041 and 2060.

Source: IHS Markit; International Labour Organization; National Center for Atmospheric Research (NCAR) Integrated Assessment Modeling (IAM) group; Socioeconomic Data and Applications Center (SEDAC); Woodwell Climate Research Center; World Resources Institute (WRI); United Nations and McKinsey analysis (disputed border)

In all, our analysis suggests that nearly twice as many highly vulnerable people (those estimated to have lower income and who may also have inadequate shelter, transportation, skills, or funds to protect themselves from climate risks) could be exposed to a climate hazard (Exhibit 5).

One of the implications of these findings is that certain countries are likely to be disproportionately affected. Two-thirds of the people who could be exposed to a climate hazard in a 2.0°C warming scenario by 2050 are concentrated in just ten countries. In two of these, Bangladesh and Pakistan, more than 90 percent of the population could be exposed to at least one climate hazard.

A vast number of people in India could also be exposed. Under a scenario with warming 2.0°C above preindustrial levels by 2050, nearly half of India's projected population—approximately 850 million—could be exposed to a severe climate hazard. This equates to nearly one-quarter of the estimated 3.1 billion people likely to be exposed to a severe climate hazard globally by 2050 under a 2.0°C warming scenario (see sidebar “India's vulnerability to climate hazards”).

Between now and 2050, population models¹³ project that the world could gain an additional

1.6 billion people, a proportion of whom are likely to be more exposed, more vulnerable, and less resilient to climate impacts.

For example, much of this population growth is likely to come from urban areas. Urbanization is likely to exacerbate the urban heat-island effect—in which human activities cause cities to be warmer than outlying areas—and humid heat waves could take an even greater toll. Urbanization is likely a driver in increased exposure of populations in coastal and riverine cities.

In India and other less developed economies, water stress is less of a climate problem and more of a socioeconomic problem. Our work and previous work on the topic has shown that increased water stress is mostly due to increases in demand—which is primarily driven by population growth in urban areas.

As labor shifts away from agriculture and other outdoor occupations toward indoor work, fewer people may be exposed to the effects of agricultural drought and heat stress. But on balance, many more people will likely be exposed to climate hazards by 2050 than today under either a 1.5°C or a 2.0°C warming scenario above preindustrial levels.

Exhibit 5

In a 2.0°C warming scenario, climate hazards could affect a larger number of people in lower-income countries than in middle- and upper-income countries.

Population exposed to climate hazards by vulnerability grouping by 2050¹ in a scenario with warming 2.0°C above preindustrial levels,² billions

Based on RCP 8.5



Note: All projections based on Representative Concentration Pathway (RCP) 8.5 and a multimodel ensemble.

¹ Following standard practice, 2050 estimates represent the average climatic behavior between 2041 and 2060.

² Vulnerability calculated by combining Subnational Human Development Index (SHDI) data and data from the Notre Dame Global Adaptation Initiative (ND-GAIN).

Source: IHS Markit; International Labour Organization; National Center for Atmospheric Research (NCAR) Integrated Assessment Modeling (IAM) group; Notre Dame Global Adaptation Initiative (ND-GAIN); Socioeconomic Data and Applications Center (SEDAC); Subnational Human Development Index (SHDI); Woodwell Climate Research Center; World Resources Institute (WRI); McKinsey analysis

¹³ “Spatial Population Scenarios,” City University of New York and NCAR, updated August 2018, cgd.ucar.edu.

India's vulnerability to climate hazards

Today, India accounts for more than 17 percent of the world's population. In a scenario with 2.0°C warming above preindustrial levels by 2050, nearly 70 percent of India's projected population, or 1.2 billion people, is likely to be exposed to one of the four climate hazards analyzed in this report, compared with the current exposure of nearly half of India's population (0.7 billion). India could account for about 25 percent of the total global population

likely to be exposed to a climate hazard under a 2.0°C warming scenario by 2050, relative to today.

