2025

February

Weathering the Storm: The Impact, Risks and Opportunities of Extreme Weather Events

Sustainability Research Paper

The Al-Attiyah Foundation

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Extreme weather events are becoming increasingly frequent, severe, and unpredictable, causing widespread economic, social, and environmental disruptions. Rising global temperatures are driving more intense storms, wildfires, and floods, while chronic climate risks, such as prolonged droughts and shifting precipitation patterns, continue to reshape ecosystems and economies. These escalating threats expose businesses, governments, and communities to compounding vulnerabilities, requiring a shift from reactive disaster response to proactive risk management.

This report examines the far-reaching impacts of extreme weather events, highlighting the financial, operational, and infrastructural risks they pose. Key areas of focus include the role of parametric insurance in closing the protection gap, enterprise risk management (ERM) for climate resilience, and investments in adaptive infrastructure and nature-based solutions (NbS).

SUSTAINABILITY RESEARCH PAPER

This research paper is part of a 12-month series published by the Al-Attiyah Foundation every year. Each in-depth research paper focuses on a current sustainability topic that is of interest to the Foundation's members and partners. The 12 technical papers are distributed to members, partners, and universities, as well as made available on the Foundation's website.

- Extreme weather events are increasing in frequency, intensity, and unpredictability, posing severe economic and infrastructural risks. As climate volatility escalates, businesses, governments, and financial institutions must transition from reactive disaster relief to proactive risk management.
- The growing prevalence of hurricanes, wildfires, droughts, and extreme temperature events highlights the urgency of developing resilient frameworks that safeguard infrastructure, mitigate financial losses, and ensure long-term sustainability.
- However, traditional risk management strategies and insurance models are proving inadequate in addressing the scale and unpredictability of climate-driven disasters, necessitating innovative financial mechanisms and comprehensive adaptation strategies.
- The global insurance industry is facing a significant protection gap, with rising premiums and underinsurance leaving economies vulnerable to financial shocks following climate disasters. In 2023, the global insurance protection gap reached USD 1.8 trillion, with only 33% of natural catastrophe-related losses covered in the previous decade. This widening gap underscores the limitations of conventional indemnity-based insurance in responding to climate volatility.
- Parametric insurance has emerged as a vital solution, offering pre-agreed payouts based on event triggers. This model ensures that funds are disbursed rapidly following extreme weather events, providing immediate liquidity to governments, businesses, and communities to support relief and recovery efforts.[1]

- The MENA region is particularly exposed to climate-related risks, including heatwaves, droughts, and sandstorms, which are exacerbated by its economic reliance on climate-sensitive industries such as oil, tourism, and agriculture. While many MENA nations possess substantial financial reserves, economic cyclicity and liquidity constraints can delay or limit disaster response efforts.

- Parametric insurance presents a compelling financial mechanism for the region, ensuring predictable funding for climate emergencies while reducing reliance on emergency budget reallocations. Establishing a regional parametric insurance risk pool, similar to the Caribbean Catastrophe Risk Insurance Facility (CCRIF) and the African Risk Capacity (ARC), could enhance financial security, lower insurance costs, and improve disaster preparedness across participating nations.[2 3]

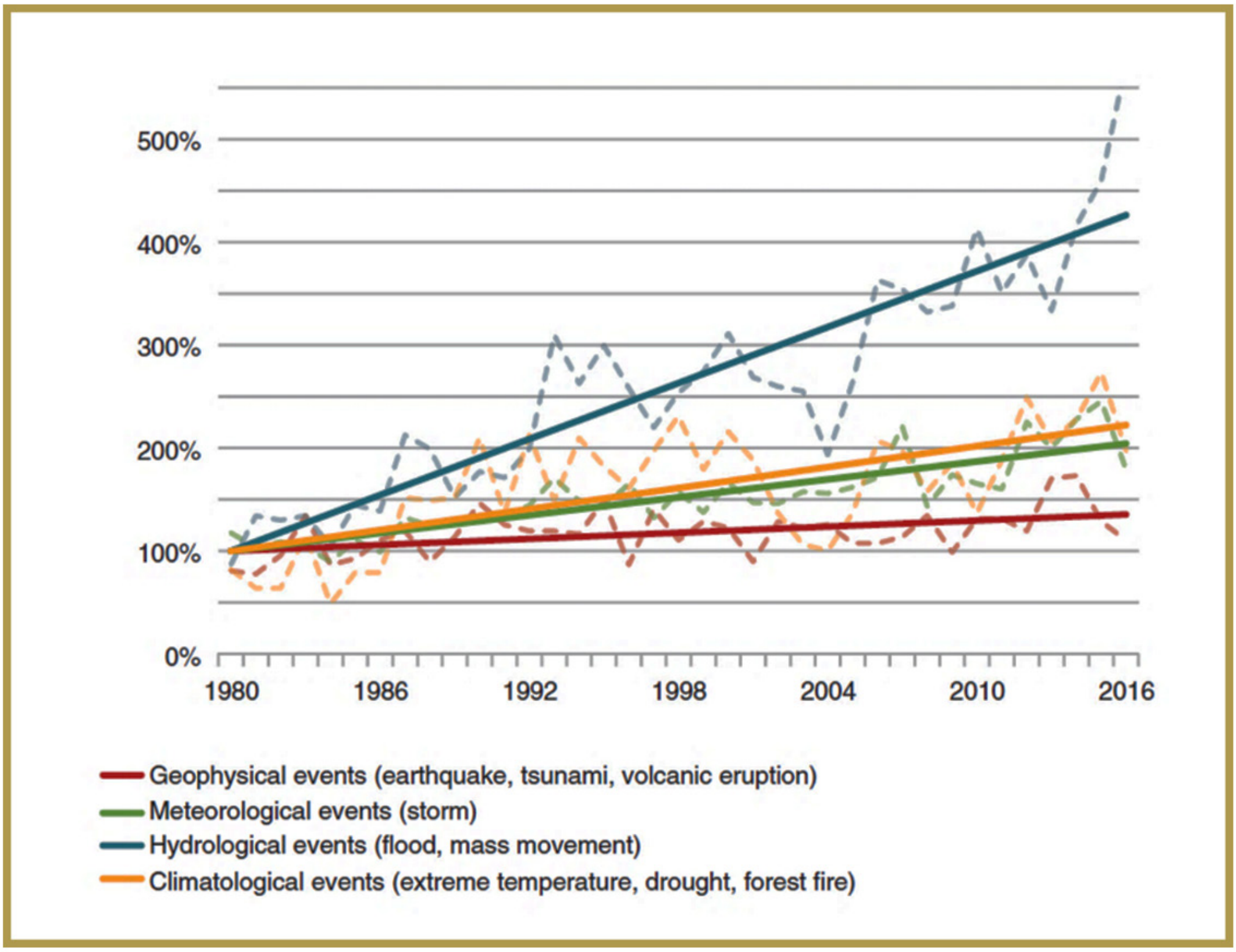
- Enterprise Risk Management (ERM) frameworks provide structured methodologies for integrating climate risk into corporate governance, strategy, and decision-making. By embedding climate risk considerations into operational planning, businesses and governments can enhance resilience and minimise financial and infrastructural disruptions.

- Beyond financial instruments and ERM frameworks, policymakers must prioritise investments in adaptive infrastructure, nature-based solutions (NbS), and advanced technologies to complement financial resilience strategies. At the same time, integrating early warning systems within ERM frameworks provides a structured approach to assessing extreme weather risks, enabling businesses to leverage technology and data-driven insights to identify strategic opportunities that enhance operational resilience.

- At the national level, adaptation planning, guided by the best available science and technological advancements, remains essential for evaluating climate vulnerabilities and directing effective strategic interventions.

- Extreme weather events will continue to pose an existential threat to sustainable development. However, by embracing a multi-faceted climate resilience strategy that combines parametric insurance, enterprise risk management, early warning systems, adaptive infrastructure, and nature-based solutions, businesses and governments can proactively safeguard against climate risks while leveraging opportunities for long-term sustainability.

Figure 1: Trends in Different Types of Natural Catastrophes Worldwide (1980–2016), With 1980 Levels Set at 100%.

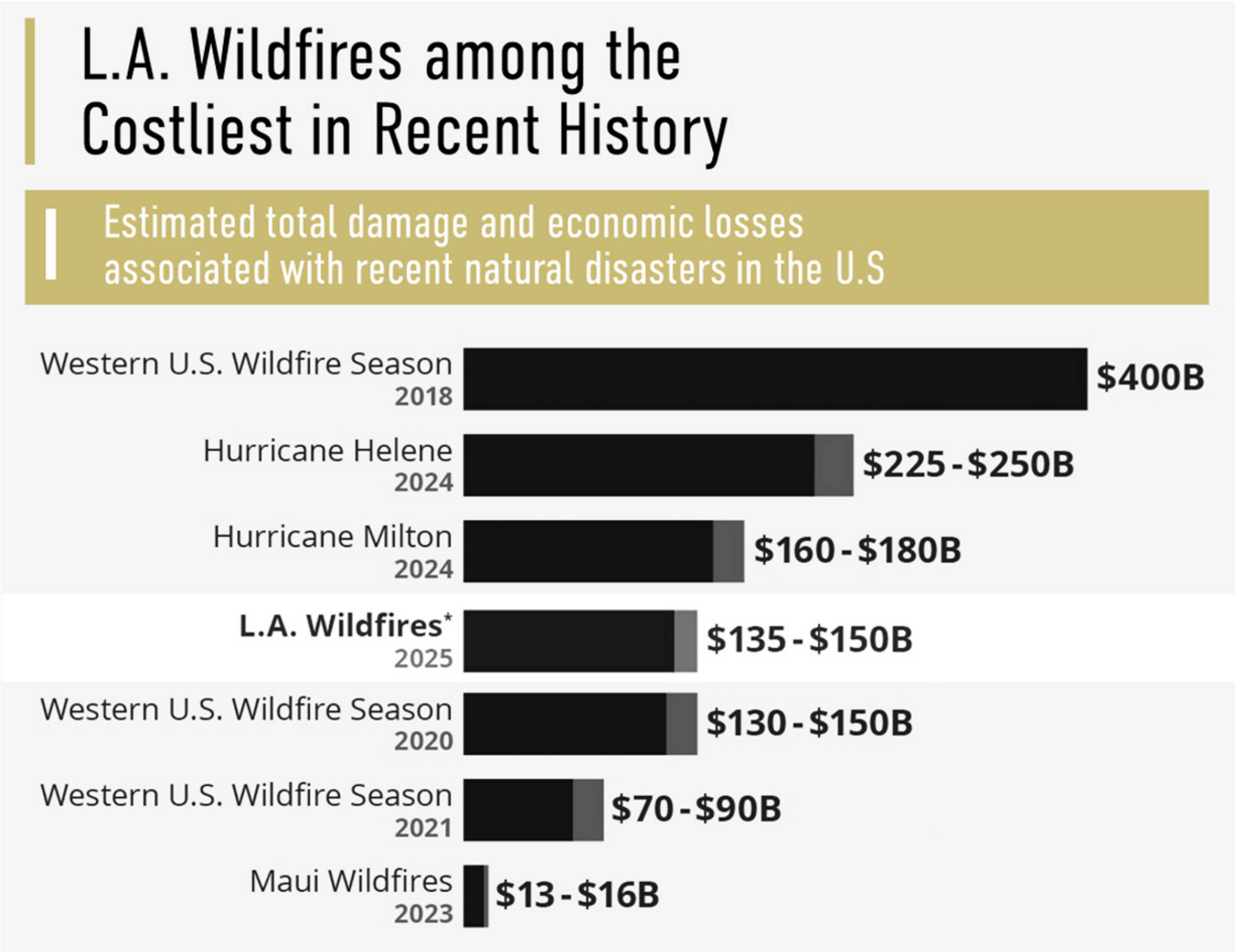


Source: EASAC (2013), Adapted From Munich Re NatCatSERVICE .

As global temperatures rise, so too will the likelihood of catastrophic events. One of the most immediate and destructive effects of rising temperatures is the increasing prevalence of wildfires, which are intensifying as rising global temperatures dry out vegetation and create ideal conditions for combustion. The 2025 California wildfires devastated thousands of buildings, displaced hundreds of thousands of people, and resulted in economic losses between US$ 135 billion and US$ 150 billion, as shown in Figure 2, which also highlights the broader economic impact of recent major disasters in the U.S.[4 5 6 7]

Yet, with only around US$ 28 billion covered by insurance, the vast majority of the financial burden fell on homeowners, businesses, and local governments, underscoring the growing gap between escalating disaster costs and available coverage. These fires were the result of multiple converging variables which created the conditions for a highly destructive event. Among them, record-breaking droughts and exceptionally fast-moving Santa Ana winds not only intensified the spread of the flames but also played a critical role in ignition by stripping moisture from vegetation.

Figure 2: Estimated Total Damage and Economic Losses Associated With Recent Natural Disasters in the U.S.



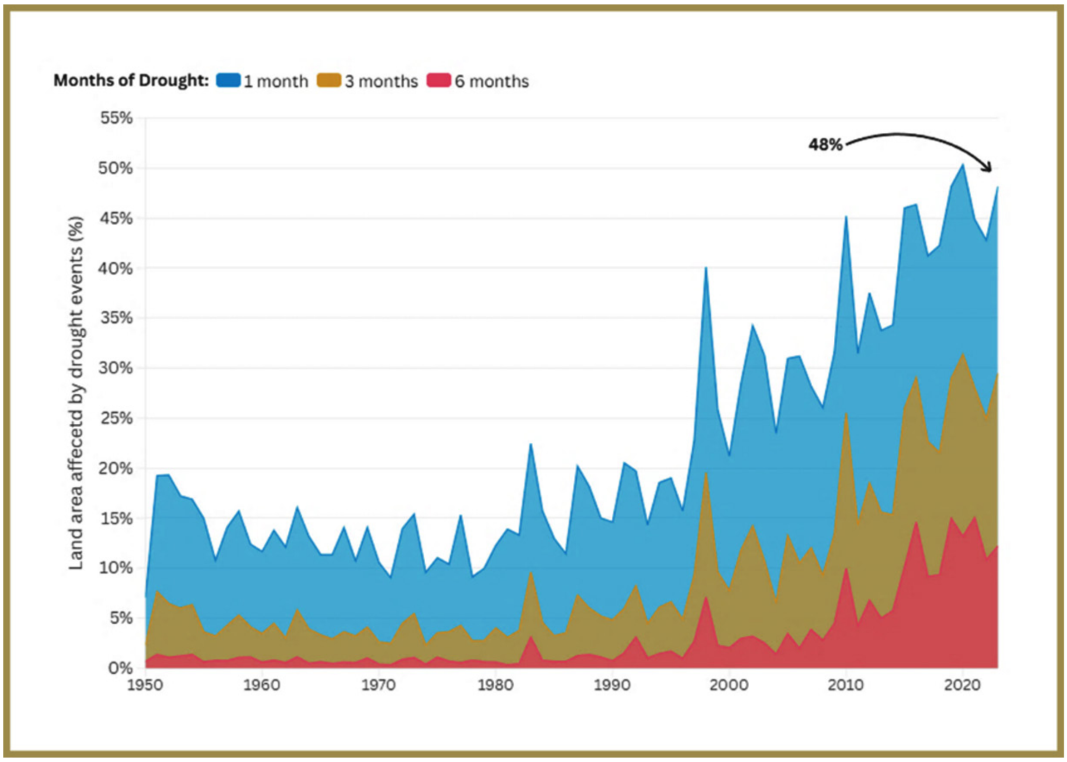
Source: Statista, Based on Data From AccuWeather .

Scientists warn that with each fraction of a degree of warming, combustible conditions will intensify, leading to more frequent and severe wildfires in temperate woodlands, dry shrublands and drought prone semi-arid landscapes.[6 7]

On the other end of the spectrum, extreme winter storms and polar vortex disruptions underscore the growing volatility of climate systems. While global warming fuels more heatwaves and wildfires, it is also destabilising traditional cold weather patterns. The North American Cold Waves of 2019 and 2021 exemplify the other extreme of climate change. Research suggests that Arctic warming may be weakening the polar vortex, allowing frigid air to spill into lower latitudes and triggering record-breaking winter storms that disrupt entire regions. However, this relationship remains an area of ongoing scientific investigation. What is clear is that the world is not just warming, it is becoming increasingly unstable, with more pronounced climate extremes at both ends of the spectrum.[8]

Warming is not confined to the Arctic; rising temperatures in high-altitude regions like the Himalayas are also accelerating glacial melt, contributing to rising sea levels and more intense flooding.

Figure 3: Percentage of Global Land Area Affected by Extreme Drought Events From 1950 -2020.

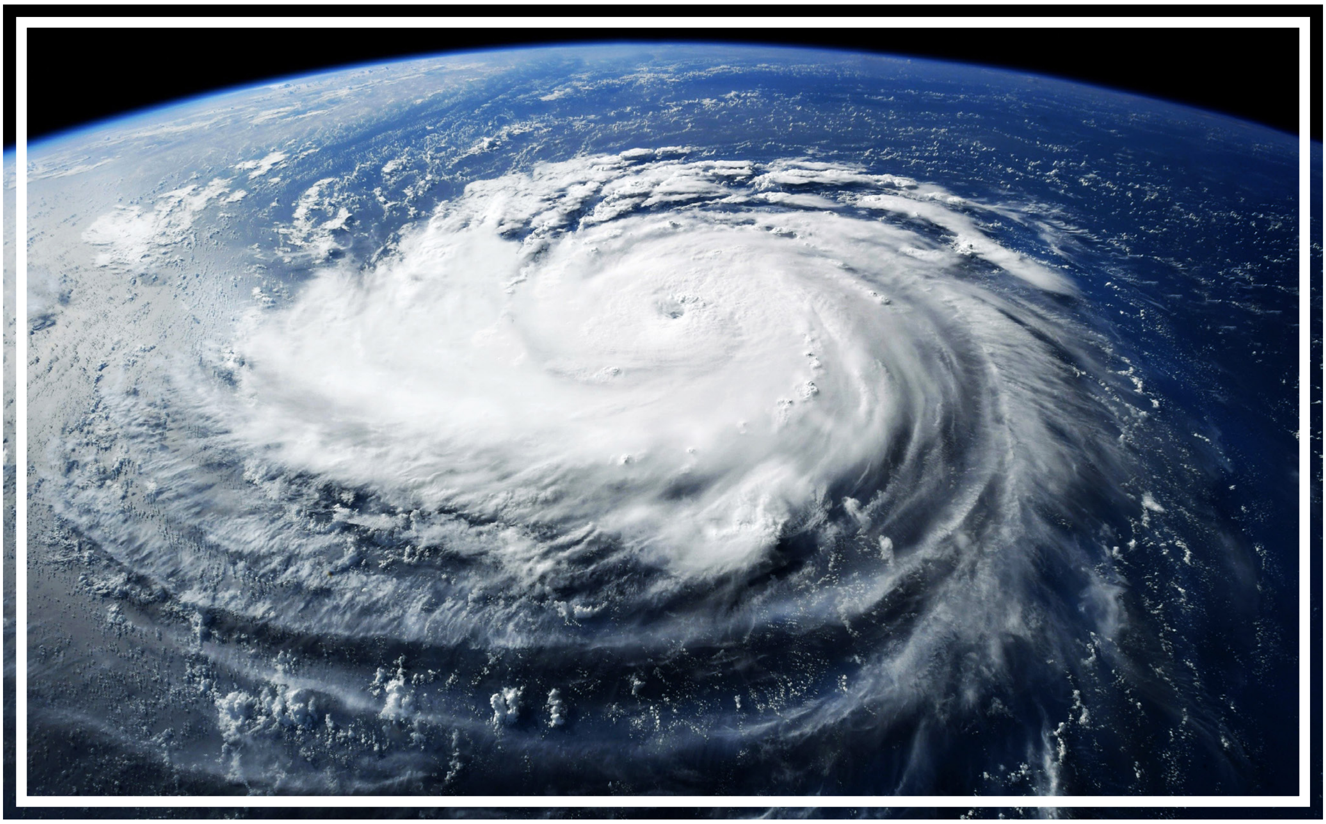


Source: 2024 Report of the Lancet Countdown.

This effect is often amplified by increased humidity and precipitation, triggering flash floods, as seen in North India in 2023 and 2024. The intensification of hurricanes and tropical storms is another consequence of warming-driven moisture cycles, which are fuelling stronger and more destructive storms. The 2024 hurricane season saw the emergence of Hurricane Helene and Hurricane Milton, both exhibiting unprecedented intensification rates. Milton became the second most intense hurricane ever recorded in the Gulf of Mexico, and while it weakened before landfall, it still caused widespread destruction and severe damage in its downgraded state.[9 10]

In contrast to excessive rainfall, water scarcity is emerging as an equally urgent challenge, with severe droughts threatening water supplies in arid and semi-arid regions. The increasing frequency and intensity of droughts are evident in long-term trends, as illustrated in Figure 3, which shows a significant rise in the percentage of land affected by extreme drought events from 1950 to 2020, reaching a peak of 48% in recent years. These prolonged dry spells not only disrupt agriculture and water security but also amplify socio-economic vulnerabilities. One of the most striking examples of this escalating crisis was the 2018 Cape Town Water Crisis which underscores how climate change, coupled with poor resource management, can push a major city to the brink of collapse.[11]

The increasing frequency and intensity of extreme weather events are not only causing widespread destruction but also placing immense strain on critical infrastructure, with water, energy, drainage, and transportation systems among the most vulnerable. As climate extremes intensify, these cascading failures compound the impact of each disaster, amplifying disruptions to urban infrastructure, healthcare systems, and marginalised populations.

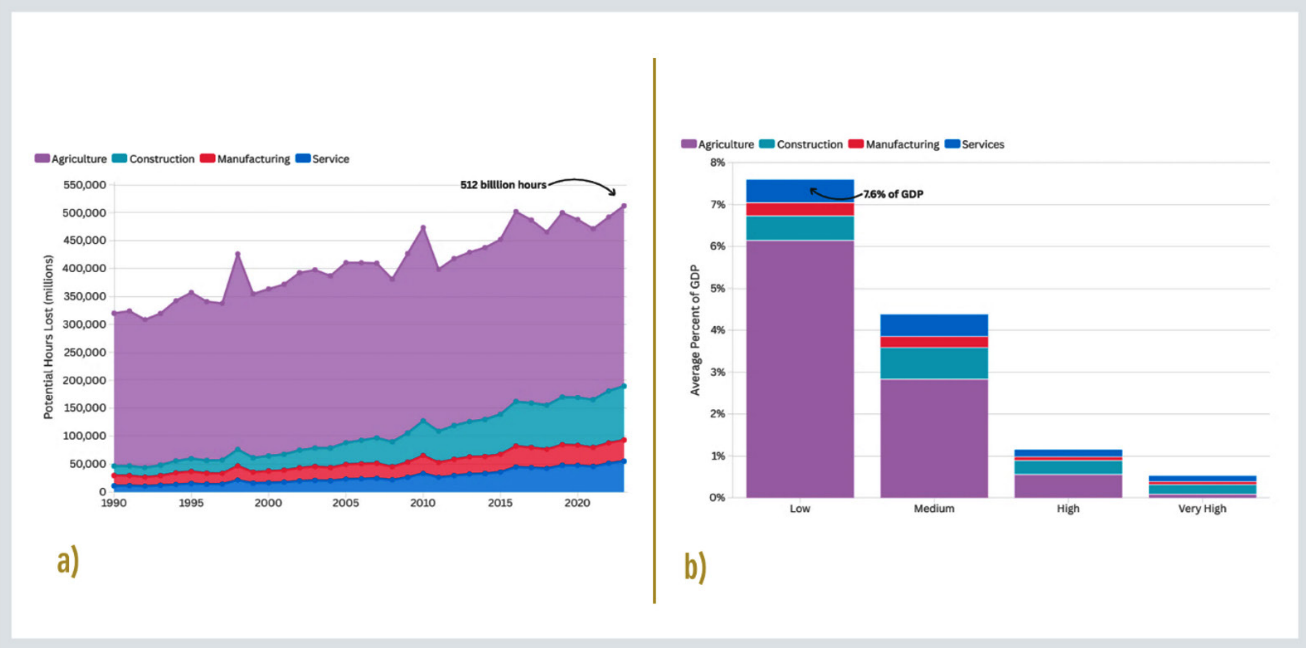


The strain on critical infrastructure varies across economic sectors, making it difficult for industries to consolidate and coordinate effective responses. Sector-specific challenges are often addressed in isolation, resulting in limited collaboration and underexplored opportunities for innovation. As extreme heat, precipitation, and climate variability intensify, industries are experiencing growing operational risks, financial losses, and supply chain disruptions, forcing businesses to confront systemic vulnerabilities that threaten long-term economic stability.

The 2024 Lancet Countdown Report highlights the increasing impact of extreme heat on global labour productivity. Heat exposure led to a record 512 billion potential hours of labour lost globally in 2023, a 49% increase from the 1990–1999 average (Figure 14a). These losses disproportionately affect industries that rely on outdoor and non-climate-controlled environments such as agriculture, construction, and manufacturing. The financial implications are equally severe, with heat-related reductions in labour capacity contributing to a record-high income loss of US$ 835 billion. The hardest-hit regions are low Human Development Index (HDI) countries, where labour losses amounted to 7.6% of GDP, exacerbating economic inequalities (Figure 14b).[12 13 14]

Beyond direct productivity losses, extreme heat also amplifies industrial hazards, particularly in chemical and high-temperature manufacturing sectors. Heatwaves increase the risk of exothermic reaction hazards in chemical processing plants, where a 0.5°C temperature drift can elevate explosion risks. At the same time, high humidity levels weaken biodegradable materials, with 43% of compostable wraps failing within 48 hours at relative humidity levels above 80%.

Figure 4: Percentage of Global Land Area Affected by Extreme Drought Events From 1950 -2020.



Source: 2024 Report of the Lancet Countdown.

The systemic impact of extreme weather extends across global supply chains, where disruptions are becoming more frequent and costly. In 2024, a significant number of organisations reported climate-related supply chain disruptions, exposing the vulnerabilities of traditional supply chain and inventory models.[15]

Sector-Specific Climate Vulnerabilities

Extreme weather events pose sector-specific risks, with manufacturing, food production, chemicals, and energy among the most vulnerable industries. Manufacturing faces heat-related productivity losses in non-climate-controlled facilities and flood-induced supply chain disruptions, as seen in the 2024 Rhine River floods, which caused semiconductor shortages and financial losses. Similarly, food production and aquaculture are impacted by marine heatwaves, ocean acidification, and extreme temperatures, with heatwaves disrupting fermentation processes and reducing fish stocks.[16] The chemical and packaging industries are at heightened risk from heat and humidity, which elevate explosion hazards, while endothermic reactions under extreme cold conditions may lead to containment failures or structural ruptures. Additionally, biodegradable materials deteriorate more rapidly in high humidity, compromising their structural integrity, safety, and suitability for consumption or use.[14]

The energy sector faces mounting technical and financial risks as extreme weather events disrupt both fossil fuel and renewable energy production. Droughts have reduced hydropower capacity, increasing dependence on fossil fuels during heatwaves, while wind turbine icing in colder climates raises maintenance costs and operational downtime.

Flooding further compounds challenges, delaying wind energy projects by disrupting construction, limiting site accessibility, and weakening soil stability for turbine foundations. It also damages underground cables, substations, and grid connections, postponing electrical integration and project commissioning—ultimately extending timelines, increasing costs, and prolonging return on investment (ROI) periods. Additionally, climate variability is straining renewable energy infrastructure, as seen in the 2024 Australian hailstorms, which caused significant damage to solar panels, underscoring the sector's growing exposure to extreme weather events and the expanding range of climate-related vulnerabilities.[17] [18]

The food and beverage industry also faces escalating vulnerabilities, particularly in agriculture and aquaculture, where extreme weather disrupts production cycles and supply chains. Marine heatwaves have decimated fish stocks, with the 2014–2016 Gulf of Alaska marine heatwave causing a 71% decline in Pacific cod populations, while cyclones in Bangladesh wipe out 30–50% of shrimp farms annually. Meanwhile, land-based food production faces compounding risks, with heatwaves interfering with fermentation processes, as seen in the 2024 EU brewery closures, where EUR 220 million in spoiled batches underscored the fragility of temperature-sensitive processing systems.[19]

11 MANAGING CLIMATE RISKS: STRATEGIC APPROACHES FOR BUSINESS RESILIENCE

In light of the escalating climate volatility extensively outlined in the preceding sections, it is evident that businesses require a structured framework to proactively address climate-related disruptions. This necessitates an approach that integrates climate risk considerations into strategic planning and operational decision-making, enabling organisations to anticipate threats, enhance resilience, and mitigate financial and operational impacts.

Enterprise Risk Management (ERM) provides this structured framework, offering a systematic approach to identifying, assessing, and responding to climate risks. Two widely recognised ERM frameworks; the COSO (Committee of Sponsoring Organizations of the Treadway Commission) ERM Framework and the WBCSD (World Business Council for Sustainable Development) ERM Approach, offer methodologies to embed climate risk considerations into corporate governance, strategy, and operations.

- COSO's ERM Framework (Figure 5) emphasises integrating risk management with strategic and performance objectives, enabling businesses to evaluate climate risks within the broader context of financial and operational decision-making. It provides a structured process for identifying, assessing, and mitigating risks that could disrupt long-term business sustainability.[19]
- The WBCSD ERM Approach (Figure 6) builds on COSO's principles but places a stronger emphasis on sustainability and climate-related risks, encouraging businesses to assess their exposure to physical risks (extreme weather events, rising temperatures) and transition risks (policy changes, carbon pricing, market shifts). It promotes scenario-based risk assessment to strengthen business resilience in an increasingly volatile climate landscape.[20]

Figure 5: WBCSD Guidance on the Application of COSO ERM Framework for ESG Related Risks.

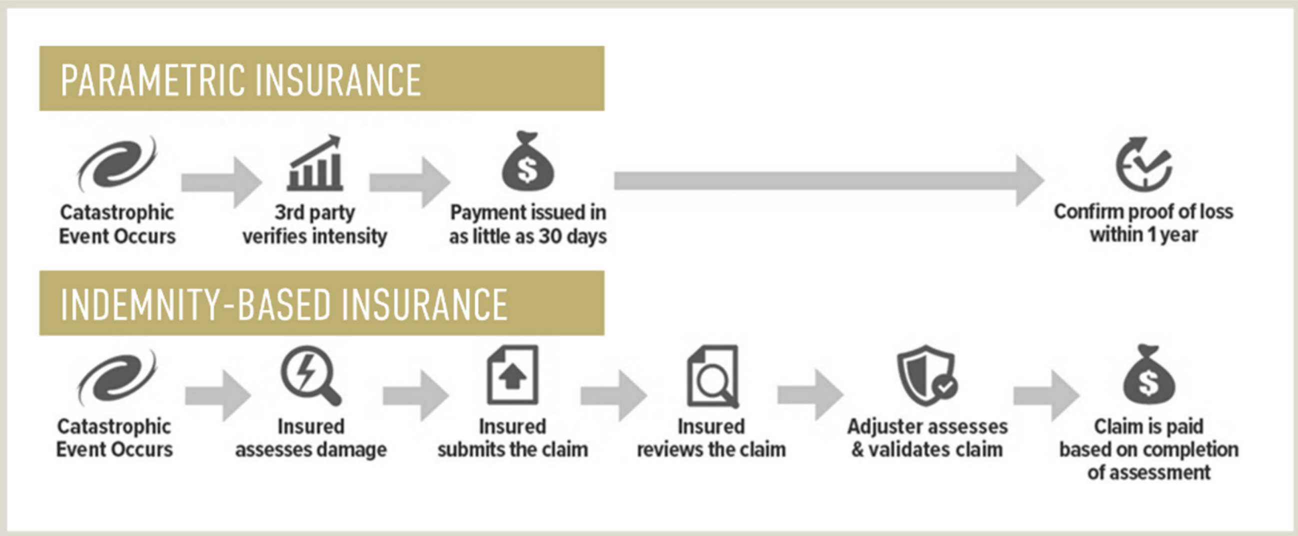
Effectively integrating climate risks into Enterprise Risk Management (ERM) requires a deep understanding of the complex, multi-dimensional nature of climate-related threats. These risks are not uniform; they manifest at varying scales, intensities, and timeframes, with different levels of exposure, vulnerability, and adaptive capacity across regions and sectors. ERM frameworks provide structured methodologies for assessing these risks, identifying vulnerabilities, and unlocking resilience-building measures. However, the distribution of risks and opportunities are uneven, with Least Developed Countries (LDCs) and Small Island Developing States (SIDS) facing disproportionate exposure to climate-induced disasters, which tend to be more severe and costly in developing economies. Moreover, extreme weather events, whether hurricanes, floods, or heatwaves, exacerbate socio-economic inequalities, further straining local communities and financial systems.

The complexity of climate risks underscores the need for adaptive infrastructure investments and innovative financial instruments to enhance resilience.[21] [22] [23]

Figure 6: The COSO Framework

Source: COSO Internal Control Framework ©2013

Figure 7: Comparison of the Parametric Insurance Claims Process vs the Traditional Indemnity-Based Insurance Process.



As climate risks become more frequent and severe, traditional insurance models often struggle to provide timely and effective financial relief. Parametric insurance, also known as index-based insurance, offers a more agile and responsive alternative by issuing pre-determined payouts based on the occurrence of specific events, rather than requiring detailed post-disaster assessments of actual losses. This distinction makes parametric insurance particularly well-suited for managing climate-induced disasters, where rapid financial response is crucial for relief and recovery efforts.[1]

Unlike standard indemnity insurance, which can take months or even years to process claims, parametric contracts enable swift disbursement of funds, often within weeks. Parametric policies enhance flexibility and efficiency in risk management by utilising a network of objective data sources, such as satellite imagery, seismic activity monitors, and weather stations, rather than depending on a single assessor.

This ensures that resources are deployed at the most critical time, immediately following a disaster, rather than being delayed by bureaucratic and logistical hurdles.[1]

Parametric insurance is particularly effective in mitigating the financial impact of extreme weather events, aligning well with the unpredictable nature of climate volatility. Governments, businesses, and communities gain immediate liquidity when predefined event-based triggers are met, such as a specific rainfall threshold, wind speed, temperature increase, or earthquake magnitude. This approach is designed to focus on defining the triggering event rather than the complex claims assessment process, ensuring clarity, speed, and efficiency.[1]

Global case studies highlight the effectiveness of parametric insurance in delivering rapid financial relief and strengthening resilience against extreme weather events. Two key initiatives; the Caribbean Catastrophe Risk Insurance Facility (CCRIF SPC) and the African Risk Capacity (ARC), demonstrate how innovative risk pooling mechanisms and predefined climate triggers can enhance disaster response, particularly in vulnerable regions.[2 3]

The Caribbean Catastrophe Risk Insurance Facility (CCRIF SPC)

Established in 2007, the CCRIF SPC was the world's first multi-country risk pool and the first insurance instrument to successfully develop parametric policies backed by both traditional and capital markets. This facility was designed to limit the financial impact of natural disasters on Caribbean and Central American governments by providing rapid liquidity when a policy is triggered.[2]

One of the most notable examples of CCRIF's impact occurred in the Dominican Republic following a devastating hurricane. Within just 14 days of the hurricane's passage, CCRIF disbursed approximately US$ 19.3 million to the Dominican government, enabling urgent relief efforts and ensuring that critical resources were mobilised swiftly. The facility has since expanded its offerings beyond tropical cyclones and earthquakes to include excess rainfall, fisheries, and utility sector insurance, further enhancing regional resilience. In 2014, CCRIF was restructured into a segregated portfolio company (SPC) to facilitate the development of new products and its expansion into new geographic areas.[24]

By providing timely financial support to affected governments, CCRIF SPC has reduced the reliance on post-disaster humanitarian aid, allowing nations to respond more efficiently and rebuild their economies without severe fiscal strain.

The African Risk Capacity (ARC)

The African Risk Capacity (ARC), established in 2014, operates as a Specialized Agency of the African Union and is led by 29 AU Member States. Designed to address the unique climate risks faced by African nations, ARC combines traditional disaster relief mechanisms with risk pooling and risk transfer strategies, creating a pan-African disaster response system that enables governments to respond to extreme weather events in a timely and efficient manner.[3]

Unlike the Caribbean, where hurricanes and earthquakes dominate climate risk, African nations face prolonged droughts, extreme heat, and erratic rainfall patterns. The ARC solution provides parametric insurance tailored to the African context, ensuring that financial assistance is triggered based on drought severity, rainfall deficits, and temperature thresholds.[3]

A major success of ARC was its US$ 11.2 million payout to the government of Malawi following a severe drought. This payout enabled the government to provide direct relief to over 350,000 affected households, ensuring access to food, water, and emergency resources. The effectiveness of ARC lies in its ability to deliver funding quickly, preventing humanitarian crises from escalating due to funding delays.

By leveraging climate modelling and data-driven risk assessment, ARC ensures that governments can proactively prepare for and respond to extreme weather events rather than relying on slow-moving international aid mechanisms. This African-led initiative represents a sustainable model for managing climate risks, reducing economic volatility, and improving long-term disaster preparedness.[25]

Expanding Parametric Insurance Through Temperature-Based Triggers

While existing parametric insurance models primarily focus on hurricanes, earthquakes, and droughts, there is growing recognition of the need to expand parametric solutions to cover temperature-driven climate risks. As outlined in the preceding discussions, extreme heat poses a major threat to human health, labour productivity, and infrastructure stability, particularly in regions such as MENA (Middle East and North Africa), which are highly vulnerable to heatwaves, prolonged droughts, and sandstorms.[26 27]

By setting predefined temperature thresholds, parametric insurance could provide rapid financial support to governments and businesses when extreme heat events reach levels that endanger public health, energy grids, and economic activity. Such models could be particularly valuable in urban centres with high exposure to heat stress, where temperature spikes disrupt industries, increase healthcare costs, and threaten food and water security.[26 27]

The Role of Parametric Insurance in the MENA Region

While many MENA countries possess significant financial reserves, parametric insurance remains a strategic tool to alleviate potential liquidity constraints. Wealth does not equate financial flexibility in the face of acute and extreme climate events. Even the most well-resourced governments would have to reallocate budgets in order to respond to unforeseen and sometimes unprecedented climate events. This is particularly crucial for MENA's dominant-sector economies, where a single industry, often oil and gas, tourism, or agriculture, account for a disproportionate share of national revenues.

If an extreme weather event directly impacts that sector, the financial strain can be immediate and severe. Parametric insurance mitigates this risk by ensuring that, even in a worst-case scenario, financial support remains intact and readily available.

Economic downturns further highlight the necessity of pre-arranged financial mechanisms. Global oil price fluctuations, inflation, and shifting trade dynamics can all strain government finances, making it less viable to allocate large emergency funds in advance.

Beyond economic losses, slow or inadequate disaster response can have profound socio-political consequences. The MENA region has a complex history of economic volatility, political unrest, and social discontent—often triggered or exacerbated by economic shocks.

Climate-related disasters have the potential to destabilise governments, particularly if affected populations perceive response efforts as insufficient or delayed. Rapid payouts from parametric insurance can play a crucial role in mitigating these risks.

MENA countries could benefit from a regional risk pool, similar to CCRIF in the Caribbean and ARC in Africa, where multiple nations share financial risks, reducing the cost of individual insurance policies. For climate-vulnerable countries such as Jordan, Morocco, Egypt, and Sudan, participating in a regional parametric insurance program backed by wealthier Gulf states could enhance financial security while lowering premium costs.

For businesses and governments, an effective climate risk management framework must incorporate early warning systems, adaptive infrastructure investments, and nature-based solutions. Early warning systems (EWS) are essential for reducing disaster risks, minimising economic losses, and enhancing climate resilience by providing advance notice of extreme weather events. By leveraging AI, predictive modeling, and real-time climate monitoring, EWS empower governments, businesses, and individuals to take proactive measures before disasters occur, significantly improving preparedness and response strategies.[28]

Advancements in climate stress testing, satellite-based fire alerts, and hydrodynamic modeling have enhanced forecasting accuracy, allowing for more precise predictions of extreme weather events. Technologies such as NASA's C-FIRST instrument for wildfire detection, IoT-enabled heat mapping, and AI-integrated weather stations are transforming disaster preparedness by providing real-time environmental data that enables early intervention. In agriculture, spectroscopic sensors and precision irrigation systems are being refined to adjust for shifting microclimates, improving resilience in food production systems.[28 29 31]

Recent technological advancements have significantly enhanced global forecasting capabilities. For example, in 2024, the United Nation's Early Warnings for All initiative (EW4All) introduced cutting-edge AI-powered early warning systems. These innovations provide the baseline data for governments and industries to make informed, data-driven decisions ahead of impending disasters.[29 30 31]

Adaptation is the crucial bridge between climate risk and long-term resilience, shaping how societies, economies, and ecosystems adjust, evolve, and in some cases, thrive amid increasing climate volatility.

While mitigation efforts can reduce future risks, adaptation is an immediate necessity for climate-vulnerable regions facing frequent and intensifying extreme weather events. The challenge lies not only in strengthening physical infrastructure but in reimagining the built environment as an active component of resilience, capable of withstanding environmental stressors, absorbing climate shocks, and enabling rapid recovery.[28]

Adaptive infrastructure extends beyond traditional engineering solutions, requiring systemic changes in urban planning, economic structures, and institutional capacity. Climate change impacts are felt most acutely at local and regional levels, making ground-level adaptation strategies essential for addressing distinct risk landscapes. However, as climate extremes become more severe, adaptation costs will rise, often yielding diminishing marginal returns. This raises the strategic question of resource efficiency, how much adaptation is "enough" to ensure stability without overextending financial and technological capacity?[28]

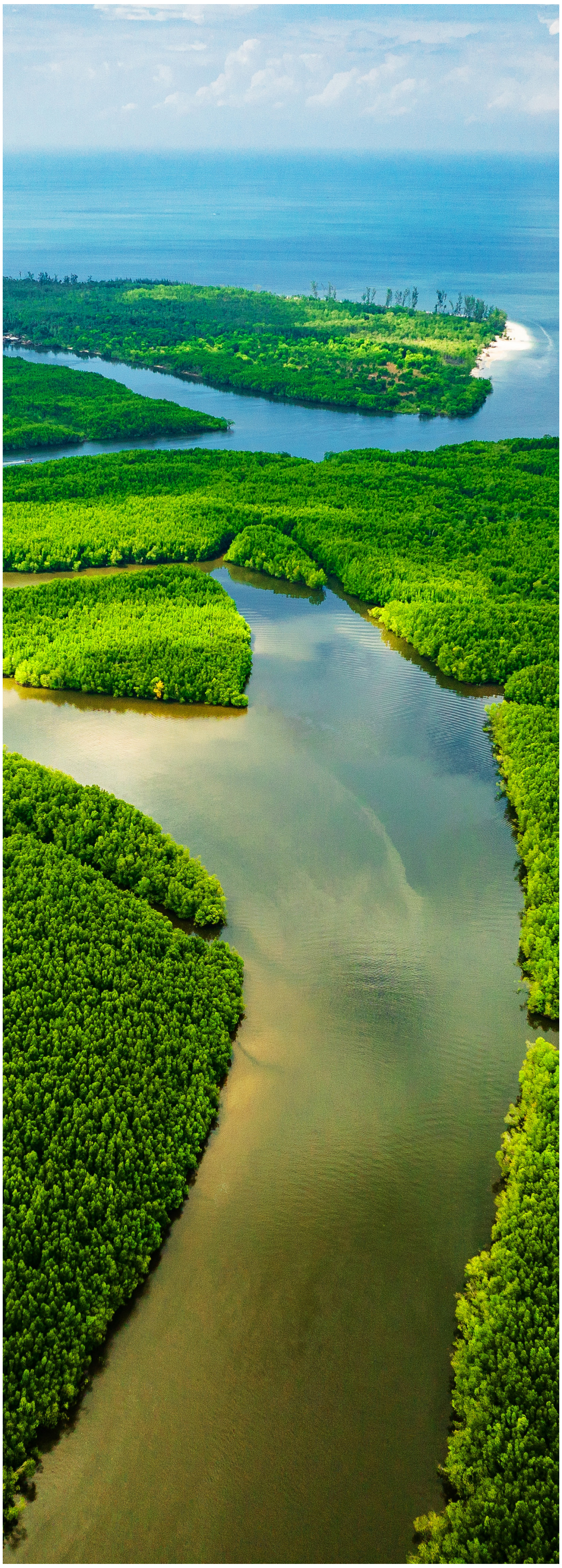
Economic diversification is a critical yet often overlooked aspect of adaptation, reducing dependence on climate-sensitive industries and strengthening socioeconomic resilience. Beyond infrastructure reinforcement, adaptation requires investment in low-carbon industries, technological innovation, and financial safety nets to buffer against climate-driven economic shocks. Without these systemic changes, even the most fortified physical infrastructure may prove insufficient in sustaining long-term resilience.

Adaptation extends beyond human systems to natural ecosystems, which serve as powerful buffers against climate shocks. Nature-based solutions (NbS) offer low-cost, high-impact strategies for reducing disaster risks, protecting critical infrastructure, and enhancing biodiversity, environmental health, and local economies.

By integrating NbS into adaptation planning, governments and businesses can leverage the resilience of natural ecosystems to mitigate the impacts of extreme weather events while delivering long-term economic and ecological benefits.[28 32]

One of the most widely adopted nature-based solutions (NbS) is mangrove restoration, which has emerged as a scientifically validated adaptation mechanism against coastal erosion, storm surges, and flooding. Mangrove forests act as natural coastal barriers, significantly reducing wave energy, stabilising shorelines, and protecting coastal communities from extreme weather impacts. Countries investing in large-scale mangrove restoration, such as Bangladesh, Indonesia, the Philippines, India, Thailand, Vietnam, Brazil, Mexico, and the United Arab Emirates, have reported substantial reductions in economic losses caused by tropical cyclones and rising sea levels. These projects highlight the financial and ecological value of integrating nature into climate adaptation strategies, ensuring both immediate disaster risk reduction and long-term environmental resilience.[32]

Beyond coastal resilience, sustainable land management practices, wetland conservation, and large-scale reforestation initiatives contribute to ecosystem stability while simultaneously sequestering carbon. These approaches highlight how adaptation and mitigation can be pursued in tandem, reinforcing both climate resilience and long-term sustainability. By restoring degraded landscapes and protecting natural ecosystems, NbS not only moderate climate risks but also enhance water security, improve soil quality, and strengthen local livelihoods, making them a cost-effective and scalable approach to climate adaptation.[32]



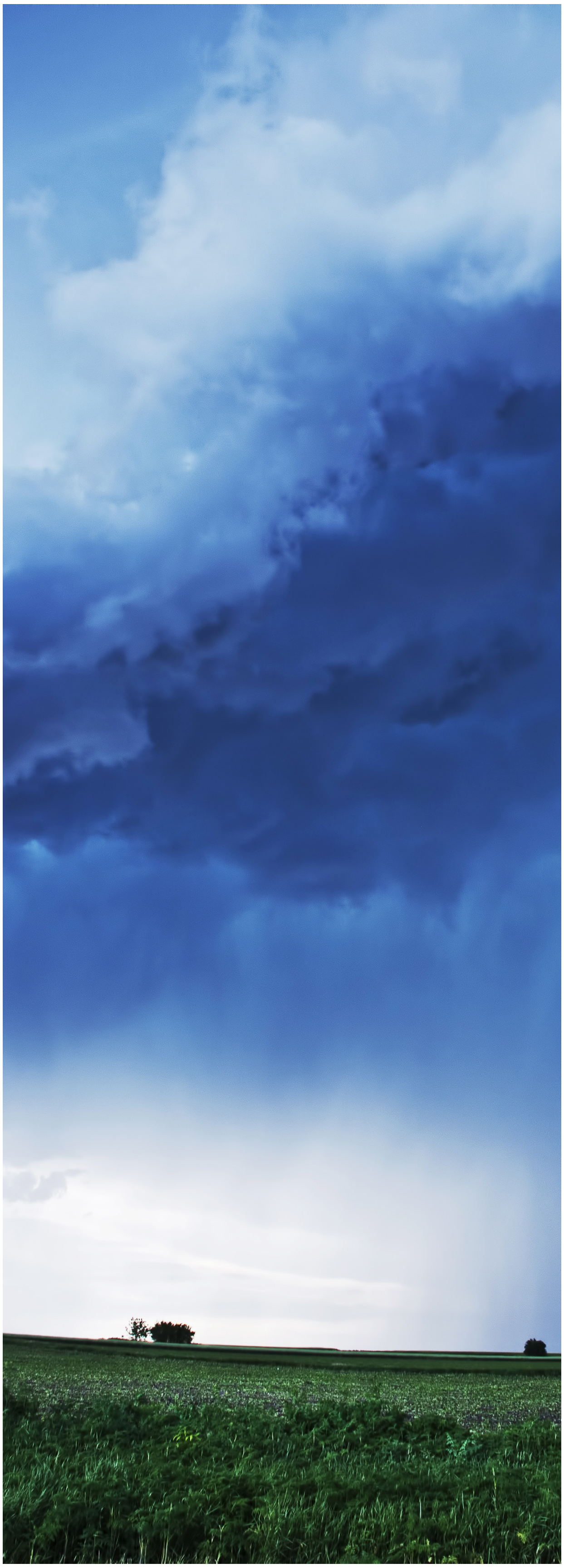
The increasing frequency and severity of extreme weather events underscore the escalating risks posed by climate change and shifting atmospheric patterns. The world is becoming increasingly unstable, with more pronounced climate extremes occurring at both ends of the spectrum—from intensifying heatwaves and wildfires to record-breaking winter storms and floods. These risks are neither uniform nor isolated; they manifest at varying scales, intensities, and timeframes, with different levels of exposure, vulnerability, and adaptive capacity across regions and economic sectors. This complexity necessitates a structured and proactive approach to climate risk management that integrates scientific insights, financial resilience mechanisms, and strategic planning.

Enterprise Risk Management (ERM) provides a systematic framework for embedding climate risk considerations into governance, strategy, and operations, ensuring that businesses and governments can anticipate, assess, and mitigate climate-related disruptions. The COSO and WBCSD ERM frameworks, highlighted in this report, illustrate how structured risk management methodologies can enhance climate resilience, though they are merely examples among a broader suite of risk management approaches available. Beyond ERM, early warning systems (EWS), adaptive infrastructure investments, and nature-based solutions (NbS) offer additional pathways for enhancing preparedness and reducing disaster impacts.

Parametric insurance stands out as a highly effective financial instrument for enhancing climate resilience, offering a rapid and structured response to extreme weather events.

By ensuring immediate liquidity through predefined event-based triggers, parametric insurance facilitates swift financial support when disasters occur, closing the gap between climate shocks and effective recovery. In the MENA region, where geographic and climatic conditions heighten vulnerability to heatwaves, droughts, and extreme weather variability, parametric insurance presents a tailored and pragmatic solution. Beyond providing liquidity and financial flexibility, it is particularly well-suited to MENA's economies, which are heavily influenced by dominant industries, where economic cyclicity and external market fluctuations can make disaster response funding unpredictable. Establishing a regional parametric insurance risk pool—similar to the Caribbean Catastrophe Risk Insurance Facility (CCRIF) and the African Risk Capacity (ARC)—could enhance financial security while reducing premium costs for participating nations.

Ultimately, climate resilience requires a multifaceted approach, combining ERM frameworks, parametric insurance models, advanced EWS technologies, adaptive infrastructure investments, and nature-based solutions. National adaptation planning, informed by the best available science and data-driven risk assessment, is indispensable for guiding strategic interventions that reduce vulnerabilities while leveraging opportunities for economic diversification and long-term resilience. The challenges of climate volatility are immense, but by redefining resilience, leveraging innovative financial instruments, and transforming vulnerabilities into strategic advantages, businesses and governments can build a future that is not only more adaptive but also more secure and sustainable in the face of extreme weather events.



1 National Association of Insurance Commissioners (2023), Parameter Disaster Insurance. https://content.naic.org/insurance-topics/parametric-disaster-insurance (Accessed 07 March 2025).

2 CCRIF SPC (2024), Annual Report 2023–2024. https://www.ccrif.org/ (Accessed 07 March 2025).

3 African Risk Capacity (ARC) (2024), ARC annual report 2023. https://www.arc.int (Accessed 07 March 2025).

4 Heim, E. (2025), NASA Uses New Technology to Understand California Wildfires. NASA. https://www.nasa.gov/science-research/earth-science/nasa-uses-new-technology-to-understand-california-wildfires/#:~:text=Based%20at%20NASA's%20Armstrong%20Flight,suited%20for%20testing%20c%2DFIRST (Accessed 28 February 2025).

5 Linnane, C. (2025), L.A. wildfires have caused more than $135 billion in economic losses — and counting. MarketWatch. https://www.marketwatch.com/story/la-wildfires-have-caused-more-than-50-billion-of-economic-loss-and-counting-f57662eb (Accessed 10 March 2025).

6 MacCarthy, J., Richter, J. (2025), 4 graphics explain Los Angeles' rare and devastating January fires. UNDRR. https://www.preventionweb.net/news/4-graphics-explain-los-angeles-rare-and-devastating-january-fires (Accessed 10 March 2025).

7 Di Giuseppe, F., Hewson, T., McNorton, J., Parrington, M., Keune, M., El Garrousi, S. (2025), 2025 California wildfires: insights from ECMWF forecasts. ECMWF. https://www.ecmwf.int/en/about/media-centre/science-blog/2025/2025-california-wildfires-insights-ecmwf-forecasts (Accessed 28 February 2025).

8 Gao, C., Zhang, J. (2022), Dynamic synergistic effects of large-scale three-dimensional circulation anomalies on the record-breaking cold wave in February 2021 in North America. Atmospheric Research. 284(6):106594. DOI:10.1016/j.atmosres.2022.106594.

9 Kushwaha, A. P., Solanki, H., Vegad, U., Mahto, S. S., Mishra, V. (2024), Land and Atmospheric Drivers of the 2023 Flood in India. Earth and Space Science. Volume 11, Issue 10. https://doi.org/10.1029/2024EA003750.

10 International Federation of Red Cross and Red Crescent Societies (IFRC) (2024), DREF Final Report: India Flood 2023 (MDRIN028). https://go.ifrc.org/emergencies (Accessed 05 March 2025).

11 Calverley, C. M., Walther, S. C. (2022), Drought, water management, and social equity: Analyzing Cape Town, South Africa's water crisis. Sec. Water Resource Management. Volume 4 – 2022. https://doi.org/10.3389/frwa.2022.910149.

12 Romanello, M. et al. (2024), The 2024 report of the Lancet Countdown on health and climate change: facing record-breaking threats from delayed action. The Lancet. Volume 404, Issue 10465, 2024, Pages 1847-1896. ISSN 0140-6736, https://doi.org/10.1016/S0140-6736(24)01822-1.

13 Somanathan, E., Somanathan, R., Sudarshan, A.,Tewari, A. (2021), The Impact of Temperature on Productivity and Labor Supply: Evidence from Indian Manufacturing. Journal of Political Economy.129:6, 1797-1827. https://doi.org/10.1086/713733.

14 Costa, H., Franco, G., Unsal, F., Mudigonda, S., Caldas, M. P. (2024), The heat is on: Heat stress, productivity and adaptation among firms. ECOSCOPE. https://oecdecoscope.blog/2024/12/12/the-heat-is-on-heat-stress-productivity-and-adaptation-among-firms/ (Accessed: 25 February 2025).

15 McKinsey Global Institute (2020), Climate risk and response: Physical hazards and socioeconomic impacts. https://www.mckinsey.com/capabilities/sustainability/our-insights/climate-risk-and-response-physical-hazards-and-socioeconomic-impacts (Accessed: 25 February 2025).

16 WorldFish Center. Policy brief: The threat to fisheries and aquaculture from climate change, https://digitalarchive.worldfishcenter.org/bitstreams/01f70f94-bdef-46b2-8071-e23490be52c2/download (Accessed: 25 February 2025).

17 FERC, NERC and Regional Entity Staff Report (2021), The February 2021 Cold Weather Outages in Texas and the South Central United States. https://ferc.gov/media/february-2021-cold-weather-outages-texas-and-south-central-united-states-ferc-nerc-and (Accessed: 25 February 2025).

18 European Environment Agency (2024), European Climate Risk Assessment, https://www.eea.europa.eu/en/analysis/publications/european-climate-risk-assessment (Accessed: 25 February 2025).

19 SCCE, HCCA (2020), Compliance Risk Management: Applying the COSO ERM Framework. COSO.

20 COSO, WBCSD (2018), Enterprise Risk Management: Applying enterprise risk management to environmental, social and governance-related risks. COSO and WBCSD.

21 Romanello, M. et al. (2024), The 2024 report of the Lancet Countdown on health and climate change: facing record-breaking threats from delayed action. The Lancet. Volume 404, Issue 10465, 2024, Pages 1847-1896. ISSN 0140-6736, https://doi.org/10.1016/S0140-6736(24)01822-1 (Accessed: 25 February 2025).

22 UN-HABITAT (2024), World Cities Report 2024: Cities and Climate Action, https://unhabitat.org/world-cities-report-2024-cities-and-climate-action (Accessed: 25 February 2025).

23 UNDRR (2024), When risks become reality: Extreme weather in 2024, https://www.preventionweb.net/news/when-risks-become-reality-extreme-weather-2024 (Accessed: 25 February 2025).

24 Caribbean Catastrophe Risk Insurance Facility (2017), CCRIF to Make Payout to Dominica of US$19 million Following the Passage of Hurricane Maria. https://www.ccrif.org/node/11921 (Accessed 07 March 2025).

25 African Development Bank Group (2024), African Development Bank Group and African Risk Capacity Group issue $11.2 million insurance payout to the Government of Malawi. https://www.afdb.org/en/news-and-events/press-releases/african-development-bank-group-and-african-risk-capacity-group-issue-112-million-insurance-payout-government-malawi-73593 (Accessed 07 March 2025).

26 Swiss Re (2024), Sigma Resilience Index: encouraging resilience gains, but more is needed, https://www.swissre.com/institute/research/sigma-research/natural-catastrophe-insurance-global-resilience-index-2024.html (Accessed: February 25, 2025).

27 World Economic Forum (2025), What is parametric insurance and how is it building climate resilience? https://www.weforum.org/stories/2025/01/what-is-parametric-insurance-and-how-is-it-building-climate-resilience/ (Accessed: 25 February 2025).

28 Global Center on Adaptation (2022), Accelerating Adaptation Investments for Resilient Infrastructure. https://gca.org/events/accelerating-adaptation-investments-for-resilient-infrastructure/ (Accessed: 25 February 2025).

29 Baqa, M. F., Lu, L., Guo, H., Song, X., Alavipanah, S. K., Nawaz-ul-Huda, S., Li, Q., Chen, F. (2025), Investigating heat-related health risks related to local climate zones using SDGSAT-1 high-resolution thermal infrared imagery in an arid megacity. International Journal of Applied Earth Observation and Geoinformation. Volume 136, 2025, 104334. ISSN 1569-8432, https://doi.org/10.1016/j.jag.2024.104334 (Accessed: 25 February 2025).

30 UNDRR (2022), Early Warnings for All. UNDRR. https://www.undrr.org/implementing-sendai-framework/sendai-framework-action/early-warnings-for-all (Accessed 03 March 2025).

31 Google (2024), How we are using AI for reliable flood forecasting at a global scale, https://blog.google/technology/ai/google-ai-global-flood-forecasting/ (Accessed: 25 February 2025).

32 Dittmann, S., Mosley, L., Stangoulis, J., Nguyen, V. L., Beaumont, K., Dang, T., Guan, H., Gutierrez-Jurado, K., Lam-Gordillo, O., McGrath, A .(2022), Effects of Extreme Salinity Stress on a Temperate Mangrove Ecosystem. Front. For. Glob. Change. 5:859283. doi: 10.3389/ffgc.2022.859283 (Accessed: 25 February 2025).

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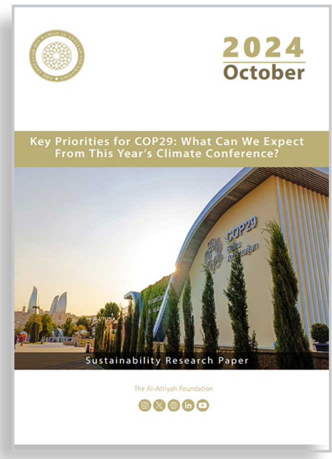

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The Al-Attiyah Foundation

Tel: +(974) 4042 8000,
Fax: +(974) 4042 8099
www.abhafoundation.org

Barzan Tower, 4th Floor, West Bay.
PO Box 1916 Doha, Qatar
Alattiyahfndn

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