# Quantifying Climate Policy Action and Its Links to Development Outcomes

## A Cross-National Data-Driven Analysis

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Climate Change AI

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# Conceptualization of the Policy Indicator

- ✓ **Goal**: To create a text-based indicator capturing policy ambition or action using textual data.

- ✓ **Data Sources used**:
  *Climate Change Laws of the World database* [1]
  Text: Policy summaries from each policy laws from the dataset,
  Indicator(s): - Policy action themes of interest *'Topic/Response'* (one or more, which was present in the dataset)

- ✓ **Topic/Response category chosen as the policy indicator**
  *Mitigation, Adaptation, Disaster Risk Management, Loss & Damage*
  - ➢ Laws and policies are categorised according to the climate policy response
  - ➢ Clear understanding of the scope and effectiveness of the climate action
  - ➢ Targeted categorization of the themes useful for text classification problems

- ✓ **Using multi-label multi-class classification**
  Each exemplar may contain more than one policy themes

# Methodology: NLP for Policy Indicator Construction

✓ **Approach**: Quantitative indicator using supervised multi-label classification with a multilingual DistilBERT USE model: *distiluse-base-multilingual-cased*

Why?
- Sentence embedding (entire sentence as a single dense vector) > token embedding
- Smaller model
- Support multi-lingual texts without needing translation
- Efficient for shorter texts

✓ **Framework:**

[Climate Law Text] → [Embeddings via distiluse-base-multilingual-cased] → [Multi-label Classifier] → [Policy Theme Probability Scores]

↓

Mitigation: ✅ Adaptation: ✅ Disaster Risk Management: ❌ Loss & Damage: ❌ [1, 1, 0, 0]

✓ **Validation:**

Threshold = 0.5 (probability of prediction of the said category is at least 50%)

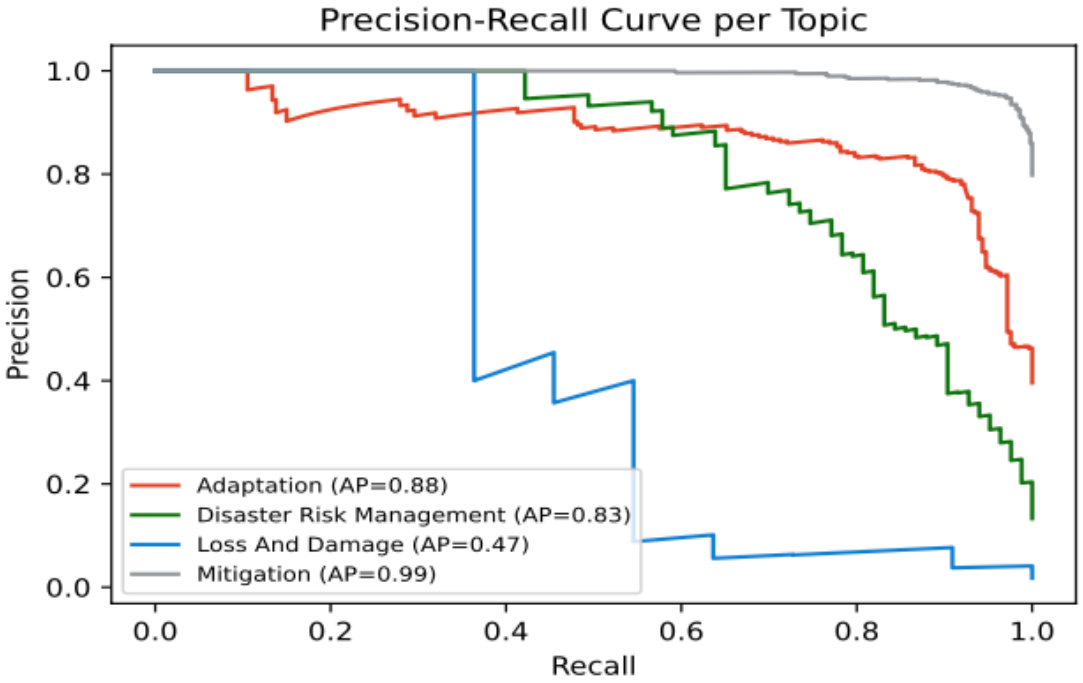
| Category | Precision | Recall | F1-Score | Support |
|---|---|---|---|---|
| Adaptation | 0.82 | 0.87 | 0.84 | 247 |
| Disaster Risk Management | 0.77 | 0.66 | 0.71 | 83 |
| Loss and Damage | 1.00 | 0.36 | 0.53 | 11 |
| Mitigation | 0.95 | 0.97 | 0.96 | 498 |
| Micro Avg | 0.90 | 0.90 | 0.90 | 839 |
| Macro Avg | 0.89 | 0.72 | 0.76 | 839 |
| Weighted Avg | 0.90 | 0.90 | 0.90 | 839 |
| Samples Avg | 0.92 | 0.93 | 0.91 | 839 |

