Climate Change & Insurance

Physical risks on the insurance industry

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POLICY PAPER

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This paper is the first in a three-part comprehensive assessment of climate change on the insurance sector, and the third publication in GAIP's Climate Change series. Co-authored by Yao Lei and Zhan Xiong Yeo, it builds on GAIP's earlier work, Too Hot to Insure and Beyond Protection.

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Executive Summary

Physical risks are the tangible risks of climate change. They arise from how a warming planet alters the physical environment, and they are already affecting human well-being, disrupting economic stability and placing growing pressure on the insurance sector's ability to provide reliable protection.

Physical risks are shaking the core of insurance: insurability. This report examines five key categories of physical risk: heat, precipitation, wind, cryosphere change and coastal and oceanic change. While each manifests differently, together they represent the most observable impacts of a warming world. Their effects cut across all lines of business, from rising claims to impacts on investment portfolios.

Physical risks are accelerating. Extreme events are becoming more frequent, severe and unpredictable, and delayed action increases the scale and cost of future losses. With temperature records being broken year after year, extreme heat events are testing human physiological limits and reducing productivity, directly affecting life, health and business interruption claims. At the same time, stronger typhoons and cyclones are generating escalating wind losses that steadily erode the capital buffers of insurers and reinsurers.

Physical risks are interconnected. They interact with and amplify one another, requiring holistic rather than siloed responses. Heat can worsen drought, which in turn intensifies wildfire and agricultural losses. Cryosphere change, such as glacier melt, can combine with heavy rain to trigger downstream flooding and landslides. These interactions show that physical risks rarely occur in isolation; they converge.

Physical risks are systemic. The shocks ripple across sectors, geographies and entire economies. The report's analysis of Typhoon Yagi shows how a single wind event can strike multiple systems at once: damaging homes and commercial property, disrupting transport and power networks, contaminating coastal waters, harming aquaculture operations and increasing health emergencies. These combined impacts place pressure on public finances and disrupt regional supply chains. Coastal storm surges during the same event further intensified losses, demonstrating how one hazard can cascade through many sectors and undermine diversification on both the underwriting and investment sides of insurers' balance sheets.

Physical risks also create new opportunities for innovation and resilience. The accelerating nature of physical risks is driving demand for solutions that can operate where traditional indemnity products struggle. Parametric insurance is increasingly used to protect vulnerable groups against heatwaves, typhoons and floods, offering rapid pay-outs when conventional coverage is unavailable or unaffordable. Public and private partnerships are emerging to pool climate-related risks, mobilise capital and test new insurance structures that can function in high-exposure environments. Advances in climate data, modelling and analytics are improving insurers' ability to integrate forward-looking physical risk information into underwriting, pricing and reserving decisions.

Sustaining insurability requires changes in how insurers respond to physical risks. New tools are needed to capture their accelerating, interconnected and systemic nature. New partnerships are essential to reduce losses before they occur, especially in regions where physical risks are rising fastest. New products are required to support households, businesses and governments facing mounting climate exposure. As physical risks continue to redefine the boundaries of what can be insured, this analysis calls on industry, governments and academia to work together to confront the realities of a warming world and to ensure that protection remains available for those most exposed.

This paper is the first of a three-part comprehensive assessment of how climate change is placing sustained pressure on the insurance sector. It focuses on physical risks and their implications for insurability. A subsequent paper will examine transition risks arising from technological development, policy change and market dynamics. A final paper will analyse the interplay between physical and transition risks, summarises the implications across both physical and transition risks for actors in the insurance ecosystem, and provide recommendations on strategic actions for private and public sector actors.

Introduction

Physical risks refer to the damages and losses arising from climate-related physical phenomena, including both long-term environmental trends, such as changing weather patterns and rising sea levels, and acute events, such as natural disasters and extreme weather. These risks place direct pressure on insurers' underwriting, pricing, and risk management frameworks by altering the frequency, severity and correlation of losses across regions and lines of business.

The insurance industry has a long history of managing weather- and hazard-related risks. However, climate change is reshaping these hazards in ways that challenge established assumptions. Losses are becoming more correlated, exposure patterns are shifting, and historical data is proving less reliable as a guide to future risk. Together, these developments are testing the limits of traditional approaches and increasing the need for adaptive capacity and innovation.

This paper forms the first part of a structured assessment of climate change and the insurance sector. Its focus is on physical risks and the ways in which they are already reshaping underwriting, pricing, risk management and insurability. A subsequent paper will examine transition risks associated with policy change, technological shifts and evolving market dynamics. A final paper will consolidate the findings from the physical and transition risk assessments, summarise the implications for the insurance ecosystem, and outline considerations for insurers, reinsurers and insurance brokers, alongside regulators and policymakers.

The analysis that follows examines physical risks across five categories, assessing their impacts on ecosystems, human well-being and economic systems, and considering how these effects translate into challenges and opportunities for the insurance industry:

1) Heat
2) Precipitation
3) Wind
4) Cryosphere Change
5) Coastal and Oceanic Changes

Heat

Rising global temperature represents one of the most visible manifestations of climate change. The year 2024 marked the hottest year on record, with average global temperatures reaching 1.55 °C above pre-industrial levels, surpassing the long-term temperature threshold of 1.5 °C set in the Paris Agreement for the first time. The intensification of heat-related risks is driven primarily by four interrelated factors: rising mean air temperatures, the increasing frequency and intensity of extreme heat events, the reduction of frost days, and the shortening of cold spells. These factors mutually reinforce one another, magnifying the overall heat burden.

Urban areas face particularly acute exposure, as dense development and limited vegetation amplify the "urban heat island" effect. Hotter conditions not only heighten wildfire risk but also exacerbate air pollution, thereby compounding systemic stresses on ecosystem, human well-being and the economy. These have significant implications for the insurance industry.

Regional snapshot:

In Hong Kong, 2024 set multiple new records[1], including the highest March temperature and the highest winter maximum. The number of very hot days (≥33 °C) reached 52, compared to a historical average of 17.5. Despite the government giving timely heat-stress warnings and encouraging work breaks of 15 to 45 minutes for outdoor workers[2], a study[3] by the Concern for Grassroots' Livelihood Alliance found 9 in 10 street cleaners still experiencing heat stress. Researchers from the University of Hong Kong estimated an extra 1,677 deaths from the 18 heatwaves between 2014 and 2023 and urged for more efforts to mitigate extreme weather[4].

In Singapore, research under Project HeatSafe[5] found that heat stress reduced annual productivity time by 11.3% in 2018, equivalent to a loss of S$1.18 billion across services, manufacturing, agriculture, and construction. Loss of work hours is projected to rise to 14% by 2035, with an annual loss of S$2.22 billion.

[1] Hong Kong Observatory. (2025). *The Year's Weather – 2024*. Hong Kong Observatory. https://www.hko.gov.hk/en/wxinfo/pastwx/2024/ywx2024.htm

[2] Wong, D. (2024). *Sweltering heat in Hong Kong hits outdoor workers, lower-income residents*. CNA. https://www.channelnewsasia.com/east-asia/hong-kong-weather-heat-stress-observatory-workers-4547981

[3] Ho, K. (2024). *HK heat stress at work system not protecting outdoor workers*. Hong Kong Free Press. http://hongkongfp.com/2024/08/01/hong-kong-urged-to-review-heat-stress-warning-system-as-street-cleaners-show-signs-of-heat-stroke-at-work/

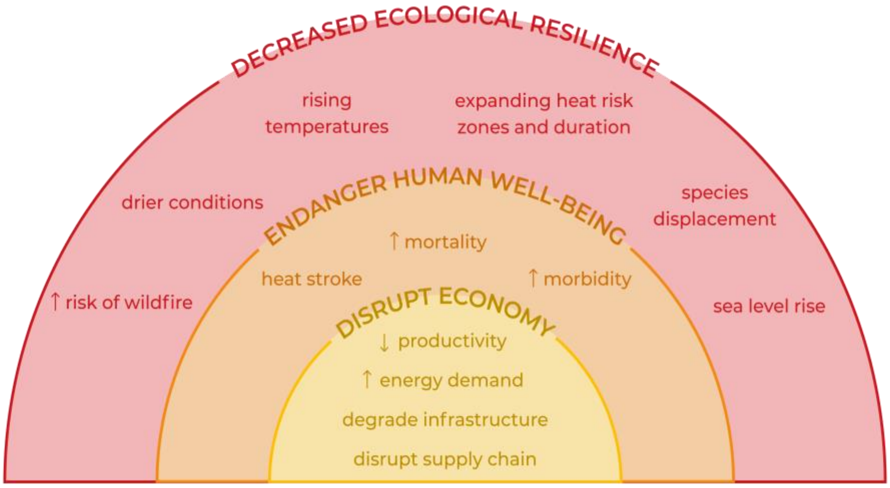
[4] Cheung, E. (2024). *Hong Kong heatwaves may have contributed to 1,677 excess deaths: Study*. South China Morning Post. https://www.scmp.com/news/hong-kong/health-environment/article/3273162/hong-kongs-past-heatwaves-potentially-contributed-1677-excess-deaths-university-study

[5] NUS. (2024). *Heat stress causes lower fertility, productivity and reduced cognitive capacity: Project HeatSafe*. NUS Medicine. https://medicine.nus.edu.sg/news/heat-stress-causes-lower-fertility-productivity-and-reduced-cognitive-capacity-project-heatsafe/

Impact on Ecosystems

As shown in Figure 1, heat stress destabilises ecosystems through multiple channels. In regions where warmer conditions coincide with or lead to drier conditions, both the frequency and severity of wildfires increase, destroying forests and habitats. Many species are forced to migrate to higher altitudes or latitudes, disrupting predator/prey dynamics and weakening food chains. Heatwaves further interfere with pollination cycles, threatening crop yields and biodiversity. Livestock under heat stress exhibit reduced feed intake and diminished fertility, leading to lower productivity and heightened risks to food security. These ecological disruptions are mutually reinforcing, creating feedback loops that erode ecosystems' resilience to climate shocks.

Figure 1. Heat Impacts



Impact on Human Well-being

Extreme heat exerts profound consequences for human health. The human body regulates temperature primarily through perspiration, which has limits. The critical "wet-bulb" temperature was traditionally estimated at 35 °C[6]. However, recent studies suggest thresholds as low as 31 °C[7]-under humid or high-activity conditions, thereby expanding the geographic scope of dangerous heat exposure, particularly in equatorial regions.

Empirical evidence demonstrates the severity of these effects. A global meta-analysis found that each 1° C increase in ambient temperature raises cardiovascular disease-related mortality by 2.1% and illness incidence by 0.5%, with stroke and coronary heart disease

[6] Sherwood, S. C., & Huber, M. (2010). An adaptability limit to climate change due to heat stress. *Proceedings of the National Academy of Sciences*, *107*(21), 9552–9555. https://doi.org/10.1073/pnas.0913352107

[7] Vecellio, D. J., Cottle, R. M., Tony Wolf, S., & Larry Kenney, W. (2023). Critical Environmental Limits for Human Thermoregulation in the Context of a Changing Climate. *Exercise, Sport, & Movement*, *1*(2), e00008. https://doi.org/10.1249/esm.0000000000000008

contributing more greatly to mortality[8]. This has significant implications for health systems and insurance provisions, as even limited warming beyond 1.5 °C is projected to strain medical resources and complicate coverage frameworks. Table 1 below provides additional examples of heat-related impacts in South-east Asia in 2024, summarised by *The Straits Times*.

