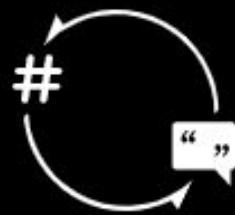


D3M@Tufts

PFI 3: International trade, conflict, and catastrophe in GCAM



Connecting Numbers and Narratives



Learning How to Learn



Embracing Complexity



GCAM Student Projects

International trade, conflict, and catastrophe

Overall comments

- Shift focus a bit to pedagogy
 - Group 1 slide on what it is like to run GCAM was really clever
 - what is it like working in an interdisciplinary setting?
- Less words on slides
- simpler figures
- instead of focus on results, focus on what we learned
- where did we fail and what challenges did we face?
- How does our work relate to the three D3M tenets:
 - Numbers and narratives
 - learning how to learn
 - embracing complexity

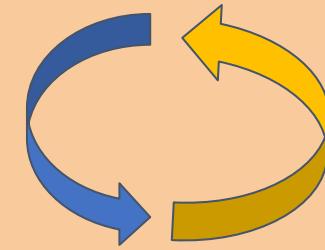
Agenda



Approaches

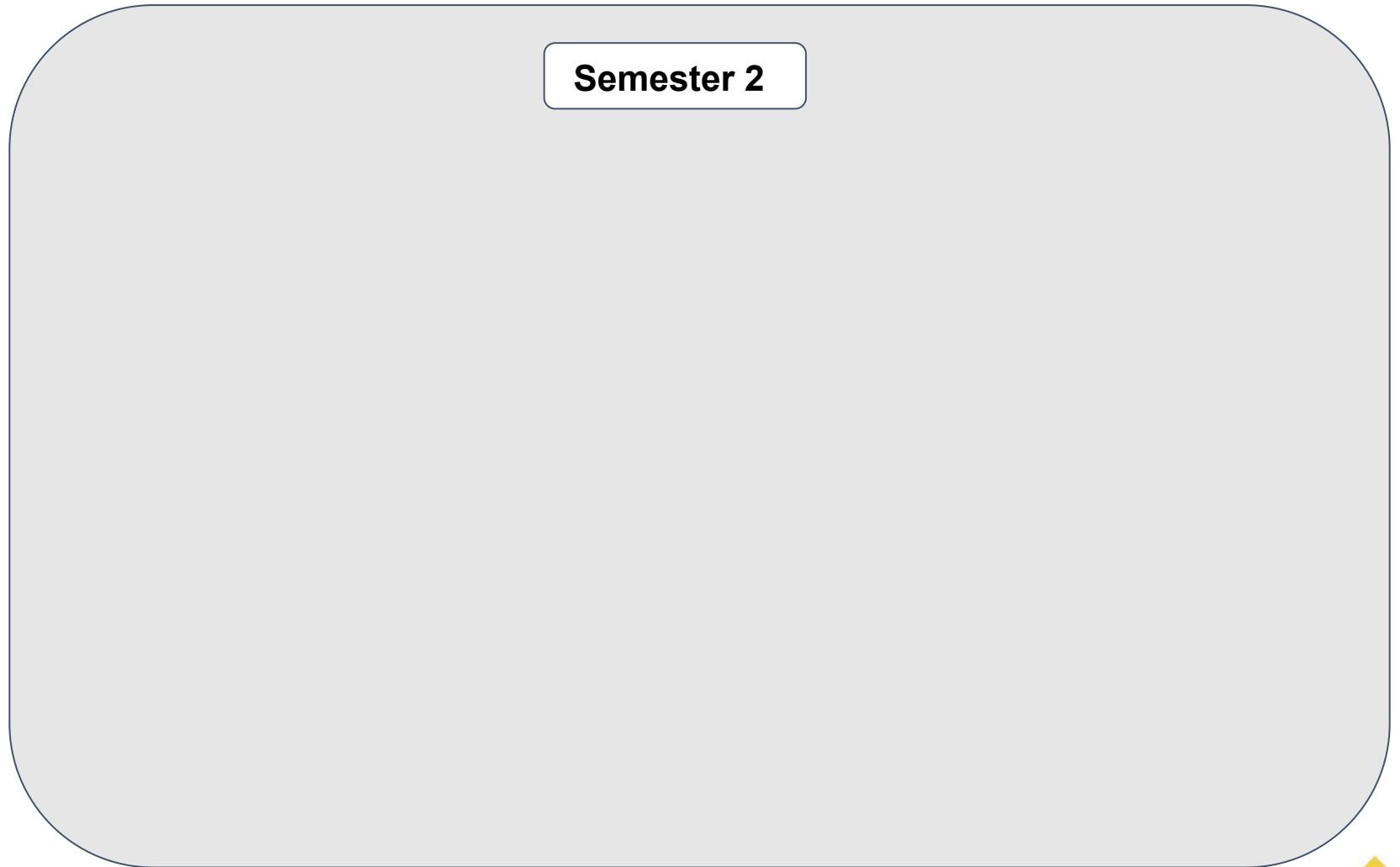
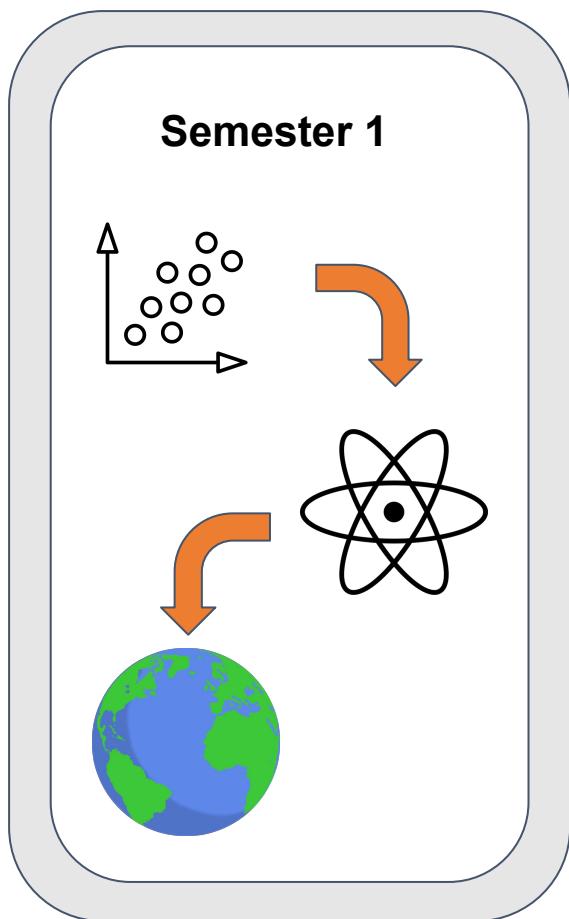


