FINANCE ON THE CLIMATE FRONTLINE

HOW CLIMATE CHANGE IS IMPACTING SOUTH AFRICA'S FINANCIAL MARKETS

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QUANTITATIVE CLIMATE FINANCE WORKSHOP

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EXECUTIVE SUMMARY

This report synthesises insights from the Quantitative Climate Finance Workshop (QCFW), convened by the African Institute for Financial Markets and Risk Management (AIFMRM) in November 2025. The workshop brought together senior representatives from financial institutions, insurers, asset managers, regulators, and academia. The aim was to discuss the quantitative climate finance challenges faced by the industry as a whole and scope out the main research priorities geared towards advancing climate-related financial solutions and risk management practices in South Africa.

HIGHLIGHTS FROM THE WORKSHOP INCLUDE:

Nature and biodiversity loss represent a material financial and systemic risk
Approximately USD 44 trillion of global economic value is moderately or highly dependent on nature, making biodiversity loss a risk equal to or greater than climate change.

Carbon pricing is central to quantitative climate finance but remains fragmented and inconsistent
Carbon pricing is increasingly embedded in financial modelling, credit assessment, and portfolio strategy. However, fragmented markets, wide price dispersion, non-fungibility of credits, and integrity concerns undermine price discovery, hedging, and robust risk modelling.

Data quality, standardisation, and scenario coherence are major barriers to effective climate risk integration
Across asset management, banking, insurance, and trading activities, inconsistent data and simplistic scenarios limit the ability to integrate climate risks into quantitative models, stress testing, and valuation, particularly for long-dated and credit-related risks.

Climate change is driving uninsurability and asset stranding with systemic financial implications
Rising physical risks are causing insurers to retreat from regions and sectors, creating insurance protection gaps. This directly affects access to finance, collateral values, credit risk, and refinancing ability, increasing the likelihood of widespread asset stranding across sectors such as energy, agriculture, infrastructure, and real estate.

KEY INSIGHTS AND TAKEAWAYS:

Accelerate integration of TNFD-, ISSB-, and nature-aligned frameworks into core financial processes

Organisations should proactively embed nature-related and climate-related risk assessment, governance, and disclosure frameworks into risk management, reporting, and decision-making to prepare for evolving regulatory and market expectations

Develop coherent climate scenarios for quantitative use

It is vital to standardise internally consistent climate scenarios that can be applied across trading books, banking books, insurance models, and portfolio analytics

Transparent and consistent carbon pricing

There is also a clear need for harmonised carbon pricing benchmarks, and improved integrity standards for carbon credits

Improve measurement of impacts, dependencies, and risk transmission channels

Financial institutions and corporates should strengthen their ability to measure biodiversity footprints, carbon exposures, physical risk impacts, and their impact on credit risk, defaults, and asset stranding

Mobilise finance toward nature-positive, adaptive, and resilient economic models

There is a need to direct capital toward biodiversity protection and restoration, developing innovative financial instruments (e.g. nature credits, sustainability-linked bonds), supporting circular and regenerative economic models to ensure long-term resilience

FRAMING THE CONVERSATION

Climate change presents both acute and structural risks to financial systems. In South Africa and other emerging markets, the impact of these shocks are often compounded by these regions' high exposure to physical climate risk, reliance on natural capital, energy-intensive means of production, and socio-economic vulnerabilities.

Climate finance is no longer a peripheral issue. It is central to risk management, financial stability, and long-term economic resilience – across the world, and most definitely in South Africa.

Quantitative approaches that translate climate risks into financial metrics are essential to inform capital allocation, pricing, and policy decisions.

AIFMRM has adopted quantitative climate finance as a core research and teaching focus, reflecting its mandate to address emerging risks in financial markets through rigorous, applied analysis. The workshop forms part of a broader programme that includes academic research, industry engagement, and postgraduate education aimed at strengthening climate risk capacity within the financial sector. The insights captured in this report are intended to inform future research projects, teaching initiatives, and policy engagement.