Table 1: Instances of Heat-Related Impacts in South-east Asia9

Country	Period	Impacts
Laos	May 2024	Lower yield from coffee and vegetable harvest
Indonesia	Jan-Mar 2024	35,500 dengue infections and 290 deaths attributed to increased spread due to heat
Malaysia	Jan-Apr 2024	At least 45 cases of heat-related illnesses
Philippines	Jan-Apr 2024	77 heat-related illnesses with at least 7 deaths
Thailand	Jan- Apr 2024	61 heat-related deaths

Beyond physical morbidity and mortality, prolonged heat exposure contributes to deteriorating mental health, including higher rates of anxiety and depression. In the United Kingdom, suicide risk was twice as high when temperatures increased from 22 °C to 32 °C[10].

These pressures are often compounded by other adverse impacts. Food insecurity, arising from ecosystem disruptions, can exacerbate these risks by generating broader social pressures. For instance, a meta-analysis of 60 primary studies found that a one standard deviation increase in local temperature was associated with a 2.3% rise in interpersonal conflict and a 13.2% rise in intergroup conflict[11]. Bollfrass and Shaver further confirmed positive correlations between rising heat and conflict across both agricultural and non-agricultural regions[12]. These findings underscore the extent to which heat stress undermines not only individual health and well-being but also the collective safety, stability and resilience of human society.

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[8] Liu, J., Varghese, B. M., Hansen, A., Zhang, Y., Driscoll, T., Morgan, G., Dear, K., Gourley, M., Capon, A., & Bi, P. (2022). Heat exposure and cardiovascular health outcomes: A systematic review and meta-analysis. *The Lancet Planetary Health*, 6(6), e484–e495. https://doi.org/10.1016/S2542-5196(22)00117-6

[9] Chin, D., & Begum, R. (2025). Degrees of danger: Beating the heat in South-east Asia. *The Straits Times*. https://www.straitstimes.com/asia/se-asia/degrees-of-danger-beating-the-heat-in-south-east-asia

[10] Boyd, E. H., Leigh, G., & Sutton, J. (2024). *The London Climate Resilience Review*. https://www.london.gov.uk/sites/default/files/2024-07/The_London_Climate_Resillience_Review_July_2024_FA.pdf

[11] Hsiang, S. M., Burke, M., & Miguel, E. (2013). Quantifying the Influence of Climate on Human Conflict. *Science*, *341*(6151), 1235367. https://doi.org/10.1126/science.1235367

[12] Bollfrass, A., & Shaver, A. (2015). The Effects of Temperature on Political Violence: Global Evidence at the Subnational Level. *PLoS ONE*, *10*(5), e0123505. https://doi.org/10.1371/journal.pone.0123505

Impact on Economy

Extreme heat exerts multifaceted pressures on economies. Labour productivity declines significantly in outdoor industries such as agriculture, construction, and mining, reducing both livelihoods and aggregate output. Heat-related illnesses and sickness further constrain workforce participation, leading to job losses, income insecurity, and rising healthcare expenditures. As disposable income falls, aggregate demand weakens, eroding economic resilience.

Heat stress also damages infrastructure, increasing maintenance and replacement costs. Prolonged high temperatures cause roads to buckle, rail lines to warp, and energy grids to overload, resulting in power outages and reduced industrial activity. Governments are compelled to undertake costly adaptation and emergency measures, For instance, during the July 2022 heatwave in China, temperatures above 40 °C melted building roofs and buckled road surfaces in multiple cities, forcing emergency repairs and transport disruptions[13].

Agriculture is especially vulnerable. Reduced crop yields, higher livestock mortality, and water scarcity drive up food prices, depress household purchasing power, and fuel inflation. Although livestock consume less feed under heat stress, the overall effect is lower productivity and diminished supply, threatening food security. These cascading effects, where declining yields lead to reduced affordability, health deterioration, and social unrest, highlight the systemic nature of heat-related risks.

Finally, prolonged exposure to heat risks undermines investor confidence and deters foreign direct investment (FDI). Empirical studies confirm a negative relationship between climate vulnerability and FDI inflows, likely attributed to higher vulnerability from increasing temperatures: temperature increases resulted in reduced FDI in developing countries[14], and higher vulnerability scores correlate with lower investment[15]. Such reductions in capital flows usually create a downward economic spiral, as highly affected regions face declining external investment, slower growth, and weakened resilience.

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[13] Reuters. (2022, July 12). Dozens of Chinese cities on heatwave alert as roofs melt, roads buckle. NDTV. https://www.ndtv.com/world-news/dozens-of-chinese-cities-on-heatwave-alert-as-roofs-melt-roads-buckle-3149635

[14] Barua, S., Ng, A. W., & Upadhyay, A. (2020). Climate change impact on foreign direct investment inflows: A dynamic assessment at the global, regional and economic level. ResearchGate. https://www.researchgate.net/publication/343815626

[15] Shear, F., Ashraf, B., & Butt, H. (2022). Sensing the Heat: Climate Change Vulnerability and Foreign Direct Investment. SSRN. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4272457

Implications for the Insurance Industry

Rising heat risks pose systemic challenges for the insurance industry, undermining its role as a cornerstone of financial stability. As claims become more frequent and severe, affordability declines and risk pools weaken, creating pressure at a time when demand for coverage is rising. GAIP has described this dynamic as the "insurability tipping point"[16].

Health and Life Insurance

Higher incidence of heat-related illness and premature mortality is already increasing health and life claims, especially among the elderly, children, and outdoor workers. Chronic conditions are aggravated by hotter climates, and prolonged exposure contributes to increased incidences of mental health problems, complicating underwriting and benefit design. These trends mean that reliance solely on historical mortality and morbidity data is becoming insufficient, necessitating the integration of forward-looking climate models and stress testing alongside adjustments to pricing and product structures to maintain affordability.

Agricultural Insurance

Reduced crop yields, lower livestock productivity, and water scarcity will increase claims on agricultural insurance. At the same time, volatility in production raises the demand for protection. The sustainability of agricultural coverage calls for innovative models, such as parametric insurance, which can enable faster pay-outs and simplified claims process, as well as strong public–private partnerships to share risks more effectively.

Property and Infrastructure Insurance

Extreme heat damages assets and infrastructure, from roads, railways to energy grids. Because such events often occur simultaneously across multiple regions, insurers face higher aggregated risks and fewer opportunities to diversify geographically. Loss severity may strain reserves and may reduce the availability of coverage in highly exposed areas.

Business Interruption and Liability Insurance

Heat-related productivity losses heighten the risk of business interruption claims, particularly in labour-intensive sectors such as agriculture, construction, and manufacturing. Liability risks are also increasing, as firms may be held accountable for inadequate protection of workers during extreme heat.

[16] Cheng, M. H., Khoo, F., & Lei, Y. (2024). Beyond protection: Steering towards net zero. Global Asia Insurance Partnership. https://www.gaip.global/publications/beyond-protection/

Investment Portfolios

Heat risk also affects the asset side of insurers' balance sheets. Physical risks diminish the value of investments in real estate, infrastructure, and agriculture, while transition pressures reshape the profitability of heat-exposed sectors. As long-term institutional investors, insurers are well placed to direct capital toward adaptation measures and resilient infrastructure, but failure to integrate heat risk into portfolio management could undermine solvency and financial stability.

Systemic Risks

Heat impacts not only increase claims and investment volatility but may also constrain premium growth. In developing markets with already low insurance penetration, protection gaps are driven by a combination of affordability constraints, limited awareness, and insufficient distribution infrastructure. These challenges could be further compounded with slower economic expansion, reduced investment, and declining household purchasing power further erode the customer base for coverage.

Opportunities

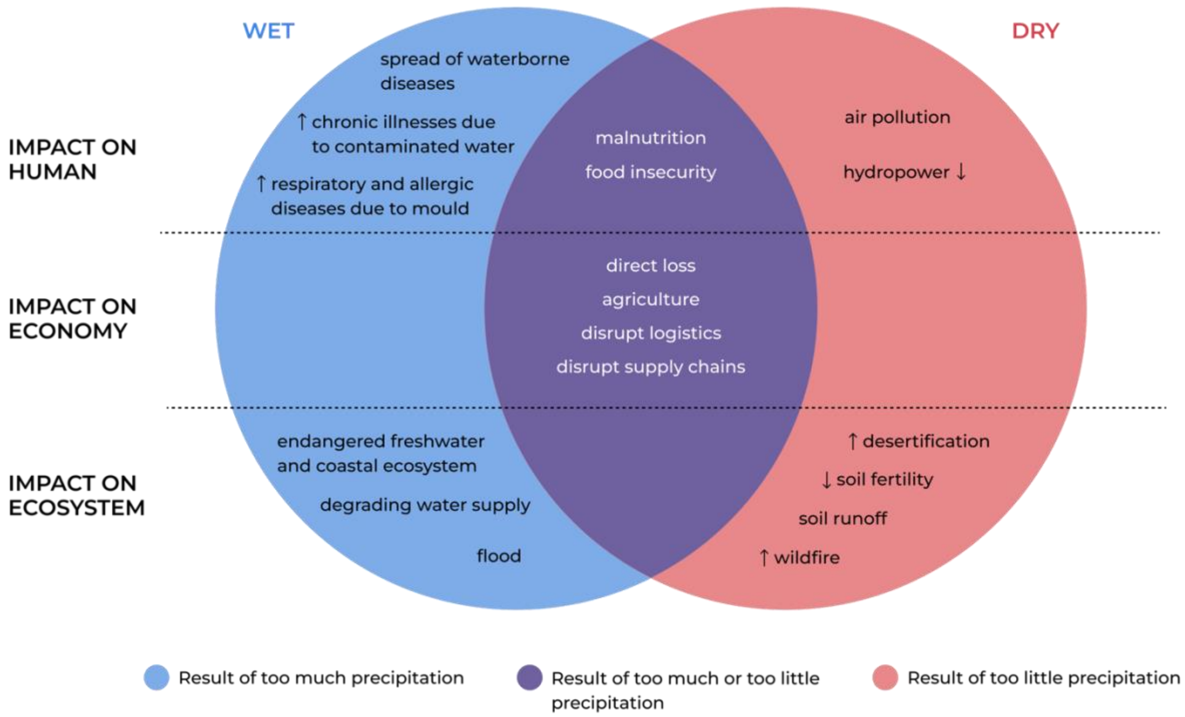
Despite these pressures, the insurance industry has opportunities to play a catalytic role in resilience-building. The Women's Climate Shock Insurance and Livelihoods Initiative (WCSI) is a good example, showing how insurance products can support both financial protection and climate adaptation. Launched in April 2024 by Climate Resilience for All in partnership with SEWA and Swiss Re, WCSI is a pilot parametric heat-index scheme designed to protect informal women workers in India from income loss during extreme heat. For an annual premium of US$1–3, participants receive direct cash transfers equivalent to a day's wages when district temperatures reach 40 °C. During the May 2024 heatwave, pay-outs covered over 42,000 women, representing approximately 92 percent of participants, and all beneficiaries received at least one cash transfer[17]. The program also integrates early warning systems and low-cost protective measures such as shading tarps and cooling boxes. By coupling parametric insurance with complementary adaptation tools, WCSI illustrates the potential for insurers to expand coverage in underserved markets while simultaneously contributing to broader societal resilience under rising heat stress.