Adaptation (& DRM): Balanced performance
Mitigation: Best
Loss and damage: Poorest

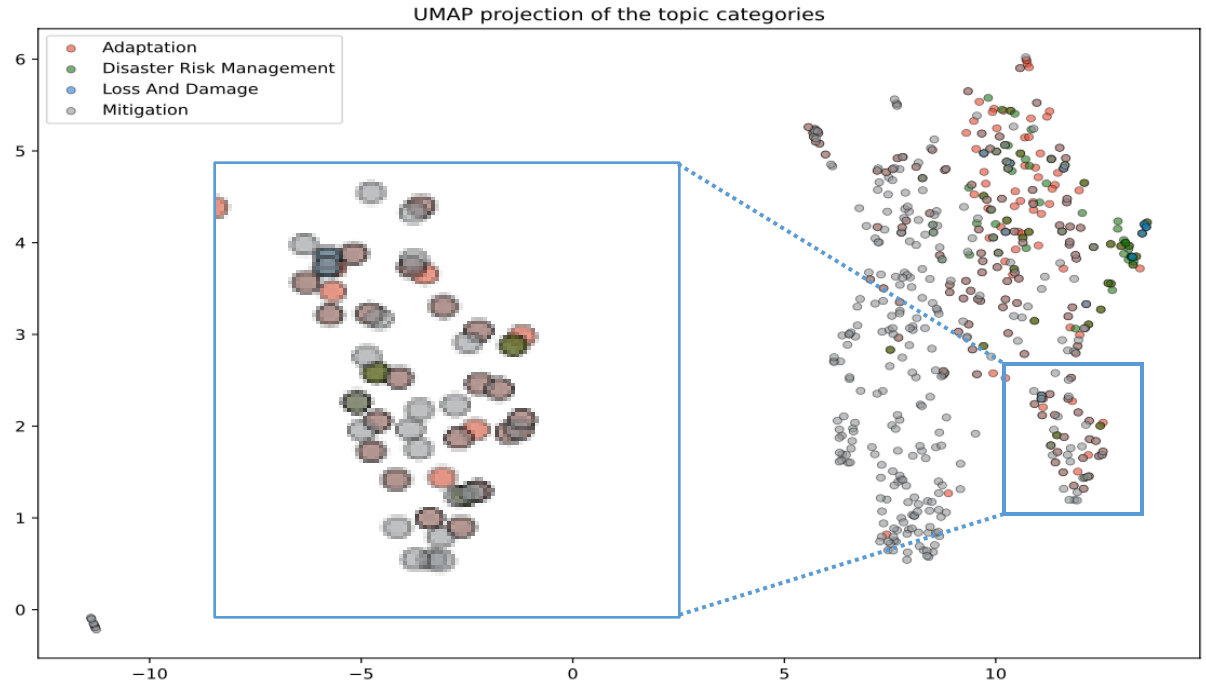
Precision: "Of all the occurrences of the theme the model identified as positive, how many were actually positive?"

Recall: "Of all the actual positive items, how many did the model correctly identify?"

# Model Performance and Embedding Insights




- Class frequency affects performance:
- Mitigation (most frequent) → Excellent performance
- Adaptation → Strong balance
- Disaster Risk Management → Moderate
- Loss and Damage (only 11 samples) → High precision, poor recall




- Shows semantic similarity: policies with similar themes appear closer together.
- Loss & Damage, Disaster Risk Management form distinct smaller clusters.
- Mitigation dominates and blends with other categories.
- 20% of outliers removed using Local Outlier Factor to improve clarity.

# Methodology: Association and Statistical Analysis

✓ **Data:**

1. *Climate Change Laws of the World database (CCLW)* [1]
2. *World Development Indicators (WDI)* [2] (subset taken from 2015 onwards)

Panel data created with countries (entities) × years (time)

- From CCLW, created a matrix of Topic/Response flags per year per country
- From WDI, got annual socio-economic indicators per country.