WORKSHOP OVERVIEW

The workshop was structured around plenary discussions and six parallel, chaired roundtable sessions. Each roundtable focused on a specific thematic area within quantitative climate finance, enabling in-depth, technically grounded discussion. Participants were selected to ensure a balance between industry practitioners, regulators, and researchers, with representation from banking, insurance, asset management, academia, and policy institutions. Each roundtable was chaired by a subject-matter practitioner or academic with experience spanning both theory and practice, ensuring focused and constructive discussion.

Participants were provided with framing questions in advance to guide discussion and encourage consistency across tables. These questions focused on current practices, key challenges, data and modelling gaps, and priorities for future work. We are grateful to those who attended QCFW 2025, and of course, to our excellent roundtable chairs: Christine van der Walt, Head of CIB Risk Data, Models and Innovation, Nedbank; Paramesan Mathen, Head: Institutional Sales Sub-Saharan Africa, HSBC; Dr Benno Guenther, Adjunct Senior Lecturer, AIFMRM; Professor Tom McWalter, Adjunct Professor, AIFMRM; Professor Andrea Macrina, Professor, University College London and Honorary Professor, AIFMRM; Associate Professor Tanja Tippett, Adjunct Associate Professor, AIFMRM.

1. HOW WILL NATURE DISRUPT ECONOMIC SYSTEMS?

BIODIVERSITY AND NATURE-RELATED RISK: IMPLICATIONS FOR ECONOMIC AND FINANCIAL SYSTEMS

Table 1: Chaired by Christine van der Walt, Head of CIB Risk Data, Models and Innovation, Nedbank

Nature forms the foundation of economic activity, underpinning virtually every sector through the provision of ecosystem services such as water regulation, soil fertility, pollination, and climate stability. Increasingly , biodiversity loss is recognised not as a peripheral environmental concern, but as a systemic economic and financial risk. Emerging evidence suggests that nature-related risk is comparable to, and in some cases exceeds, climate risk in its potential to disrupt economic systems, financial stability, and social outcomes.

A defining characteristic of nature-related risk is its regional specificity. While climate change operates at a global scale, biodiversity loss manifests locally through the degradation of ecosystems that directly support production and livelihoods. In South Africa, for example, water availability and ecosystem health are central to the national risk profile.

These risks are largely human-driven, stemming from overconsumption, pollution, land-use change, and the persistent undervaluation of ecosystem services in economic decision-making. But there are regulatory and market responses to nature-related risks that are evolving rapidly. The Taskforce on Nature-related Financial Disclosures (TNFD) has developed a comprehensive framework to help organisations identify, assess, and disclose their dependencies and impacts on nature. This framework is expected to be incorporated into the work of the International Sustainability Standards Board, potentially as a future IFRS standard, thereby mainstreaming nature-related disclosures across financial markets.

Agriculture, fisheries, and water-intensive industries are particularly exposed, with cascading effects along domestic and global supply chains.

The financial sector has a critical role to play in enabling a nature-positive transition.

In parallel, the Kunming–Montreal Global Biodiversity Framework sets ambitious targets to halt and reverse biodiversity loss by 2030, explicitly calling for the alignment of financial flows with nature-positive outcomes and enhanced disclosure by large companies and financial institutions. An estimated $44 trillion of global economic value is moderately or highly dependent on nature.

Biodiversity loss threatens essential ecosystem services, undermining food security, public health, and business continuity, while also jeopardising progress toward approximately 80% of the United Nations Sustainable Development Goals. These impacts are particularly acute in emerging economies, where livelihoods and economic resilience are closely tied to natural capital.

Addressing biodiversity loss also requires a rethinking of how economic growth and wealth are measured. Traditional metrics such as GDP fail to account for the depletion of natural capital. There is growing interest in biodiversity-adjusted measures of economic performance, as well as the development of “nature balance sheets” that treat ecosystems as assets and liabilities. Indigenous and local communities, many of whom operate within circular and regenerative economic models, offer valuable insights into sustainable resource management that can inform broader economic transitions.