Just as the absolute number of people likely to be exposed to hazards is increasing, so too is the proportion of people likely to be exposed to a severe climate hazard. Today, approximately one in six people in India are likely to be exposed to a severe climate hazard that puts lives and livelihoods at risk.

Using 2050 population estimates and a scenario with 2.0°C warming above preindustrial levels by 2050, we estimate that this proportion could increase to nearly one in two people.

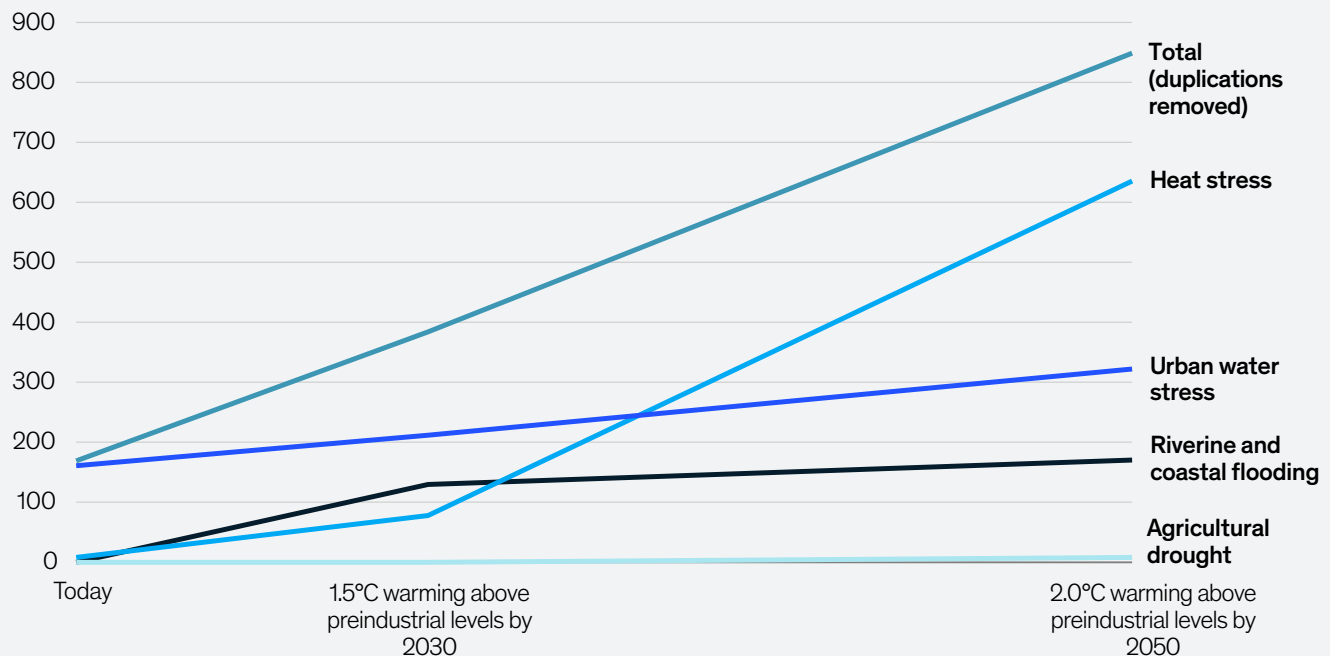
Severe heat stress is the primary culprit of severe climate hazard exposure, potentially affecting approximately 650 million residents of India by 2050 in the 2.0°C warming scenario, compared with just under ten million today (exhibit).

Exhibit

While flooding and water stress are concerns, nearly half of India's population could be exposed to severe heat stress by 2050 in a 2.0°C warming scenario.