Student Projects

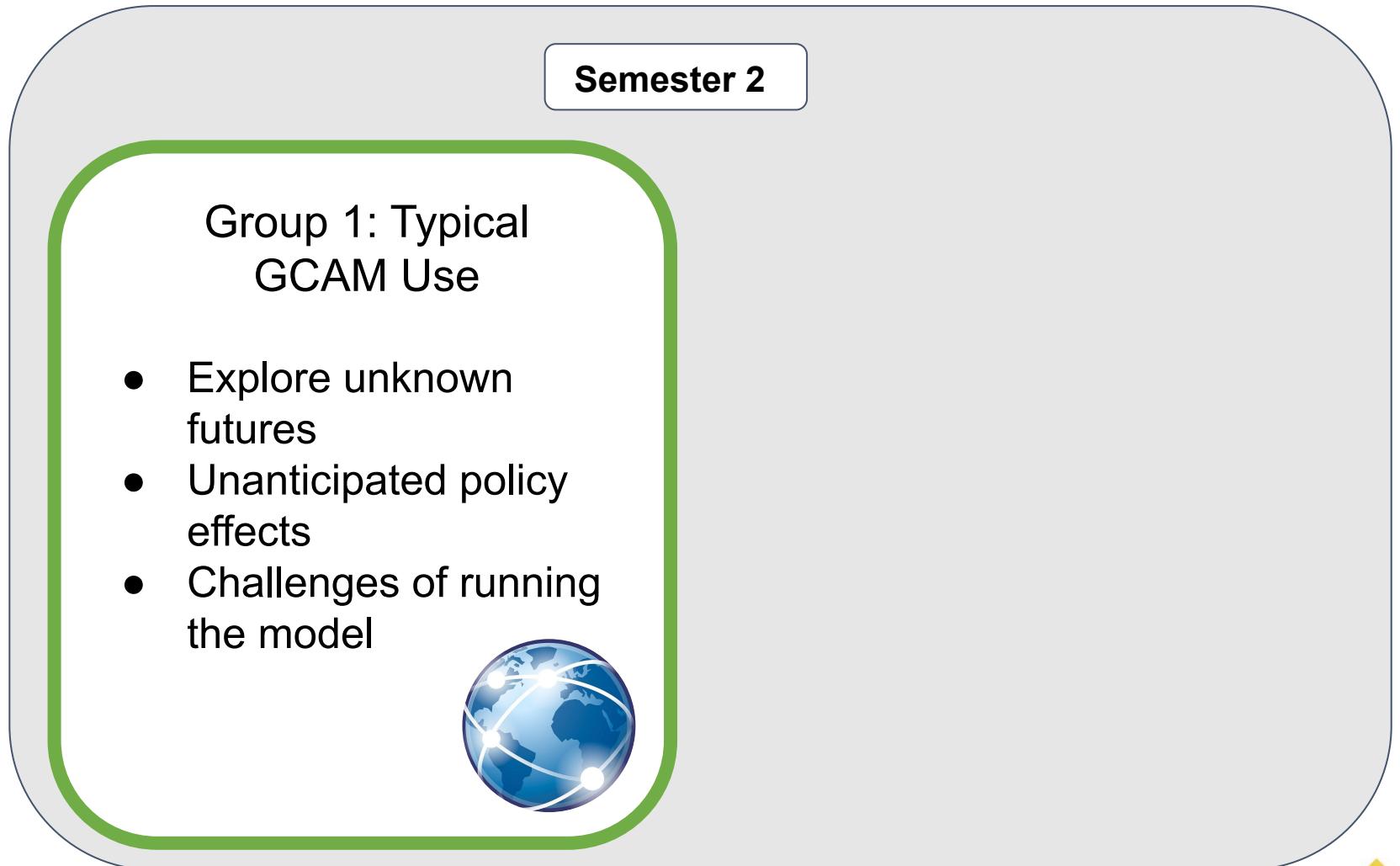
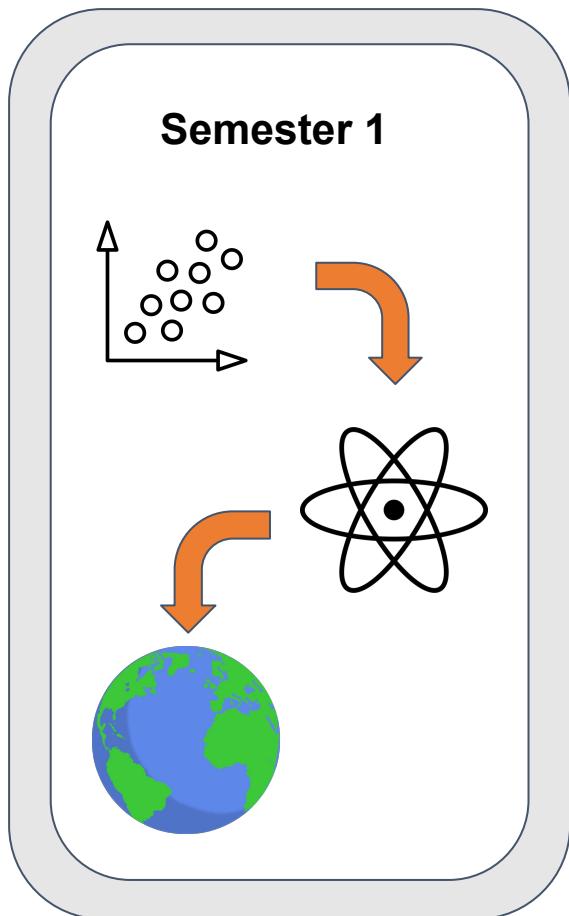