✓ **Plots/Models:**

1. Box–plots and Correspondence analysis across the countries and climate policy categories

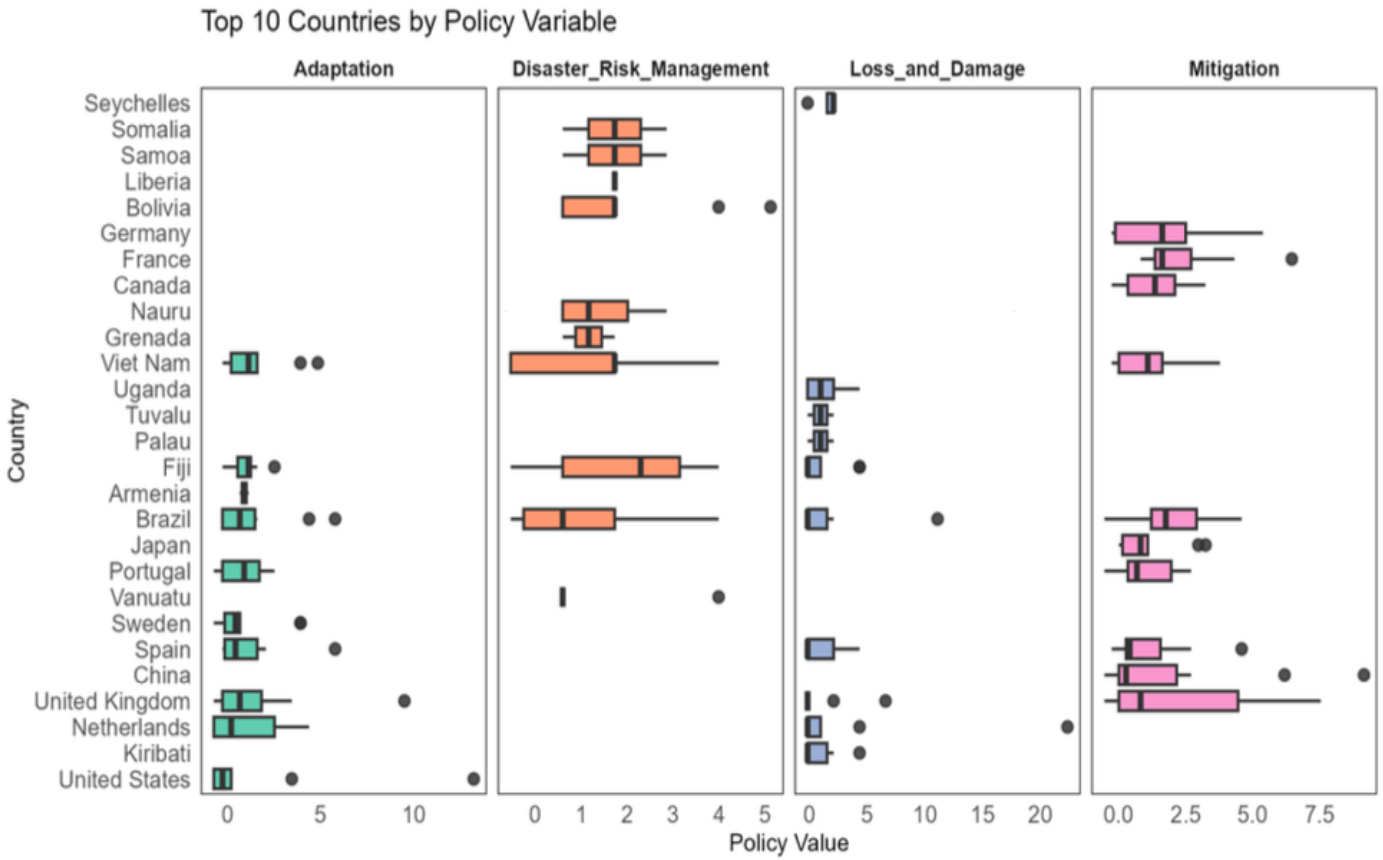
   To explore the association between countries and their implementation of the policy categories through relative scores or intensities across categories (like how much a country focuses on each policy themes).
2. Two-way fixed effects panel model across country-year panels

   To examine how variations in climate policy indicators within countries over time relate to changes in health outcomes, controlling for unobserved heterogeneity.

✓ **Justification:** Fixed effects model handles unobserved heterogeneity within countries; robustness checks (using Breusch–Pagan and Panel BG tests) for random effects model ruled it out. Two-ways to control for both dimensions – countries & years.

