Becoming Evolvers Rather than Forecasters Alone: Climate Risk and the Future of Actuarial Risk Management

Syed Danish Ali, CSPA

WHEN FORECASTING BECOMES A LIABILITY

Actuarial risk management has long been built around forecasting. We estimate frequencies, severities, correlations, and trends, then translate those estimates into pricing, capital, and governance decisions. This approach works when the future behaves broadly like the past. Climate change disrupts that bargain. The problem is not that forecasts are wrong. The problem is that the conditions under which forecasting remains useful are quietly eroding.

Climate risk introduces non-stationarity in its most practical form. Hazard distributions shift. Exposure migrates. Vulnerability evolves as households, firms, and governments respond unevenly. When actuaries rely on historical calibration as the primary anchor, they assume that the system generating losses is stable enough for extrapolation. Under climate change, that assumption fails gradually rather than dramatically. The danger is not model collapse, but misplaced confidence delivered with precise-looking outputs.

Climate change also occupies an uncomfortable time horizon. It is not distant enough to dismiss with the argument that long-run uncertainty makes action futile. Nor is it so immediate that it forces a crisis-driven response. It unfolds in a Goldilocks risk zone: slow, compounding, and accelerating just fast enough to matter within institutional planning cycles. This is precisely the terrain actuaries are trained to manage. Insurance liabilities, pension promises, and asset strategies already operate on horizons where small misalignments accumulate into material outcomes.

Yet many risk frameworks still treat climate as an incremental adjustment rather than a structural shift. A new scenario is appended. A sensitivity is run. The core architecture of forecasting remains unchanged. What results is the appearance of diligence without corresponding adaptability. Forecasting precision is preserved even as the underlying system evolves between observation points.

This tendency is reinforced by institutional incentives. Narrow ranges feel professional. Clean estimates feel controllable. In a climate context, however, precision can become a liability. Highly refined forecasts built on fragile assumptions crowd out alternative views and delay escalation. When the world moves faster than the data, the most statistically elegant estimate is often the least useful input for decision-making.

Climate risk behaves less like a shock to be measured and more like a process that unfolds. Drought alters land use. Land use reshapes flood severity. Flood losses trigger insurer withdrawal. Withdrawal changes behavior, asset values, and political responses. By the time these dynamics appear in loss data or balance sheets, the window for proactive adjustment has narrowed. Forecasts lag not because actuaries are slow, but because the system itself is evolving between forecasts.

Forecasting remains necessary. It is no longer sufficient. Under climate change, the dominant failure mode of risk management is not miscalculation. It is delayed adaptation. Institutions optimize prediction quality when they should be optimizing for learning speed. Becoming evolvers rather than forecasters alone starts by recognizing when the distribution itself is becoming unstable and acting before statistical certainty arrives.

CLIMATE RISK AS A LIVING SYSTEM, NOT A SHOCK

Traditional actuarial frameworks tend to treat risk as additive. A peril is identified, modeled, priced, and capitalized. Climate risk resists this structure because it is rarely isolated. It interacts across underwriting risk, reserving risk, asset risk, operational risk, and governance risk. More importantly, these interactions are not linear. They feed back into one another.

Consider flood risk. The hazard may increase gradually, but exposure can grow rapidly as development follows perceived protection. Flood defenses reduce frequent losses, encouraging higher density and higher asset values in vulnerable areas. When defenses fail, severity explodes. The loss is not merely the sum of water damage. It includes disrupted supply chains, insurer retreat, litigation, and long-term depreciation of local assets. What appears as a single peril is, in reality, a system of reinforcing effects.

This pattern repeats elsewhere. In wildfire-prone regions, climate conditions increase ignition and spread. Losses rise, but the more destabilizing effect is insurer withdrawal. As coverage becomes unavailable or unaffordable, property values decline, mortgage risk increases, and public entities face pressure to act as insurers of last resort. Climate risk migrates from underwriting portfolios into credit risk, municipal finance, and social stability. Treating wildfire purely as a catastrophe modeling problem misses the broader transformation underway.

Pension systems face similar dynamics, albeit less visibly. Heatwaves affect mortality and morbidity unevenly across populations. Urban heat islands, occupational exposure, and income disparities create divergence within cohorts traditionally modeled as homogeneous. At the same time, asset portfolios are exposed to physical risk, transition risk, and policy responses that evolve faster than actuarial assumptions. The result is not a single shock, but persistent erosion of the assumptions underpinning funding adequacy.