Opportunities include directing capital toward nature-positive investments, developing innovative instruments such as nature credits and green bonds, and embedding long-term stewardship into investment and lending decisions. Effective action will depend on improved measurement and management of biodiversity impacts at a regional level, meaningful engagement with local communities, and a shift toward broader definitions of value that incorporate social and ecological dividends alongside financial returns.

2. A POWERFUL MECHANISM FOR A LOW-CARBON ECONOMY

CARBON PRICING AND ITS ROLE IN QUANTITATIVE CLIMATE FINANCE

Table 2: Chaired by Dr Benno Guenther, Adjunct Senior Lecturer, AIFMRM

Carbon pricing has emerged as an effective tool in driving the global transition towards a low-carbon economy. While carbon pricing is increasingly embedded in financial decision-making, there remain complexities related to market fragmentation, risk management, integrity, and the urgent need for greater standardisation.

At its core, carbon pricing creates an economic signal that incentivises emission reductions and removals and informs capital allocation. By assigning a cost to carbon, markets can internalise climate externalities and better align financial flows with sustainability goals. For financial institutions, carbon pricing is no longer a purely theoretical construct; it is becoming a practical input shaping portfolio strategies, credit assessments, and product innovation. However, there is no single or universal price for carbon. Instead, multiple frameworks and methodologies coexist, each attempting to quantify the cost of greenhouse gas emissions in different ways, with significant implications for comparability and modelling.

Compliance markets operate largely through emissions trading schemes (ETS), where allowances or credits are standardised and fungible. These cap-and-trade systems offer emissions certainty but can be characterised by price volatility. Prominent examples include the EU Emissions Trading System, California's Cap-and-Trade programme, and China's ETS. In contrast, tax-based systems rely on government-imposed carbon taxes, sending a price signal through a fixed cost per tonne of CO_2 emitted.

While these systems provide price certainty, emissions outcomes depend on demand elasticity. Finally, voluntary carbon markets represent a third category and are diverse and less regulated, with project-based credits exhibiting wide price dispersion and varying integrity, making comparing and hedging difficult. Prices in these markets can range from around one US dollar per tonne of CO_2 to thousands of dollars.

Price variability and limited transparency undermine confidence across markets, particularly in the voluntary space. Methodologies for assessing additionality, permanence, and co-benefits are not consistently applied, causing trust concerns. At the heart of these concerns is whether a carbon credit genuinely represents one tonne of CO_2. Risk management and hedging present further difficulties, as the non-fungibility of voluntary credits limits their integration into traditional risk systems and stress testing frameworks. Data and methodology gaps compound these challenges, with inconsistent reporting and verification standards hindering comparability and forward-looking modelling.

Additionality remains a central challenge, requiring projects to demonstrate that emissions reductions would not have occurred without carbon finance. Permanence presents another risk, particularly for nature-based solutions where reversals are possible. Other integrity issues include over-crediting, leakage, and limited transparency.

These integrity issues have long been a concern in project-based carbon credit markets, especially within voluntary markets.

Together, these factors create reputational and financial risks for buyers and have driven calls for stricter governance, standardised methodologies, and independent auditing. While initiatives such as the Core Carbon Principles represent significant progress, integrity remains an ongoing area of debate.

Prices vary widely between various markets, be it between different compliance markets but also within the voluntary carbon space. ETS prices fluctuate due to policy changes, allowance supply, and macroeconomic factors. Voluntary credit prices vary hugely by project type, vintage, and buyer preferences. While futures and options on carbon allowances allow hedging and speculation these are mostly only liquid in the context of the EU-ETS. Price discovery and hedgeability is hindered by fragmented markets, particularly the voluntary markets.

In the early days of the EU-ETS, the principle that "a ton is a ton is a ton" underpinned market design. Emissions reductions were treated as equivalent regardless of origin, creating a fungible and liquid market. While this approach supported early market development, it overlooked qualitative differences such as co-benefits and permanence risks, which have since become central to pricing and integrity debates. Some market participants now advocate revisiting this approach where other attributes such as biodiversity are captured separately to the CO^2 benefit.

Historical perspectives offer useful context.