[17] Climate Resilience for All. Women's Climate Shock Insurance and Livelihoods Initiative (WCSI). https://www.climateresilience.org/wcsprogram

Precipitation

Precipitation is a critical component of Earth's natural systems. It sustains the global water cycle, provides cooling effects for the environment, and influences air quality. Climate change has significantly altered precipitation patterns worldwide, producing higher mean precipitation and more frequent flooding events in some regions, and prolonged droughts in others. This variability between wet and dry extremes is one of the most consequential impacts of a warming climate. Intense rainfall at one end of the spectrum and severe droughts at the other are becoming increasingly common, generating wide-ranging impacts on ecosystems, human well-being, and economies. These shifts also carry significant implications for the insurance industry. While precipitation occurs in multiple forms, this section focuses on rainfall. Snow and ice will be discussed separately.

Figure 2. Changing Precipitation Impacts



Impact on Ecosystems

Changing precipitation regimes destabilise both terrestrial and aquatic ecosystems. Increased mean precipitation, heavier and more irregular rainfall, degrade soil quality, disrupt carbon and nutrient cycles, and heighten environmental risks. Flooding damages freshwater and coastal ecosystems, accelerates soil erosion, and mobilises long-accumulated pollutants. Conversely, hydrological drought reduces soil fertility, alters vegetation patterns, and raise wildfire risk. Evidence from a global meta-analysis shows that altered intra-annual precipitation patterns reduced plant diversity by 6.3%[18]. Not only do the visible plants change, the underground ecosystems—roots, soil microbes, fungi—also shift, underscoring the destabilising impact ecosystem resilience.

Rainfall is also a vital source of freshwater, sustaining terrestrial and aquatic life. Altered rainfall regimes disturbs plant growth cycles and degrades soil stability. Persistent heavy rainfall or long dry spells reduce soil water retention and increase water repellence, making soils less able to absorb moisture. The surface runoff and erosion further exacerbate the loss of vegetation cover and soil instability, creating feedback loops that magnify ecological deterioration. One such loop is wildfire risk, which is increasingly linked to prolonged drought and altered precipitation.

Impact on Human Well-being

Shifts in precipitation patterns directly affect human well-being through diseases, pollutant exposure, and food and water insecurity. In urban areas, pluvial floods can overwhelm drainage systems, helping the spread of waterborne diseases such as cholera and diarrhoeal infections, particularly among vulnerable communities. In September 2025, Bali, Indonesia suffered an extreme rainfall event of more than 385 millimetres in 24 hours, which carried sewage into water supplies, and raised serious concerns about contamination and disease outbreaks[19].

Floods can also mobilise trace metalloids such as arsenic, which accumulate in soils and waterways. In Bangladesh, surface flooding has been identified as a driver of arsenic contamination in shallow groundwater, with long-term consumption of arsenic-contaminated drinking water linked to arsenicosis (skin lesions), kidney disease, and increased risks of cancers such as skin, bladder, and lung cancer. Combined with mould

[18] Xie, Y., Shi, X., Xu, C., Li, M., Wang, Z., & Yan, Y. (2023). Responses of terrestrial ecosystem productivity and community structure to intra-annual precipitation patterns. Frontiers in Plant Science, 13, 1088202. https://doi.org/10.3389/fpls.2022.1088202

[19] The Guardian. (2025, September 15). Bali battles worst floods in more than a decade. The Guardian. https://www.theguardian.com/environment/2025/sep/15/bali-worst-floods-decade-landslides-rain-india-pakistan-australia

and fungal growth in inundated homes, these toxic exposures compound the health burdens faced by flood-affected communities[20].

Altered precipitation patterns bring about prolonged dry periods. Dry weather, by contrast, heightens the risks of wildfires and water scarcity. Wildfires release hazardous pollutants that degrade air quality and increase long-term health risks. A Canadian population-based study found that individuals living within 50 kilometres of wildfires in the prior 10 years were associated with a 10% higher incidence of brain tumours and a 4.9% higher incidence of lung cancer compared with unexposed populations. The study notes that wildfires release carcinogenic pollutants that contaminate air, water, and terrestrial environment[21].

Droughts further undermine human well-being by reducing access to safe drinking water, irrigation, and sanitation, with cascading consequences for nutrition and public health. In 2022, prolonged droughts in Central Asia, the Yangtze River Basin in China, and the lower reaches of the Ganges and Brahmaputra Rivers in India and Bangladesh lowered crop yields, constrained hydropower generation, and limited water supplies for millions of people[22]. These shortages deepened food insecurity, weakened child nutrition, and increased vulnerability to disease, demonstrating the severe health implications of shifting precipitation regimes.

Impact on Economy

Shifts in precipitation patterns strain economies through both direct damages and indirect costs. Flooding inflicts severe losses on homes, businesses, and infrastructure, while river floods disrupt transport and energy networks, slowing logistics and reducing industrial output. In 2022, unusually intense rainfall in Pakistan caused floods, landslides, and glacial lake outbursts that affected about 33 million people. The disaster damaged 1.7 million hectares of farmland, killed approximately 800,000 livestock, and resulted in US$14.9 billion in damages and US$15.2 billion in economic losses. The World Bank estimated the direct GDP impact to be around 2.2% of FY22 GDP[23].

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[20] Connolly, C. T., Stahl, M. O., DeYoung, B. A., & Bostick, B. C. (2022). Surface flooding as a key driver of groundwater arsenic contamination in Southeast Asia. Environmental Science & Technology, 56(2), 928–937. https://doi.org/10.1021/acs.est.1c05955

[21] Korsiak, J., Pinault, L., Christidis, T., Burnett, R. T., Abrahamowicz, M., & Weichenthal, S. (2022). Long-term exposure to wildfires and cancer incidence in Canada: A population-based observational cohort study. *The Lancet Planetary Health*, 6(5), e400–e409. https://doi.org/10.1016/S2542-5196(22)00067-5

[22] World Meteorological Organization (WMO). (2023b). *State of the Climate in Asia 2022* (p. 36). WMO. https://library.wmo.int/idurl/4/66314

[23] World Bank. (2022, October 28). Pakistan: Flood damages and economic losses over USD 30 billion and reconstruction needs over USD 16 billion – New assessment. https://www.worldbank.org/en/news/press-release/2022/10/28/pakistan-flood-damages-and-economic-losses-over-usd-30-billion-and-reconstruction-needs-over-usd-16-billion-new-assessme

Droughts can be just as disruptive as floods. Agricultural output declines sharply as crop yields fall and livestock perish, driving food price inflation and eroding rural incomes. Energy systems are equally vulnerable. In 2022, a prolonged Yangtze basin drought slashed river inflows and crippled hydropower production. In China's Sichuan Province, where hydropower accounts for about 80% of total electricity supply, output fell by nearly 50%[24]. The power shortage forced widespread factory shutdowns, disrupted supply chains, and led to national economic losses estimated at over 12.3 billion yuan (around US$1.7 billion)[25].

Wildfires are also costly economic events. In January 2025, the Los Angeles area endured massive wildfires that destroyed more than 16,000 structures and burned over 40,000 acres. The economic loss was estimated at US$28 – 53.8 billion, with a regional GDP decline of about US$4.6 -8.9 billion (0.3% - 0.6%)[26]. Such events also disrupt tourism, utilities, and local supply chains, while clean-up and recovery impose further strain on public finances.

These are further compounded by the health impacts of flood- and drought-related illnesses, which increase healthcare expenditure and reduce labour productivity. In many regions, repeated weather extremes impose lasting pressure on public budgets and workforce performance, constraining long-term growth.

Implications for the Insurance Industry

Shifts in precipitation patterns create complex and often simultaneous risks for the insurance industry. Unlike temperature-driven hazards, wet and dry extremes manifest in multiple forms: river floods, pluvial floods, droughts, and landslides, each with distinct implications for underwriting, portfolio management, and long-term market viability. The combined effect is a more volatile claims environment and a growing mismatch between risk-based pricing and insurance affordability.

Health and Life Insurance

Extreme heat is the most direct driver of health-related claims, but precipitation extremes create parallel risks. Flooding increases exposure to infectious diseases, pollutants, and mould-related conditions, while drought-driven wildfires release carcinogenic

[24] Reuters. (2022, August 26). The power crunch in China's Sichuan and why it matters. Reuters. https://www.reuters.com/world/china/power-crunch-chinas-sichuan-why-it-matters-2022-08-26/

[25] Liu, C., Lu, B., Liu, J., Yang, F., Jiang, H., Ma, Z., Liu, Q., Li, J., & Liu, W. (2025). The compound heatwave and drought event in the summer of 2022 and the impacts on the power system in Southwest China. Energies, 18(10), 2424. https://ideas.repec.org/a/gam/jeners/v18y2025i10p2424-d1651777.html

[26] Los Angeles Economic Development Corporation (LAEDC). (2025, February). Impact of 2025 Los Angeles Wildfires. https://laedc.org/wpcms/wp-content/uploads/2025/02/LAEDC-2025-LA-Wildfires-Study.pdf

particulates. These hazards raise mortality and morbidity burdens, complicating long-term actuarial assumptions.

For health insurers, the main difficulty is not repricing but affordability. Climate-related health risks can lead to higher healthcare demand and utilisation, compounding medical inflation, making it harder to design products that remain sustainable for insurers and accessible to policyholders. In this way, climate change multiplies existing cost pressures and widens protection gaps.

Agricultural and Livestock Insurance

Precipitation variability directly affects crop yields, livestock health, and water availability, making agriculture one of the most vulnerable sectors. Extended droughts lead to crop failures and livestock mortality, while floods destroy arable land and contaminate water sources. Both outcomes drive higher claims and increase demand for protection in rural economies. Parametric products provide faster pay-outs, but frequent triggering under more volatile weather conditions raises sustainability concerns unless supported by public subsidies or blended finance arrangements.

Property and Infrastructure Insurance

Extreme weather events concentrate risks in ways that are particularly challenging for insurers. When thousands of homes, businesses, and infrastructure assets are damaged simultaneously, claims accumulate rapidly and test both reserves and reinsurance capacity. Unlike gradual attributional losses, clustered catastrophes create correlation across portfolios that insurers cannot easily diversify away.

The 2025 Los Angeles wildfires illustrate this catastrophic exposure. In their immediate aftermath, 33,717 property, business, and living-expense claims were filed, and insurers disbursed more than USD 6.94 billion to policyholders, with further payments pending[27]. These claims spanned residential, commercial, and auto lines, underscoring how a single event can trigger highly correlated liabilities across multiple classes of insurance. For insurers and reinsurers, the challenge lies in absorbing such concentrated surges without undermining market stability.

