

Quantify Risk & Insurance Case Competition 2025

Team: 20

1. Introduction & Background

Quant Co. is a leading Canadian integrated oil and gas firm transitioning into renewable energy through wind and solar infrastructure. With climate-driven catastrophic (CAT) weather events growing in severity and 2024 recording the highest losses in Canadian insurance history, the company is exploring parametric insurance to manage future risks. Parametric insurance offers fast, predictable payouts based on predefined weather conditions such as wind speed or hail size, but relies on heavy data analysis to validate the thresholds used. We are assessing whether proposed parametric insurance triggers (wind ≥ 119 km/h and hail ≥ 6.5 cm) are suitable, and to identify which weather features most strongly predict high-loss CAT events that could jeopardize new solar and wind investments.

2. Objective:

To build a classification model that predicts whether a catastrophic (CAT) event causes a high financial loss based on measurable features such as wind speed, hail size, rainfall, and structural damage. This supports Stronghold's goal of evaluating whether their proposed parametric insurance triggers are appropriate for Quant Co.'s renewable energy projects.

3. Research Question:

How can Quant Co. use data to identify the key weather risks to its new solar and wind projects, and validate whether Stronghold's proposed parametric insurance triggers are appropriate for managing these risks?

Sub-question:

- Risk Identification

Which catastrophic weather events (hail, wind, flood, fire) cause the highest losses and which features (wind speed, hail size) are most predictive of high-loss events?

- Trigger Validation

How often do real events exceed the Stronghold's triggers (wind ≥ 119 km/h, hail ≥ 6.5 cm)

- Model Support

Build a classification model to predict high-loss events using weather metrics and use feature importance to support Stronghold's trigger design.

4. Data Preparation

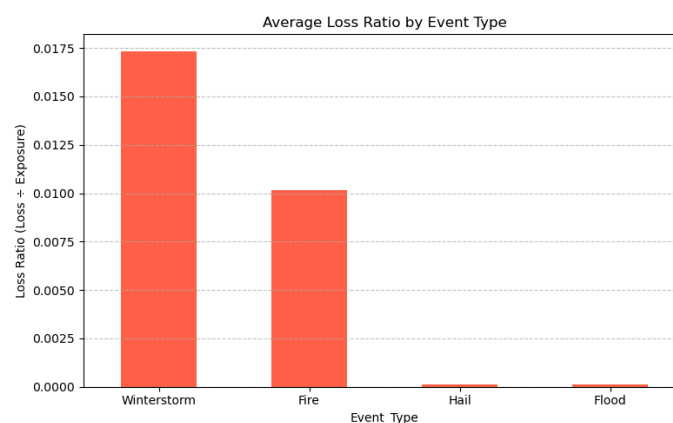
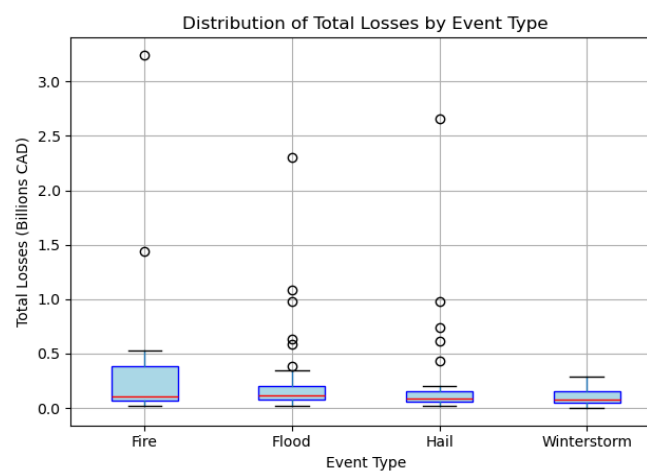
We have been provided four datasets representing different categories of catastrophic(CAT) events: hail, fire, flood, and winterstorms. Each dataset included variables such as total exposure, total losses, event year, and event-specific weather metrics (e.g., wind speed, hail scale, rainfall, hectares burned, structures destroyed). In total, the merged dataset contained 152 historical CAT events across Canada.

To prepare the data for analysis, all datasets were standardized and merged into a single structured DataFrame. We did this by creating consistent column names and event types, as well as handling missing values in features that did not apply to all event types. Missing numerical values were set to 0 to ensure model compatibility.

A new binary target variable, “high_loss,” was created to classify events as either high-loss or low-loss. Events in the top 25% of total financial loss were labelled as high-loss(1), and all others were labelled as low-loss(0). This allowed for supervised classification modelling to predict future high-risk events based on their weather characteristics.

5. Risk Identification

5.1. What kinds of events and features cause the biggest losses?



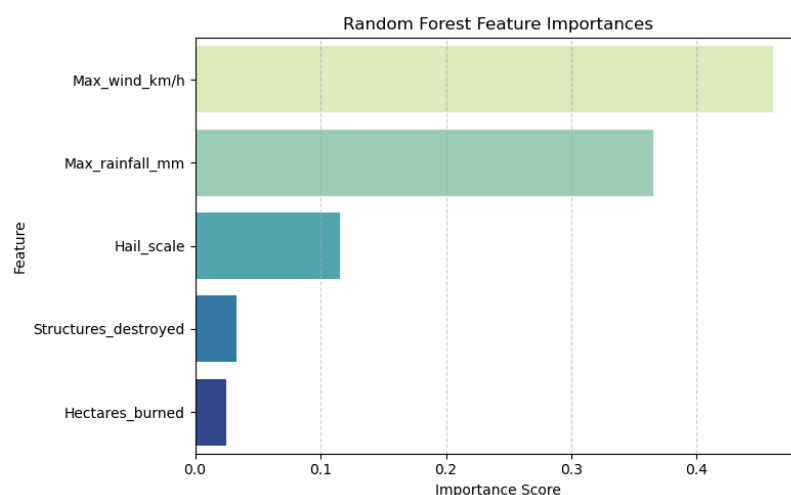
To understand which types of catastrophic events cause the greatest financial damage, two key visual analyses were conducted: a box plot of total losses by event type and a bar chart of average loss ratio (total losses divided by exposure).

The first plot compares the distribution of absolute losses (in billions CAD) for each event type. From that, fire events show the largest range and highest outliers, with several events over \$1B and even \$3B in damage. Flood and hail events show moderate loss variability, with some spikes. Winterstorm events appear more tightly clustered with lower total losses. In terms of financial impact, fire events are the most extreme. This suggests that while fire events may be less frequent, when they occur, they cause devastating losses — a key concern for insurance underwriting.

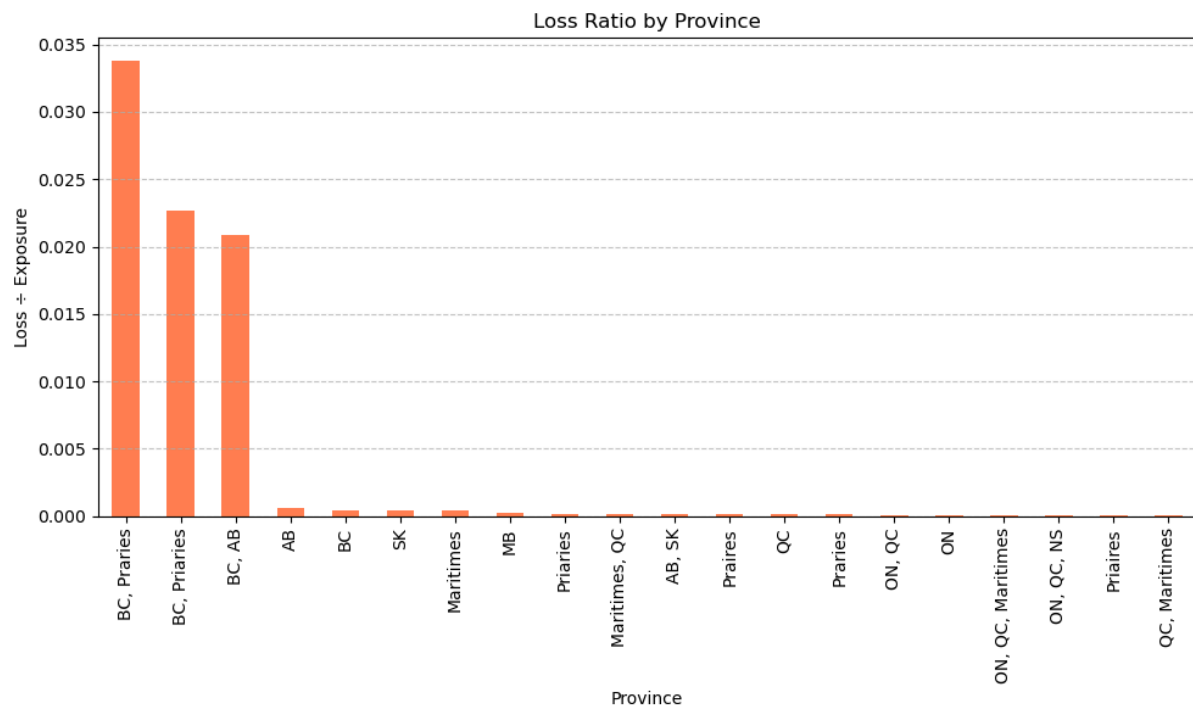
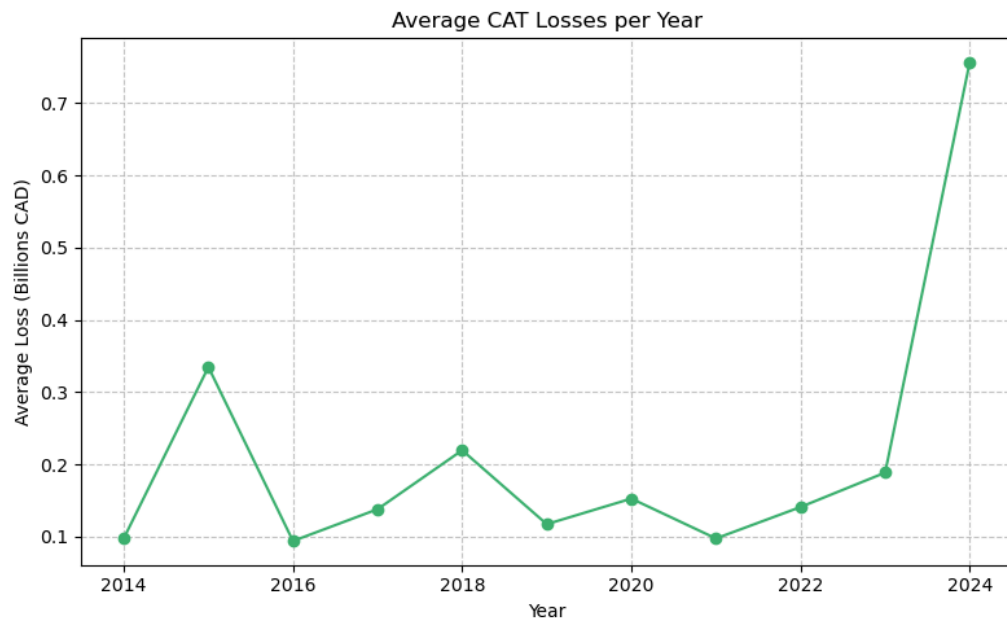
The second plot compares loss ratio (total losses ÷ total exposure) across event types. From that, we find that winterstorms have the highest loss ratio, even though their absolute losses were lower. Fire is next, showing both high loss and relatively high risk per dollar of exposure. Flood and hail have very low loss ratios, suggesting they may be more predictable or easier to mitigate. This shifts from “how big is the damage?” to “how risky is the exposure?”

These visuals show that fire causes the highest absolute financial losses, while winterstorms are the most dangerous relative to exposure. This dual perspective supports prioritizing these two event types when designing parametric insurance products.

5.2. Which features predict high-loss events?



5.3 Regional & Temporal Risk Trends



The bar chart compares losses relative to exposure across provinces. From the chart, provinces such as BC, Prairies, and BC + AB stand out with higher loss ratios which shows that these regions convert exposure into financial loss more efficiently than others. These provinces are significantly more vulnerable to financial damage from CAT events, which suggests that parametric insurance should be customized by region.

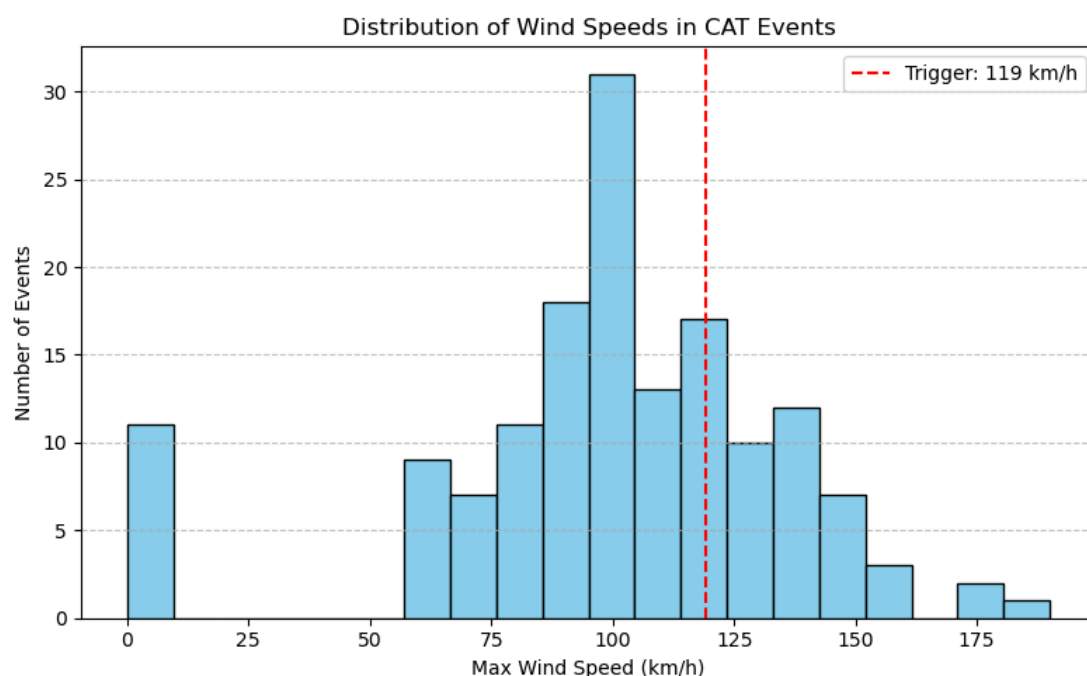
The line chart captures the average annual loss from CAT events from 2014 to 2024. The curve shows a clear upward spike in 2024 which aligns with Stronghold's concern that climate events are becoming more unpredictable and highlights the need for future insurance solutions like parametric triggers. Overall, these two visuals show why trigger design should vary by location and why Quant Co. should act urgently.

6. Trigger Validation

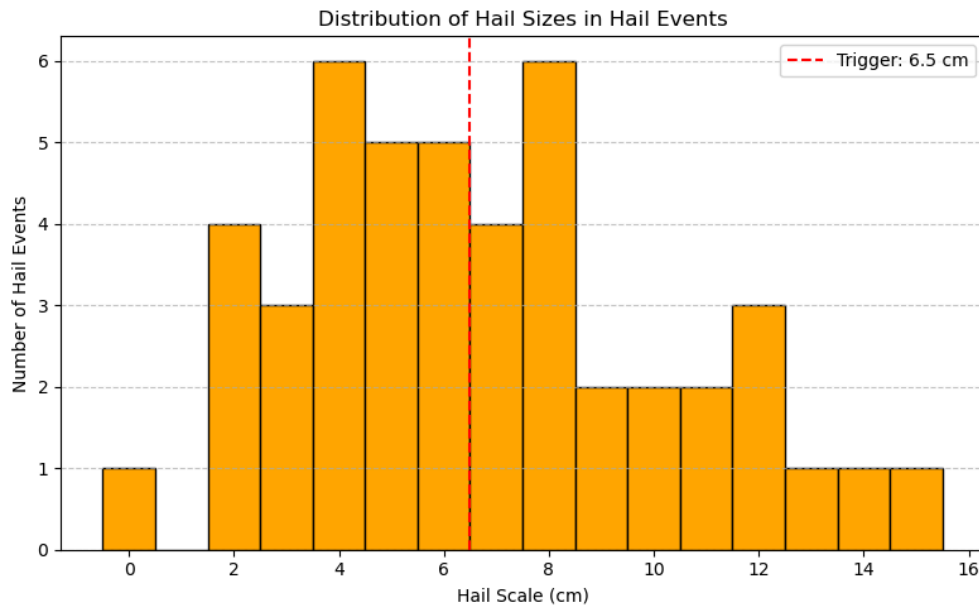
In this section we will evaluate whether Stronghold's proposed thresholds: wind speed ≥ 119 km/h and hail size ≥ 6.5 cm aligns with historical weather patterns.

Trigger Threshold Frequency:

- Histogram of wind speed events with 119 km/h line



- Histogram of hail size with 6.5 cm line



The wind speed histogram shows a relatively normal distribution, with a modest number of events exceeding 119 km/h. This threshold appears to capture the higher-risk events while maintaining payout selectivity. The proposed wind trigger is therefore reasonable and aligns with both historical data and industry standards.

In the hail size histogram, only a small minority of hail events exceed this threshold, suggesting that the current trigger may be too conservative. As a result, it may lead to undercoverage for moderately severe hail events that still cause substantial losses.

Overall, $\text{Wind} \geq 119 \text{ km/h}$ is a justifiable threshold based on historical frequency and alignment with loss risk. $\text{Hail} \geq 6.5 \text{ cm}$, however, is rare in past events and may require adjustment (e.g., to 5.5 cm) to ensure practical and effective coverage for Quant Co.'s infrastructure.

7. Predictive Modelling

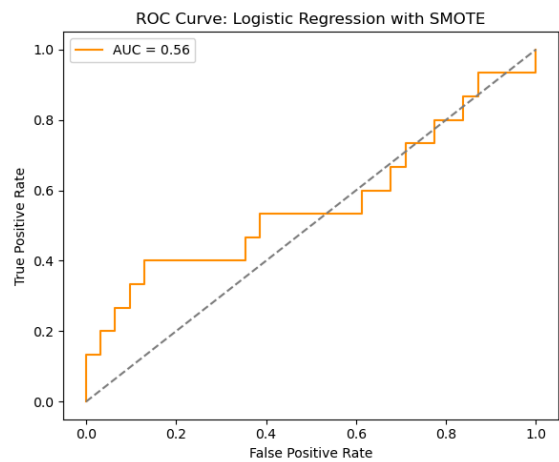
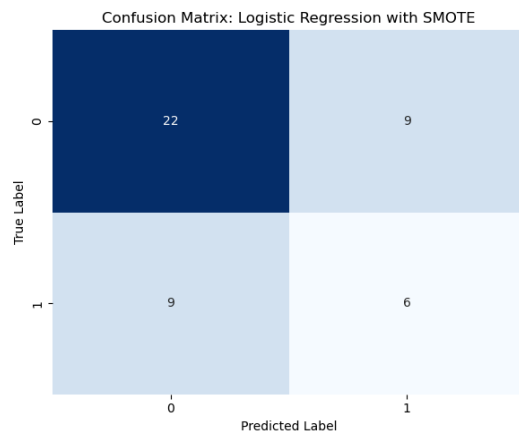
Build and evaluate a predictive model to support Stronghold's trigger decisions by determining whether high-loss CAT events can be reliably identified based on historical weather patterns.

7.1. Model Training

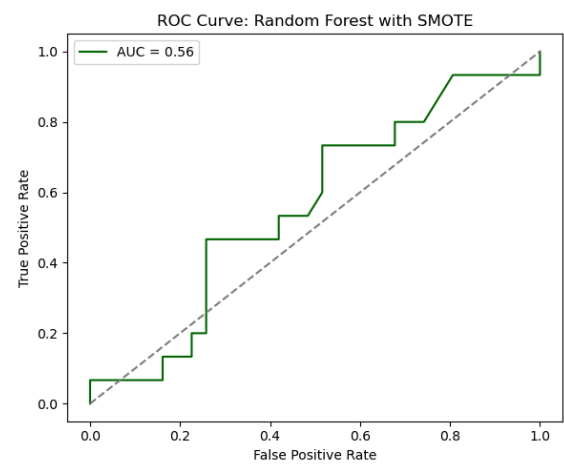
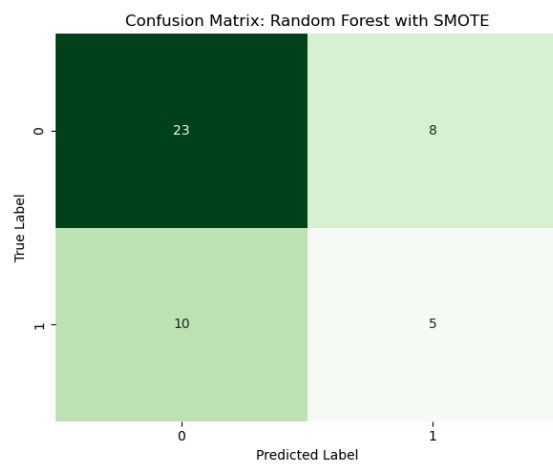
Three supervised Machine Learning models were used: Logistic Regression, Random Forest, and XGBoost. Each model was trained to classify CAT events as either high-loss or low-loss based on features like wind speed, hail scale, rainfall, hectares burned, and structures destroyed. Due to high class imbalance, we conduct the Synthetic Minority Oversampling Technique (SMOTE) to address the issue.

7.2. Model Evaluation

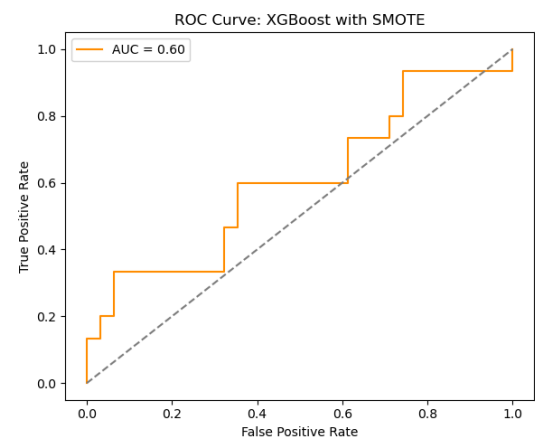
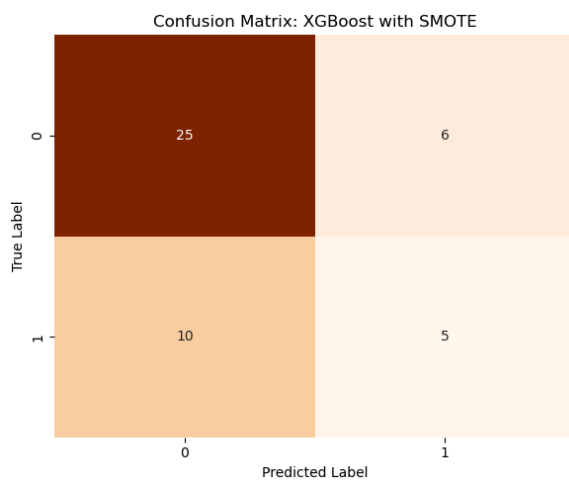
- Logistic regression + SMOTE



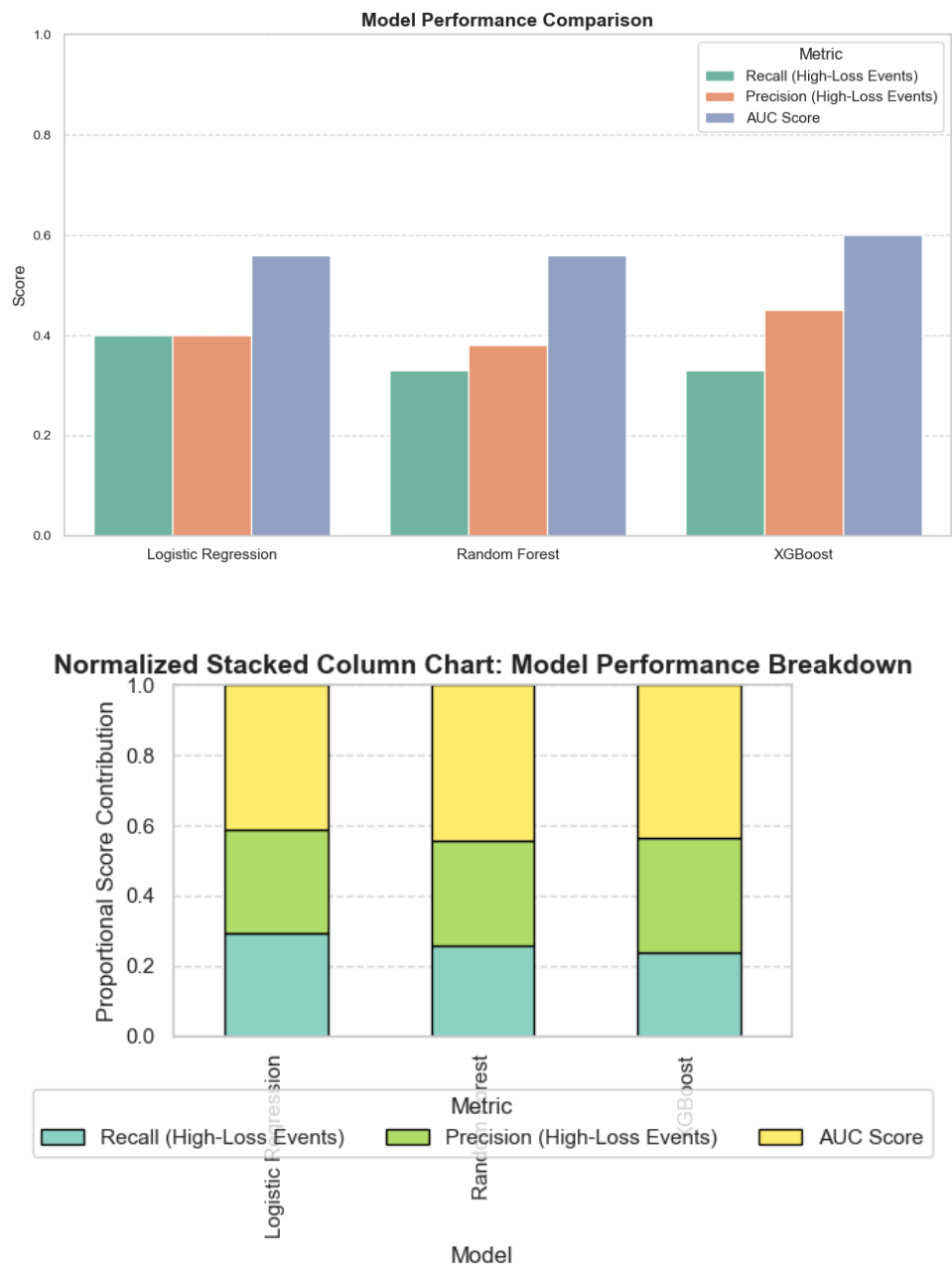
- Random Forest + SMOTE



- XGBoost + SMOTE



7.3. Model Comparison

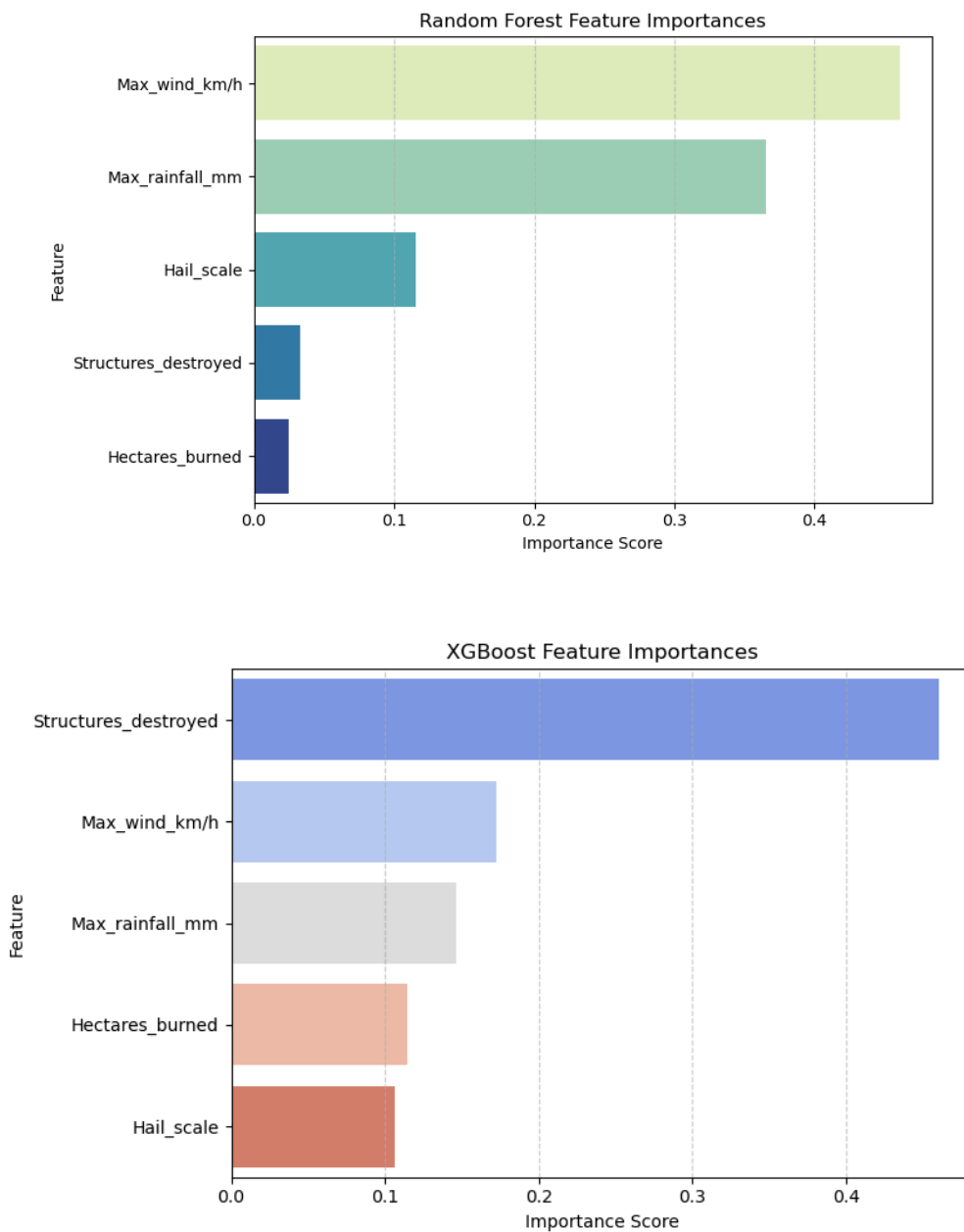


From the model comparison output, XGBoost achieved the highest AUC(0.60) and highest precision(0.45), which indicates that it is the most accurate in identifying high-loss events with fewer false positives.

For Logistic regression, it had a balanced recall and precision, which makes it the most interpretable and consistent model.

For Random Forest, it performed moderately across all metrics but slightly lower in recall.

7.4. Feature Importance



Across all models, the most influential predictors of high-loss events were: Max_wind_km/h, Max_rainfall_mm, and Structures_destroyed. For Random Forest, it confirms that core weather metrics such as wind and rainfall are leading drivers of high-loss events. This aligns directly with the rationale behind Stronghold's parametric insurance triggers. For XGBoost, structures_destroyed was ranked highest. It adds another layer by highlighting destruction severity, reinforcing the idea that loss depends not only on the weather itself (like wind or hail) but also on how vulnerable the area is. While wind and hail are still useful as triggers, this suggests that including damage-related features could improve risk prediction.

8. Quant Co. Renewable Energy Business Expansion Strategy Analysis: Feasibility Assessment for Entering Solar and Wind Power Markets

Quant Co. has a clear opportunity to diversify its portfolio into sustainable energy by expanding its renewable energy sector. Government support, market growth trends, and strengthening ESG regulations support this transition. However, significant exposure to natural disaster risks necessitates the adoption of parametric or traditional insurance solutions to protect renewable energy assets. Coupled with robust risk management strategies, this expansion is expected to enhance Quant Co.'s long-term sustainability and competitiveness.

- **Market Opportunities and Government Support Analysis:**

The global renewable energy industry is growing rapidly, led by solar and wind power. Quant Co.'s existing vertical integration structure and market positioning as an energy company can generate significant synergies upon entering the renewable energy sector. As the global energy market shifts toward decarbonization, expanding into renewables is critical for maintaining long-term competitiveness. Government incentives, including subsidies, tax benefits, and policy support, are improving the economic viability of renewable projects. Only 44% of Canadian fossil fuel and mining companies have "robust" greenhouse gas reduction programs, lagging behind the U.S. and Europe. Quant Co.'s preemptive investments in renewables, leveraging its existing infrastructure and expertise, can strengthen its competitive edge in this underserved market.

- **Financial Impact and ROI Analysis:**

Expanding into renewables requires significant upfront capital, but long-term stable revenue streams are anticipated. Quant Co.'s strong financial foundation-supported by an 18.85% CAGR from 2020–2023-positions it to fund this transition. Renewable projects offer predictable long-term returns, bolstering financial stability. Low operational and zero fuel costs for solar/wind power improve profitability post-initial investment. Aligning with ESG criteria will also restore investor confidence and improve capital accessibility. Diversification into renewables enhances resilience against energy price volatility and climate shocks. With fossil fuel companies facing capital acquisition challenges due to poor ESG performance, Quant Co.'s pivot to renewables opens new funding avenues.

- **CAT Risk Exposure Analysis:**

Renewable infrastructure, particularly solar panels and wind turbines, is vulnerable to natural disasters. In 2024, Canada's property insurance industry recorded historic losses, highlighting these risks. Solar panels are highly susceptible to hail damage, while wind turbines face structural risks from storms. A single hailstorm in Alberta caused 265 million CAD in losses, underscoring the financial impact of localized disasters. Wildfires and floods also threaten renewable assets. Floods in Ontario and

Quebec led to 230 million CAD in insurance claims. Climate change is intensifying the frequency and severity of such events, exacerbating long-term risks.

- Necessity of Adopting Renewable Energy with Insurance Solutions:

Quant Co. must balance maximizing oil/gas efficiency with aggressive investments in low-carbon energy. Parametric insurance-triggered by predefined metrics like wind speed or rainfall-and traditional insurance can mitigate disaster risks, protect assets, and strengthen investor trust. By leveraging vertical integration, market presence, and financial strength, Quant Co. can secure long-term sustainability. Proactive risk management, coupled with renewable expansion, will enable adaptive responses to regulatory and market shifts, ensuring sustained success.

9. Quant Co. Strategic Analysis: Strengths and Risk Assessment of Current Oil & Gas Operations.

Strength #1: Vertical Integration

Quant Co. secures a substantial competitive advantage through its vertically integrated structure, encompassing upstream, midstream, and downstream operations. This integration provides comprehensive control over the supply chain, enhancing operational efficiency and profitability. The balanced approach inherent in vertical integration also acts as a natural hedge against market uncertainties such as oil price fluctuations. When oil prices are low, the refining and marketing segments can generate profits, while high prices maximize gains in the production segment.

Strength #2: Market Position and Distribution Network

Quant Co.'s strong market position delivers a competitive edge through network effects. Its extensive distribution network contributes to stable revenue generation and reinforces brand recognition. In the natural gas sector, where pipeline infrastructure is critical, Quant Co. controls key network nodes, enabling the company to create value beyond simple production.

Strength #3: Financial Foundation and Asset Portfolio

As of 2023, Quant Co. reported total revenue of CAD 9.399 billion, a 12.88% decrease from the previous year. However, the company maintained a robust long-term growth trend, with a compound annual growth rate (CAGR) of 18.85% from 2020 to 2023. Operating income peaked at CAD 2.131 billion in 2021 before declining to CAD 715.5 million in 2023, yet the company still maintained a positive operating margin of 7.61%. Gross profit in 2023 stood at CAD 2.515 billion, with a gross margin of 26.76%. Although this margin adjusted from its 2021 peak of 39.54%, Quant Co. continues to demonstrate a strong financial foundation. This resilience enables the company to withstand market downturns and price volatility, while also laying the groundwork for strategic investments in renewable energy during the energy transition.

Risk #1: Regulatory Pressure

Quant Co. faces mounting pressure from both investors and regulators to decarbonize. Fossil fuels account for approximately 79% of global greenhouse gas emissions and are a primary driver of the climate crisis. As a result, oil and gas companies are under unprecedented scrutiny, which poses significant risks to their long-term viability and profitability. According to recent IEA forecasts, global demand for oil and gas is expected to peak by 2030 under current policies, with demand for both fuels projected to decline sharply as climate action intensifies. If governments fulfill their national energy and climate commitments, oil and gas demand could fall by 45% from current levels by 2050.

Risk #2: Difficulty in Attracting New Investment

Quant Co. continues to struggle with attracting new investment. Factors such as price volatility, demand uncertainty, and climate concerns deter investors, while Canada's adoption of ESG standards lags behind the US and Europe. Only 44% of Canadian oil and gas companies are rated as having "strong" or "very strong" greenhouse gas reduction programs, compared to 52% in the US and 63% in Europe. Conversely, 18% of Canadian firms are rated as "vulnerable," higher than the US and Europe, highlighting a relative weakness in ESG response. This has led investors to question the sustainability of Canada's oil and gas sector, and in recent years, Canadian fossil fuel and mining companies have faced increasing difficulty securing new capital due to inadequate ESG performance.

Risk #3: Catastrophic and Climate Risks

Quant Co.'s oil and gas operations are exposed to significant operational and financial risks from extreme weather events. For example, a major hailstorm in Alberta resulted in CAN\$2.65 billion in losses from a single event, while flooding in Ontario and Quebec triggered CAN\$2.3 billion in insurance claims. In 2024, Canada's property insurance industry recorded its highest-ever loss. Residents near oil and gas facilities may suffer health impacts, exposing the company to legal and social risks. Climate disasters linked to fossil fuels can cause trillions in economic damage, and accidents involving oil and gas infrastructure can result in long-term environmental harm.

The Need for Strategic Transition to Renewable Energy

Quant Co.'s current oil and gas business possesses clear competitive advantages, including vertical integration, strong market position, and a solid financial base. These strengths provide natural hedges against market volatility and have been validated by the company's financial performance in recent years.

However, the intensification of ESG regulations, the surge in climate-related disasters, and mounting investment challenges are emerging as serious constraints on Quant Co.'s long-term growth and sustainability. Structural changes in the global energy market, stronger decarbonization policies, and stricter ESG criteria among investors are increasing uncertainty over the future profitability of a fossil fuel-centric business model. The relatively weak ESG

performance of Canada's oil and gas sector, combined with large-scale economic losses from climate disasters and growing social and legal risks, further highlight the vulnerabilities of the current business.

To achieve sustainable growth, Quant Co. must leverage its existing strengths while strategically expanding into renewable energy. Moving into renewables offers several benefits:

- Mitigating regulatory and investment risks by meeting carbon-neutral and ESG requirements, thereby restoring investor confidence and improving capital access.
- Diversifying the portfolio to enhance resilience against external shocks such as energy price volatility and climate disasters.
- Securing long-term growth by proactively responding to the global energy transition and maintaining competitiveness in future markets.

Therefore, Quant Co. should maximize the efficiency and profitability of its existing oil and gas operations while actively increasing investment in low-carbon businesses such as renewable energy. This approach will enable the company to respond flexibly to regulatory and market changes and achieve sustainable growth.