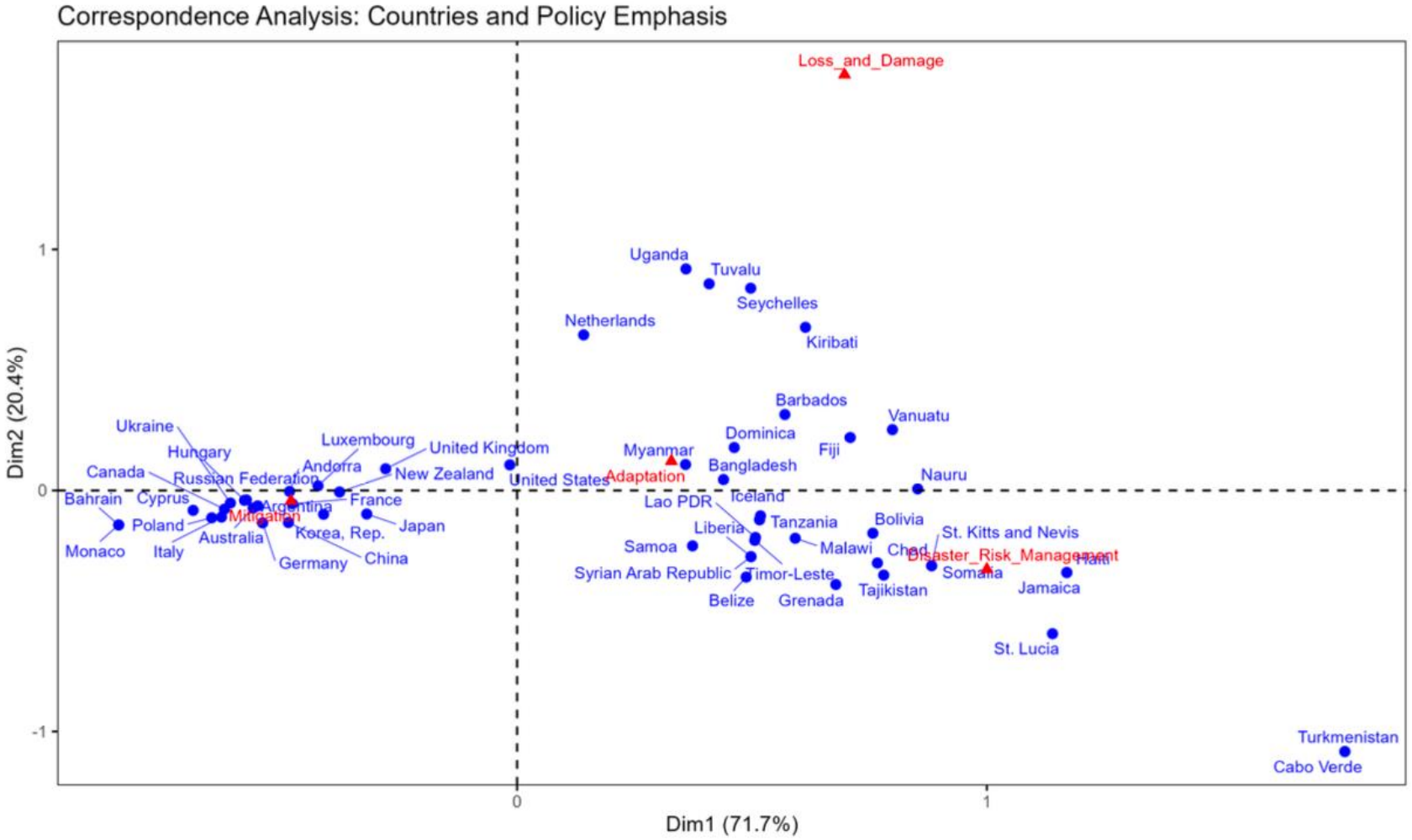
✓ **Variables:** All four policy categories as predictors, with health & economic indicators as outcomes.

