EGU General Assembly 2025

Normatively Robust Mitigation Policy to Equitably Distribute the Remaining Carbon Budget

Palok Biswas
Jazmin Zatarain Salazar
Jan H. Kwakkel

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Abstract

Equity in Climate Negotiations

Cop29 climate finance deal criticised as 'travesty of justice' and 'stage-managed'

Some countries say deal should not have been done and is 'abysmally poor' compared with what is needed

Activists stage a protest following the closing ceremony in Baku amid anger over the deal and the negotiation process Photograph: Dominika Zarzycka/SOPA Images/REX/Shutterstock

Who Pays and How: The COP28 Dilemma of Debt and Equity

COP28 will take stock of the step change in ambition needed, but the gulf

nature

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NEWS | 10 November 2021

COP architects furious at lack of climate justice at pivotal summit

The New York Times

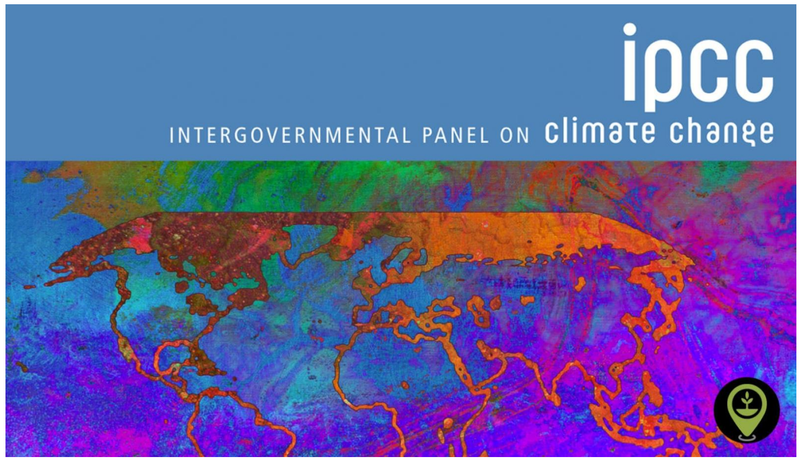
Countries Most at Risk Call Proposed Climate Agreement a 'Death Warrant'

The working draft made public at the U.N. summit in Dubai would not commit nations to phasing out the fossil fuels that are dangerously heating the planet.

Integrated Assessment Models

Integrated Assessment Models **(IAMs)** are the **dominant tool** used to design **global mitigation pathways** in **IPCC** reports[1].

IAMs *lack explicit consideration* for **distributive justice**[2].



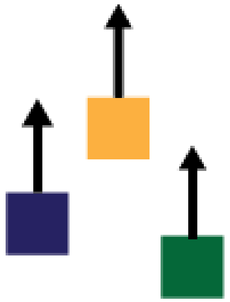
1. Cointe et al. 2019
2. Budolfson et al 2021

Results in a **misalignment** between IAM *prescriptions* and actual *decision needs*.

The Double Dilemma

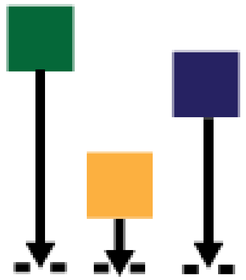
Deep Uncertainty	Normative Uncertainty
- Future socio-economic projections - Economic *impacts* of climate damages	- Arising in a *multi-actor* setting with *perspectival diversity*. - Different *theories* prescribe *different courses of action* in response to climate change.

Rival Ethical Framings



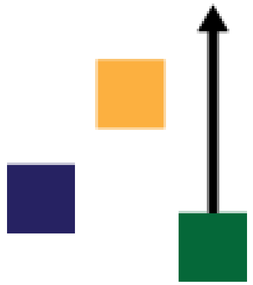
UTILITARIAN

Maximizes the sum of utility without taking distribution into account



LIMITARIAN

Puts an upper limit on well-being; exceeding which is unjust



PRIORITARIAN

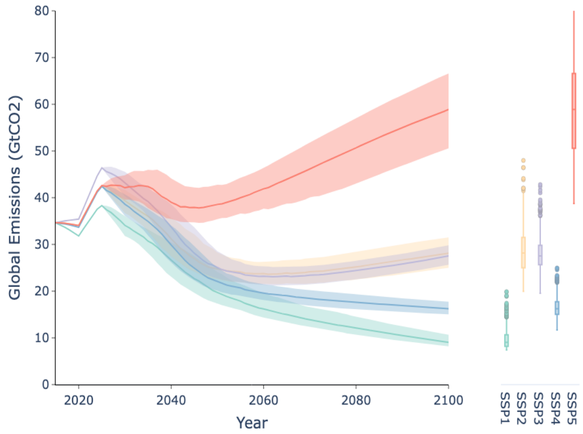
Prioritizes the welfare of the least well-off

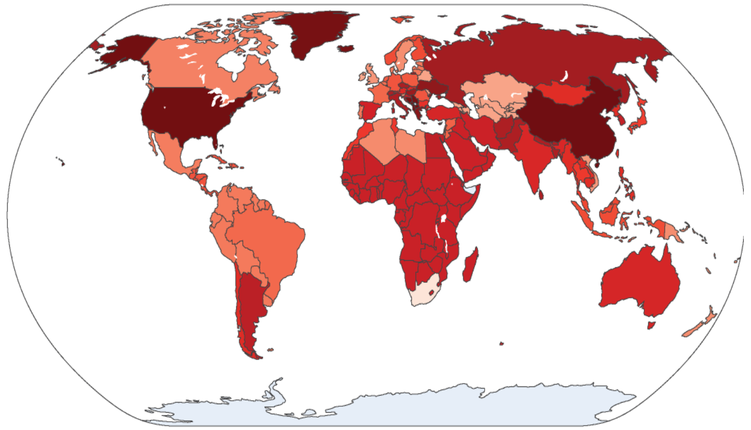
Exploring Normative Uncertainty in IAMs

Global Emissions

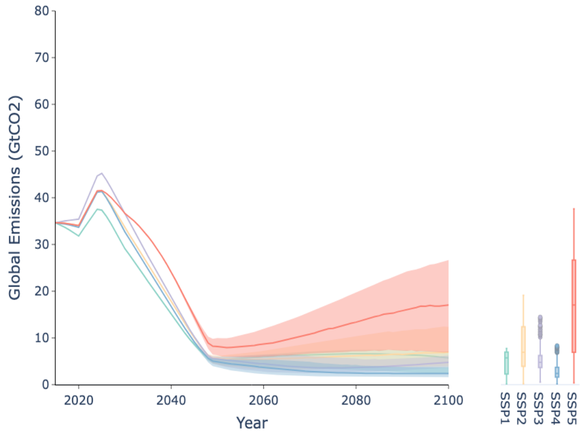
Mitigation Burden Distribution

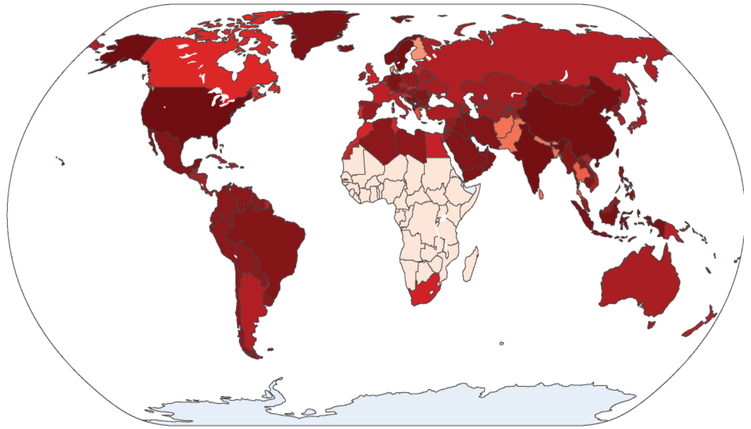
Utilitarian





Prioritarian





Normatively Robust Mitigation Policy to Equitably Distribute the Remaining Carbon Budget

