[*CLIFIN: A FLEXIBLE FRAMEWORK FOR ASSET-LEVEL CLIMATE RISK ASSESSMENT IN INFRASTRUCTURE INVESTMENT*]

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Overview

The intensification of climate change presents unprecedented challenges to financial system stability through both physical risks (from extreme weather events and chronic climatic changes) and transition risks (from the global shift towards carbon neutrality). While existing climate risk assessment approaches, such as integrated assessment models (IAMs) and multi-sector dynamic models, provide valuable macro-level insights, they face significant limitations in capturing asset-level financial implications. Traditional approaches often rely on oversimplified assumptions, struggle with complex financial mechanisms, and fail to adequately represent the dynamic interactions between financial institutions and climate risks. Additionally, conventional scenario analyses face challenges in translating climate scenarios into financial impacts, particularly for infrastructure-specific vulnerabilities and local climate effects. These limitations are especially critical in the infrastructure sector, where asset-specific characteristics and geographical locations significantly influence climate risk exposure.

This study addresses these challenges by introducing ***CliFin***, a novel Python-based framework designed to evaluate climate risk at the asset level. Our framework overcomes key limitations of existing climate risk assessment tools by enabling granular analysis of financial impacts on infrastructure assets while maintaining flexibility in climate assumptions and providing probabilistic insights for decision-making. The framework is built on three core principles: flexibility in modeling diverse financial assets, extensibility for scenario analysis, and productivity through integration with the Python ecosystem.

Methods

CliFin's architecture comprises three key components, (1) ***CliFin Core***, (2) ***Clifin Infra***, and (3) ***Clifin Dataset***, designed to enable comprehensive climate risk assessment (see Figure 1).

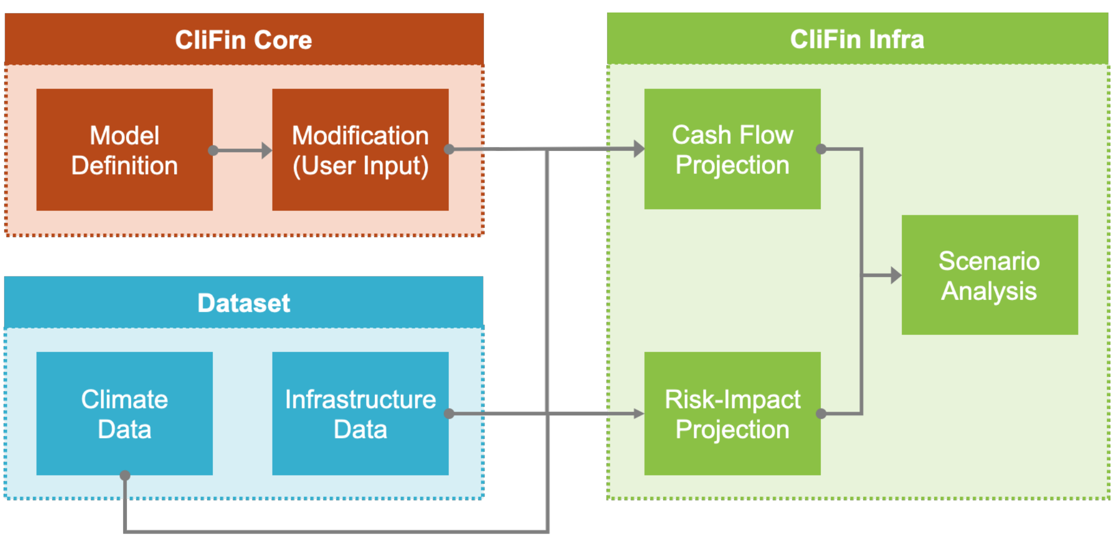

Figure 1. *CliFin* Framework Architecture

- ***CliFin Core*** provides a Domain-Specific Language (DSL) embedded in Python, allowing users to define and modify asset and financial models with high flexibility. This component enables surgical changes to initial models for sensitivity analyses and scenario testing without manual intervention.
- ***CliFin Infra*** consists of two integrated modules: (1) a Cash-flow Module that calculates financial metrics such as Debt Service Coverage Ratio (DSCR) and Internal Rate of Return (IRR) while forecasting baseline cash

flows, and (2) a Risk-Impact Module that identifies and defines climate risk factors for each infrastructure asset through impact mechanism analysis. These modules work together to conduct detailed climate scenario analyses.

- ***CliFin Dataset*** establishes an integrated database combining climate data with infrastructure specifications, enabling comprehensive risk evaluation under various climate scenarios. This component synthesizes data from multiple sources to provide historical and projected information necessary for robust analysis.

Results

We demonstrated ***CliFin***'s capabilities through a case study of 73 U.S. energy infrastructure assets, including 37 coal plants, 7 natural gas combined cycle gas turbines (CCGT), and 29 solar facilities. The analysis covered the period from 2023 to 2052 under multiple IPCC climate scenarios. Our findings revealed significant variations in climate risk impacts across different asset types and geographical locations.

The results show distinct patterns in DSCR projections across asset types under various climate scenarios, indicating that financial impacts vary substantially even within the same climate scenario. Geographic analysis revealed notable regional differences in DSCR values for CCGT and solar power plants, suggesting that location plays a crucial role in determining climate risk exposure. These findings highlight the importance of considering both asset-specific characteristics and geographical factors in climate risk assessment.

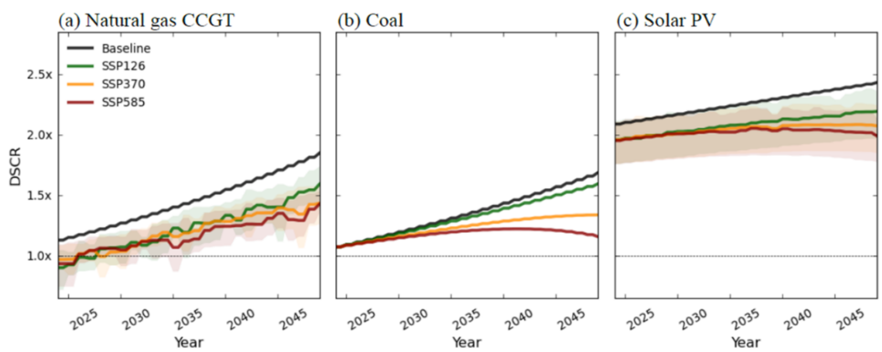

Figure 2. *CliFin* Demonstaction: DSCR projection for three energy asset types under IPCC climate scenarios
Figure 2 shows the forecast values of DSCR by energy infrastructure asset under various climate scenarios. From this, it can be seen that even in the same climate scenario, the financial impact may differ for each energy infrastructure.

Figure 3. *CliFin* Demonstaction: Geographic distribution of average DSCR for power plants by asset location
Figure 3 shows that in the case of CCGT power plants and solar power plants, there are regional differences in DSCR values according to climate scenarios. In other words, it implies that the financial impact of climate risk may vary depending on the region where the plant is located.

Conclusions

CliFin represents a significant advancement in climate risk assessment methodology, offering a robust and scalable solution for analyzing climate-related financial risks at the asset level. The framework's ability to provide granular, asset-specific insights while maintaining flexibility in scenario analysis makes it a valuable tool for stakeholders and policymakers in developing climate-resilient infrastructure strategies. Furthermore, ***CliFin***'s extensible design ensures its applicability to new infrastructure types not covered in this study, contributing to long-term adaptation and mitigation strategies for climate change challenges in the infrastructure sector.