[27] California Department of Insurance. (2025, February). Public consumer claims tracker: Wildfire claims paid, Southern California [Press release]. Insurance.ca.gov. https://www.insurance.ca.gov/0400-news/0100-press-releases/2025/release016-2025.cfm

Business Interruption and Liability Insurance

Floods, landslides, and wildfires disrupt supply chains, utilities, and access to markets, triggering business interruption claims across multiple sectors. The 2025 Los Angeles wildfires illustrate this impact: 1,863 businesses employing nearly 9,600 people and generating USD 1.4 billion in annual sales were within the burn areas[28]. Such concentrated shocks generate overlapping claims that sharply increase loss severity for insurers and reinsurers.

Systemic Risks

Shifts in precipitation extremes are accelerating what has been described as an "insurability tipping point". When catastrophic events generate thousands of simultaneous claims across property, business interruption, and liability lines, insurers and reinsurers face highly correlated losses that cannot be diversified away. Even in mature markets, affordability and availability are eroding. In California, State Farm halted new homeowner business in 2023[29] and announced the non-renewal of 72,000 property policies in 2024[30], citing wildfire losses and reinsurance pressures. Such retrenchment highlights how climate-driven clustering of events can undermine the basic premise of risk pooling and deepen protection gaps.

Opportunities

These same pressures are also creating opportunities for structural innovation. Regulatory reforms can stabilise markets by sharing risks more broadly and incentivising insurer participation. In September 2025, California enacted Senate Bill 254[31] as part of a wider whole-of-government climate insurance initiative, directing agencies to develop durable frameworks to expand coverage, improve affordability, and more fairly distribute recovery costs. Such measures demonstrate how public policy can support risk reduction, expand insurance penetration, and employ ex-ante financing to address protection gaps.

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[28] Los Angeles Economic Development Corporation (LAEDC). (2025, February). Impact of 2025 Los Angeles Wildfires. https://laedc.org/wpcms/wp-content/uploads/2025/02/LAEDC-2025-LA-Wildfires-Study.pdf

[29] Reuters. (2023, May 27). State Farm halts new California home insurance policies due to wildfire risks. Reuters. https://www.reuters.com/world/us/state-farm-stops-new-home-insurance-sales-california-wildfire-risks-grow-2023-05-30/

[30] Darmiento, L. (2025, February 26). State Farm says it will pay $7.6 billion for L.A. fires but reinsurance will slash losses. Los Angeles Times. https://www.latimes.com/business/story/2025-02-25/state-farm-says-it-will-pay-7-6-billion-for-l-a-fires-but-reinsurance-will-cut-losses

[31] Office of Governor Gavin Newsom. (2025, September 30). Governor Newsom signs executive order launching next phase of whole-of-government response to the economic and insurance consequences of climate crisis. State of California. https://www.gov.ca.gov/2025/09/30/governor-newsom-signs-executive-order-launching-next-phase-of-whole-of-government-response-to-the-economic-and-insurance-consequences-of-climate-crisis/

Wind

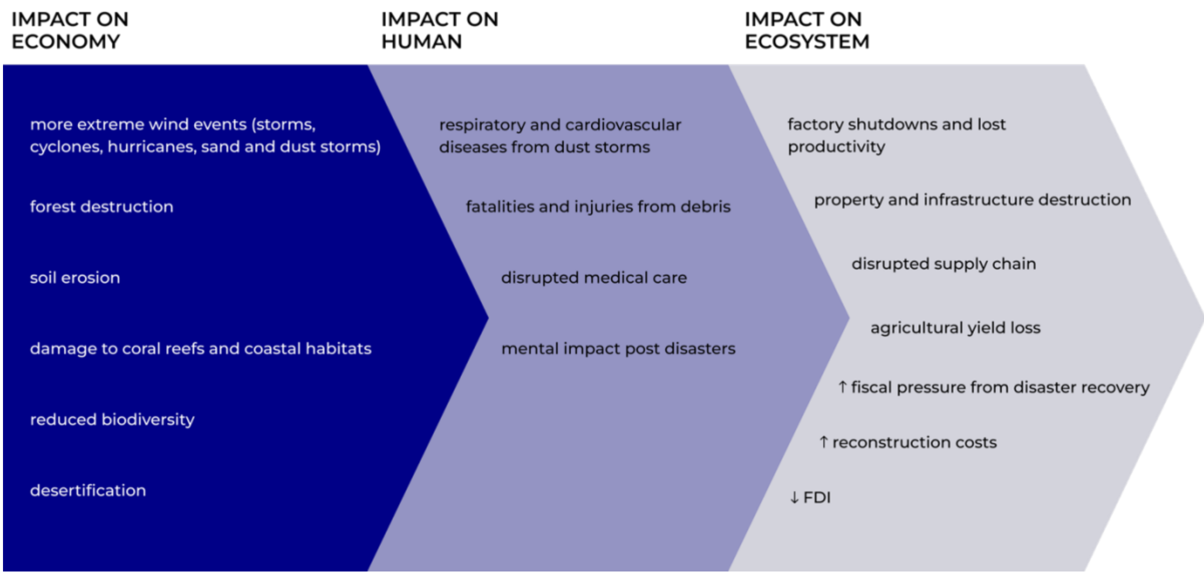
Climate change is reshaping global wind patterns. Windstorms, tropical cyclones, sand and dust storms (SDSs), typhoons, and hurricanes are occurring with greater frequency and intensity than in the past. In addition, shifts in mean wind speed have been observed across regions. These changes are exerting profound effects on ecosystems, human well-being, and the economy, carrying significant implications for the insurance industry.

Impact on Ecosystems

Altered wind regimes affect oceanic, lacustrine, forest and other ecosystems. For instance, salinity levels may shift due to enhanced evaporation or changes in rainfall volume. Reduced mean wind speeds in lakes slow the vertical mixing of surface and deep waters, diminishing nutrient availability and biological productivity, which in turn lowers fish and algae output. Strong windstorms damage forests by uprooting trees, breaking stems, and destroying crops, while tropical cyclones inflict widespread ecological damages.

Wind also influences the dispersal of seeds, pests, diseases, dust, and pollen. Unlike localized storm impacts, these processes occur across wide geographic areas. For example, Saharan dust storms contributed to record glacier loss in the European Alps in 2022[32]. Similarly, sand and dust storms accelerate desertification, compounding the effects of climate change[33].

Figure 3. Wind Impacts



[32] World Meteorological Organization (WMO). (2025). *Sand and dust storms*. World Meteorological Organization. https://wmo.int/topics/sand-and-dust-storms

[33] United Nations Environment Programme (UNEP). (2023a). *As climate changes, sand storms wreak havoc on desert communities*. United Nations Environment Programme (UNEP). https://www.unep.org/news-and-stories/story/climate-changes-sand-storms-wreak-havoc-desert-communities

Impact on Human Well-being

For human communities, the most immediate consequence of intensified wind events is physical hazards. Strong winds can lift and hurl debris, while hurricanes and typhoons devastate entire cities. For example, Typhoon Yagi in 2024 resulted in at least 321 fatalities, over 1,978 injuries, and damage to 237,000 homes in Vietnam alone, with estimated economic losses of VN$81 trillion (≈ US$3.3 billion)[34]. Tropical cyclones combine destructive winds with torrential rainfall, frequently triggering severe flooding (as demonstrated earlier in the precipitation section). In addition, strong winds increase the risk of road-traffic accidents by impairing vehicle control and reducing visibility.

Beyond these direct effects, indirect health impacts are also substantial and well documented. Post-event occurrences like power outages following hurricanes and typhoons can interrupt hospital operations and critical medical treatments such as dialysis, ventilator support, and emergency surgeries, thereby increasing morbidity and mortality[35].

Impact on Economy

Wind-related disasters generate some of the highest economic costs among climate hazards. Between 1980 and 2023, tropical cyclones alone caused an estimated US$2.1 trillion in global losses, of which only 37% was insured[36]. The gap between total and insured losses underscores a large protection gap. Some individual events illustrate the magnitude of economic exposure. Typhoon Doksuri (2023) caused approximately US$25 billion in damages across China, the Philippines, Taiwan, and Vietnam, but only about 8% of that was covered by insurance[37]. Beyond property losses, wind and storm damage also ripple through energy and agricultural sectors. Extreme wind events damage infrastructure, degrade soils, and interrupt supply chains, increasing production costs and reducing output. Moreover, changes in wind patterns affect renewable energy generation: weaker winds reduce wind-power yields, while dust and particulate deposition from storms diminish solar panel efficiency.

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[34] United Nations Office for the Resident Coordinator in Viet Nam. (2024, October). Typhoon Yagi and floods: Situation update no. 5. Retrieved from https://vietnam.un.org/en/281770-viet-nam-typhoon-yagi-office-resident-coordinator-situation-update-no-5

[35] Goldman, A., Eggen, B., & Murray, V. (2014). The health impacts of windstorms: A systematic literature review. Public Health, 128(1), 17–27. https://doi.org/10.1016/j.puhe.2013.09.022

[36] Insurance Journal. (2025, January 27). Insured losses from natural disasters hit $140B as climate change intensifies [Article]. https://www.insurancejournal.com/magazines/mag-features/2025/01/27/809388.htm

[37] South China Morning Post. (2024, January 9). Typhoon Doksuri's 2023 rampage across China leaves US$23 billion shortfall in insurance coverage, Munich Re says. https://www.scmp.com/business/china-business/article/3247753/typhoon-doksuris-2023-rampage-across-china-leaves-us23-billion-shortfall-insurance-coverage-munich

Implications for the Insurance Industry

Wind hazards stand apart from heat and precipitation for their acute and mechanical destructiveness. Unlike slow-onset or hydrological risks, wind events can trigger simultaneous losses across multiple insurance lines, from property and agriculture to health and business interruption. This correlation makes wind a leading driver of catastrophe claims. According to Munich Re's 2024 Natural Disaster Figures[38], tropical cyclones accounted for about 42 % of total global disaster losses in 2024 (US$135 billion of US$320 billion) and 37 % of all insured catastrophe losses (US$52 billion of US$140 billion), making them the largest single contributor to insured losses among all climate risks.

Health and Life Insurance

Similar to heat and precipitation, wind hazards affect both mortality and morbidity. Fatalities and casualties arise from structural collapse and flying debris, while prolonged power outages compromise essential healthcare delivery. Post-storm flooding increases infection and respiratory diseases, and dust storms contribute to chronic respiratory and cardiovascular illness, adding to long-tail morbidity burdens. Health and life insurers must prepare for short-term surges in medical and accidental claims following severe wind events, alongside correlated losses from accidental injuries, accidental deaths, and widespread loss of life that can strain capital reserves. These pressures are particularly acute in emerging markets, where catastrophe mortality models remain limited. Strengthening mortality-shock scenarios, health-disaster coverage provisions, and reserve stress testing will be essential to maintaining solvency under intensifying wind-related risks.

Property and Catastrophe Insurance

Wind-related disasters remain a major source of insured losses, and their impacts are being intensified by climate change. Cyclone Alfred (2025) illustrates this clearly. The storm struck southeast Queensland and northern New South Wales and caused insured losses of about AUS$1.5 billion (approximately US$1 billion), making it one of the costliest cyclones in Australia's history[39]. The scale of damage, together with rising reconstruction costs, has pushed up reinsurance prices and reduced underwriting capacity in wind-exposed property markets. Events such as Alfred show how stronger and more frequent windstorms are reshaping insurance portfolios and testing the long-term insurability of coastal regions.

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[38] Munich Re. (2025, January 9). Natural disaster figures 2024: Weather disasters again dominate – total loss USD 320 billion, insured loss USD 140 billion. Munich Reinsurance Company. https://www.munichre.com/en/company/media-relations/media-information-and-corporate-news/media-information/2025/natural-disaster-figures-2024.html

[39] Insurance Council of Australia. (2025, May 12). 2025 extreme weather costs reach $1.5 billion. https://insurancecouncil.com.au/resource/2025-extreme-weather-costs-reach-1-5-billion/

Agricultural Insurance

Agricultural systems are highly vulnerable to climate variability. Wind hazards add an additional layer of exposure through immediate and mechanical destruction. High-intensity gusts can flatten crops, uproot orchards, and damage irrigation and storage infrastructure within hours, offering little opportunity for immediate mitigation once winds strike. In the Philippines, Severe Tropical Storm Kristine (Trami) in 2024 caused more than PHP 2.1 billion (approximately US$ 36 million) in agricultural losses across 33,913 hectares, damaging over 103,000 metric tons of rice, corn, cassava, and high-value crops and affecting nearly 38,000 farmers[40]. Such events demonstrate how wind-driven extremes can lead to large, sudden claims pressures for insurers and reinsurers in hazard-exposed markets.

Business Interruption and Tourism Insurance

As discussed in the Heat and Precipitation sections, climate change can disrupt supply chains and productivity. Wind hazards amplify these impacts through direct physical damage to critical infrastructure. Cyclones and typhoons can close ports and airports, sever power lines, and disable communication networks, halting commercial operations and tourism almost instantaneously. Quantitative evidence from Hurricane Ian (2022) shows that business-interruption losses linked to power outages were approximately 2.3 times higher than standard modelled BI losses[41].

Systemic Risks

Wind hazards create systemic stress across the insurance value chain. Successive years of severe wind losses have shown how quickly capital strain in one region can reverberate through global reinsurance markets. Tropical cyclones and severe convective storms in 2023 and 2024 accounted for the largest share of insured catastrophe losses globally, and their cumulative impact has weakened profitability across property and reinsurance markets. Major global reinsurers have reported property-catastrophe combined ratios at or above 100% during this period, reflecting underwriting pressure from repeated wind-driven events in North America, Europe, and Asia. The continuation of high wind-related losses into early 2025 has further tested the industry's ability to absorb correlated shocks across portfolios and geographies. For the insurance industry, systemic stress arises when physical catastrophe shocks rapidly translate into financial strain. Large wind events can

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[40] Rappler. (2024, October 28). Bicol's agricultural losses due to Kristine reach over P2 billion. https://www.rappler.com/philippines/luzon/bicol-agricultural-losses-kristine-october-28-2024/

[41] Swiss Re Institute. (2023). Complex supply chains and the amplification of business-interruption losses: Lessons from Hurricane Ian. Swiss Re Ltd. https://www.swissre.com/dam/jcr%3Af6a2a603-8f7c-483e-bab3-8dd9c7aa52e4/swiss-re-institute-expertise-publication-complex-supply-chains.pdf

significantly reduce capital reserves, drive up reinsurance costs, and amplify solvency pressures within tightly connected global markets.

Opportunities

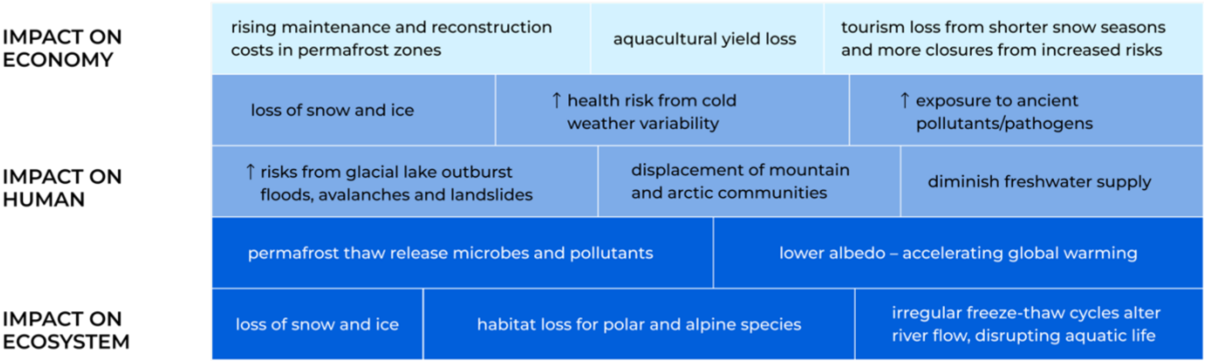
Rising wind losses are prompting the insurance industry to innovate in product design, capital management, and risk sharing. The Caribbean Catastrophe Risk Insurance Facility (CCRIF) offers a leading example. Established through collaboration between regional governments, the World Bank, and the private sector, CCRIF provides parametric coverage for tropical cyclones, delivering rapid, pre-arranged pay-outs within days of an event[42]. This mechanism reduces liquidity stress and supports fiscal resilience, showing how public–private partnerships can manage systemic wind risk more efficiently than post-disaster financing. For private insurers, CCRIF's success illustrates how parametric solutions can complement traditional indemnity coverage by shortening settlement times and improving capital efficiency. The industry is also advancing resilience-linked underwriting, where premium incentives reward wind-resistant construction and stronger building codes. Together, these innovations demonstrate how insurers and reinsurers can move beyond loss compensation toward proactive risk management.

[42] CCRIF SPC. "About Us." CCRIF SPC, accessed October 15, 2025, https://www.ccrif.org/about-us .

Cryosphere Change

The cryosphere, the frozen components of the Earth's system, including glaciers, permafrost (permanently frozen ground in polar and high-altitude regions), and seasonal snowmelt, plays a critical role in regulating the global climate and water cycle. It stores most of the world's freshwater and reflects sunlight through the albedo effect, helping to moderate global temperature. Declining snowfall and glacier retreat are altering river flows, reducing water availability, and threatening habitats and livelihoods. Concentrated in polar and high-mountain regions, these changes have cascading ecological and socioeconomic consequences that extend far beyond their source, posing distinctive challenges and emerging opportunities for the insurance industry.

Figure 4. Cryosphere Change Impacts



Impact on Ecosystems

The rapid loss of snow and ice is transforming ecosystems most visibly in polar and alpine regions, yet its effects are felt worldwide through shifts in temperature, ocean circulation, and atmospheric systems. As reflective snow and ice surfaces shrink, the Earth's albedo declines, allowing more solar energy to be absorbed and accelerating warming. Thawing permafrost releases stored methane, along with contaminants such as mercury and persistent organic pollutants that flow into rivers and lakes, threatening aquatic life. Glacier discharge further alters nutrient balance and light penetration; studies show these changes reduce macronutrients essential for phytoplankton, disrupting food chains from zooplankton to fish and seabirds[43].

[43] Hopwood, M. J., Carroll, D., Dunse, T., Hodson, A., Holding, J. M., Iriarte, J. L., Ribeiro, S., Achterberg, E. P., Cantoni, C., Carlson, D. F., Chierici, M., Clarke, J. S., Cozzi, S., Fransson, A., Juul-Pedersen, T., Winding, M. H. S., & Meire, L. (2020). Review article: How does glacier discharge affect marine biogeochemistry and primary production in the Arctic? The Cryosphere, 14(4), 1347–1383. https://doi.org/10.5194/tc-14-1347-2020

Species used to cold environments face rapid habitat loss and shifting ecological boundaries. Polar bears and walruses are losing sea ice platforms essential for hunting and breeding, while mountain flora and fauna experience range contraction. In alpine regions, ice storms and hailstorms damage forests and accelerate soil erosion, destabilising fragile slopes and degrading mountain catchments. Shorter ice seasons on lakes also encourage algal blooms and deplete oxygen, further undermining biodiversity.

Together, these processes weaken ecosystem resilience and reduce the natural carbon-regulating capacity of snow- and ice-dependent environments. The result is a dangerous feedback loop that amplifies global warming.

Impact on Human Well-being

The loss of snow and ice is intensifying risks to human lives and livelihoods through negative impact on water availability, health, and physical safety. Diminishing snowmelt reduces freshwater for irrigation, hydropower, and domestic use, heightening competition for resources and threatening food security in glacier-fed basins. In South Asia's Indo-Gangetic Plain, meltwater supports food production equivalent to the diets of approximately 38 million people and underpins livelihoods for approximately 129 million farmers[44]. Melting glaciers and permafrost also release pollutants and pathogens long trapped in ice. Persistent organic pollutants (POPs) can be remobilised as ice and permafrost thaw, contaminating aquatic food chains and drinking water, and increasing the risk of cancer and reproductive disorders. Scientists further warn that ancient microbes preserved in permafrost could re-emerge as temperatures rise[45]. Terrain instability adds another dimension of risk. Glacial lake outburst floods (GLOF), avalanches, and landslides threaten mountain communities. In Nepal, the 2024 Thame GLOF displaced 135 people and damaged homes and a hydropower facility[46].

Impact on Economy

The economic effects of snow and ice decline are increasingly visible, especially across hydropower, agriculture, tourism, and infrastructure in Asia's high-mountain regions.

Hydropower faces both short-term gains and long-term risks. Melting glaciers initially increase river flows, boosting energy generation, but once "peak water" (expected

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[44] Biemans, H., Siderius, C., Lutz, A. F., et al. (2019). Importance of snow and glacier meltwater for agriculture on the Indo-Gangetic Plain. Nature Sustainability, 2, 594–601. https://doi.org/10.1038/s41893-019-0305-3

[45] Miner, K. R., Turetsky, M. R., Malina, E., Bartsch, A., Tamminen, J., McGuire, A. D., … Natali, S. M. (2021). Emergent biogeochemical risks from Arctic permafrost degradation. https://doi.org/10.1038/s41558-021-01162-y

[46] National Disaster Risk Reduction and Management Authority (Nepal) & ICIMOD. (2025). Thame Valley Glacial Lake Outburst Flood 2024: Causes, impacts and future risks. Kathmandu: ICIMOD. https://doi.org/10.53055/ICIMOD.1101

between 2030 and 2050 for High Mountain Asia) passes, flows are expected to decline sharply as glaciers retreat[47]. Such events damage turbines, silt reservoirs, and strain public finances as governments divert funds toward repairs and compensation.

Agriculture suffers from erratic water supply and declining soil fertility. Irregular snowmelt and permafrost thaw disrupt irrigation systems, while sand-hail erosion in northern China has reduced winter wheat yields by about 15%[48]. Reduced food output lowers farm income and raises food prices, which can depress insurance affordability and widen rural protection gaps.

Tourism and infrastructure are also at risk. Shorter snow seasons and unstable slopes are shrinking ski seasons and raising avalanche-related liability costs. In 2024, heavy snowstorms during China's Lunar New Year caused nationwide transport disruption, prompting the government to mobilise RMB 141 million (≈US$20 million) for snow removal and emergency repairs[49]. Such an event adds fiscal pressure and highlights the economic volatility linked to cryosphere change.