Carbon markets are increasingly converging as global climate policy evolves. The EU's Carbon Border Adjustment Mechanism applies ETS-equivalent carbon costs to carbon-intensive imports, incentivising trading partners to adopt comparable pricing systems. The reintroduction of project-based credits for partial compliance within the EU-ETS further signals growing interaction between market types. International aviation's CORSIA scheme, South Africa's carbon tax offset provisions, and potential alignment under Article 6 all point toward a more interconnected global carbon pricing architecture.

For quantitative climate finance, carbon pricing is becoming a core modelling input, influencing credit risk assessment, scenario analysis, and asset valuation. However, without improved standardisation and transparency, uncertainty remains embedded in these models.

The roundtable highlighted the importance of collaboration between academia and industry to develop credible methodologies, harmonised standards, and robust benchmarks. Looking ahead, carbon pricing will play a central role in shaping sustainable finance, as institutions move from reactive compliance toward strategic integration within forward-looking financial systems.

3. RAPID ADJUSTMENT OF MODELS IN INDUSTRY

QUANTITATIVE INTEGRATION OF CLIMATE RISK IN PORTFOLIO MANAGEMENT

Table 3: Chaired by Paramesan Mathen, Head: Institutional Sales Sub-Sahara Africa, HSBC

The incorporation of climate-related financial risks into core quantitative models – spanning asset allocation, credit risk assessment, and equity valuation – is transitioning quickly from a nascent due diligence exercise to a fundamental requirement for systemic risk management. Robust financial modelling must integrate climate risk into forward-looking, return-based valuation assessments that measure potential impacts on firm valuations and investment portfolios.

Within the investment management community, climate risk has historically been approached primarily from a qualitative perspective. Increasingly, however, there is a need to shift toward quantitative integration that aligns climate risk with established investment frameworks. While investment managers currently face limited direct regulatory requirements to incorporate climate risk into investment decision-making – either through reporting obligations or statutory investment mandates – market forces are playing a stronger role in shaping climate-aware investment strategies.

Changes in investor expectations, capital allocation dynamics, and market perceptions of risk are influencing how climate-related considerations are embedded in portfolio construction and risk assessment. Balancing climate objectives with broader economic realities is therefore essential. Achieving improved biodiversity outcomes, while desirable, should not come at the cost of reduced food production. Similarly, reducing exposure to fossil fuel-intensive sectors carries the risk of job losses, particularly in economies where these sectors play a significant role.

> *A persistent challenge in this transition is the quality and availability of climate-related data.*

Data limitations remain a significant hurdle to quantitative integration, constraining the robustness of modelling approaches and comparability across portfolios. In response, a pragmatic approach to measurement is required. One priority is to focus on real-world, tangible, and observable data where possible. For example, energy consumption can often serve as a more reliable and transparent input than estimates of true carbon emissions, which may be subject to opacity. At the same time, incorporating explicit climate goals into investment strategies introduces the risk of underperforming conventional benchmarks, particularly in the absence of mature data and widely accepted methodologies.

Quantitative impact accounting may offer a useful metric for evaluating the distributional consequences of climate-related investment decisions alongside financial performance.

From a risk modelling perspective, physical climate risk plays a particularly important role in assessing left-tail outcomes for both credit and equity investments. Acute and chronic physical impacts can materially affect default probabilities, earnings stability, and asset valuations, and therefore need to be incorporated into downside risk analysis and stress testing.

In the South African context, financial inclusion is a critical consideration.

Valuing corporate exposures based on carbon emissions presents additional challenges, especially where carbon tax thresholds are high. In South Africa, a large share of emissions is concentrated among a small number of entities, limiting the immediate applicability of emissions-based valuation adjustments for a broad range of firms.

While the design of climate-aware investment products is an important component of this transition, it is equally important to ensure that investment decision-makers are adequately equipped to understand climate risk and its quantitative implications. Without sufficient education and capability-building, even well-designed models and products may fail to influence investment decisions effectively.

On the asset side, there is value in selecting portfolios that are less correlated with adverse climate outcomes affecting liabilities. Considering asset-liability interactions in this way can improve resilience to climate-related shocks. Factor analysis plays an important role in this context, supporting performance attribution and risk decomposition. Introducing climate-related factors alongside traditional investment factors can enhance understanding of climate-related risk premia and inform more robust investment selection processes.

Finally, indexation remains a central framework for investment decision-making. Market capitalisation-weighted indices, such as the South African TOP40 equity index, continue to underpin portfolio construction. However, evaluating alternative indexation methodologies, such as those incorporating climate risk rather than purely market capitalisation, can provide valuable insights into climate exposures embedded within existing portfolios, supporting more informed climate risk decisions.

4. THE LINK BETWEEN FINANCE AND INSURANCE

UNINSURABILITY, SUSTAINABLE LOANS, ASSET STRANDING, AND CLIMATE-LINKED DERIVATIVES

Table 4: Chaired by Professor Andrea Macrina, UCL and AIFMRM

Climate change mitigation has placed strong emphasis on transition risk – one of the major components of climate change risk – particularly within finance and policy decision-making. Much of this effort has focused on developing policies and financial mechanisms to sustain and accelerate the transition to decarbonised economies and societies.

Increasingly, however, adaptation to a changing climate is gaining traction, bringing physical risk into sharper focus. Quantifying, underwriting, and hedging physical risk lie at the core of the insurance industry, where expertise has been developed over centuries through experience and research.

These sectors enable the flow of financial and insurance risks through intertwined global networks involving both private and public stakeholders. As a result, systemic challenges to the insurance industry affect financial markets, while financial instability affects insurers as much as lenders. Climate change risk is systemic, with global ramifications. The insurance industry reports increasing year-on-year compensation claims due to growing losses inflicted by wildfires, floods, droughts, storms, et cetera.

> *Climate change risk highlights, perhaps more than any challenge before, that finance and insurance are two faces of the same coin.*

Uninsurability has gained much attention, and it now regularly features in news headlines and important industry meetings and publications. Insurance has been retreating from lines of business and whole geographic areas, thus producing heightened concerns in financial markets (e.g., borrowing/lending) and for policy makers. Roughly speaking: no insurance underwriting the risk, no project financing.

Closely linked to uninsurability is the growing risk of asset stranding. While once considered a distant concern, asset stranding has become increasingly relevant as physical damages and related financial losses escalate. In the context of uninsurability, asset stranding extends beyond individual factories or firms to encompass entire economic sectors such as energy and agriculture, as well as large-scale infrastructure and real estate markets. In extreme cases, assets at risk of being stranded may extend over geographic areas as large as a big US state, a Canadian or South African province.

A critical nexus emerges between insurability, access to capital, and the capacity to adapt to climate change.

Where businesses or entire regions struggle to secure insurance, the ability to raise capital from creditors and investors deteriorates. Financing costs rise or funding becomes unavailable, reducing competitive resilience and limiting the ability to adapt business models or invest in mitigation and adaptation strategies. This loss of agility reinforces a vicious circle: declining insurability constrains funding sources, which in turn weakens adaptation opportunities, increasing exposure to climate impacts and accelerating the path towards asset stranding.

Uninsurability also has direct implications for credit risk and asset valuation. Banks rely on collateral protection, and a deterioration in the creditworthiness of collateral assets can lead to higher capital charges due to increased loss-given-default ratios. These dynamics undermine refinancing capacity and raise funding costs. Project finance, particularly in sectors involving the exploration and extraction of natural resources, is especially vulnerable, as such projects are often exposed to both transition and physical risks. Understanding how insurance protection gaps translate into impaired access to capital and declining collateral values is therefore a key challenge in quantitative climate finance.

Measuring this gap requires careful considerations about available data, methodological approaches, and the appropriate level of granularity. One approach is to analyse risks by individual perils such as flooding, droughts, or wildfires; another is to focus on sectors such as housing, industrial facilities, or agricultural land. A combined approach may be necessary to capture interactions across hazards and sectors. Importantly, the protection gap does not affect all populations equally. Differences in income, location, and asset ownership shape vulnerability, with uninsurability often exacerbating existing inequalities.

Housing provides a clear illustration of these dynamics. Mortgage-backed home purchases are increasingly affected by rising insurance costs or the unavailability of coverage. As insurance becomes more expensive or inaccessible, housing affordability deteriorates, particularly for lower-income households. In this way, climate change risk further skews housing markets against vulnerable populations, reinforcing broader socio-economic challenges.

The widening insurance protection gap also raises important questions about fiscal policy and the role of government. If private insurance becomes unaffordable or unavailable, responsibility for covering climate-related losses may shift towards the public sector, effectively turning the state into an insurer of last resort. Such a shift would have implications for taxpayers, sovereign creditworthiness, and the sustainability of public finances. It also raises questions about political feasibility and whether voters would support such arrangements. At the same time, public assumption of risk could influence the pace and prioritisation of climate mitigation and adaptation policies, potentially bringing climate policy to the forefront of economic decision-making.

5. HOW CLIMATE SCENARIOS IMPACT FINANCIAL RISK

CLIMATE SCENARIOS

Table 5: Chaired by Professor Tom McWalter, AIFMRM

Climate change is increasingly recognised as a source of financial risk that can affect the stability and performance of both trading book and banking book activities. As a result, regulators, investors, and financial institutions face growing pressure to integrate climate-related considerations into their risk management frameworks.

Two sources of risk scenarios are the NGFS climate scenarios and the ISDA Climate Scenario Analysis framework. Together, these initiatives provide structured, quantitative, and comparable approaches to assessing how climate risks may translate into financial impacts.

The NGFS has developed a suite of climate transition and physical risk scenarios originally designed for central banks and financial supervisors but increasingly adopted by private-sector institutions.

These scenarios range from “Orderly Transition” pathways, where climate policies are introduced early and gradually, to “Hot House World” outcomes characterised by limited policy action and severe physical impacts. The scenarios describe alternative trajectories for macroeconomic variables, energy systems, emissions, and physical climate outcomes, depending on the speed and effectiveness of policy implementation and technological change.

The ISDA Climate Scenario Analysis Framework has been developed as a complementary approach with a specific focus on financial market activities. The framework is designed to translate climate scenarios into impacts on trading book positions, derivative exposures, and market valuations. It provides methodologies for mapping scenario variables – such as carbon prices, energy demand, or interest rates – onto financial risk factors relevant to equity valuations, credit spreads, and interest rate curves. This enables banks to incorporate climate risk into market risk and counterparty credit risk models, stress testing exercises, and valuation adjustments.

Within South Africa, the practical application of climate scenarios varies significantly across institutions and business lines. In short-term insurance, scenario analysis is not prescriptive, although firms are required to report regularly to the Prudential Authority. Insurers often rely on highly specific proprietary data derived from claims experience, using business and reserving analysis as a competitive advantage. Leading firms tend to develop their own proprietary models and scenarios, while smaller players may lack the resources to do so and would benefit from more standardised approaches.

Regulatory scenarios are often seen as simplistic and, at times, internally inconsistent.

In trading book activities, scenario analysis is currently driven largely by regulatory reporting requirements, particularly those prescribed by the South African Reserve Bank. At present, scenarios are primarily used for disclosure purposes and do not materially influence capital allocation, hedging decisions, or proprietary trading strategies.

There is concern that climate impacts are treated as intangible, underscoring the need for greater specificity. Current approaches are frequently piecemeal, for example applying shocks to individual curves such as swap or repo curves without adequate consideration of how correlated curves, assets, commodities, and other market variables may move together under climate stress.

The banking book faces many of the same challenges as the trading book, with the added complexity that banking book exposures are typically longer-dated. Scenario requirements for long-term analysis are often missing or poorly specified, limiting their usefulness for assessing credit risk over extended horizons.

There is a clear need for more robust scenario modelling that explicitly links climate pathways to credit risk drivers, defaults, and potential asset stranding.

Several research priorities emerge from these challenges. First, there is a need for a more coherent and standardised set of base scenarios that can be applied consistently across both trading and banking book activities. Such scenarios should be internally coherent, well-justified, and sufficiently standardised to allow comparison across institutions, while also reflecting local conditions. Clear guidance is required on how scenarios should be applied consistently across correlated curves, instruments, asset classes, derivatives, and products. Long-run mean and mean-reversion characteristics should be carefully defined to ensure consistency between trading and banking book analyses, with specific guidance on applications such as stress testing, expected and unexpected loss estimation, and valuation adjustments.

A second priority is strengthening the link between transition and physical risks, credit risk, and asset stranding. There remains a lack of research connecting climate scenarios to credit risk drivers, despite clear applications across banking and insurance. In this context, the rich datasets held within the insurance industry, if suitably anonymised, could provide valuable insights and support the development of more robust quantitative climate risk models.

6. THE IMPACT OF ENVIRONMENTAL REGULATION

CORPORATE VALUATIONS AND ENVIRONMENTAL REGULATIONS

Table 6: Chaired by Adjunct Associate Professor Tanja Tippett, AIFMRM

The growing need to decarbonise global energy systems has given rise to a wide range of environmental regulations across jurisdictions. One prominent policy instrument aimed at curbing greenhouse gas emissions is the implementation of carbon taxes, which set an explicit price on carbon emissions by imposing a tax rate on emissions exceeding a defined threshold.

While companies have been granted tax-free allowances that significantly reduce the effective tax paid, the National Treasury has indicated that these allowances will be gradually reduced over time.

These regulatory developments have direct implications for corporate profitability and firm valuation. Increased production costs resulting from carbon taxation place firms under financial strain, potentially affecting cash flows, balance sheet strength, and default risk. Empirical evidence from the United States highlights the magnitude of these effects: Butler and D'Erasmo (2024) show that firm market value can decline by as much as 60% as a result of carbon taxes. As costs rise and margins compress, the probability of default must be re-evaluated, with consequences for both equity and debt holders.

This raises a central question for corporate finance and valuation: what effect do environmental regulations, such as carbon taxes, have on the value of the firm?

> *In South Africa, a carbon tax of R236 per tonne of CO_2-equivalent emissions is currently in place, representing a 24% increase from 2024 and a 96.7% increase since its formal introduction in 2019.*

In the South African context, this question resonates with past regulatory experiences. Broad-Based Black Economic Empowerment (BEE) regulation provides a relevant parallel, having demonstrably affected firm value. McWalter and Ritchken (2022) model a firm subject to BEE regulation and value various claims on the firm under optimal decision-making. This work illustrates how regulatory constraints can reshape incentives, capital structure decisions, and the distribution of value between stakeholders.

Carbon taxation aims to achieve two related objectives: reducing carbon emissions and changing production behaviour. However, important questions remain as to whether the current design of tax-free allowances leads to the desired outcomes. While allowances soften the short-term economic impact, they may also delay meaningful decarbonisation by pushing behavioural change into the future. This creates uncertainty around the effectiveness of the policy in achieving emissions reductions while preserving economic stability and growth.

From a corporate perspective, regulatory uncertainty is itself a source of risk.

Business requires a transparent, long-term plan from government regarding decarbonisation policy and the carbon tax trajectory. Key issues include how and when allowances and rebates will be reduced, and what the anticipated long-run path of the carbon tax will be. Without clarity, firms face difficulty in planning capital investment, financing strategies, and transition pathways.

Lessons from BEE regulation may offer useful insights. BEE proved effective in part because procurement decisions were tied to certification, creating strong incentives for compliance. A similar mechanism could be considered for carbon emissions, for example by restricting access to government contracts above certain emissions thresholds. However, such measures would affect sectors unevenly, making it clear that a one-size-fits-all approach is unlikely to be appropriate. Any regulatory framework must account for sectoral differences to ensure an equitable transition.

The role of capital providers is also critical. Pension funds and other long-term investors need to be incentivised to supply the capital required for adaptation and decarbonisation. The release of a national tender database by National Treasury provides an example of how information infrastructure can support policy objectives. A similar database for emissions across South African businesses could enhance accountability, although this requires reliable methods for calculating or estimating CO_2 emissions.