# Cross-Country Policy Emphasis



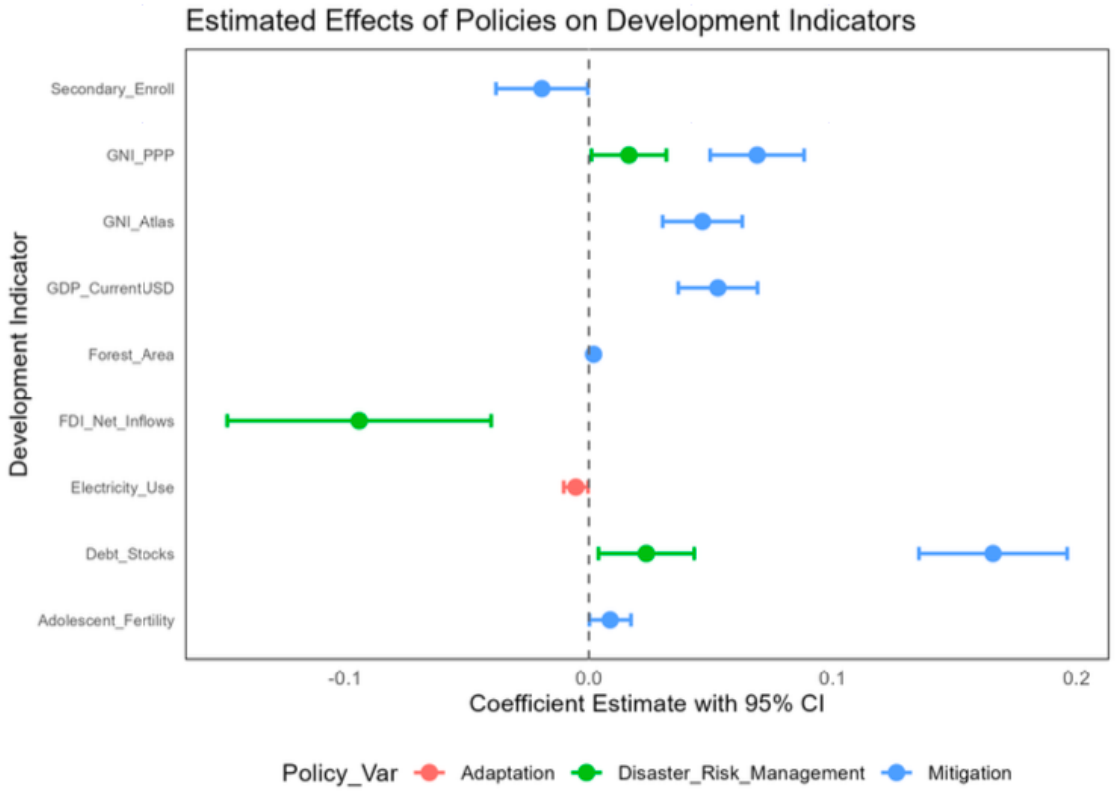

- ❑ Shows the top 10 countries by theme (Mitigation, Adaptation, DRM, Loss & Damage)
- ❑ Mitigation dominated by developed countries (e.g., Germany, France)
- ❑ Adaptation & DRM led by climate-vulnerable countries (e.g., Tuvalu, Jamaica)
- ❑ Loss & Damage underdeveloped globally
- ❑ Z-scores reflect relative thematic intensity over time

# Correspondence Analysis – Global Policy Positioning




- Axes: Dim1 (71.7%), Dim2 (20.4%) explain most variance
- Interpretation:
  - Small island states ( Fiji, Jamaica) → near Adaptation / DRM
  - Wealthy nations (UK, France, Germany) → near Mitigation
  - Loss & Damage → limited, associated with few countries (e.g., Seychelles, Tuvalu)
- Emphasize how climate policy priorities are shaped by national vulnerability and capacity

# Regression Results: Effects of Policy Emphasis on Key Outcomes




+ → positive effect
- → negative effect

✅ **Mitigation** → +GDP, +GNI, +External Debt
Suggests that economic capacity enables stronger mitigation action

⚠️ **DRM** → +Debt & GNI PPP, but −FDI
Points to financial mobilization but investment risk perception

⚠️ **Adaptation** → −Electricity Consumption
Could indicate energy efficiency or demand-side changes

❌ **Loss & Damage** → No significant effects
Reflects limited implementation or data coverage

❗ Unexpected: Mitigation → +Adolescent Fertility | −Secondary Education

- Possible reverse causality or socio-development confounders
- May reflect transitional energy demand or short-term trade-offs

# Limitations and Future Work

- **Limitations:**
  - Texts were short → limited semantic richness
  - Class imbalance → skewed model performance
  - Regression analysis doesn't capture non-linear effects or causality
  - Did not perform across country statistical analysis
  - Correlation ≠ Causation

- **Future work:**
  - Task 1: Use full-text documents, instead of just the summaries.
  - Task 1: Apply topic modelling (e.g., BERTopic) for unsupervised dimension extraction (might observe unknown patterns).
  - Task 2: Would start with a pre-existing theoretical framework and work with a broader hypothesis about relationship of the variables. May also combine data from multiple other sources.
  - Design a quasi-experimental framework using **Fixed Effects (FE) + PSM (Propensity Score Matching) + Difference-in-Differences (DiD)** models to form causal inference for policy evaluation across the countries over the years. This should account for the observable, time-invariant unobservable and the common time-varying confounders.

# Bibliography


1. Grantham Research Institute on Climate Change and the Environment and Sabin Center for Climate Change Law. Climate change laws of the world database. https://climate-laws.org, 2025. Accessed: 2025-06-30.
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Paper code: