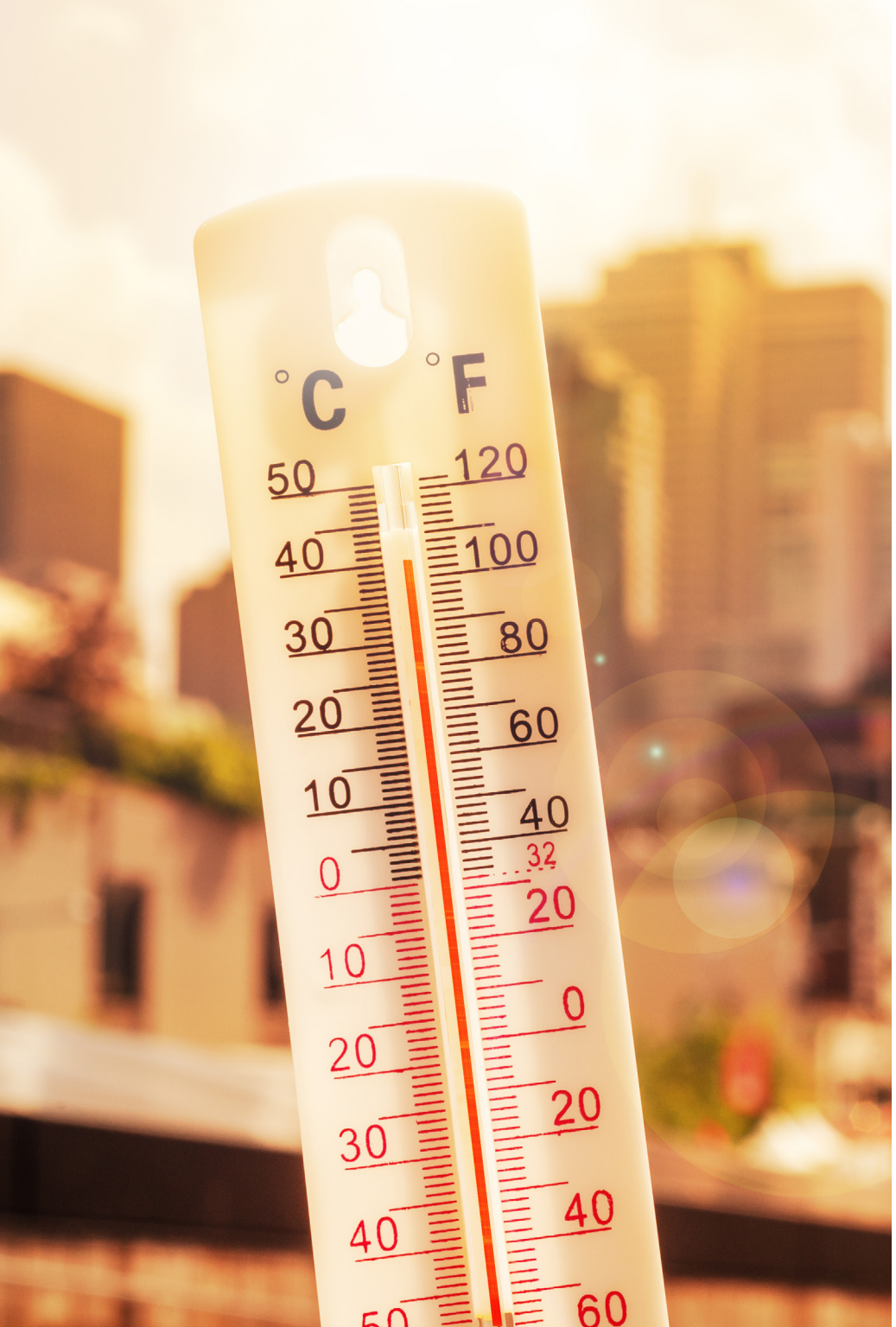
Moody's

Insights into Urban Heat Mitigation
Opportunities and Challenges



Lessons from the Hottest Summer on Record: Snapshots from Cities Across the Globe

In the scorching summer of 2023, global temperatures reached unprecedented highs, marking the hottest period on Earth since world-wide observations began in 1880. August alone surpassed preindustrial averages by 1.68 degrees Celsius (3.02 degrees Fahrenheit)[1].

Intense heatwaves, influenced by both human-induced global warming and current El Niño conditions, caused disruptions worldwide, impacting agriculture, businesses, power grids, and public health. From southern Europe to the Middle East to the southwestern United States, communities faced extreme temperatures, sometimes exceeding 43 degrees Celsius (110 degrees Fahrenheit). Around the world, over 200 weather stations with records longer than 40 years experienced all-time August heat records[2].

No longer just a future projection, summer 2023 and the underlying trends to even hotter temperatures underscore the need for business leaders in banking, commercial real estate, and insurance to make informed decisions, define goals, and prioritize investments that can mitigate the impact of record-breaking heat.

The following sections analyze the urban heat island (UHI) effect, when cities experience significantly hotter temperatures than neighboring rural areas. Targeted investments in modifying the built environment and infrastructure can significantly reduce the impacts of heat events and their economic consequences, with the goal – even in the face of the worsening impacts from climate change – to build more resilient urban communities.

[1] https://berkeleyearth.org/august-2023-temperature-update/
[2] https://yaleclimateconnections.org/2023/09/august-2023-was-earths-hottest-august-on-record/

Urban Heat Islands:
How Infrastructure Affects Extreme Heat

Urban areas can be particularly susceptible to exacerbating extreme heat due to their altered surface characteristics. Impervious and dark surfaces, tall buildings that restrict air-flow patterns, and the direct emission of heat from human activities all contribute to changes in the thermal properties of urban areas, resulting in elevated temperatures (Figure 1). In the United States, studies have shown that cities, on average, experience 8 degrees Fahrenheit higher temperatures due to the UHI effect.[3]

Urban heat islands can lead to substantial temperature increases in city centers, particularly in the late afternoon and evening. Extended periods of high day and nighttime temperatures can be extremely damaging to human health; longer periods of high heat with no relief contribute to cumulative physiological stress on the body and additional health issues.[4]

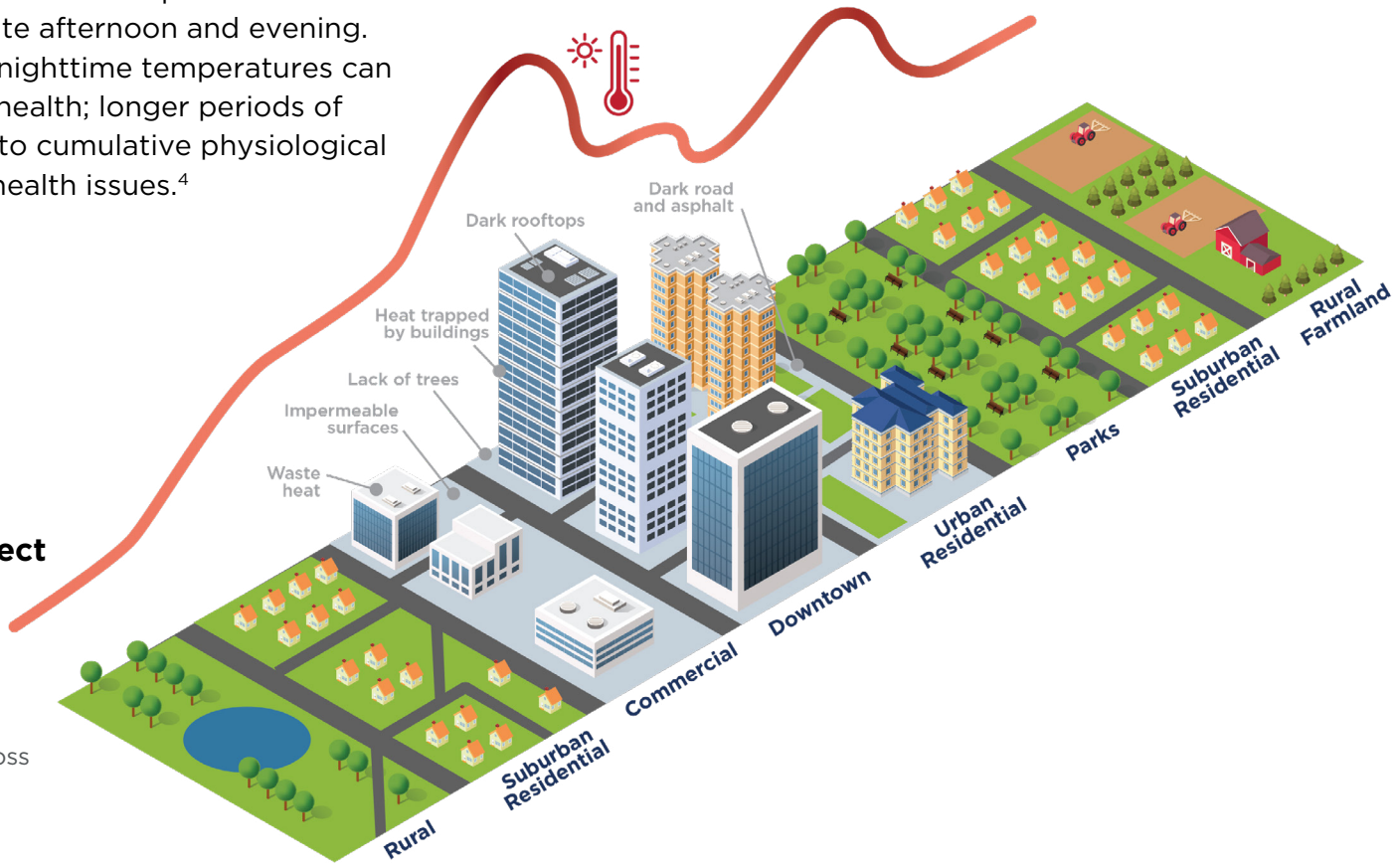


Figure 1: The urban heat island effect across rural and city communities.[5]

[3] Climate Central. (2023, July 26). *Urban* heat hot spots. https://www.climatecentral.org/climate-matters/urban-heat-islands-2023
[4] World Health Organization. (2018, June 1). *Heat and health fact sheet*. https://www.who.int/news-room/fact-sheets/detail/climate-change-heat-and-health
[5] Lemmen, D. S., & Warren, F. J. (2004). *Climate change impacts and adaptation: A Canadian perspective.* Government of Canada. https://cfs.nrcan.gc.ca/publications?id=27428

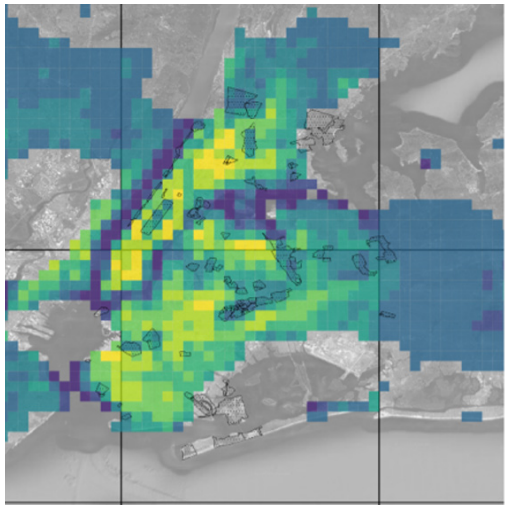
Financial Impacts of Heat in Urban Environments

Business leaders are already navigating the complexities of how to mitigate the impacts of recent extreme heat events and urban heat islands on staff and operations. Moody's high-resolution modeling of the temperature, productivity, operational and health impacts of raised urban temperatures, worldwide, provides critical information with insights into (1) the regional adoption of air conditioning (AC) by line of business; (2) the health and financial impacts resulting from the loss of worker productivity; and (3) the escalation in energy costs associated with increased AC usage.

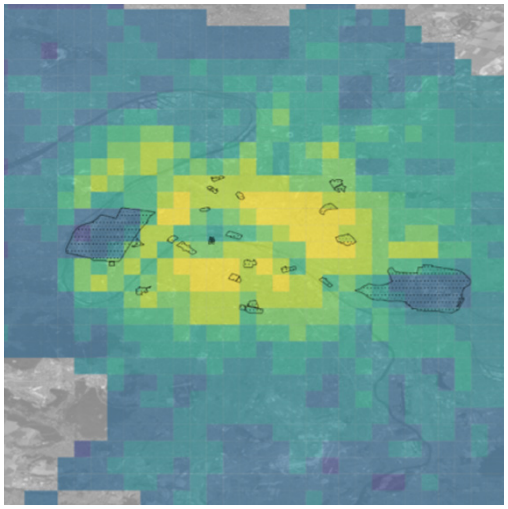
Globally, businesses and employees are having to adapt to these heat-related challenges. Economic factors, such as energy and equipment costs as a percentage of total business expenses, and environmental variables, such as historic temperatures and extreme heat wave frequency, will influence the expansion in the installation of AC. While employees in factories or those who work outdoors adjust their work schedules to cooler times of the day, businesses will be considering increased AC installation to minimize losses from heat-related reductions in worker productivity – all with revenue implications.

To highlight the localization of heat island affects, and the magnitude of their future impacts, Moody's has selected four representative metropolitan areas, for each applying a Representative Concentration Pathway (RCP) 8.5 scenario in the year 2100 (Figure 2). Detailed maps illustrate the localized effects of dense impervious infrastructure and also show the mitigating influence of green spaces and bodies of water.

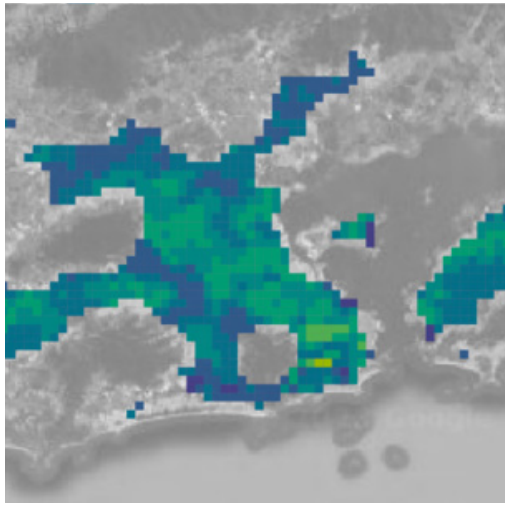
Each map of increased financial costs of lost productivity in Figure 2 is normalized relative to the heat stress financial impact in the surrounding region, thereby isolating the increased costs associated with the UHI effect. This highlights the financial costs associated with the localized impacts of extreme heat. In addition, it emphasizes the need for tailored solutions, such as those informed by Moody's comprehensive modeling insights.



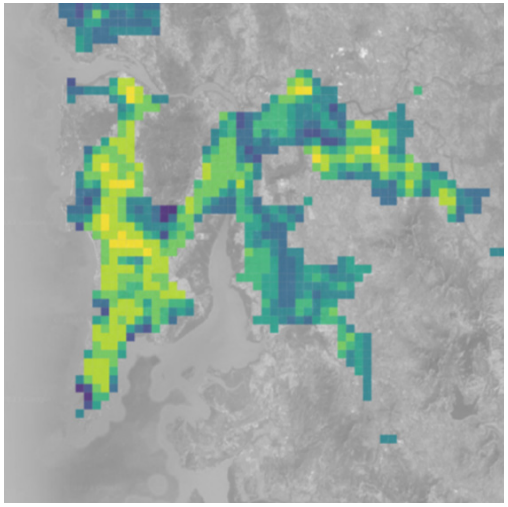
a. New York



b. Paris



c. Rio de Janeiro



d. Mumbai

Figure 2: Impact of the urban heat island effect on damage in four metropolitan areas in 2100 under the RCP 8.5 scenario for (a) New York (a grid representing the default resolution of the model is overlaid together with key natural features), (b) Paris (key natural features are overlaid), (c) Rio de Janeiro , and (d) Mumbai. The color scales – where blue and yellow represent minimum and maximum impacts, respectively – are adjusted locally to enhance spatial contrast and are not uniform.

Moody's Heat Stress Model

Moody's heat stress model incorporates both the spatial and temporal (seasonal and diurnal) variability in the UHI effect. The global model links urban characteristics and meteorological observations in a consistent way and includes the latest-available assessments from the scientific literature.

Moody's approach starts with a global high-resolution map that identifies areas with the potential for UHIs. The map is then correlated with temperature data using a regional index, derived from historical observations found in various global climate model reanalysis datasets.

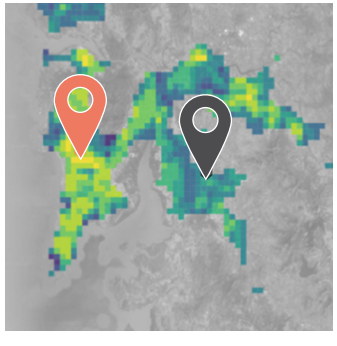
The index relies on scaling relationships based on empirical evidence, ensuring that maximum values are applied only on days particularly prone to UHI onset. Given the limitations of global climate models in representing UHIs, the results are subsequently incorporated into heat stress models designed to enhance the resolution in those specific urban concentrations.

Mumbai's Urban Heat Stress: A Localized Analysis

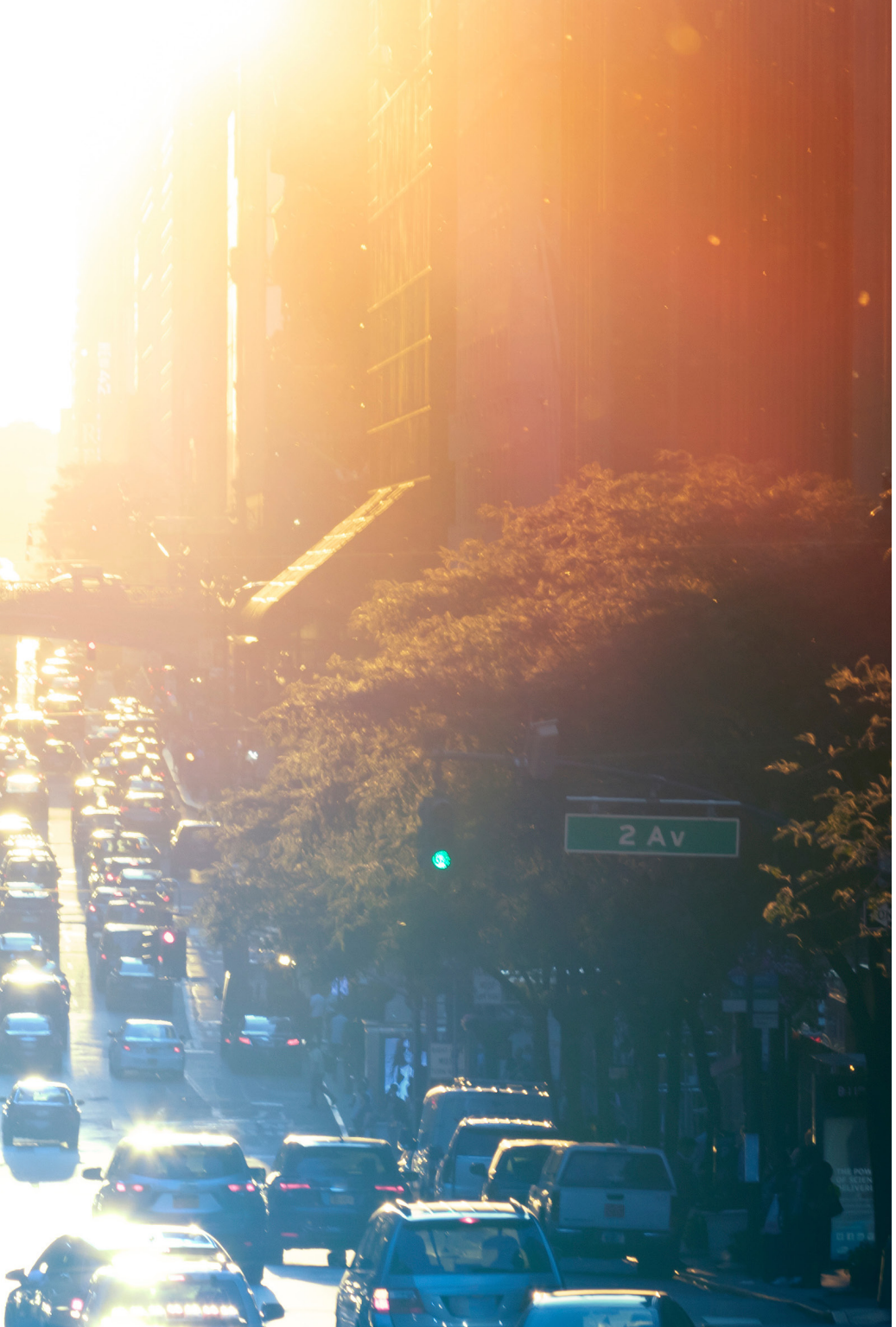
Examining specific sites in the city of Mumbai reveals a notable 126 percent increase in year-over-year incurred costs due to heightened UHI heat stress, as denoted by the annual average damage (AAD) or loss of productivity as shown on the right under a moderate 2050 scenario.

Situated on the outskirts of Mumbai, location 1 exhibits elevated but not critical heat-stress levels. In contrast, location 2, positioned in Mumbai's urban core, experiences red-flag heat stress, leading to significantly higher year-over-year losses in productivity (or costs).

When subjected to a higher emissions scenario of RCP8.5 in 2050, the disparities between the two locations are exacerbated, resulting in a 166 percent increase in costs.



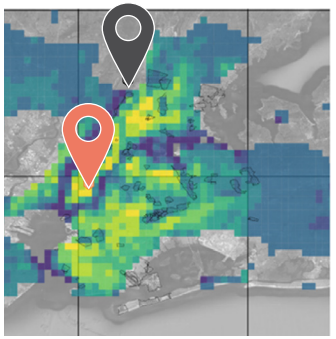
RCP 4.5 2050		
Location	**Impact Score**	**Annual Average Damage** (scaled to 1M asset)
Location 1: suburban area	55	$87
Location 2: urban center	80	$196

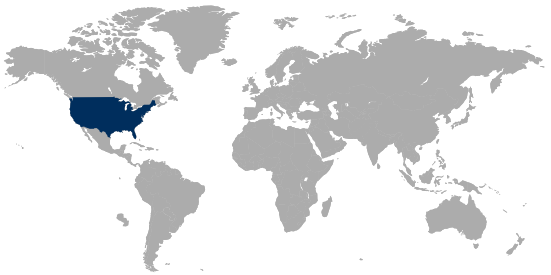


New York's Urban Heat Stress: A Localized Analysis

Much like the findings in Mumbai, the heightened impact of UHI-induced heat stress is evident in two selected New York City locations, one in the lower building-density suburbs and the second in New York's city center.

Location 2, situated in the city's urban core, exhibits red-flag heat stress, projecting a significant increase in anticipated costs attributable to heat stress under a moderate 2050 scenario as compared to the suburban site shown below.





RCP 4.5 2050		
Location	**Impact Score**	**Annual Average Damage** (scaled to 1M asset)
Location 1: suburban area	51	$91
Location 2: urban center	76	$166

Moody's Models Strategically Guide Adaptation Investment Planning

As awareness grows of the disproportionate effects of extreme heat on cities, the significance of UHIs becomes increasingly apparent, prompting the need for effective solutions. Moody's high-resolution models that output the financial costs of extreme heat to businesses have been designed to provide important tools for decision-makers considering where to locate operations and how much to expect in extra costs of reduced productivity, increased cooling costs or impacts on their workforce. The models can help business leaders evaluate options, understand costs and benefits, and make informed decisions in the context of climate change's impact on urban areas, with a particular focus on the banking, commercial real estate, and insurance sectors.

Decision-makers can leverage Moody's models to incentivize sustainable building practices, including policies to promote the adoption of heat-reducing technologies, establish green infrastructure standards, and implement zoning regulations prioritizing green spaces. Moody's models further guide business leaders in supporting building retrogrades such as green roofs and retrofits, which are key to reducing the impact of UHIs.

Ultimately, Moody's models provide the unique potential to guide adaptation investment planning in financial terms and enable data-driven decision-making. This contribution is instrumental in enhancing the overall resilience and sustainability of urban landscapes. Cities can integrate visionary measures into urban planning and development strategies to proactively address both current and future challenges posed by UHI stress and effectively mitigate the impacts.

Moody's

Moody's on Climate

Climate Risk is Business Risk

The foundation of Moody's value is market insight defining our approach to financial quantification of risk and the capabilities to deliver consistent and complete perspective on the interconnected risks impacting your business.

Moody's on Climate encompasses market-tested analytical tools designed for identifying and quantifying the impact of climate risk on global debt markets, credit performance, and financial outcomes.

Our solutions enable understanding of physical climate risks by leveraging decades of real-world data on damages and costs from climate events to inform transparent and robust solutions for modeling risk to real assets and translating it to company and entry-level impacts. We cover transition risk with comprehensive and continuously improving datasets, analytics, and assessments of policy, macroeconomic trends, and company-specific profiles to analyze the impacts of potential future climate scenarios.

Our solutions are developed to seamlessly integrate into the workflows your teams manage across the organization, in which climate data, analytics, and insights should inform strategy and decision-making to future-proof your competitive position in the market.

Learn more at **https://climate.moodys.com/**

Our physical risk capabilities are developed on the foundation of Moody's RMS climate science and modeling expertise. For more than 20 years, Moody's RMS has worked with partners and stakeholders to understand the complexity of modeling physical risks and financial impacts on P&C insurance portfolios and assets. We have extended our understanding of the interconnected and complex dimensions of current risk with globally recognized, forward-looking climate change models and best-available climate science to develop consistent frameworks for assessing future scenarios of risk applicable to enterprise risk management across sectors.

Learn more at **https://www.rms.com/climate-change**

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