Implications for the Insurance Industry

The decline of snow and ice introduces a unique challenge for the insurance industry. Compared with other physical hazards, cryosphere change progresses gradually but has long-lasting consequences. It produces both sudden shocks such as avalanches and glacial lake floods and slow stresses caused by permafrost degradation and shifting water regimes. These risks are less immediate than those from heat or wind, yet they can still be equally destabilizing, reducing the value of assets, infrastructure, and impacting livelihoods over time. For insurers, the cryosphere represents an emerging class of correlated, slow-onset risks that fall between traditional catastrophe and chronic loss categories. They require new approaches to modelling, pricing, and capital management.

Health and Life Insurance

Cryosphere change indirectly affects health and life insurers through pollution, disease exposure, and cold-weather variability. Thawing permafrost releases pollutants and dormant pathogens that heighten respiratory and cardiovascular disease risks. Irregular freeze–thaw cycles also contribute to hypothermia and accident-related injuries,

[47] Huss, M., & Hock, R. (2018). Global-Scale Hydrological Response to Future Glacier Mass Loss. Nature Climate Change, 8(2), 135–140. https://doi.org/10.1038/s41558-017-0049-x

[48] Du, J., Hou, L., Zhao, Y., & Zhang, Z. (n.d.). Impacts of Sandstorms on Wheat Yield in Northern China. American Journal of Agricultural Economics, n/a(n/a). https://doi.org/10.1111/ajae.12532

[49] Xinhua. (2024, February 6). China allocates 141 mln yuan to restore highway traffic in provinces hit by snow and freezing rain.https://english.www.gov.cn/news/202402/06/content_WS65c22ffcc6d0868f4e8e3d7b.html

especially in remote areas with limited medical care. These diffuse and data-sparse effects complicate underwriting and claims forecasting. Insurers operating in northern or alpine markets may need to include environmental health indicators in pricing and develop micro-insurance or parametric health products that provide targeted protection in climate-sensitive communities.

Property and Catastrophe Insurance

Property insurers face the most direct implications. Permafrost thaw weakens building foundations and utility networks, while extreme events continue to generate large winter losses. A recent study covering 44 European countries found that winter windstorm damage could rise by around 16 percent in the British Isles, 17 percent in western Europe, and 13 percent in Scandinavia, with severe storms that currently occur once in a century potentially striking every 28 years under high-warming scenarios[50]. This highlights the rising cost of cold-season perils once considered stable. Gradual ground movement and frost damage further blur the distinction between catastrophic and maintenance losses, creating uncertainty in coverage. For reinsurers, these evolving hazards challenge catastrophe modelling and pricing assumptions. Updating exposure data to reflect permafrost stability, snow load, and freeze–thaw variability will be essential to sustain insurability.

Agricultural Insurance

Agricultural insurers are highly exposed to snow and ice dynamics. Although snow- and ice-related hazards have long been part of agricultural insurance, increasing variability is presenting opportunities for developing new products that better reflect farmers' needs. One academic study in Inner Mongolia proposed a snow-index livestock insurance model that links pay-outs to satellite-observed snow depth and duration rather than livestock mortality[51]. Under this proposed model, when snow accumulation exceeds a threshold, herders automatically receive compensation to offset higher fodder costs and maintain animal health before major losses occurred. This concept represents a shift from reactive indemnification to proactive income stabilisation, reducing claim disputes, improving timeliness, and strengthening trust. Researchers noted that such approaches could enhance participation by aligning insurance benefits with farmers' actual cash-flow needs rather than post-disaster recovery.

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[50] Severino, L. G., et al. (2024). Projections and uncertainties of winter windstorm damage in Europe in a changing climate. Natural Hazards and Earth System Sciences, 24(7), 1555–1574. https://nhess.copernicus.org/articles/24/1555/2024/

[51] Ye, T., Li, Y., Gao, Y., Wang, J., & Yi, M. (2017). Designing index-based livestock insurance for managing snow disaster risk in Eastern Inner Mongolia, China. International Journal of Disaster Risk Reduction, 23, 160–168. https://doi.org/10.1016/j.ijdrr.2017.04.013

Tourism and Business Interruption Insurance

Shrinking snow seasons and unstable slopes are reshaping the winter tourism market. Resorts face revenue losses, cancellation claims, and rising liability costs from avalanche and slope-closure incidents. For insurers, the challenge lies in balancing affordability with expanding risk.

Energy and Infrastructure Insurance

Hydropower, pipelines, and transport systems in glacier or permafrost regions face increasing exposure to structural instability and glacial lake outburst floods. Energy insurers must adapt coverage to account for the combined hazards of flooding, sedimentation, and ground collapse, which can damage assets and disrupt operations simultaneously. Incorporating cryosphere data into engineering assessments and encouraging resilience-linked underwriting will help sustain capacity in high-altitude and Arctic markets.

Systemic Risks

Cryosphere change presents an emerging form of slow but correlated systemic risk for the insurance sector. Unlike other hazards where losses occur through discrete events, most cryosphere-related impacts accumulate gradually, reducing diversification and weakening portfolio resilience over time. Permafrost thaw is one of the most significant concerns, damaging transport networks, utilities, and buildings in Arctic and high-mountain regions. A recent study estimates that nearly 70% Arctic infrastructure lies within permafrost zones, with potential repair costs reaching around US$182 billion by 2050[52].

Scientific evidence indicates that these pressures will intensify under current warming trajectories. A study by Stokes et al. (2025) finds that even limiting global warming to 1.5 °C will not halt ice-sheet decline, and that a safer stabilisation threshold may lie nearer to 1.0 °C, beyond which adaptation capacity could be exceeded[53]. This raises the risk of compounding physical and financial losses that could test capital adequacy and push insurers closer to an insurability tipping point, underscoring the need for early integration of cryosphere data into models and greater engagement in adaptation policy.

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[52] Streletskiy, D. A., Anisimov, O. A., Vasiliev, A. A., Shiklomanov, N. I., Kokorev, V. A., & Drozdov, D. S. (2023). The costs of Arctic infrastructure damages due to permafrost degradation. Environmental Research Letters, 18(1), 015006. https://www.researchgate.net/publication/366244977_The_costs_of_arctic_infrastructure_damages_due_to_permafrost_degradation

[53] Stokes, C. R., Bamber, J. L., Dutton, A., & DeConto, R. M. (2025). Warming of +1.5 °C is too high for polar ice sheets. Communications Earth & Environment, 6(1), 1–12. https://doi.org/10.1038/s43247-025-02299-w

Opportunities

For the insurance industry, cryosphere-related risks underscore the need for scalable and cost-efficient mechanisms that can sustain coverage amid rising variability and limited data. Index-based parametric insurance offers a practical solution by linking pay-outs to measurable environmental indicators such as snow depth or temperature anomalies rather than individual loss assessments. This structure improves efficiency, transparency, and speed of payment while reducing administrative costs and moral hazard.

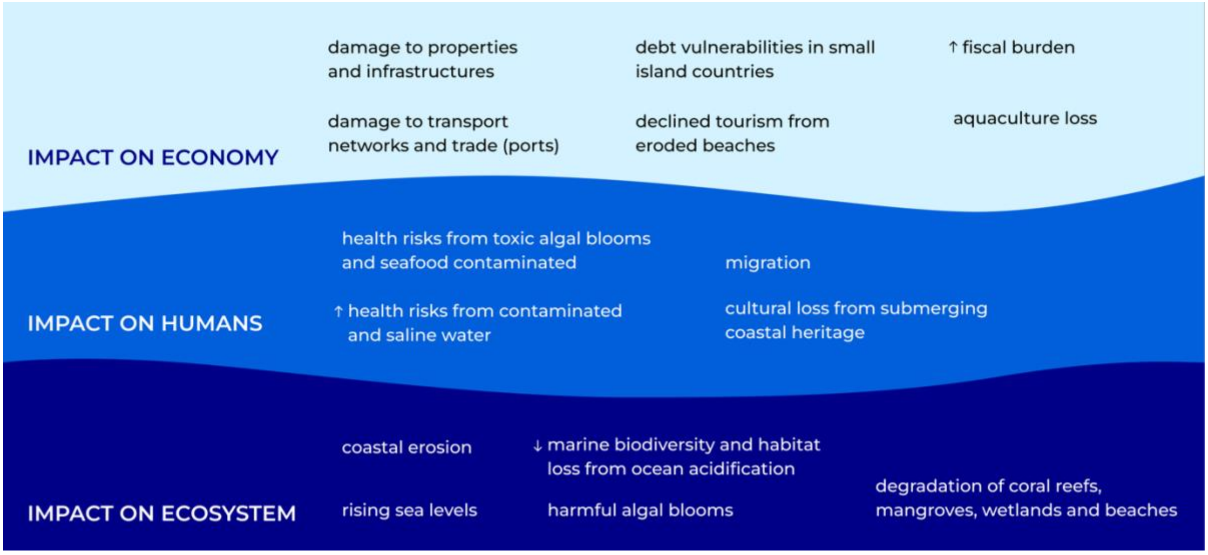
A proposed snow-index livestock insurance concept in Inner Mongolia illustrates the commercial potential of this approach. Under this proposal, utilising satellite-observed snow data, pay-outs will automatically be triggered when accumulation exceeded a preset threshold, providing herders with early liquidity to prevent livestock losses. For insurers, this approach can potentially lower claims-handling expenses, reduced disputes, and improved client retention through faster, objective payments. The model's scalability across regions with similar snow-risk profiles also enhanced portfolio diversification.

As snow and ice variability intensifies, wider adoption of index-based parametric mechanisms can help insurers manage correlated exposures, maintain affordability, and extend coverage to previously underserved regions.

Coastal and Oceanic Changes

Climate change is intensifying coastal and oceanic risks through rising sea levels, more frequent flooding, accelerating coastal erosion, and intensifying marine heatwaves. With many of the world's largest cities and millions of people concentrated along coastlines, the stakes for policymakers and insurers are particularly high. This section examines how these changes affect ecosystems, human well-being, and economies, and considers their implications for the insurance industry.

Figure 5. Coastal and Oceanic Changes Impacts



Impact on Ecosystems

Rising seas are among the most visible and far-reaching manifestations of climate change. Global average sea level has risen by approximately 21–24 centimetres since 1880, with an accelerating speed in recent decades due to thermal expansion and melting of land ice[54]. Sea level rise has reshaped coastlines and degraded marine ecosystems. Natural buffers such as wetlands, mangroves, and coral reefs are deteriorating, reducing their capacity to mitigate storm surges and flooding. Unprotected beaches are also increasingly eroded, threatening coastal infrastructure.

Ocean acidification and warming weaken calcifying organisms that sustain marine food webs. For example: juvenile Limacina helicina antarctica, a sea snail essential to the carbonate cycle, was found to suffer shell dissolution under higher acidity[55]. Harmful algal

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[54] National Oceanic and Atmospheric Administration (NOAA). (2024). Climate Change: Global Sea Level: https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level

[55] Bednaršek, N., Tarling, G. A., Bakker, D. C. E., Fielding, S., Jones, E. M., Venables, H. J., Ward, P., Kuzirian, A., Lézé, B., Feely, R. A., & Murphy, E. J. (2012). Extensive dissolution of live pteropods in the Southern Ocean. *Nature Geoscience*, *5*(12), Article 12. https://doi.org/10.1038/ngeo1635

blooms (HABs) are also becoming more frequent in parts of Asia, releasing toxins that kill fish and damage aquaculture[56] [57].

Impact on Human Well-being

Rising sea levels and intensifying coastal hazards directly threaten human settlements, livelihoods, and public health. A one-meter sea-level rise could displace up to 190 million people globally, with Asia accounting for over two-thirds of those affected[58]. Chronic flooding erodes household assets, contaminates freshwater, and increases exposure to pathogens and chemical pollutants.

As demonstrated in the precipitation section, floodwaters often carry heavy metals, hydrocarbons, and sewage, creating acute health hazards. By contrast, saltwater intrusion has more chronic implications. In deltaic regions such as Bangladesh, prolonged exposure to salinity has been linked to hypertension and adverse pregnancy outcomes[59]. These chronic exposures illustrate how climate-induced oceanic changes intersect with public-health vulnerabilities.

Climate change threatens human seafood safety and nutritional quality. Seafood provides about 17 percent of global animal protein and key nutrients such as omega-3 fatty acids that support cardiovascular and cognitive health[60]. Warmer, more acidic waters increase risks from pathogenic bacteria and biotoxins and intensify the accumulation of toxic metals such as mercury and cadmium in marine organisms. Harmful algal species can produce toxins that persist through cooking and food processing (because many marine biotoxins are heat-stable). These biotoxins, responsible for paralytic and diarrhoeic shellfish poisoning, are difficult to detect, particularly in artisanal fisheries with limited monitoring systems. Such shifts may appear minor but can cumulatively affect populations that rely on seafood as a staple, heightening the risk of nutritional deficiencies and diet-related diseases[61].

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[56] Marques, A., Nunes, M. L., Moore, S. K., & Strom, M. S. (2010). Climate change and seafood safety: Human health implications. *Food Research International*, *43*(7), 1766–1779. https://doi.org/10.1016/j.foodres.2010.02.010

[57] Woods Hole Oceanographic Institution. (n.d.). *Fish Kills*. Harmful Algal Blooms. https://hab.whoi.edu/impacts/impacts-wildlife/fish-kills/

[58] Kulp, S. A., & Strauss, B. H. (2019). New Elevation Data Triple Estimates of Global Vulnerability to Sea-Level Rise and Coastal Flooding. Nature Communications, 10(1), 4844. Available at: https://www.nature.com/articles/s41467-019-12808-z

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Finally, the erosion of cultural and social assets represents a less quantifiable but profound impact. In small-island nations and coastal communities, rising seas threaten not only land and livelihoods but also cultural identity and heritage, weakening community cohesion and long-term resilience.

Impact on Economy

Coastal and oceanic changes are imposing rising economic costs worldwide. Without additional disaster risk reduction measures, global damages from coastal flooding could surpass US$1.3 trillion annually by 2080, directly affecting more than 11 million people each year[62]. Asia, home to most of the world's low-lying megacities, already experiences about US$26.8 billion in coastal flood losses each year. Without stronger adaptation efforts, losses are projected to rise 12- to 27- fold by 2100, reaching US$336.8 billion to US$735.5 billion annually[63].

Ports, transport networks and industrial zones across the region face mounting exposure to sea-level rise and storm surges. Natural defences such as mangroves and coral reefs currently prevent over US$65 billion in property losses each year and protect roughly 15 million people from flooding[64]. Yet these ecosystems are deteriorating due to warming, pollution and human encroachment, reducing both their protective and economic value.

Tourism, a key income source for many coastal economies, is also under strain. Shoreline retreat in Vietnam, Thailand and Indonesia has reduced beach width by up to 20 percent in some areas, cutting visitor numbers and property values[65] [66] [67]. In the Maldives, where tourism contributes more than 30% of GDP, protecting resort islands from inundation could cost more than US$1 billion annually[68].

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Agriculture and aquaculture face similar pressures. In 2024, saltwater intrusion in Vietnam's Mekong Delta destroyed approximately 5,400 hectares of winter–spring rice and severely damaged nearly 28,000 hectares of fruit orchards, while about 87,000 households experienced acute freshwater shortages due to elevated salinity level[69]. Harmful algal blooms have caused repeated losses, including US$290 million in China's Fujian Province and US$53 million in Japan's Yatsushiro Sea[70].

The Singapore Case

Singapore, though less exposed to tropical cyclones, is acutely vulnerable to sea-level rise. About 30 percent of its land lies less than five metres above mean sea level, and coastal flooding already threatens low-lying districts such as Marina East, Changi and Tuas. The government has earmarked S$100 billion (approximately US$74 billion) over the next century for coastal protection measures, including sea walls, polders, and nature-based defences[71]. Such long-term planning highlights the scale of investment required even for a highly urbanised and well-resourced economy.

For small-island and low-lying states, the stakes are existential. The IMF notes that natural disasters in small states often exceed 30% of GDP, with some events, such as Cyclone Pam (2015) reaching 60%[72]. Recurrent shocks deepen debt, reduce creditworthiness, and widen protection gaps, threatening fiscal stability and long-term resilience.

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Implications for the Insurance Industry

Coastal and oceanic changes are reshaping insurance exposure across multiple lines of business. Rising sea levels, recurrent flooding and marine ecosystem degradation are increasing the frequency and severity of claims. Compounding risks such as saltwater intrusion, harmful algal blooms (HABs) and population growth along coastlines make underwriting more complex and threaten the long-term sustainability of risk pools. Conventional models built on historical loss data are becoming less reliable as climatic and oceanic baselines shift.

Life and Health Insurance

For life and health insurers, ocean-driven health risks are emerging through multiple pathways. Flooding heightens immediate injury and mortality risk, while prolonged exposure to contaminated water increases the spread of waterborne diseases and toxic pollutants. Foodborne illnesses linked to contaminated seafood and nutritional losses from declining seafood quality may also raise chronic disease burdens.

These effects are difficult to quantify because they interact with demographic and behavioural factors. As hotter conditions drive more people toward coastal recreation, exposure to marine-borne bacteria such as Vibrio species is increasing[73]. Health insurers need to timely update environmental indicators to better capture these evolving exposures. The Harmful Algae Event Database (HAEDAT), maintained by UNESCO's Intergovernmental Oceanographic Commission, offers a useful example of how scientific monitoring can inform actuarial practice[74]. Integrating real-time environmental indicators such as HAB frequency, water temperature and salinity into underwriting could help insurers anticipate health-related losses and price risks more accurately.

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Data for Analysing HABs

Given that monitoring HABs may give insights into future health claim developments, data availability is very important. Records of HABs that are associated with the different types of conditions can be found in the Harmful Algae Event Database (HAEDAT). An example of the use of this database was seen in Hallegraeff et al.[75] where they found that the perceived global increase in HABs could be attributed to the increase in monitoring efforts. The link to the database is: https://haedat.iode.org/index.php

Property and Catastrophe Insurance

Like previous sections where the other physical risks are linked to floods and extreme weather events, insurance products covering catastrophe, property damages and agricultural yield will see an increase in claims. It is also likely that business interruption claims would be higher in coastal areas where tourism is greatly impacted by rising sea levels and coastal erosion. In events where large damages can greatly set back communities (e.g. severe flooding, storms), the inclusion of "build back better" product features can play an important role in controlling claims for future events by making these communities more resilient for the future.

In the past, insurance companies were able to pool the risk of these large severity events by having insurance portfolios in different regions. However, as the frequency of such events increases and different regions are impacted by climate change in varying ways, it will be important to complement traditional risk transfer through insurance with stronger adaptation and risk reduction measures. Risk pooling remains a fundamental and effective mechanism in insurance as long as the risks in the pool retain sufficient heterogeneity and are not perfectly correlated. While there is limited evidence that coastal and oceanic changes will cause all pooled risks to become positively correlated, the increasing concentration of exposures underscores the need for proactive measures at the preparation, anticipation, and response stages. Demand for coverage is likely to grow as communities become more aware of rising risks, but affordability pressures will need to be addressed alongside these efforts.

[75] Hallegraeff, G. M., Anderson, D. M., Belin, C., Bottein, M.-Y. D., Bresnan, E., Chinain, M., Enevoldsen, H., Iwataki, M., Karlson, B., McKenzie, C. H., Sunesen, I., Pitcher, G. C., Provoost, P., Richardson, A., Schweibold, L., Tester, P. A., Trainer, V. L., Yñiguez, A. T., & Zingone, A. (2021). Perceived global increase in algal blooms is attributable to intensified monitoring and emerging bloom impacts. *Communications Earth & Environment*, *2*(1), 1–10. https://doi.org/10.1038/s43247-021-00178-8

Agriculture and Aquaculture Insurance

Aquaculture and coastal agriculture are increasingly vulnerable but remain underinsured across most of Asia. Rising sea temperatures, salinity intrusion and HABs have caused recurrent stock mortality, particularly among small-scale fishers and shrimp farmers. The Food and Agriculture Organization (FAO) reports that aquaculture insurance schemes in Japan, the Philippines and Vietnam are often supported by government subsidies and delivered through Public-Private Partnerships. However, the overall coverage remains limited[76].

Systemic Risks

Coastal and oceanic changes are amplifying systemic risk across the insurance sector. Like other physical risk drivers, they generate correlated, multi-sector impacts that cut across property, health and agriculture lines, blurring traditional portfolio boundaries. As with heat and precipitation extremes, rising seas and marine heatwaves increase both the frequency and severity of loss events. As with wind hazards, they magnify the intensity of cyclones and storm surges, producing large correlated losses across multiple insurance classes. And as with cryosphere change, they trigger cascading effects: flooding, salinisation and ecosystem collapse, that simultaneously disrupt livelihoods, infrastructure and food systems.

What makes coastal and oceanic changes distinct, however, is their slow-onset and irreversible nature, which steadily reshapes both the geography of exposure and the baseline frequency of loss. Sea-level rise and permanent coastal erosion shift where people and assets can exist, while elevated sea surfaces and warmer oceans mean storm surges and extreme winds now reach further inland. This combination erodes the two foundations of insurance—predictability and diversification.

When hazard frequency rises and asset geography contracts, losses become less random and more correlated. A single tropical cyclone or coastal flood can trigger property, business, health and life claims simultaneously, stretching capital reserves and reinsurance capacity. As multiple basins, such as the Western Pacific and Indian Ocean, experience concurrent extremes, the effectiveness of diversification across regions diminishes. In contrast to wind or precipitation hazards, which remain episodic, coastal and oceanic change represents a permanent upward drift in baseline losses. Insurers are no longer only

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pricing higher risks. They are operating in a world where the spatial and temporal foundations of risk are shifting.

Opportunities

Coastal and oceanic risks also present opportunities for insurers to move upstream in the risk cycle, investing early and working actively with policyholders to mitigate losses before they occur. By integrating risk analytics, advisory services and financing mechanisms, insurers can become partners in resilience rather than payers of recovery. This approach is particularly valuable in coastal regions where prevention can yield measurable savings: every dollar invested in flood resilience can save up to four dollars in avoided losses[77].

Second Order Effects: Credit, Mortgages and the Public Sector

Beyond the direct impacts on insurance lines, physical risks generate significant second order effects that ripple through the broader financial system and burden public sector finances. As regions become more difficult or expensive to insure due to intensifying physical hazards, the implications extend well beyond premium increases.