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METHODS

RESULTS

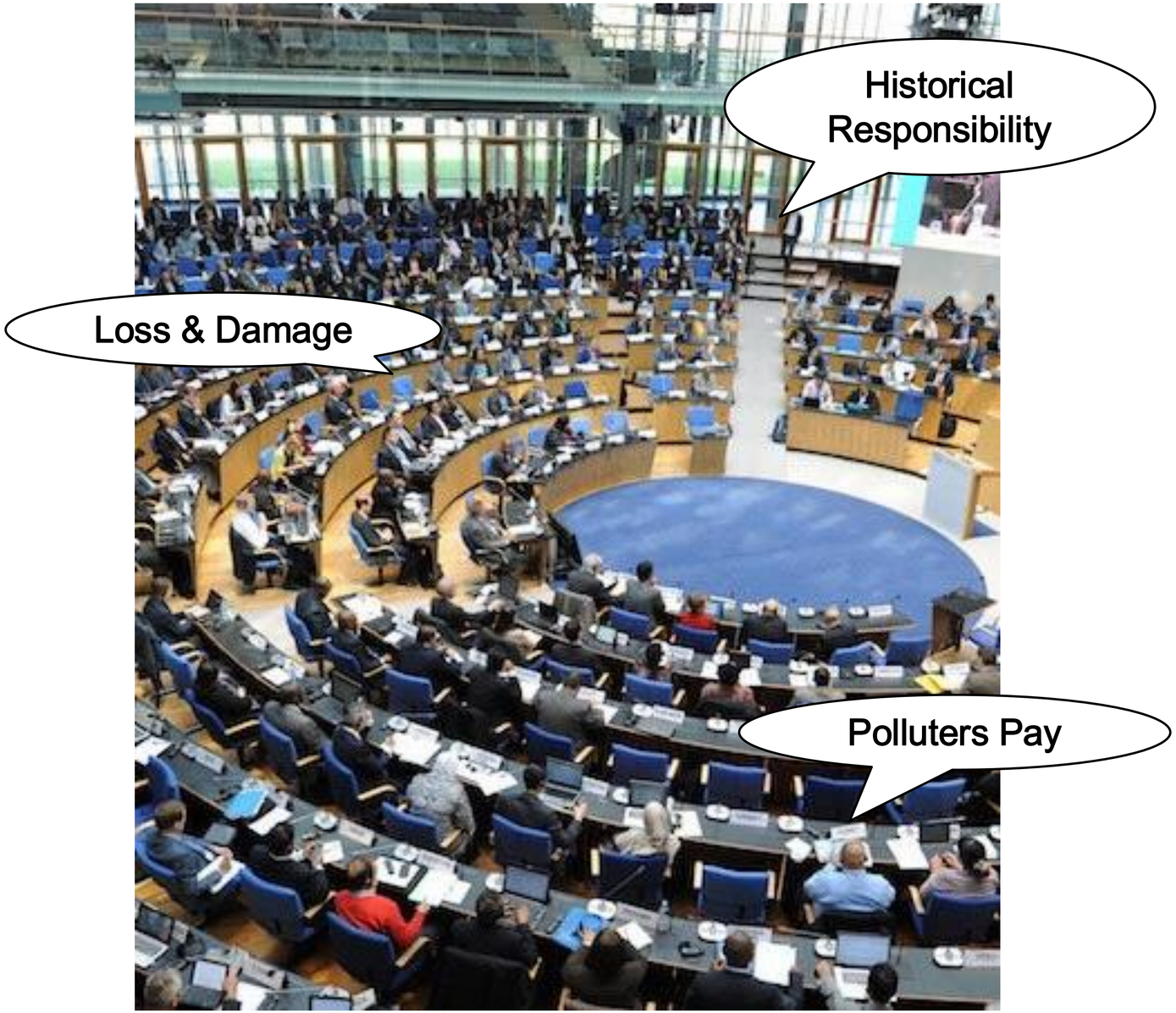
Abstract

Challenges in COP Negotiations

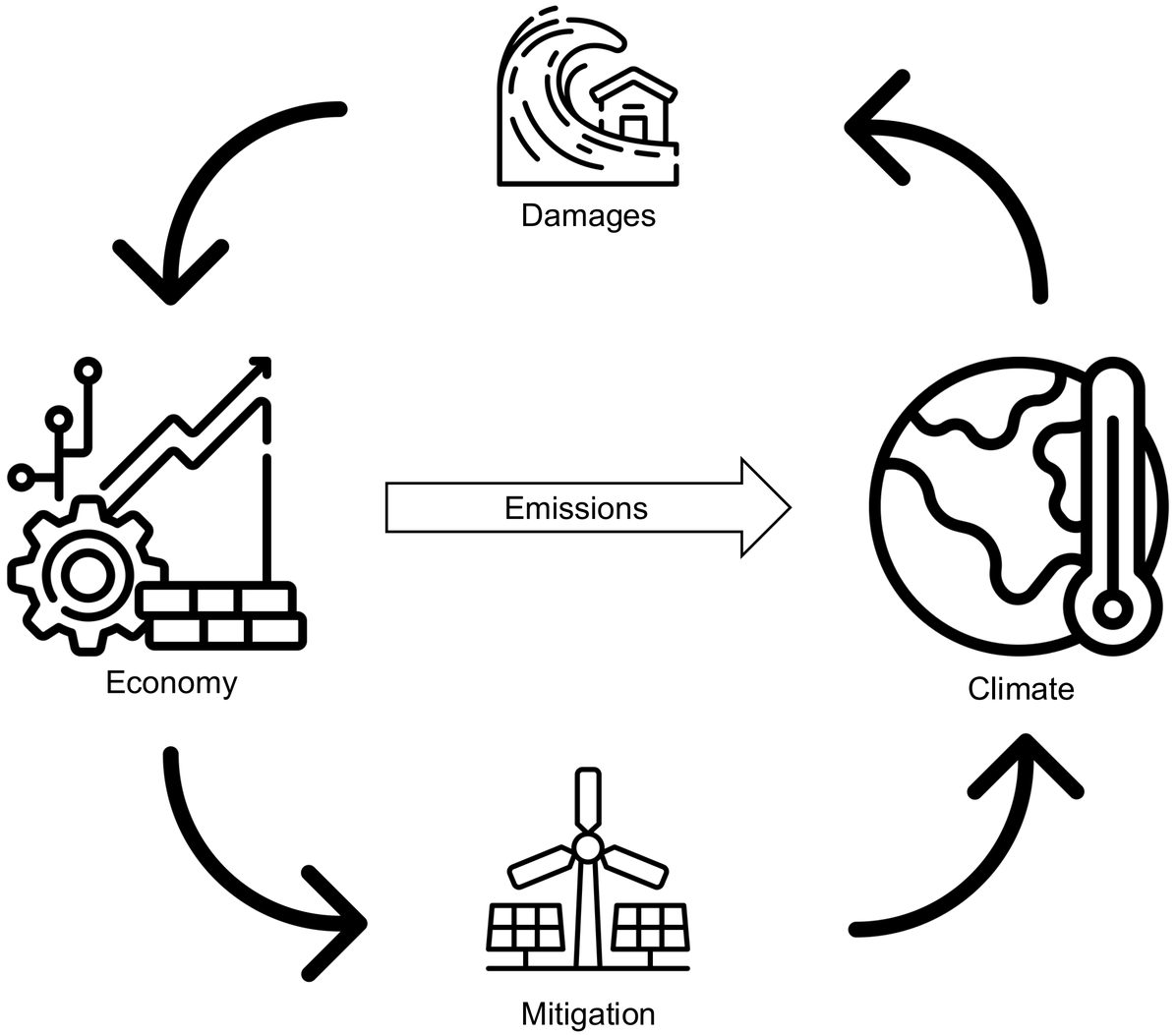
Multiple actors with **diverse** & **conflicting** interests

Uncertain future *economic* & *climate* projections

Stakeholders struggle to find **common ground**, leading to negotiation **impasse**



Integrated Assessment Models (IAMs)

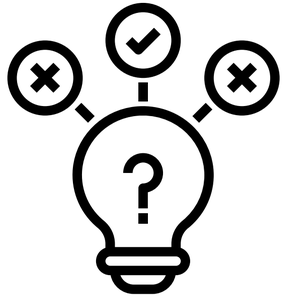


Consequences of Assumptions

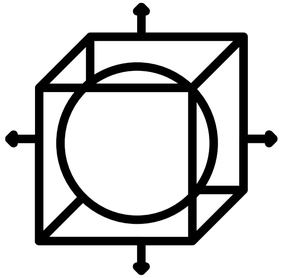
IAMs contain **different normative assumptions**

These assumptions have **different distributional consequences**

If overlooked, IAMs can **perpetuate inequalities**



Modeling Assumption



Model

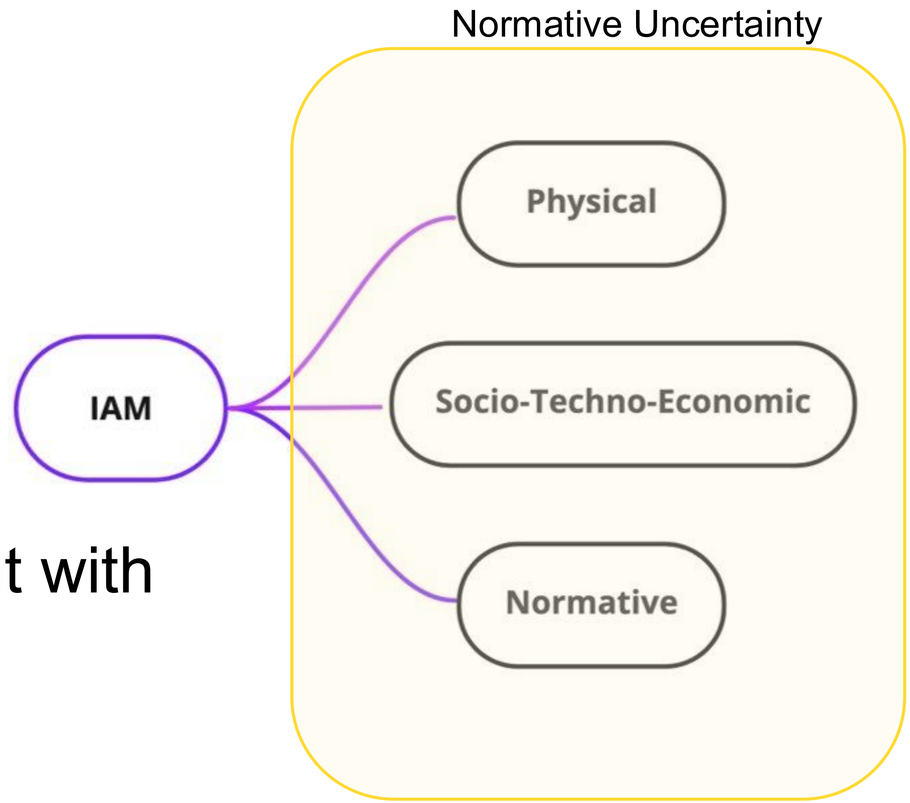
Distributional Outcomes

Normative Uncertainty in IAMs

Physical *(Climate)*

Socio-techno-economic

Normative



Normative components of IAMs, **most** fraught with **uncertainty** and yet the **least understood**[1]

1. Tavoni & Valente, 2022

Distributive Justice in IAMs

Limitarianism:

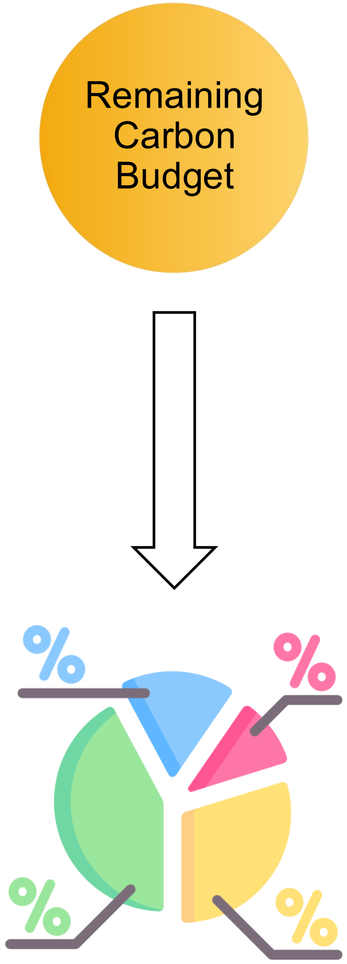
- *Sets an upper cap on total global emissions* (the remaining carbon budget) to keep warming below 2°C.

- We use *emergent constraints*[1] to ensure this budget is robust under climate uncertainties.

Distribution with Utilitarianism & Prioritarianism:

- *Utilitarianism:* Allocates the carbon budget to maximize total global well-being.

- *Prioritarianism:* Prioritizes the needs of the least advantaged nations and generations.



1. Cox et al. 2024

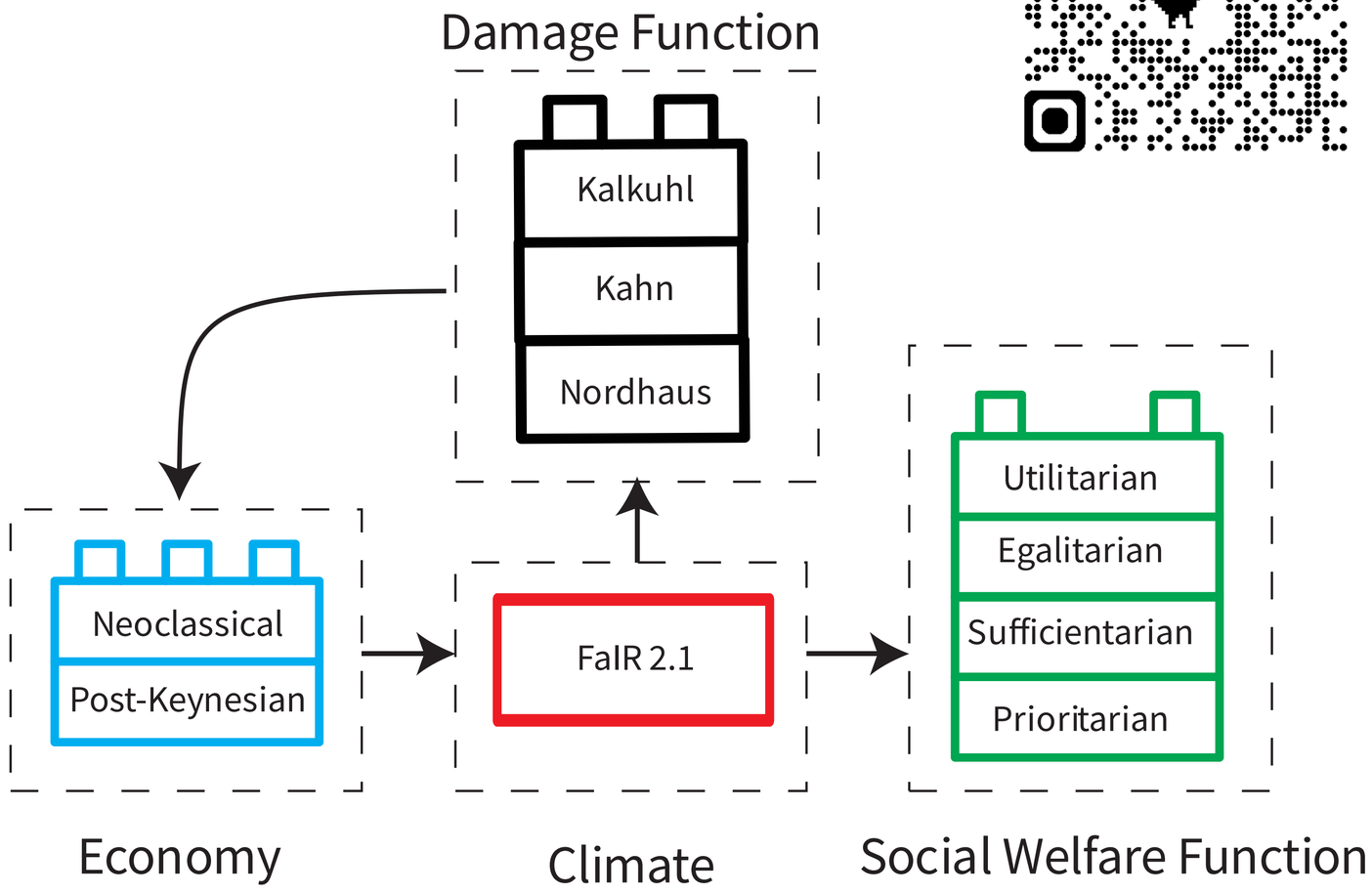
Methods

JUSTICE IAM

JUSTICE IAM Framework

Modular *Simulation-Optimization* Model Framework

Explores *distributional impacts* of *modelling assumptions*



Biswas et al. 2025. *In Review.*

DMDU Techniques to address Normative Uncertainty

Rival Ethical Framing

Social Welfare Functions rooted in different principles of *distributive justice*

• • •

Adaptive Policymaking

Closed-loop control problem using ***EMODPS*** framework

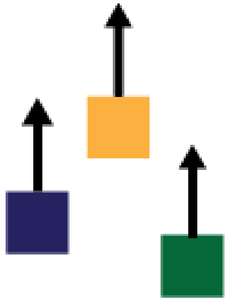
• • •

Robustness Analysis

Using ***MORDM*** to assess the *robustness of policy options*

• • •

1. Rival Ethical Framings



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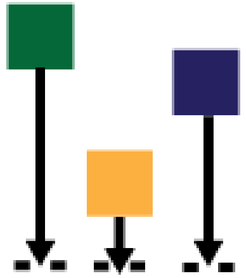

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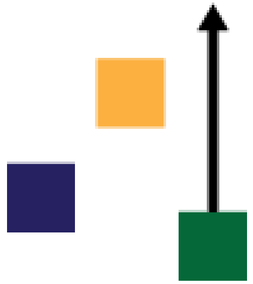


PRIORITARIAN

Prioritizes the welfare of the least well-off

1. Social Welfare Function

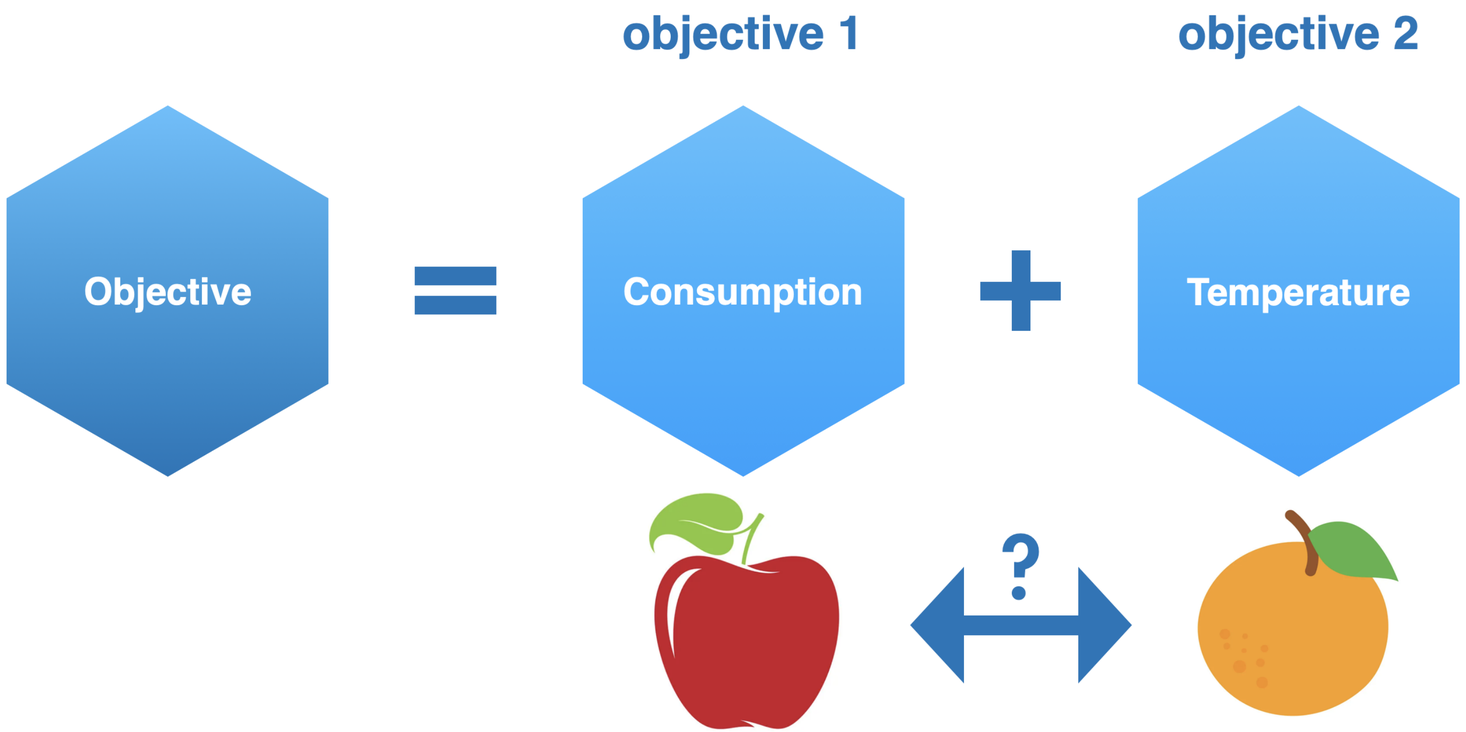
Normative Parameters

Normative Parameters	Description
ϕ_S	Risk Aversion
ϕ_N	Priority or Inequality Aversion
ϕ_T	Pure Rate of Time Preference
λ	Elasticity of Marginal Utility of Consumption
ψ	Egality Strictness
c^{Thresh}	Sufficiency Threshold
e^{Limit}	Limitarian Emission Limit

Biswas et al. 2025. *In Review.*

2. Disaggregation of Objectives

There exists **no single best** aggregation procedure to fully capture **diverse individual preferences** into a **single metric**[1]



1. **Arrow, 1950**

2. Disaggregation of Objectives

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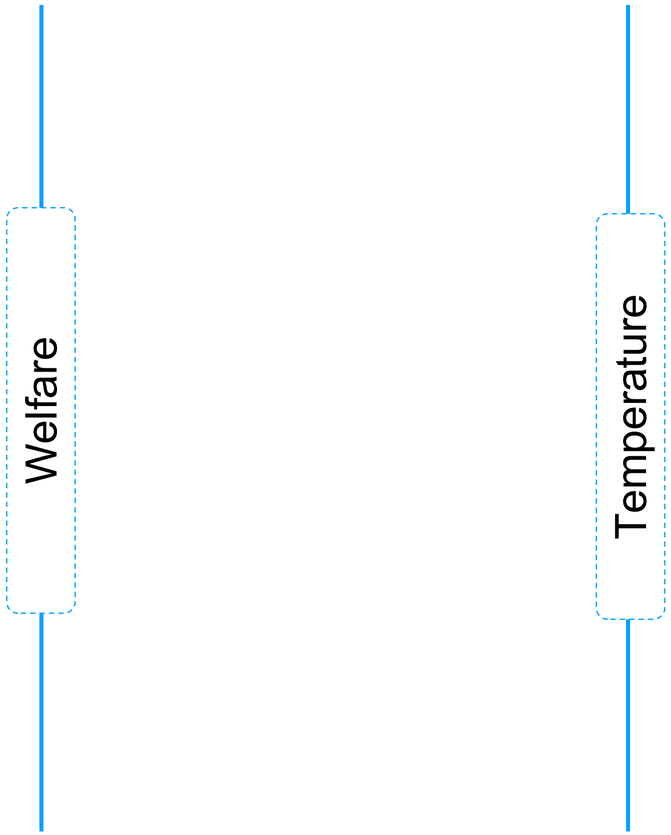
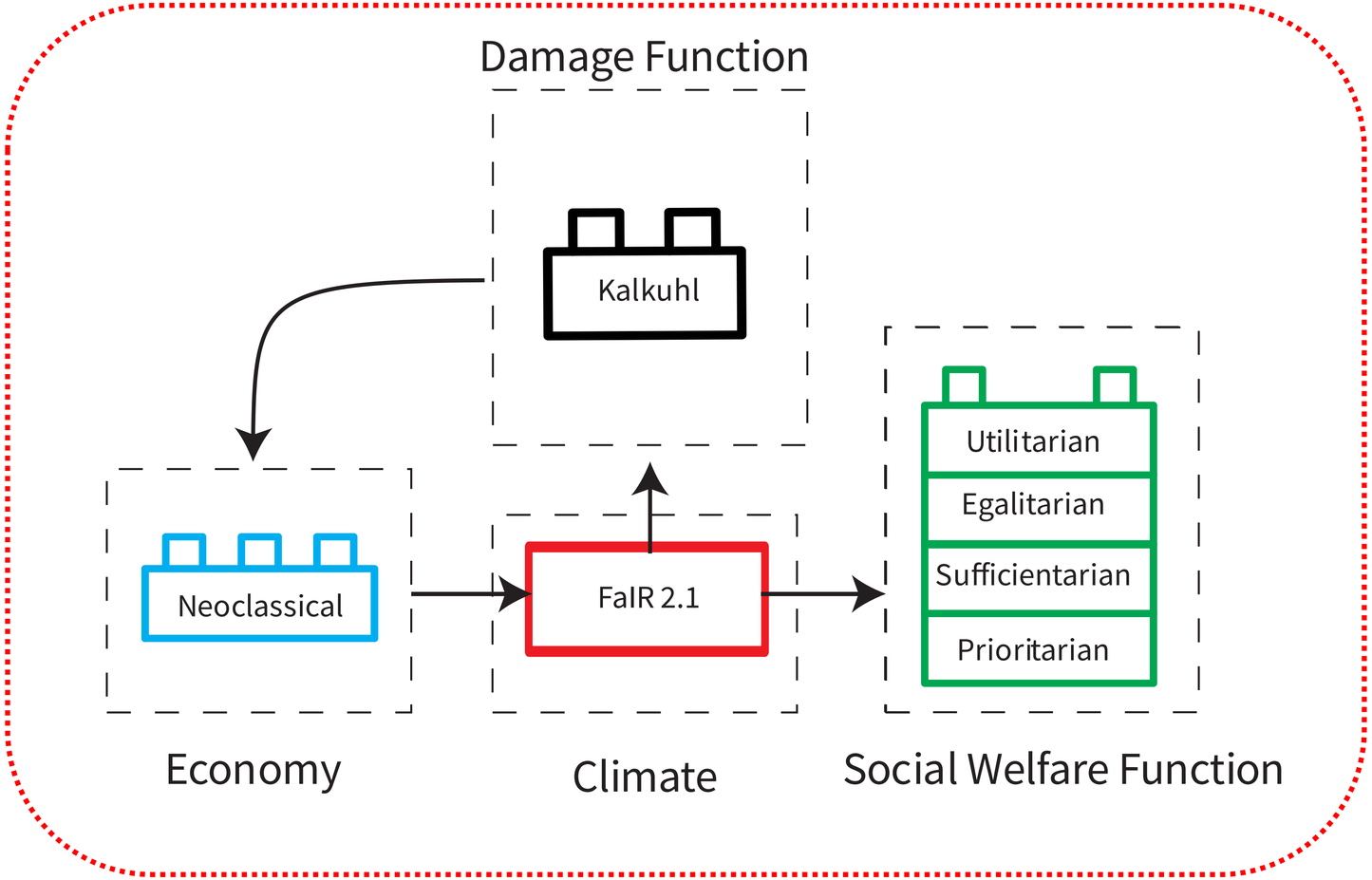


2. Evolutionary Multiobjective Direct Policy Search (EMODPS) – *Adaptive Policymaking*



Biswas et al. 2025. *In Review.*

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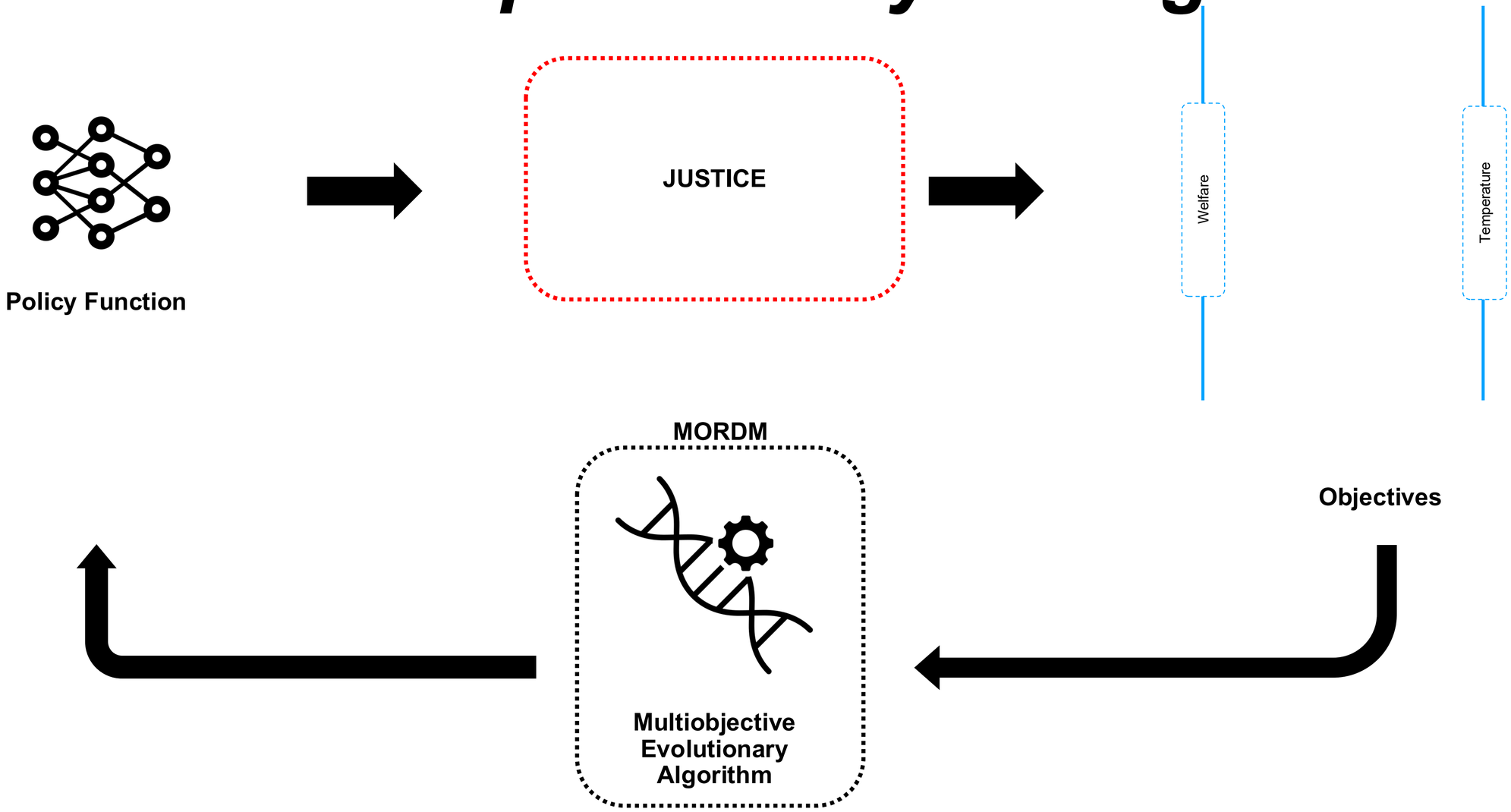
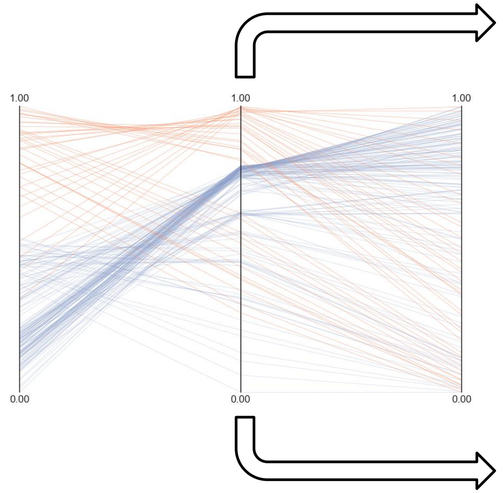


Biswas et al. (Under Submission)

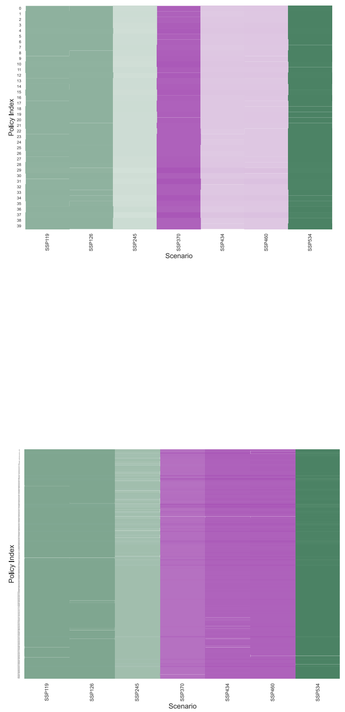
Biswas et al. 2025. *In Review.*

3. Multiobjective Robust Decision Making *(MORDM)*

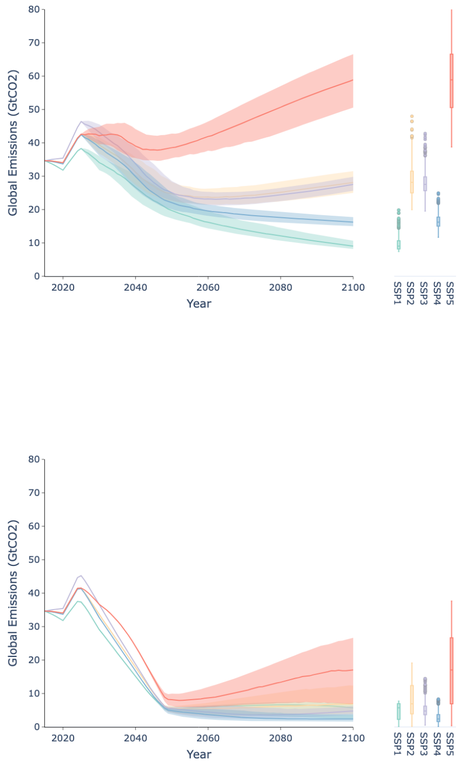
Multiobjective Optimization



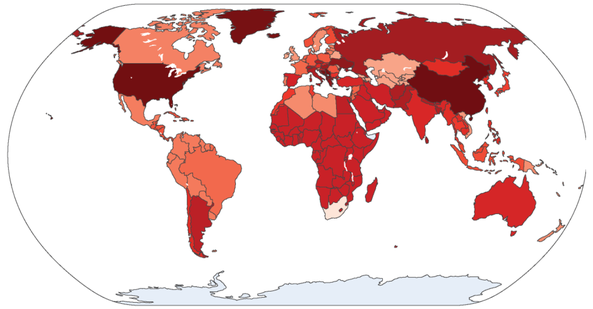
Robustness Analysis

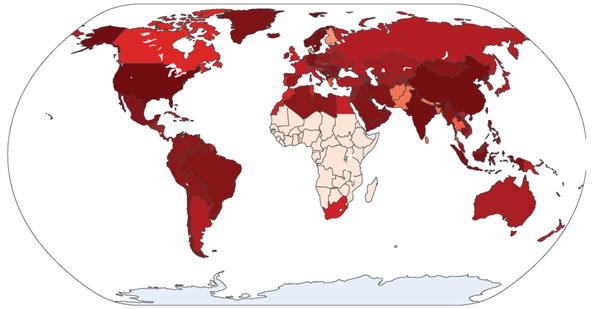


Emission Pathways



Burden Distribution

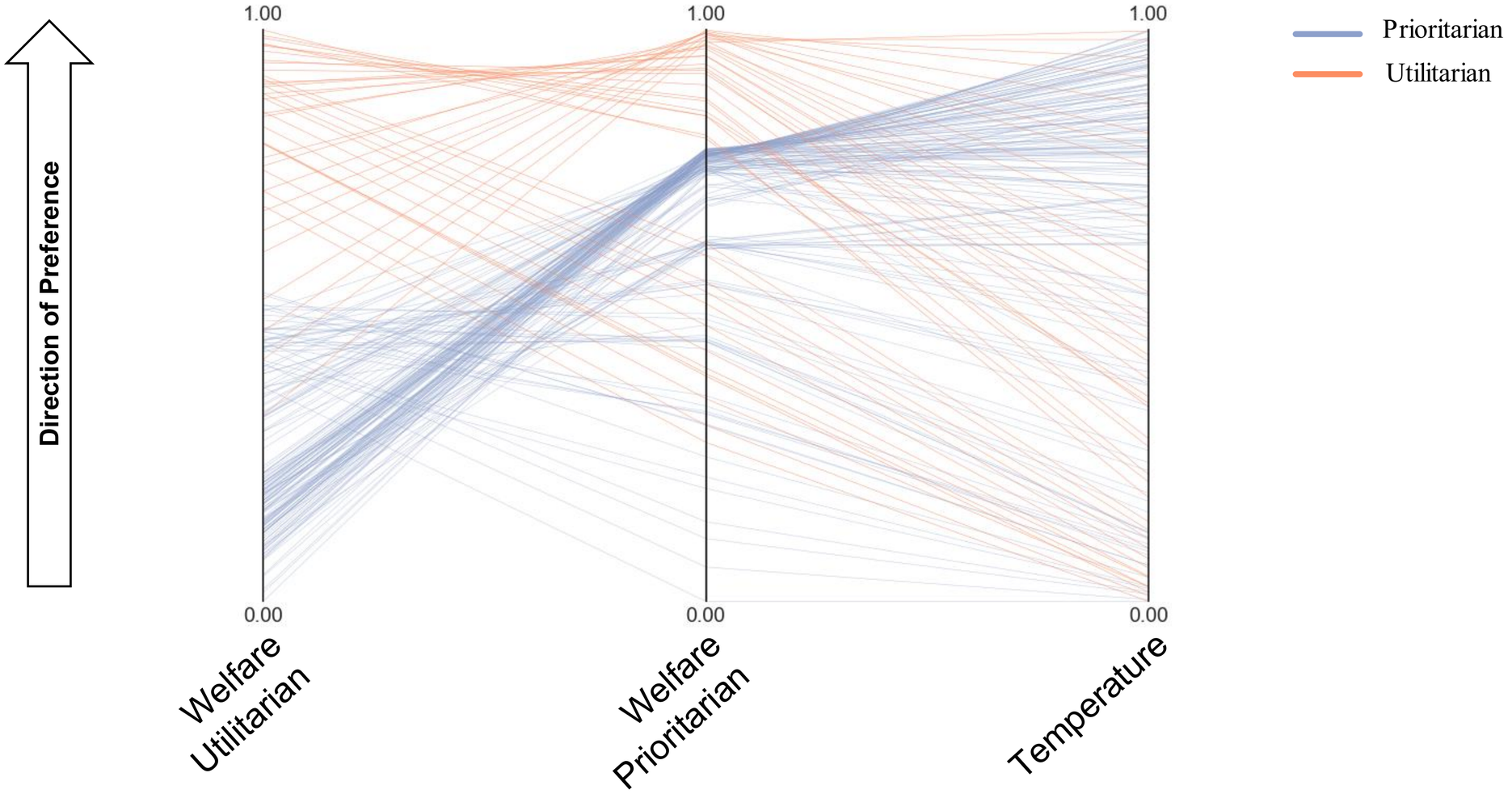




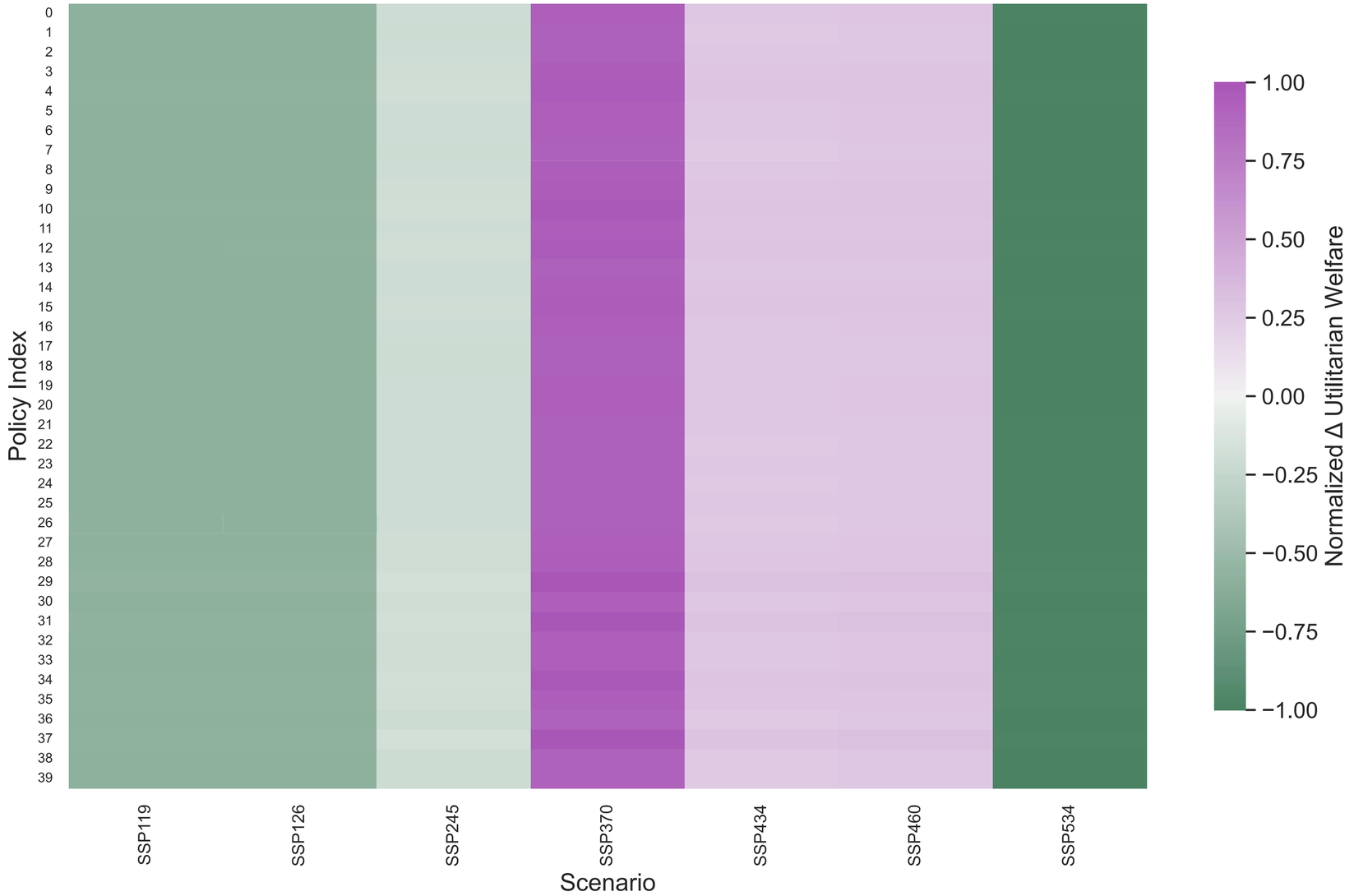
Results

Multiobjective Formulation

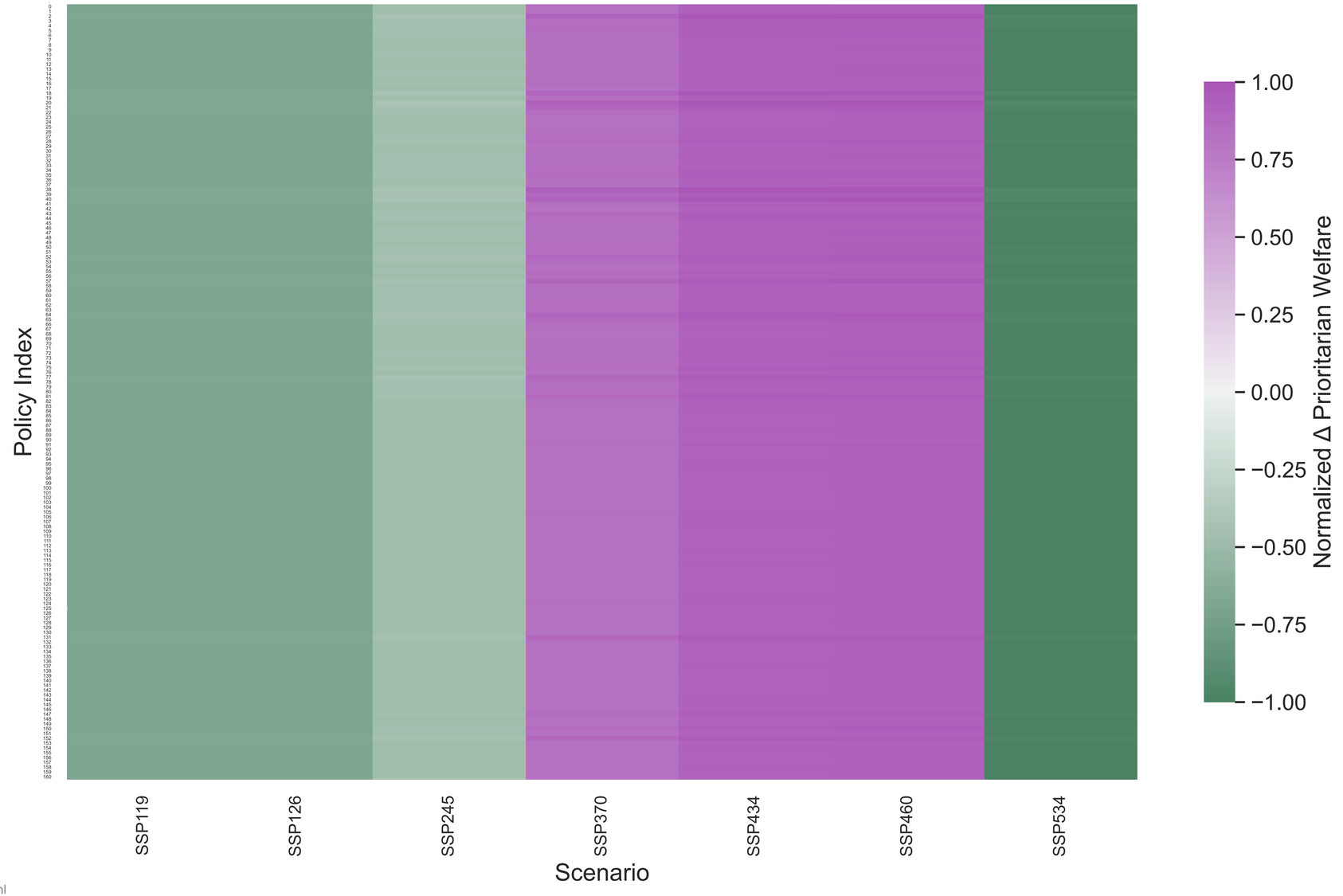
Trade-offs between Objectives



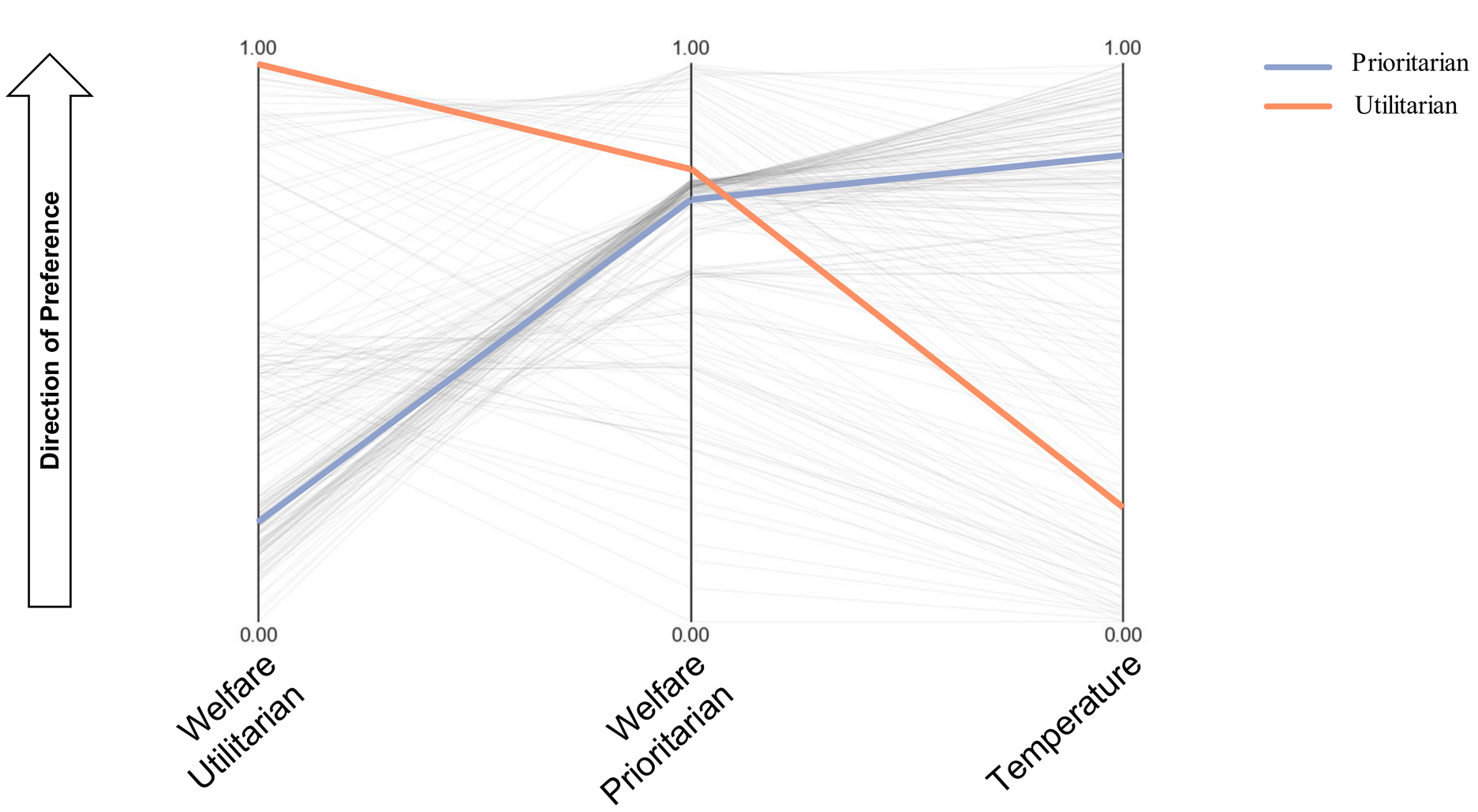
Regret Heatmap – Limitarian-Utilitarian



Regret Heatmap – Limitarian-Prioritarian

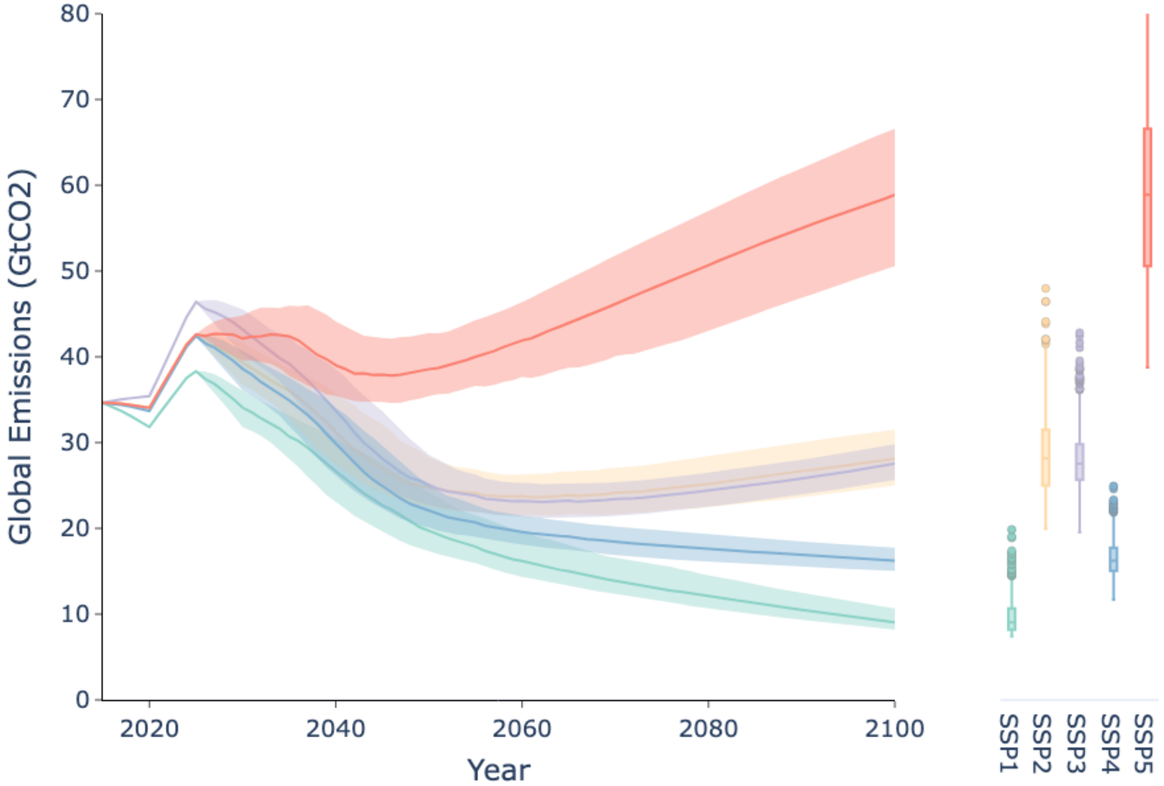


Filtering for Policies that Minimize the Maximum Regret



Global Emission Across SSP Scenarios

Limitarian-Utilitarian



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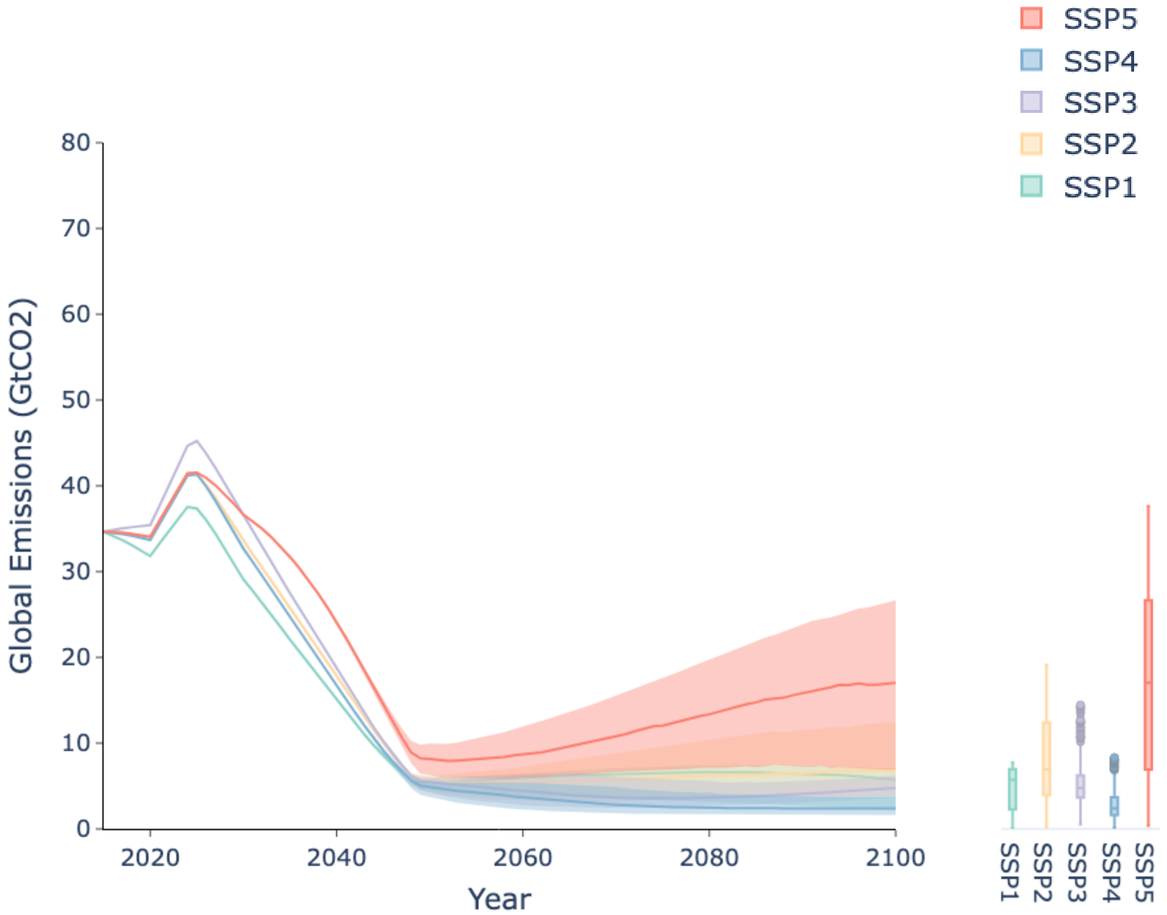
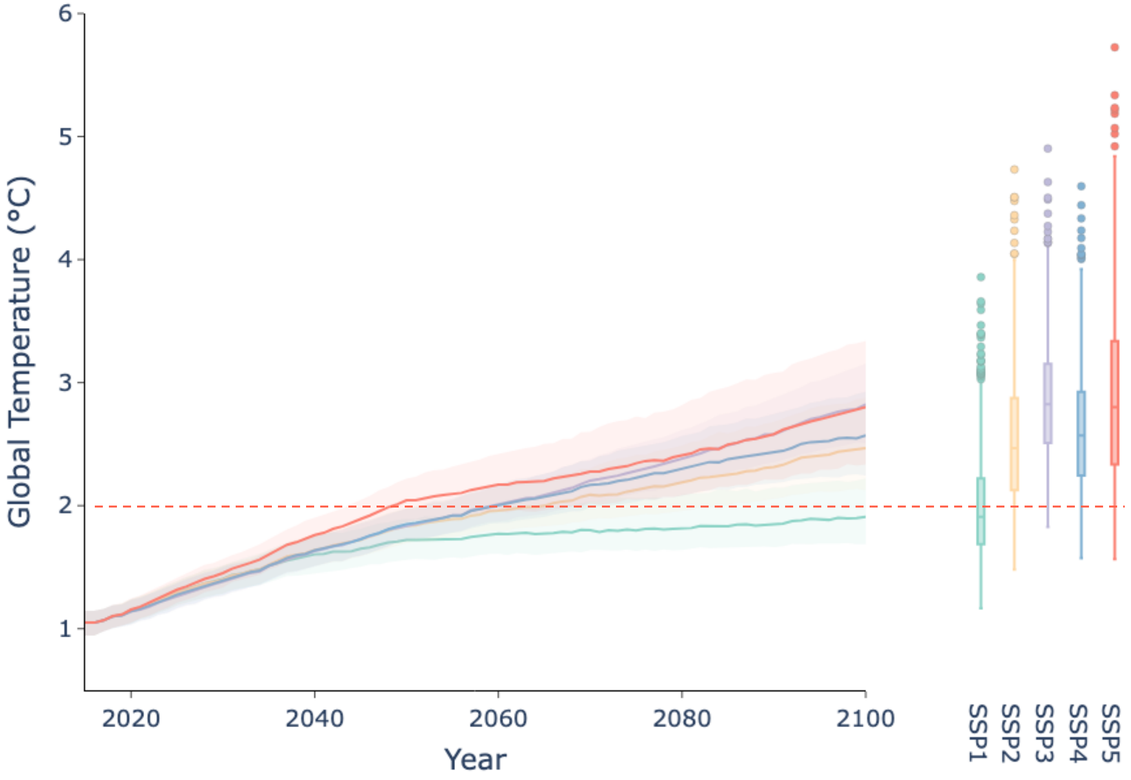


Global Temperature Across SSP Scenarios

Limitarian-Utilitarian



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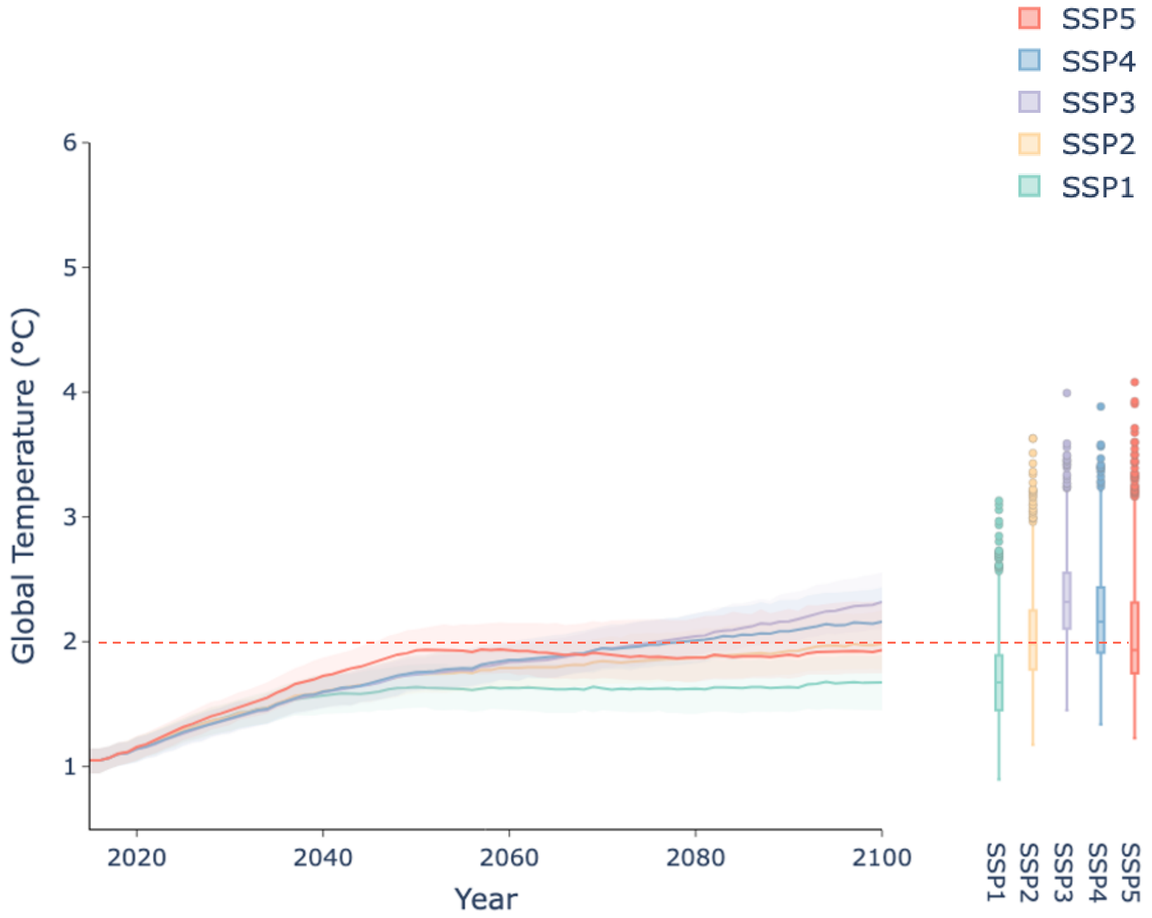
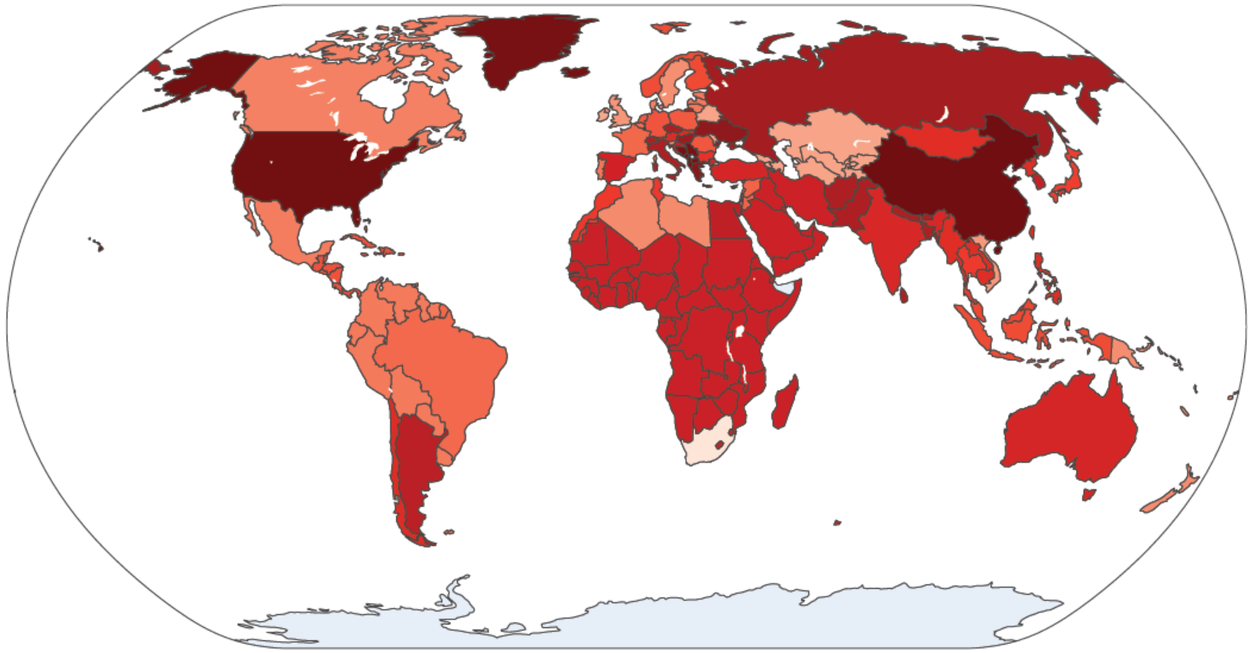


Regional Distribution of Mitigation Burden and Emission Budget – *Limitarian-Utilitarian*

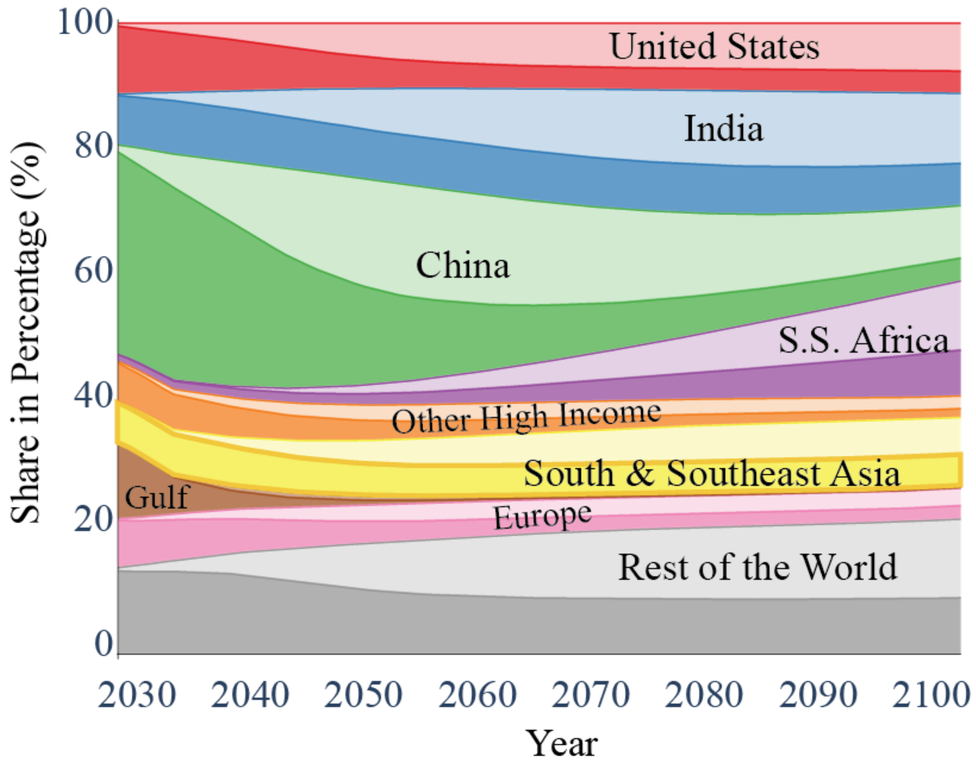
Distribution of Emission Control Rate in 2050



Average Emission Control Rate (%)

0% 25% 50% 75% 100%

Emissions and Abated Emissions



Mitigated Emissions
Emissions

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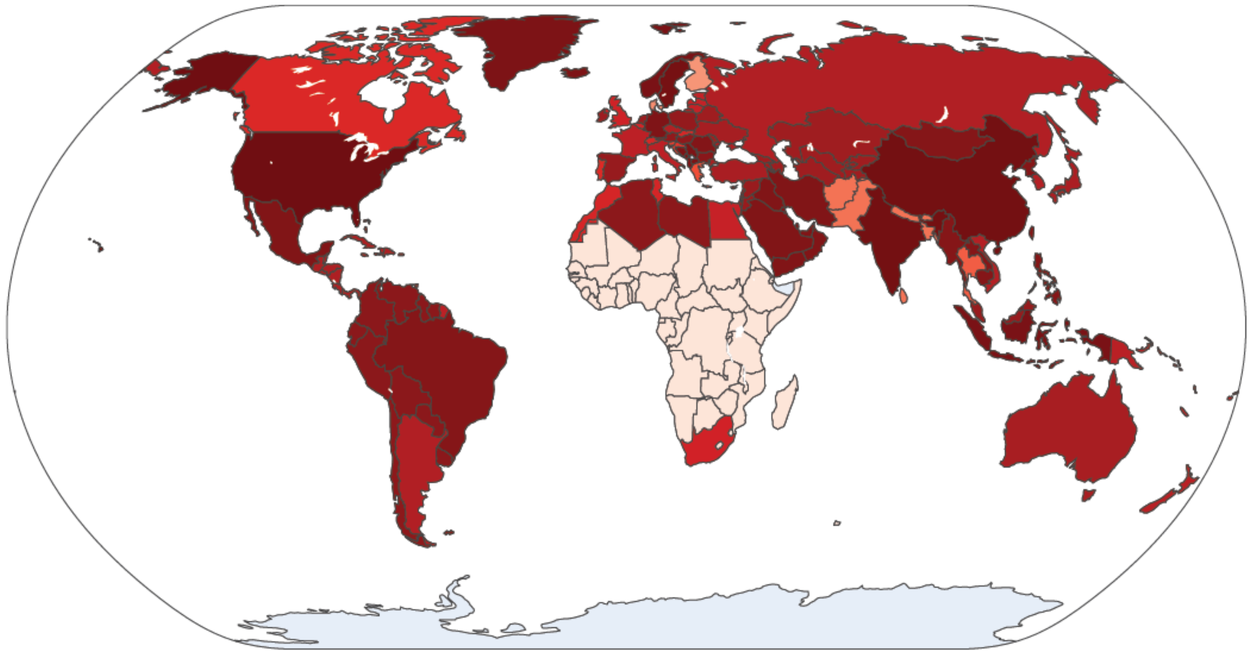

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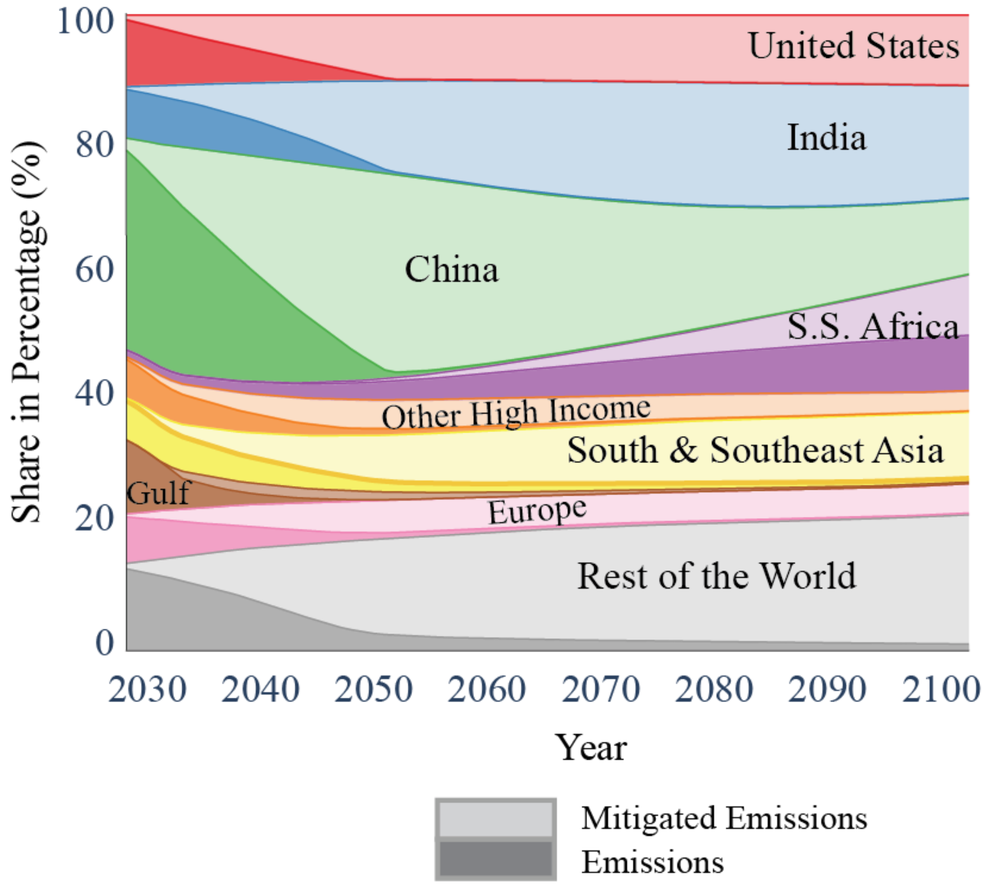
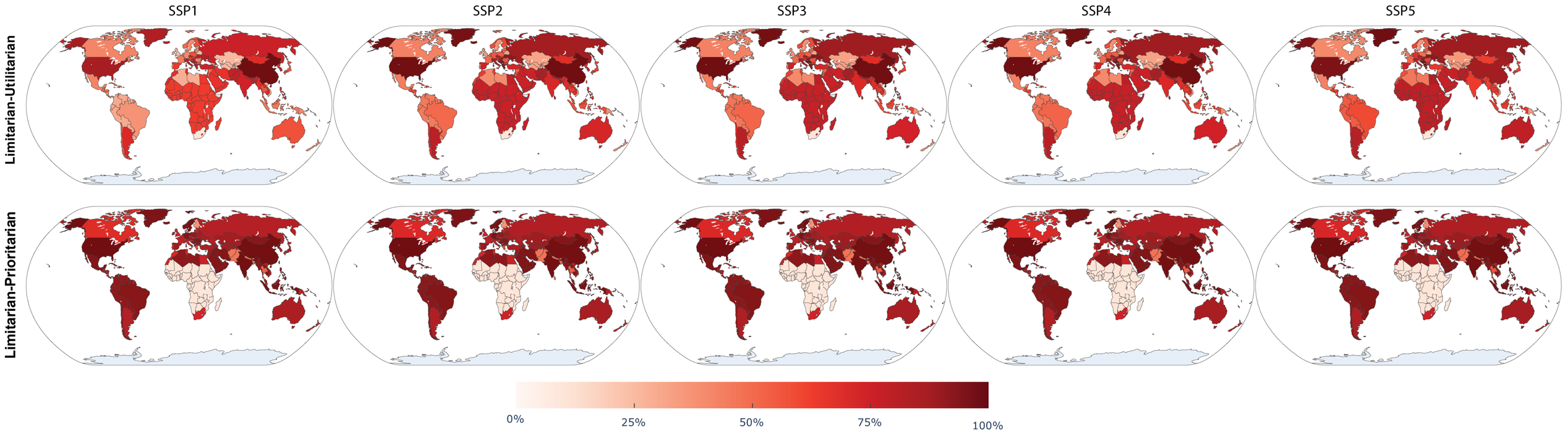


Distribution is insensitive to SSP Scenarios



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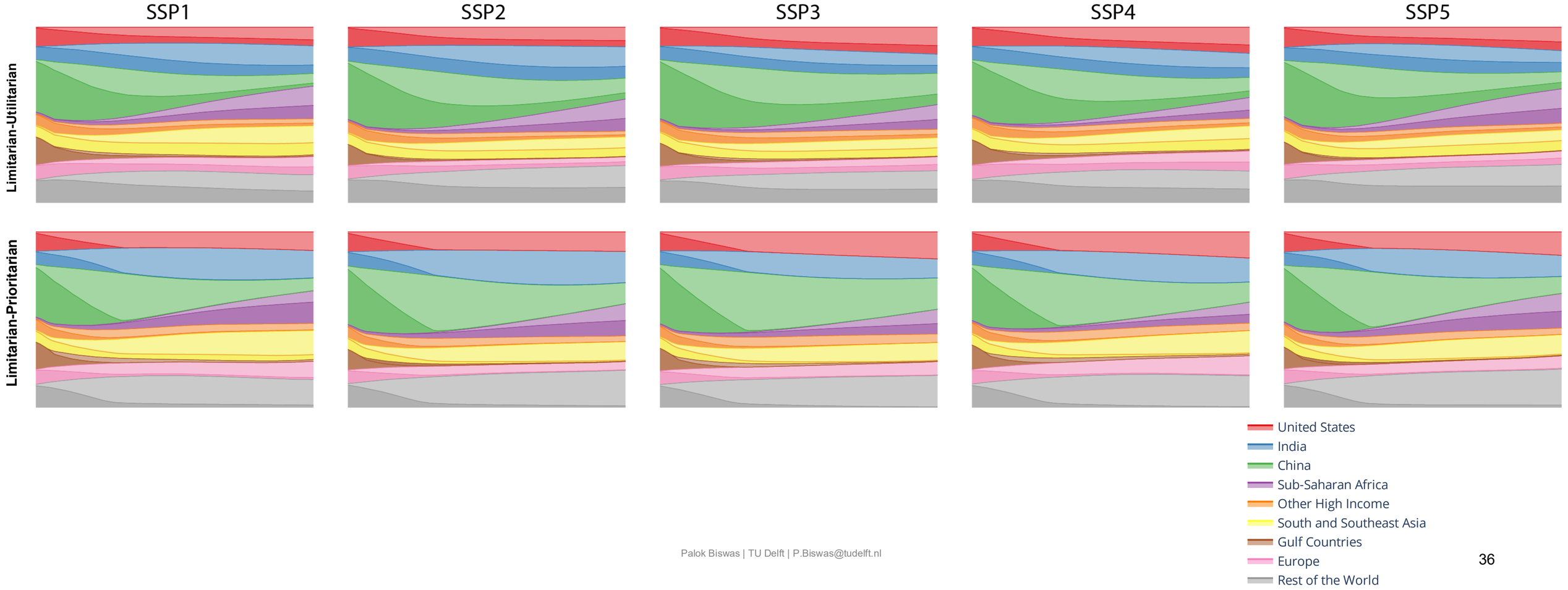

Take home message

Ethical framing matters: It shapes both the *ambition* and *distribution* of mitigation efforts.

Integrating justice principles: Aligns *policy recommendations* with the *needs* and *values* of climate policymakers.

Exploring normative uncertainty: Builds *common ground* and fosters meaningful *dialogue*—supporting *fairer*, more *robust* climate policies.

TU Delft

Thank you!

JUSTICE IAM

Abstract

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