Regulation and reporting standards can play a meaningful role in driving change by improving transparency and comparability.

Empirical evidence will be essential in informing both policy and valuation frameworks. Sector-level studies where firms have successfully reduced emissions over time, such as examples cited in the mining industry, could provide valuable insights into best practice and market responses. These cases highlight the divergence between firms that have meaningfully engaged in decarbonisation and those that have made limited progress.

Several academic questions emerge as particularly relevant. These include whether decarbonisation actions taken by a company have a measurable impact on share prices, whether there is an optimal time to transition from the perspective of shareholders, and how both optimal and sub-optimal transition strategies affect debt holders. Addressing these questions is central to understanding how environmental regulation reshapes corporate valuation, capital structure, and risk allocation in a decarbonising economy.

LOOKING BACK, MOVING FORWARD

Across biodiversity risk, carbon pricing, climate scenarios, asset valuation, portfolio modelling, and uninsurability several common themes emerged. Markets are evolving rapidly but remain immature; policy signals are strengthening but lack long-term clarity; data and methodologies are improving but remain inconsistent; and skills gaps persist in using climate and nature risks to inform core financial decisions. At the same time, climate and biodiversity risks are increasingly impacting financial risk, with growing recognition that these risks are systemic rather than peripheral.

The transition toward nature-positive and low-carbon outcomes presents clear opportunities for the development of new financial instruments, including biodiversity and nature credits, sustainability-linked bonds, and carbon-linked products. There is also room to integrate carbon pricing, biodiversity metrics, and climate scenarios explicitly into valuation, credit risk, indexation, and portfolio construction.

However, several constraints hinder this effort. Fragmented carbon markets and wide price dispersion undermine transparency and hedgeability, while limited data quality, inconsistent methodologies, and weak standardisation constrain quantitative modelling. The lack of transparent regulations across the industry and all the various stakeholders is contributing to the slow pace of capital allocation to adaptation technologies and financial innovation needed to unlock investment opportunities.

Furthermore, climate scenarios are often insufficiently granular, poorly specified for long-dated risks, and weakly linked to credit risk and asset stranding outcomes; finally, education and technical capacity remain uneven across institutions.

Participants at QCFW 2025 collated these insights and translated them into several key suggestions.

At a continental level, Africa's natural capital offers the potential to be repositioned as a global asset rather than a source of higher risk premiums.

FOCUS AREAS

For the industry as a whole

- Treat carbon pricing and biodiversity risk as core financial variables rather than disclosure-only considerations
- Develop standardised base scenarios that link transition and physical risks to asset values, defaults, and insurance availability
- Use observable, real-world data where possible to support pragmatic modelling approaches

For policymakers and regulators

- Provide clear, long-term policy trajectories for carbon taxes, allowances, and transition pathways
- Support standardisation of disclosure, scenarios, and methodologies aligned with global frameworks
- Recognise biodiversity loss and uninsurability as sources of systemic financial risk

For financial institutions

- Integrate climate and nature risks into risk management, valuation, and capital allocation
- Strengthen internal capabilities to model carbon pricing, physical risk, climate-related credit risk, asset valuation, and asset stranding
- Move from compliance-driven disclosure to strategic use of climate and biodiversity data
- Asset managers should transition to a more quantitative approach for climate-related investment decision-making

For research and education

- Focus on quantitative methods that link climate and nature risks to financial outcomes
- Advance research on scenario design, carbon pricing convergence, credit risk transmission, portfolio construction, and asset stranding
- Financial instruments that enable investments in projects or technology that address climate and biodiversity risks.
- Build practitioner-focused education that bridges theory, data, and real-world decision-making

CONTINUING THE CONVERSATION

AIFMRM is committed to advancing quantitative climate finance through research, teaching, and close engagement with South Africa's financial industry. The workshop has highlighted many interesting research questions that will form part of our research agenda. Some of these topics require industry collaborators and assistance; we will be in touch with those attendees that indicated their willingness to assist.

Lastly, we would like to say a final thank you, again, to all who attended QCFW 2025. We look forward to seeing you again and meeting with future collaborators in the near future.

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