These dynamics are characteristic of complex adaptive systems. Small changes accumulate. Feedback loops dominate outcomes. Interventions produce second-order effects that often outweigh the initial impact. Interactions matter. Complexity science, network theory, and agent-based thinking offer useful lenses, not to replace actuarial models, but to contextualize them. Climate risk is less about estimating an expected loss and more about understanding how behavior, incentives, and constraints reshape loss pathways over time.

Short illustrations make this clear. Agricultural insurance pricing may lag shifting rainfall patterns, encouraging planting decisions that amplify future losses. Energy transition policies may strand assets unevenly, creating correlated shocks across sectors previously treated as diversified. Flood events such as the Texas Hill Country 2025 floods show how drought, land use, and extreme rainfall interact to overwhelm assumptions embedded in static maps and return periods. In each case, the hazard matters, but the system response matters more.

Recognizing climate risk as a living system changes the role of actuarial risk management. The objective shifts from measuring isolated shocks to monitoring evolving patterns. Divergence between models becomes informative rather than inconvenient. Qualitative signals, governance strain, and behavioral responses become early indicators rather than afterthoughts.

WHAT ORSA, CAPITAL, AND GOVERNANCE SWEEP UNDER THE RUG

Most ORSA frameworks were built for risks that behave politely. They assume identifiable drivers, stable relationships, and management actions that can be planned and executed within familiar timeframes. Climate risk breaks those assumptions quietly. It does not arrive as a new risk category. It seeps into existing ones and changes how they behave.

In many insurers, climate risk appears in ORSA as a scenario exercise. A severe flood. A major wildfire season. A heatwave stress. These exercises are useful, but they are often treated as peripheral. The core capital assessment remains anchored to business-as-usual projections with modest overlays. This creates a structural mismatch. ORSA describes resilience while the balance sheet remains optimized for a different world.

The deeper challenge is that ORSA is still framed around forecast confidence rather than adaptation capacity. Climate risk demands the opposite. The question is no longer whether a specific scenario will occur, but whether the institution can recognize when its assumptions are breaking and respond before losses compound. That is a governance problem as much as a modeling one.

Capital adequacy under climate risk cannot be reduced to a single number. Climate-driven losses are often path-dependent. Early decisions change later outcomes. An insurer that exits a market too late absorbs concentrated losses. One that exits too early may create reputational and regulatory risk that damages franchise value. Capital planning therefore needs to incorporate decision timing, not just loss magnitude.

This is where ORSA can evolve from compliance artifact to living framework. Instead of asking whether capital is sufficient under predefined scenarios, ORSA should ask how quickly management can change course when conditions deviate from expectations. How fast can underwriting guidelines be revised? How quickly can pricing assumptions adjust without destabilizing the portfolio? How rapidly can asset allocations respond when climate correlations spike?

From a technical standpoint, this argues for a layered approach. Traditional stochastic and deterministic models remain essential, but they should be complemented by qualitative profiling and model pluralism. Divergence across models should not be averaged away. It should be tracked. When different methods begin failing differently, that divergence is often an early warning that the system is changing faster than the data.

Capital buffers should reflect this asymmetry. Climate risk is not symmetric around the mean. Upside surprises are limited. Downside surprises are not. This supports a bias toward resilience capital rather than efficiency capital and challenges the instinct to calibrate capital purely to historical volatility when the structure of volatility itself is evolving.

For pensions and asset-intensive institutions, the same logic applies. Longevity assumptions interact with heat stress, air quality, and healthcare capacity in nonlinear ways. Asset valuations embed climate exposure through supply chains, regulation, and consumer behavior long before defaults appear in financial statements. Risk management that waits for quantitative confirmation will consistently act late.

FROM BETTER MODELS TO BETTER EVOLVERS

Climate risk exposes a quiet weakness in how risk management has been practiced for decades. Most actuarial systems are designed to improve forecast accuracy within a stable structure. Climate change breaks the structure itself. When the underlying system is shifting, better calibration of yesterday's relationships does not produce better decisions tomorrow.

This is where becoming evolvers rather than forecasters matters. Forecasting assumes that the future is a variation of the past. Evolving assumes that the rules may change and prepares the institution to recognize and respond when they do.

Quantitative models remain essential, but no single model or class of models can claim authority under climate uncertainty. Frequency severity models, catastrophe simulations, climate-adjusted GLMs, machine learning approaches, and scenario analyses all capture different fragments of reality. The danger lies not in using imperfect models, but in mistaking any one of them for the system itself.

Model pluralism should therefore be deliberate. Different methods should be run in parallel, not to be averaged into a single answer, but to observe where and how they disagree. When multiple models begin to diverge in their implications, that divergence is information. It often signals regime change, emerging feedback loops, or shifts in exposure that are not yet fully visible in the data.

This is where qualitative methods stop being optional. Complexity science teaches that large system changes often emerge from small, localized interactions. Climate risk operates through these mechanisms. A drought alters migration patterns. Migration strains urban infrastructure. Infrastructure stress amplifies mortality and morbidity. Insurance losses appear last, not first. Quantitative data usually arrives after the causal chain is already underway.

This tension is especially visible in reserving. Traditional reserving practice often rewards stability of point estimates, which can quietly convert specific uncertainty into hidden systematic risk. We can frame this as a simple but uncomfortable question: are we reducing volatility in normal periods only to manufacture fat tails in stress? Bayesian machine learning offers a practical alternative. By treating reserve estimates as evolving probability distributions rather than fixed numbers, Bayesian approaches force uncertainty onto the surface instead of sweeping it under the rug. In a climate-stressed world, where reporting lags, development patterns, and tail behavior shift together, reserving needs to adapt in the same way as pricing and capital models: by explicitly modeling uncertainty, not minimizing its appearance.

Qualitative profiling helps actuaries map these chains early. This includes structured expert judgment, behavioral analysis, governance review, and sociological insight into how policyholders, regulators, and markets respond under stress. These inputs do not replace models. They guide where models should be stressed, where assumptions should be loosened, and where blind spots may exist.

Agent based modeling and network theory provide bridges between the quantitative and qualitative worlds. They allow actuaries to explore how individual behaviors aggregate into systemic outcomes without assuming equilibrium. In climate risk, equilibrium is often the wrong assumption. Feedback dominates. Delays matter. Nonlinear thresholds exist.

Game theory also has a role. Climate adaptation decisions are rarely taken in isolation. Insurers respond to competitors. Governments respond to voters. Policyholders respond to incentives. Modeling climate risk without considering strategic interaction risks producing technically elegant but operationally irrelevant results.

A practical example appears in underwriting cycles. Climate losses tighten markets. Tight markets alter behavior. Altered behavior reshapes risk pools. These dynamics cannot be captured by static capital models alone. They require iterative thinking that blends numbers with narrative.

The goal of this broader approach is not precision. It is preparedness. Institutions that evolve well are not those that predict losses most accurately, but those that detect when their assumptions no longer hold and adjust before losses compound. Climate risk management rewards humility, curiosity, and adaptability more than confidence in any single technique.

RISK MANAGEMENT WHERE THE SYSTEM IS ALREADY MOVING

Climate risk does not arrive through one channel. It enters balance sheets through many doors at once. Insurance claims, pension liabilities, asset impairments, operational strain, and reputational risk often appear disconnected on paper but are tightly linked in reality.

In insurance, climate change challenges the separation between underwriting, reserving, and capital risk. A flood is not just property damage. It is delayed reporting, litigation, asset volatility, and reinsurance uncertainty. ORSA processes that treat these independently miss the compounding effect.

Short illustrations make this tangible. A heatwave increases health claims while straining power grids insurers rely on for operations. A wildfire season worsens loss ratios and forces asset sales at depressed prices. A flood damages insured property and erodes municipal tax bases, weakening the credit quality of bonds held by the same insurer. These are interacting stressors, not isolated tails.

For pensions, climate risk hides behind long horizons. Longevity assumptions, contribution adequacy, and asset returns are all exposed. Climate migration reshapes labor markets. Heat stress affects mortality unevenly. A pension fund that models climate impacts only through asset stress tests manages half the problem.

Asset owners face a related challenge. Traditional diversification assumes correlations rise temporarily and then revert. Climate risk questions that assumption. Physical risks cluster geographically. Transition risks cluster by sector. Policy responses create sudden repricing. Risk management must focus less on optimization and more on fragility.

Across domains, the lesson repeats. Climate risk is not a parameter to be adjusted. It is a condition under which the system operates.

Actuaries are trained to work in the Goldilocks zone of time, long enough for compounding to matter, short enough for intervention to still work. Climate change sits squarely in that zone. It is already affecting results, but its full shape is still forming.

The most effective climate risk management frameworks will not be those with the most sophisticated models. They will be those that notice early when reality diverges from expectation and adjust course without waiting for perfect data. They will favor adaptability over optimization, resilience over precision, and learning over control.

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Syed Danish Ali, CSPA is an actuarial professional with 15 years of consulting experience in multiple countries across the world. He is Certified Specialist in Predictive Analytics from Institute of CAS and a graduate of University of London. He can be reached at sd.ali90@ymail.com.