Number of people exposed to severe hazards in India in scenario with 2.0°C warming above preindustrial levels by 2050, millions

Based on RCP 8.5



Note: All projections based on Representative Concentration Pathway (RCP) 8.5 and a multimodel ensemble. This analysis assesses the incremental changes in exposure to hazards relative to today. Figures may not sum, because of rounding. For definition of "moderate" and "severe," see exhibit in sidebar "A climate risk analysis focused on people: Our methodology in brief" and technical appendix. Following standard practice, future estimates for 2030 and 2050 represent average climatic behavior over multidecadal periods: 2030 represents the average of the 2021–2040 period, and 2050 represents the average of the 2041–2060 period. Climate today is defined as the average of a reference period, which differs by hazard: heat, 1998–2017; agricultural drought, 1986–2005; riverine flooding, 1960–1999; coastal flooding, 1979–2014; and urban water stress, 1950–2010. This is applied to 2020 population numbers to identify the number of people affected. Only agricultural workers were analyzed for exposure to drought. While land area affected by drought is likely to increase in future warming scenarios, the number of agricultural workers exposed to drought is likely to decrease due to occupational shifts away from agriculture in the future.

Source: IHS Markit; International Labour Organization; National Center for Atmospheric Research (NCAR) Integrated Assessment Modeling (IAM) group; Socioeconomic Data and Applications Center (SEDAC); Woodwell Climate Research Center; World Resources Institute (WRI); McKinsey analysis

Many regions of the world are already experiencing elevated warming on a regional scale. It is estimated that 20 to 40 percent of today's global population (depending on the temperature data set used) has experienced mean temperatures of at least 1.5°C higher than the preindustrial average in at least one season.¹⁴

Mitigation will be critical to minimizing risk. However, much of the warming likely to occur in the next decade has already been “locked in” based on past emissions and physical inertia in the climate system.¹⁵ Therefore, in addition to accelerating a path to lower emissions, leaders need to build resilience against climate events into their plans.

Around the world, there are examples of innovative ways to build resilience against climate hazards. For example, the regional government of Quintana Roo on Mexico's Yucatán Peninsula insured its coral reefs in an arrangement with an insurance firm, providing incentives for the insurer to manage any degradation,¹⁶ and a redesigned levee system put in place after Hurricane Katrina may have mitigated the worst effects of Hurricane Ida for the citizens of New Orleans.¹⁷

Nonstate actors may have particular opportunities to help build resilience. For instance, insurance companies may be in a position to encourage institutions to build resilience by offering insurance products for those that make the right investments. This can lower reliance on public money as the first source of funding for recovery from climate events. Civil-engineering companies can participate in innovative public–private partnerships to accelerate infrastructure projects. Companies in the agricultural and food sectors can help farmers around the world mitigate the effects that climate hazards can have on food production—for example, offers of financing can encourage farmers to make investments in resilience. The financial-services sector can get involved by offering better financing rates to borrowers who agree to disclose and reduce emissions and make progress on sustainability goals. And, among other actions, all companies can work to make their own operations and supply chains more resilient.

Accelerating this innovation, and scaling solutions that work quickly, could help us build resilience ahead of the most severe climate hazards.

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The authors wish to thank Shruti Badri, Riley Brady, Zach Bruick, Hauke Engel, Meredith Fish, Fabian Franzini, Kelly Kochanski, Romain Paniagua, Hamid Samandari, Humayun Tai, and Kasia Torkarska for their contributions to this article. They also wish to thank external adviser Guiling Wang and the Woodwell Climate Research Center.

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¹⁴ “Chapter 1: Framing and context,” *Special report: Global warming of 1.5°C*, International Panel on Climate Change (IPCC), 2018, [ipcc.ch](https://www.ipcc.ch).

¹⁵ H. Damon Matthews et al., “Focus on cumulative emissions, global carbon budgets, and the implications for climate mitigation targets,” *Environmental Research Letters*, January 2018, Volume 13, Number 1.

¹⁶ “World's first coral reef insurance policy triggered by Hurricane Delta,” *Nature Conservancy*, December 07, 2020, [nature.org](https://www.nature.org).

¹⁷ Sarah McQuate, “UW engineer explains how the redesigned levee system in New Orleans helped mitigate the impact of Hurricane Ida,” *University of Washington*, September 2, 2021, [washington.edu](https://www.washington.edu).