Credit markets are increasingly sensitive to physical risk exposure. Lenders recognise that properties in high-risk areas may face declining values if insurance becomes unaffordable or unavailable. This creates a feedback loop: as insurance retreats, mortgage lending conditions tighten, property values decline, and collateral quality deteriorates. In Thailand, for example, a World Bank and Bank of Thailand study found that 41% of corporate lending by banks is located in districts with high riverine flood risk, underscoring the sector's exposure to climate-related credit losses[78]. Homeowners in affected areas may find themselves unable to refinance, sell, or maintain adequate coverage, deepening financial vulnerability at the household level.

The retreat of private insurance capacity increasingly shifts risk to the public sector. Governments are often required to step in as insurers of last resort, establish residual market mechanisms, or fund post-disaster recovery directly from public budgets. This burden is particularly acute in Southeast Asia, where in middle and low-income

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[78] World Bank, "Assessing and managing natural disaster risks for the financial sector in Thailand," 2024, https://www.financialprotectionforum.org/blog/assessing-and-managing-natural-disaster-risks-financial-sector-thailand

nations, 90% disaster losses are uninsured [79]. As physical risks intensify, the pressure on public finances compounds, potentially crowding out other essential public investments in infrastructure, education and healthcare.

Alternative financing solutions are emerging to address these challenges. The Philippines has pioneered the first sovereign catastrophe bond in Southeast Asia, a US$225 million instrument issued by the World Bank providing protection against earthquake and tropical cyclone risks[80]. This mechanism could bridge the gap between commercial viability and social need, while the development of resilience bonds and other innovative instruments offers pathways for spreading risk more broadly across capital markets and providing pre-arranged financing for recovery. More opportunities like this would be covered in the last paper of this series.

[79] SEADRIF, "The SEADRIF Initiative," https://seadrif.org/

[80] Guy Carpenter, "Natural Catastrophe Protection Gap in Asia Calls for Collaborative Innovation," 2022, https://www.guycarp.com/insights/2022/07/natural-catastrophe-protection-gap-in-asia-calls-for-collaborative-innovation.html

Conclusion

Physical risks, including heat, precipitation, wind, cryosphere change and coastal and oceanic change, are interlinked dimensions of climate change. Their impacts are no longer episodic or easily contained. They could be systemic, correlated, and compounding. In the absence of sustained adaptation and mitigation efforts, they have the potential to become systemic, correlated, and compounding. While many diversified insurers currently manage these risks within existing frameworks, the trend toward greater frequency and severity underscores the importance of proactive action.

Heat is the most pervasive and rapidly intensifying hazard, marked by record-breaking temperatures and longer heatwaves. Its most direct impacts on insurance are rising health and life claims, higher mortality among vulnerable groups and productivity losses that increase business interruption exposures. Precipitation extremes, from floods to droughts, exemplify volatility, producing highly correlated, multi-peril losses across property, agriculture and liability lines. Insurers face mounting solvency pressures as traditional models struggle to capture compounding wet-and-dry dynamics. Wind hazards stand out for their acute destructiveness and their global transmission through reinsurance markets, with successive typhoons and cyclones eroding capital buffers and profitability. Cryosphere change represents a slow onset yet cumulative risk, undermining infrastructure stability, energy reliability and winter tourism. Permafrost thaw and irregular freeze–thaw cycles blur the line between maintenance and catastrophe losses. Coastal and oceanic changes are unique for their permanence. Rising seas, erosion and marine heatwaves are steadily reshaping the geography of exposure and generating correlated losses across property, health and aquaculture lines, weakening diversification across insurance portfolios.

Across these five risk categories, common patterns emerge. Physical risks are becoming systemic rather than isolated: single events increasingly trigger simultaneous losses across multiple insurance lines. Each peril also erodes natural buffers such as forests, soils, ice and reefs that once moderated disaster intensity. For insurers, this convergence translates into more correlated portfolios, shrinking diversification benefits and heightened claims volatility.

Yet these same forces open space for innovation and partnership. The insurance sector can play a catalytic role in loss prevention and resilience-building, as highlighted in the coastal and oceanic section, where insurers are working proactively with policyholders to reduce future losses. Tailored, inclusive products, such as the Women's Climate Shock

Insurance and Livelihoods Initiative (WCSI), demonstrate how insurance can reach vulnerable groups and provide rapid relief during extreme heat. Index-based parametric mechanisms, like the proposed snow-index livestock insurance model in Inner Mongolia, have the potential to offer efficient, data-driven protection for herders by linking pay-outs to measurable environmental indicators. Public–private partnerships (PPPs) such as the Caribbean Catastrophe Risk Insurance Facility (CCRIF) show how pre-arranged, parametric coverage can stabilise fiscal systems and reduce reinsurance dependence. The California Climate Insurance Initiative underscores the role of regulatory frameworks and blended finance in sustaining affordability and market participation in high-risk regions. Finally, the growing use of forward-looking data and environmental indicators in underwriting and actuarial pricing, rather than reliance on historical data, will be essential to strengthen solvency and adaptability.

The overall picture that emerges is that climate-driven physical risks are no longer future projections but present realities. They place sustained pressure on the insurance mechanisms and outcomes. Sustaining insurability in the coming decades will depend on integrating science, finance, policy making, and cooperation among governments, businesses and communities. This paper contributes the physical risk dimension of a broader climate assessment of the insurance sector. The appendix to this paper provides a structured summary of these physical risk impacts across insurance market segments.

The next paper will examine transition risks, focusing on how policy change, technological developments and market dynamics test existing insurance business model. A final paper will bring physical and transition risks together, assess their combined implications across the insurance ecosystem and outline the strategic actions required to respond. Together, the three papers aim to equip insurers, regulators and policymakers with a coherent perspective on how climate change is testing existing insurance arrangements and the actions required to respond effectively.

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Appendix: Physical Risk Impact Tables

The following tables summarise the anticipated physical risk implications for the insurance sector, structured by market segment. These tables are also appear in the third paper of this series, on integrated physical and transition risks.

Table A1: Life & Health Insurance — Physical Risk Impacts on Revenue and Expenses

Category	Physical Risk Impacts
Revenue	**Life insurance:** Rising mortality and morbidity from heat stress, extreme weather events, and shifting disease patterns can increase demand for life cover. However, income disruption from climate-related losses can erode premium affordability, particularly among lower-income policyholders. **Health insurance:** Higher incidence of heat-related illness, respiratory conditions, and vector-borne disease elevates utilisation of health insurance and raises demand for coverage. As medical costs rise alongside broader economic disruption, affordability constraints intensify.
Expenses	**Underwriting:** Climate-adjusted data — heat indices, disaster exposure maps — must be integrated into pricing. Premium loadings require more frequent revision as risk profiles shift. **Claims and reinsurance:** Physical risks directly affect mortality and morbidity through disasters and worsening health conditions. Earlier and larger claims raise cession volumes and reinsurance costs.

Table A2: Property & Casualty Insurance — Physical Risk Impacts on Revenue and Expenses

Category	Physical Risk Impacts
Revenue	**Property insurance:** Rising flood, storm, and wildfire risk intensifies demand for property cover. However, in areas of highest physical risk concentration, insurers face growing pressure to withdraw from the market, eliminating revenue streams while widening the protection gap for households and small businesses. **Catastrophe insurance:** Greater awareness of protection gaps — by governments, corporates, and individuals — drives demand for catastrophe cover and parametric triggers. Where physical risks reach insurability tipping points, coverage withdrawal creates hard limits on premium growth. **Agriculture insurance:** Changing temperature and precipitation patterns raise crop yield volatility, increasing demand for agricultural and livestock cover across the food supply chain. **New parametric products:** Climate-linked parametric triggers (extreme heat, rainfall index) create new revenue opportunities, particularly in markets underserved by indemnity products.
Expenses	**Underwriting and claims:** Higher frequency and severity raise loss ratios across property, agriculture, and cat lines. Adverse selection worsens as high-risk customers seek cover; more granular segmentation is needed to price accurately. **Reinsurance:** Increasing peak exposures drive greater cession volumes. Reinsurers responding to their own loss experience raise rates, compressing primary insurers' underwriting margins.

Table A3: Insurance Brokers — Physical Risk Impacts on Revenue and Expenses

Category	Physical Risk Impacts
Revenue	**Commission revenue:** Greater demand for tailored and affordable coverage — driven by rising physical risk awareness — increases client engagement and commission income, especially for brokers offering a wide product range.
Expenses	**Data and communications:** Insurers require more granular client risk data for underwriting. Rising claim frequency also adds submission, follow-up, and case management workload. **Distribution:** New climate-linked products (parametric, micro-insurance) require additional distribution effort and client education to reach end users effectively.

Table A4: Reinsurance Market — Physical Risk Impacts on Revenue and Expenses

Category	Physical Risk Impacts
Revenue	**Reinsurance premiums (L&H and P&C):** Higher cession volumes from primary insurers across both life/health and property/casualty lines as physical risks escalate. Reinsurers can command higher rates for peak exposures, supporting revenue growth in hard market conditions. **Parametric and new products:** Primary insurers cede larger initial shares of innovative climate products. Reinsurers willing to take early positions can earn premium margins, while gaining proprietary loss data. **Investment returns:** Physical risk-linked damage to real estate and business disruption can weigh on investment returns from property and equity holdings.
Expenses	**L&H underwriting and claims:** Sustained mortality and morbidity deterioration from chronic physical risks generates persistent cession pressure. Large events (disasters, pandemics) require rapid and high-volume claims processing. **P&C underwriting and claims:** Catastrophe, property, and agriculture lines face surging loss ratios. More granular climate and flood data is needed for accurate risk stratification at the reinsurance level.

Table A5: Supervisory, Fiscal & Macroeconomic, and Social Protection — Physical Risk Impacts

Category	Physical Risk Impacts
Prudential Supervisory	**Solvency and capital:** More frequent and severe climate losses drive higher and more volatile claims, straining insurers' capital buffers. Greater loss uncertainty makes traditional capital models less reliable, requiring higher reserve requirements over time. **Reinsurance market tightening:** As global reinsurance capacity tightens and coverage becomes more restrictive, primary insurers retain more risk on their own balance sheets. This amplifies net loss volatility and widens protection gaps domestically.
Fiscal & Macroeconomic	**Productivity and GDP:** Extreme heat, flooding, and chronic weather disruption lower labour productivity and business output, contributing to slower or more volatile economic growth. **Fiscal pressures:** Disaster response and resilient infrastructure investment compete with other budget priorities, compressing fiscal space available for adaptation. **Supply chain and infrastructure:** Damage to transport networks, utilities, and logistics hubs raises operating costs and constrains economic output across affected regions. **Social vulnerability:** Uninsured losses disproportionately affect lower-income groups, increasing demand for social support and widening economic inequality.
Social Protection	**Protection gap:** More frequent and severe climate events widen uninsured losses, increasing reliance on government support and raising long-term pressure on public budgets. **Public health:** Chronic heat, air pollution, and climate-related disease outbreaks raise healthcare demand and pressure public health systems.

	Social equity: Physical climate impacts concentrate in vulnerable communities, amplifying spatial and income disparities and increasing the need for targeted protection.