**Takeaways,
Critiques,
Numbers and
Narratives**

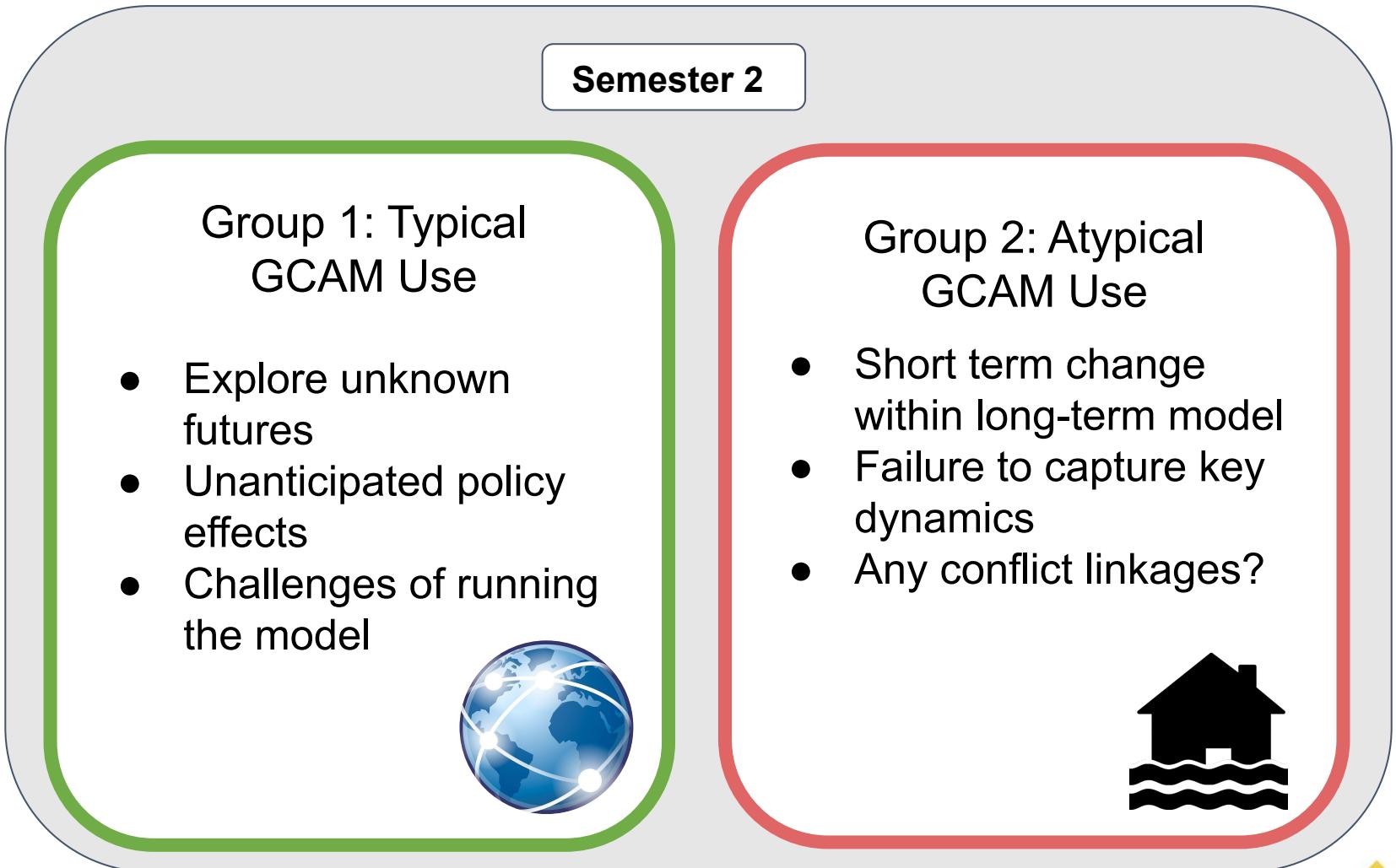
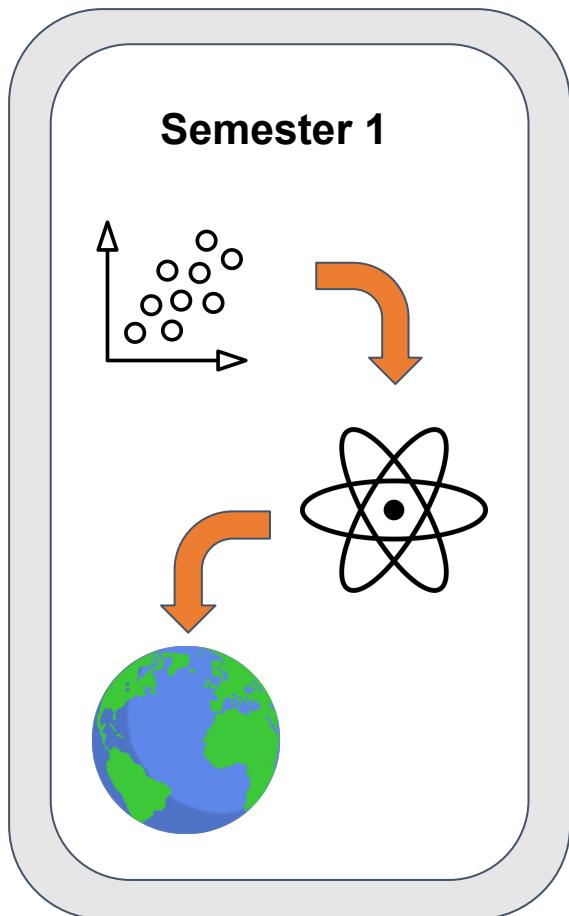
Two ways to approach GCAM....



Two ways to approach GCAM....



Two ways to approach GCAM....



Evaluating Potential Impacts of Policy on Food and Water System Dynamics

Ian Moore, Tyrine Pangan, Isaac Thompson, Maggie Roberts

Pedagogy for Interdisciplinary Immersion Program (PFI-1)

Team-based Problem-solving

Working with peers in an immersive data-focused experience that promotes rapid iterations, feedback, and revisions to enhance learning skills

Project-based Course

Primary goal across two semesters is to explore initial ideas to research a problem and create a demonstrable prototype from the chosen problem

Exploring how Climate Change Policy Implementation Affects Global Food and Water Systems

Part 1

What shifting dynamics do we see across global water and agriculture sectors when climate change policy is implemented?

Part 2

Can implementing preferences for international vs. domestic alleviate water and food stress introduced by climate change policy implementation?

Reality of Implementing Different GCAM Scenarios



Learning to Navigate

Received helpful instructions and tips from Delilah Maloney to navigate the Tufts HPC Cluster



Troubleshooting

Even with proper instructions, ran into issues setting up GCAM and learning how to troubleshoot



Seeking Expertise

Reached out to other students from Jon's lab (Abigail and Jake) to get useful .xml files for policies

Methodology using GCAM

Running Four GCAM Scenarios

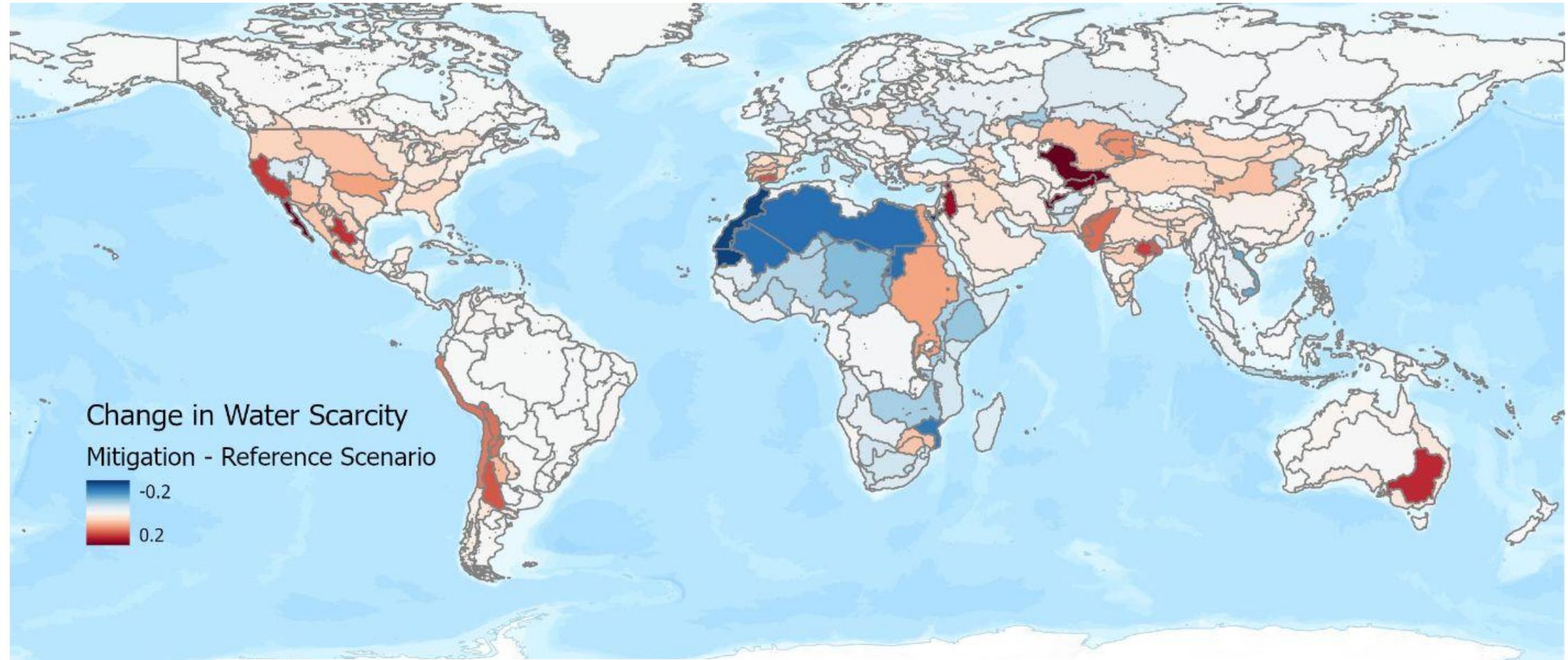
Reference	Historic preferences for trade No climate change mitigation implemented						
Climate Change Mitigation Scenario <small>Paris Agreement CO₂ equiv. emissions regulations</small>	 <table><tr><td>High</td><td>High preference for international trade</td></tr><tr><td>Medium</td><td>Historic preference for international trade</td></tr><tr><td>Low</td><td>Low preference for international trade</td></tr></table>	High	High preference for international trade	Medium	Historic preference for international trade	Low	Low preference for international trade
High	High preference for international trade						
Medium	Historic preference for international trade						
Low	Low preference for international trade						

Evaluating Changes

- 1 Water withdrawals by basin
- 2 Staple food prices by region

Changing Dynamics in Water Withdrawal:

Change in total physical water scarcity in 2100 between Climate Change Mitigation and Reference Scenario



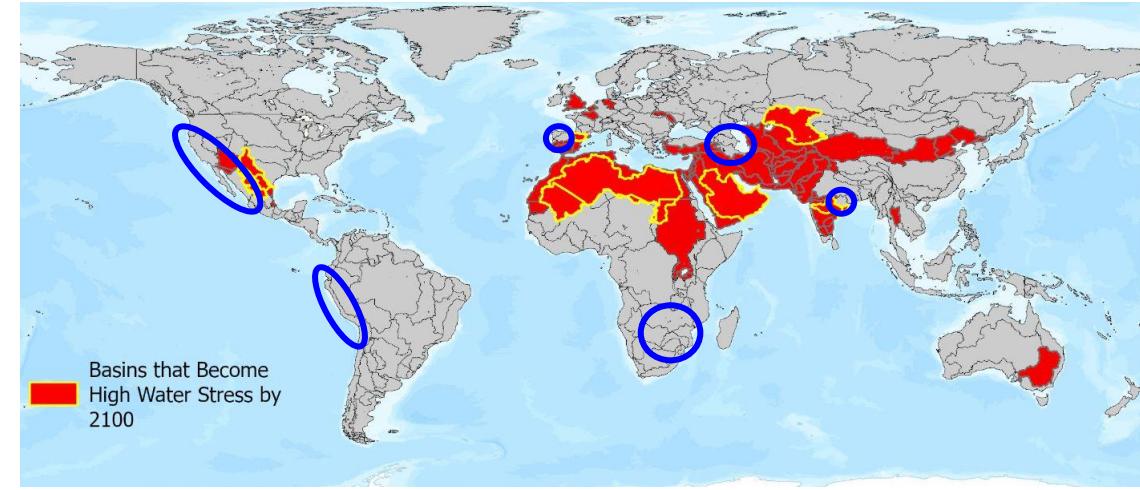
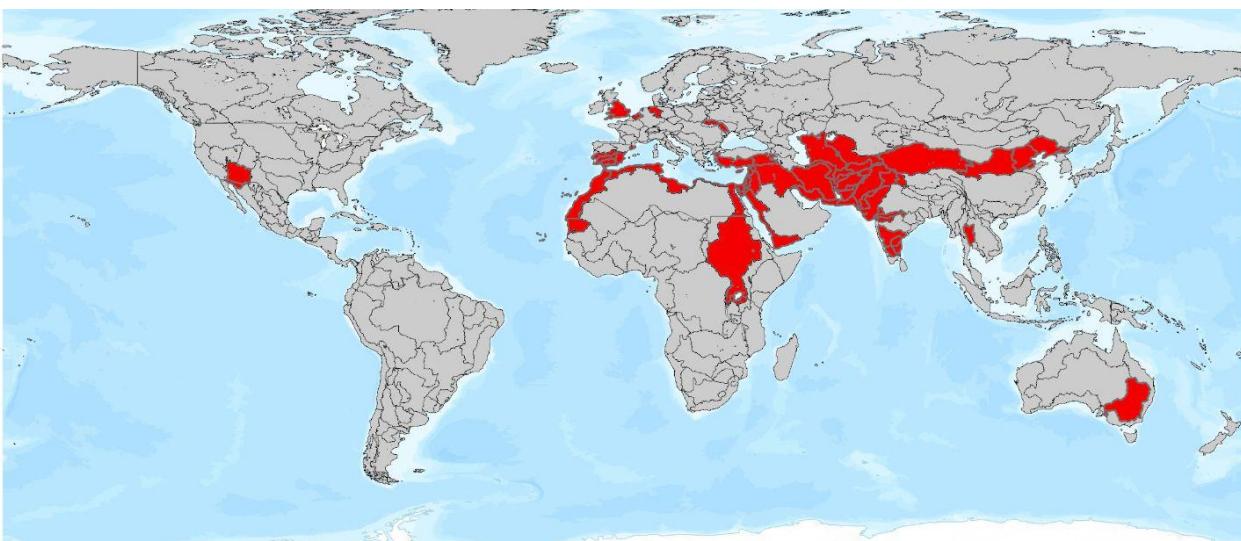
Physical Water Scarcity - Ratio of water withdrawals to renewable water supply

High Water Stress Basins

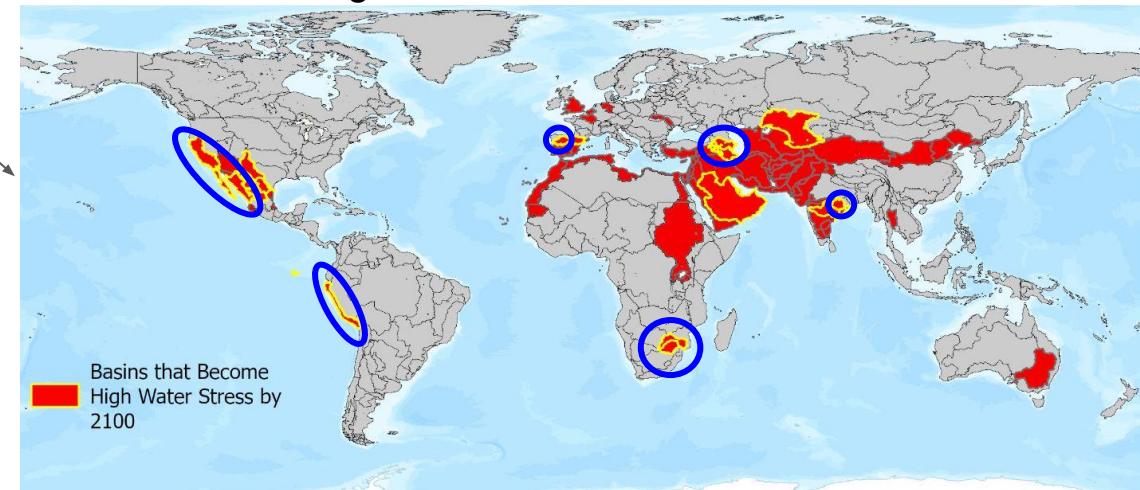
(Physical Water Scarcity > 0.4)

Reference:
High Water Stress Basins in 2100

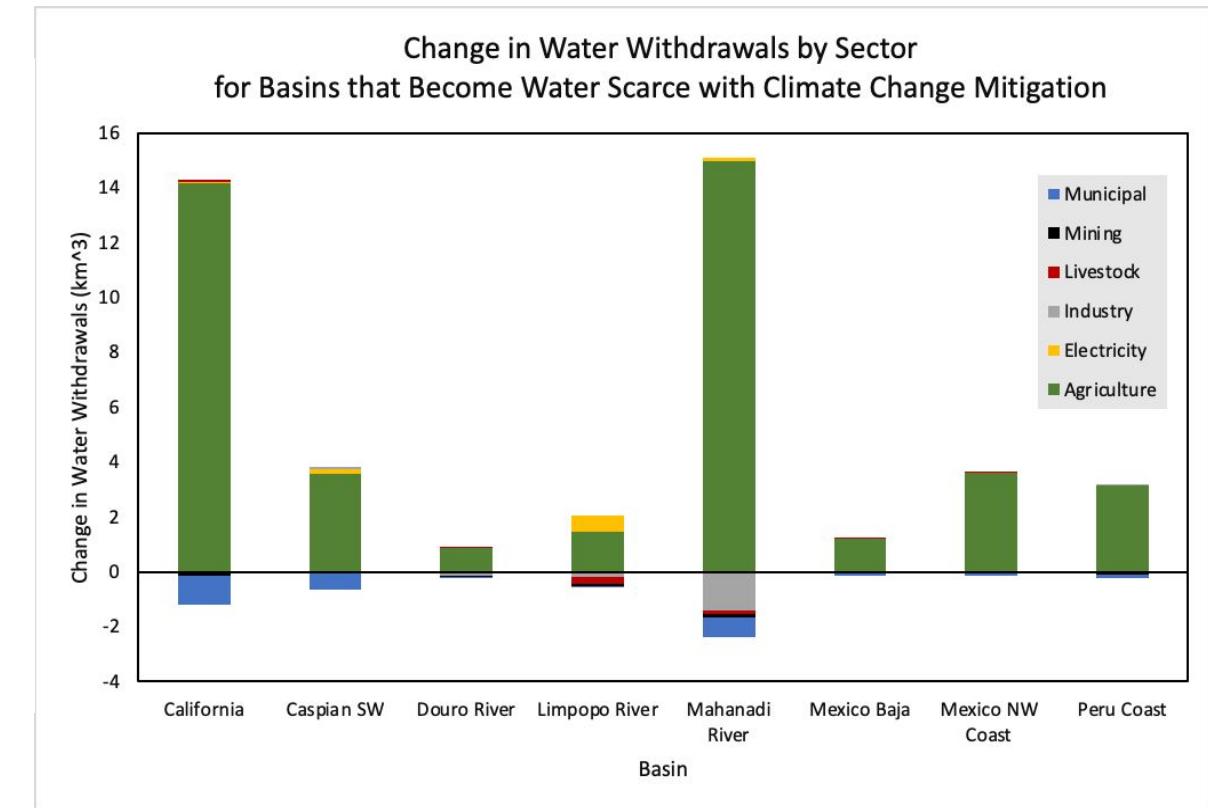
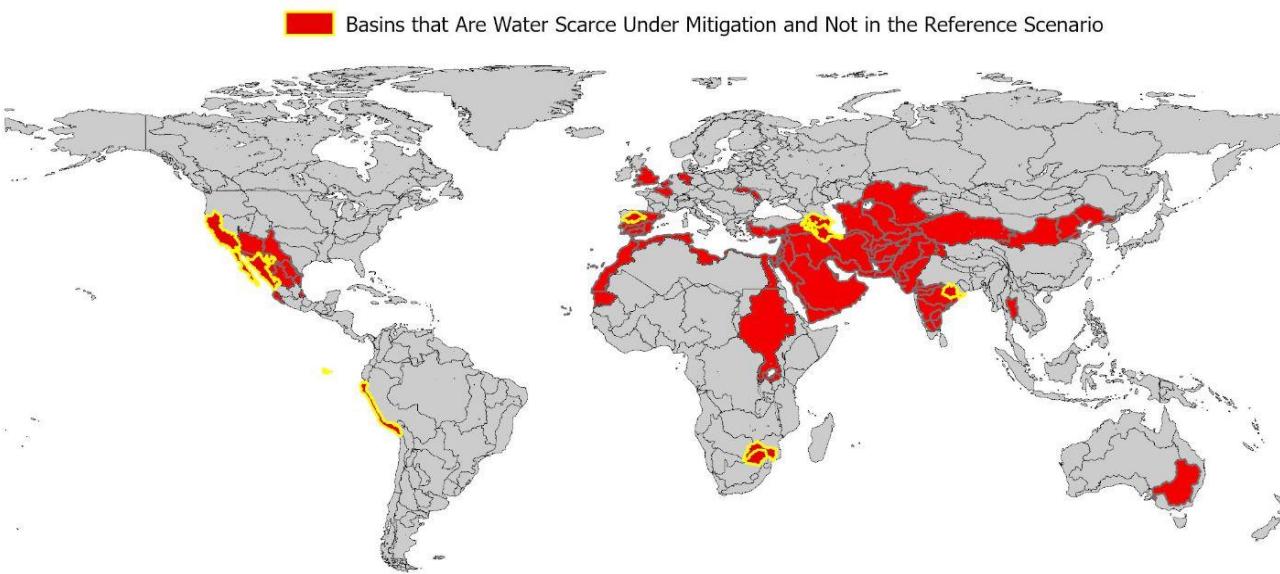
High Water Stress Basins 2020



Climate Change Mitigation:
High Water Stress Basins in 2100



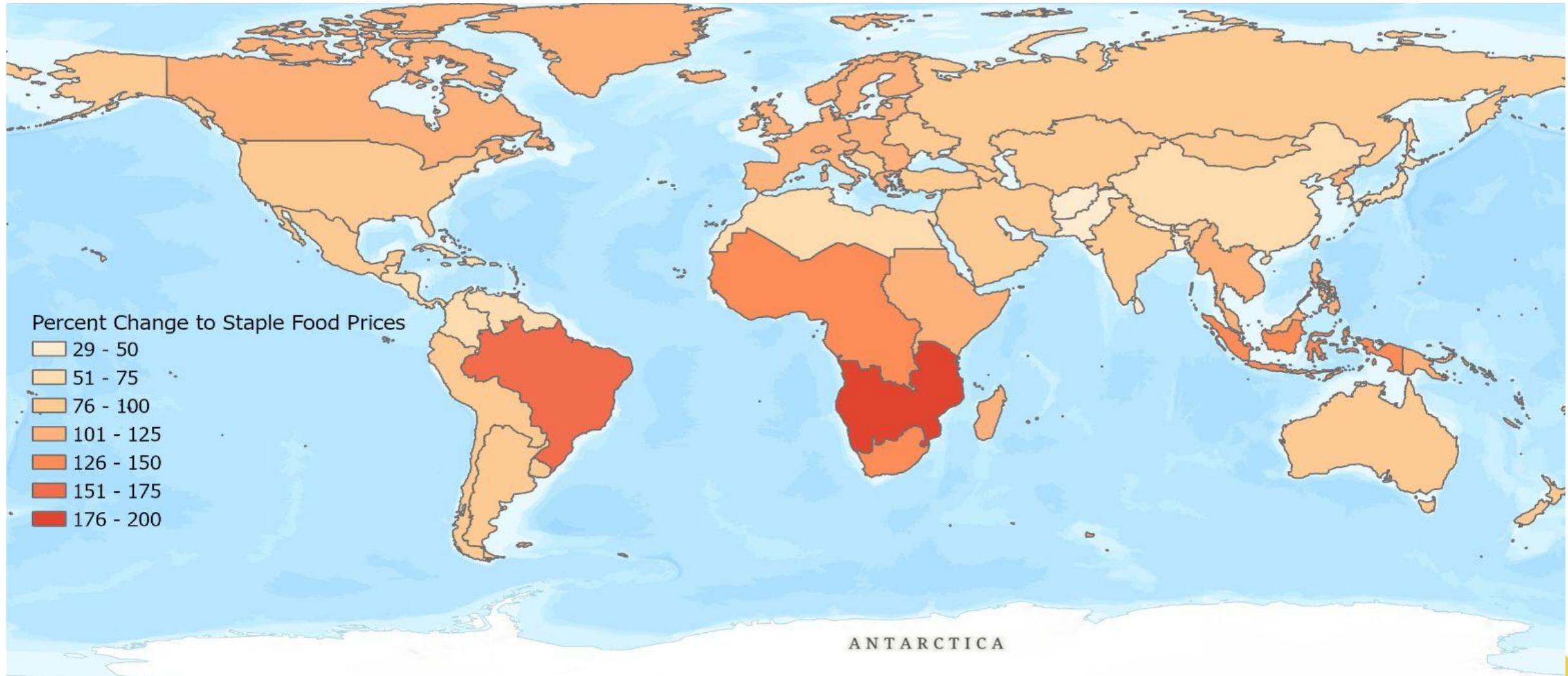
Change in Water Withdrawals in Basins that Become High Water Stress in the Mitigation Scenario



Agriculture drives water withdrawal changes in basins that become high water stress in 2100 when climate change mitigation is implemented

Changing Dynamics in Staple Food Prices:

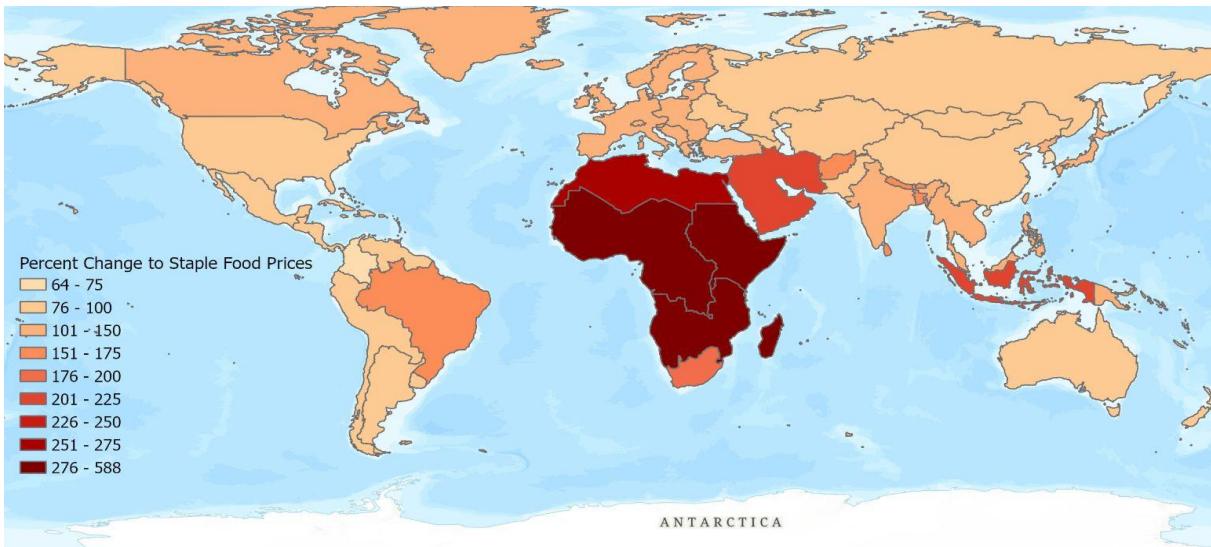
Change in Average 2100 Staple Food prices between Climate Change Mitigation and Reference Scenario



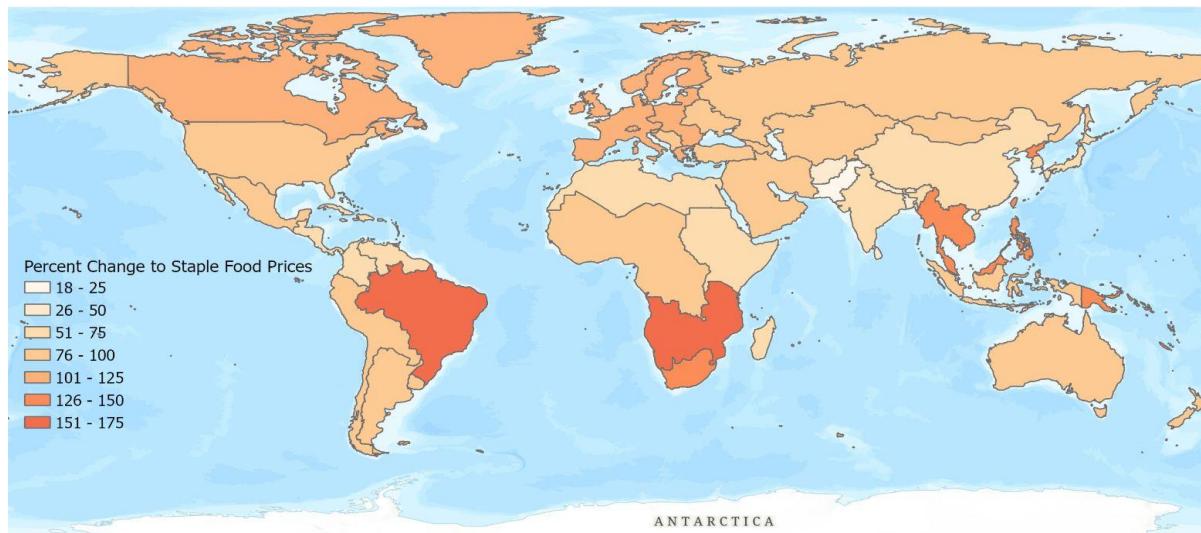
Shifting Trade Preferences Influences Climate Change Mitigation Impacts

- Staple food prices increase under climate change mitigation
- Most significant change is seen in Africa and the Middle East
- Shifting towards a higher preference for international trade could alleviate some of the increase

Change to Staple Food Prices with Mitigation and Low Preference for International Trade

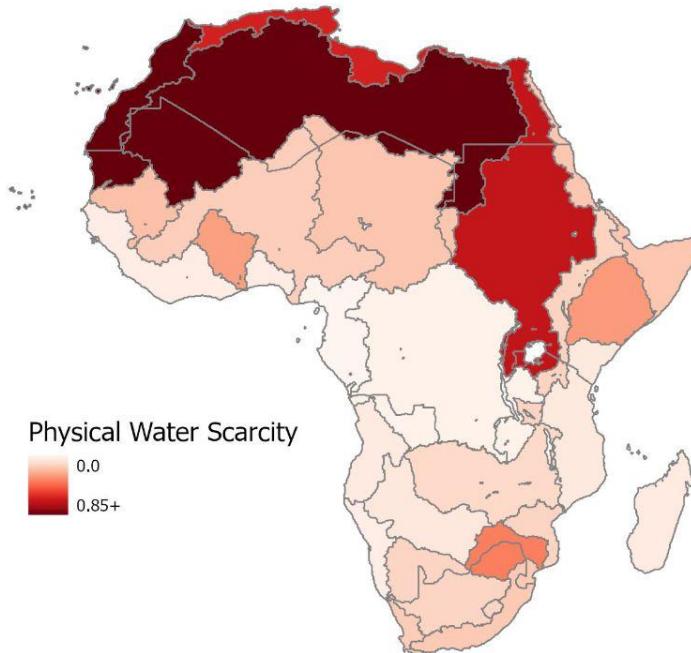


Change to Staple Food Prices with Mitigation and High Preference for International Trade

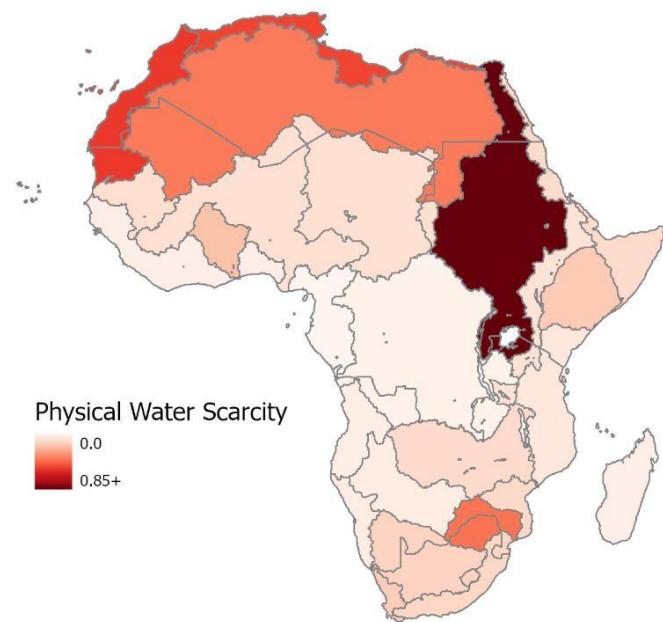


Impact of International Trade Preference and Climate Change Mitigation on Water Stress and Staple Food Prices in 2100

Physical Water Scarcity:
Mitigation + Low trade



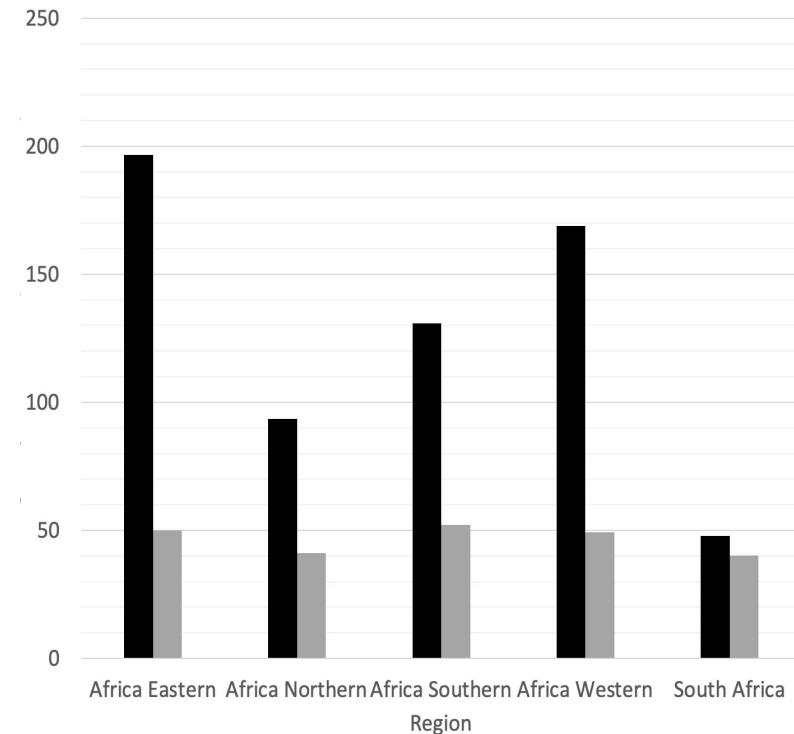
Physical Water Scarcity:
Mitigation + High trade



Staple Food Prices:

Average Staple Food Prices in 2100 by Region

■ Mitigation + Low International Trade ■ Mitigation + High International Trade



Conclusions

GCAM helps us explore the interactions between food and water systems at a global scale

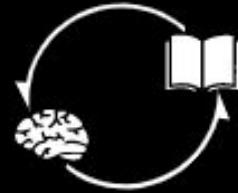
- Evaluate a suite of “what-if” scenarios to determine what drives positive and negative changes to metrics of interest
- Identify potential side-effects of mitigation policies

Reflections



Connecting Numbers and Narratives

Investigated ways GCAM can be integrated with narratives around climate change policy relating to water and food stress



Learning How to Learn

Importance of learning how to fail and keep moving forward with our available resources



Embracing Complexity

Climate change policy is complex and there are limits of what GCAM can do

Conflict and Catastrophe

Ymbar, Kaustuv, David, Joe, Isaac,
Catherine



D3M@Tufts

Numbers



We had many
questions for GCAM
about disaster...

Numbers

and

Narratives



We had many
questions for GCAM
about disaster...



Model is used to
develop significant
policies....

Numbers

and

Narratives

and

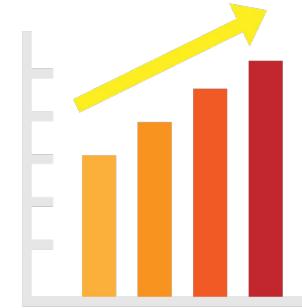
Numbers and Narratives



We had many questions for GCAM about disaster...



Model is used to develop significant policies....



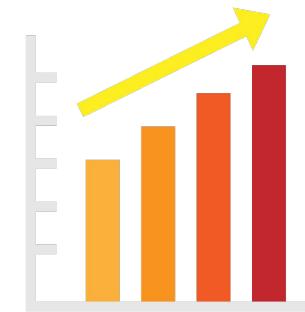
What are the limits of a complicated model for complex systems?

To what extent can we capture
concepts relating to conflict or
catastrophe in GCAM?

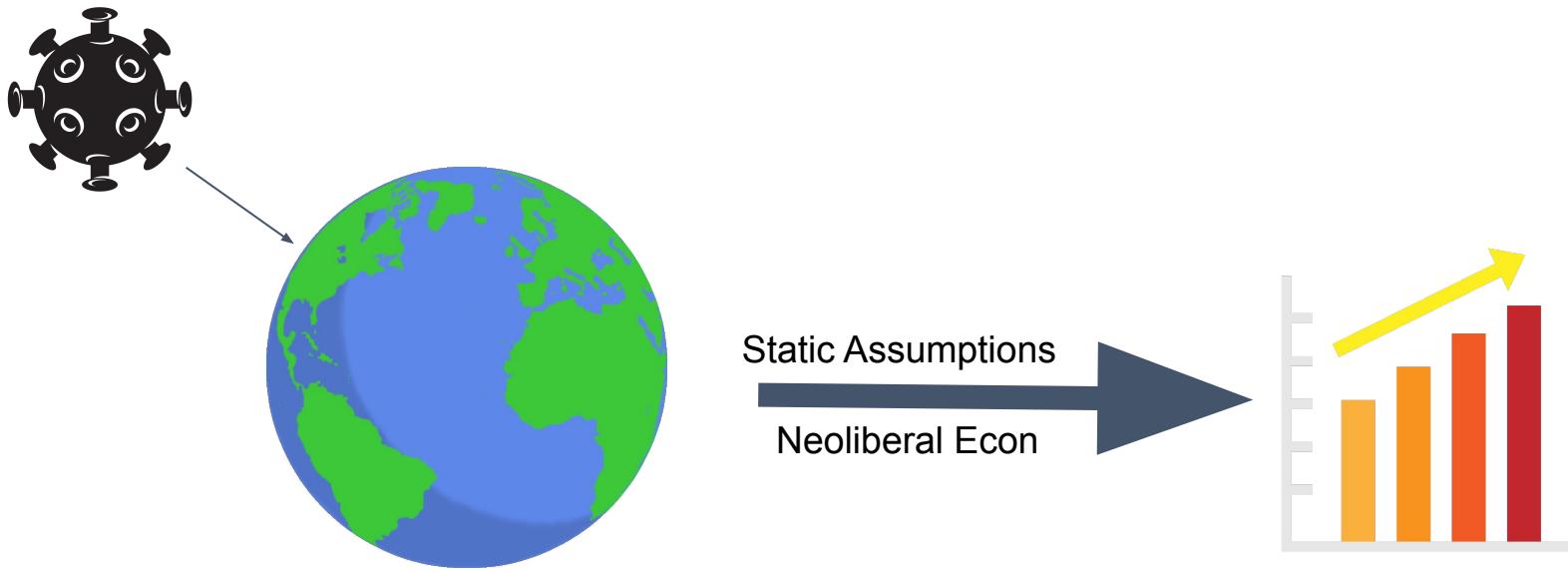
Our world rapidly evolves.... does GCAM?



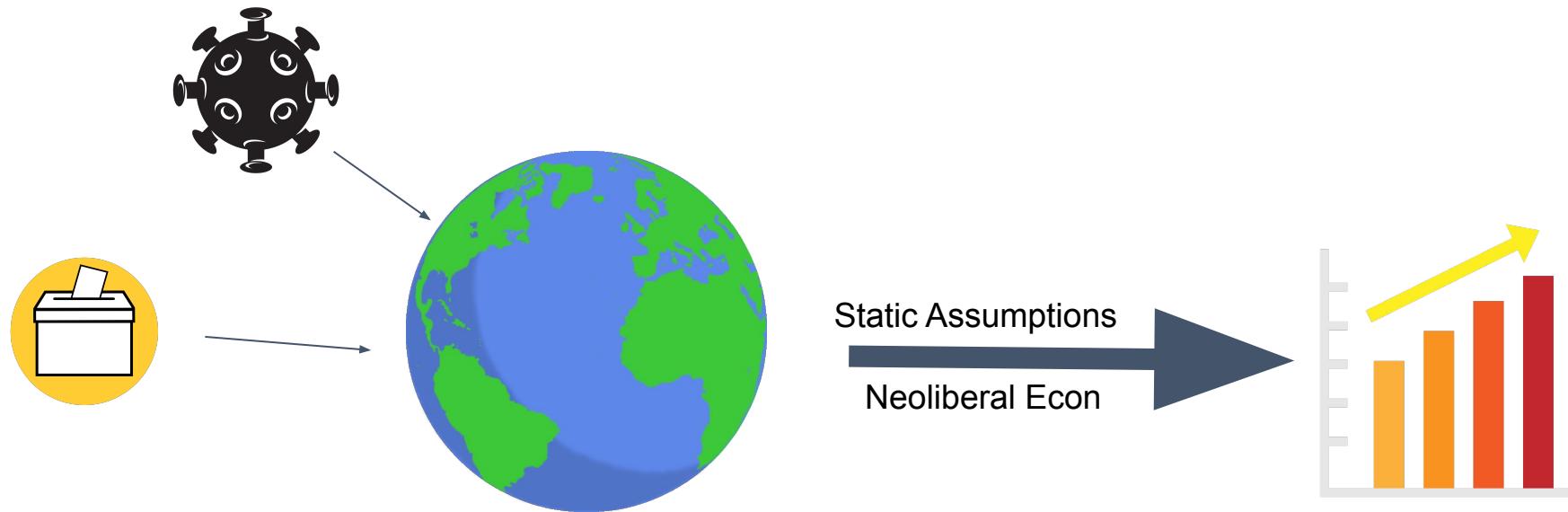
Static Assumptions
Neoliberal Econ



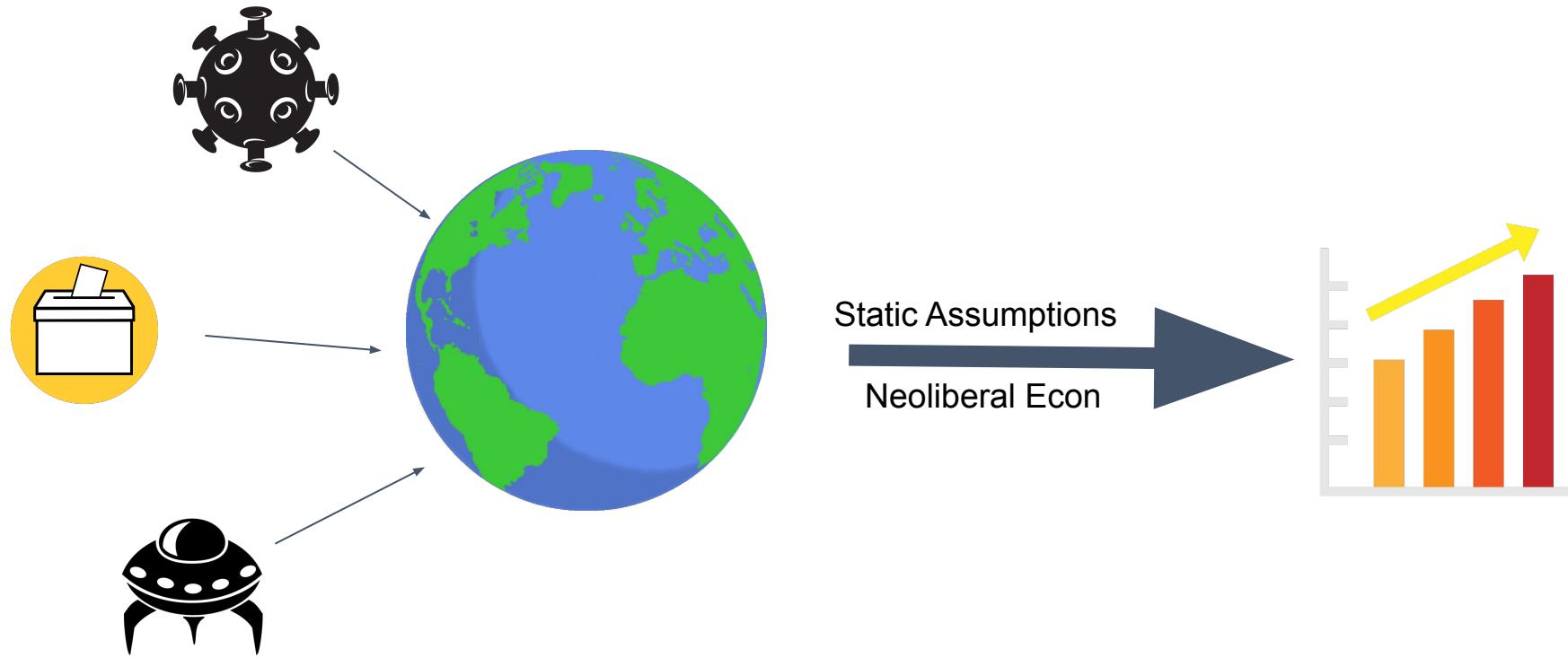
Our world rapidly evolves.... does GCAM?



Our world rapidly evolves.... does GCAM?



Our world rapidly evolves.... does GCAM?



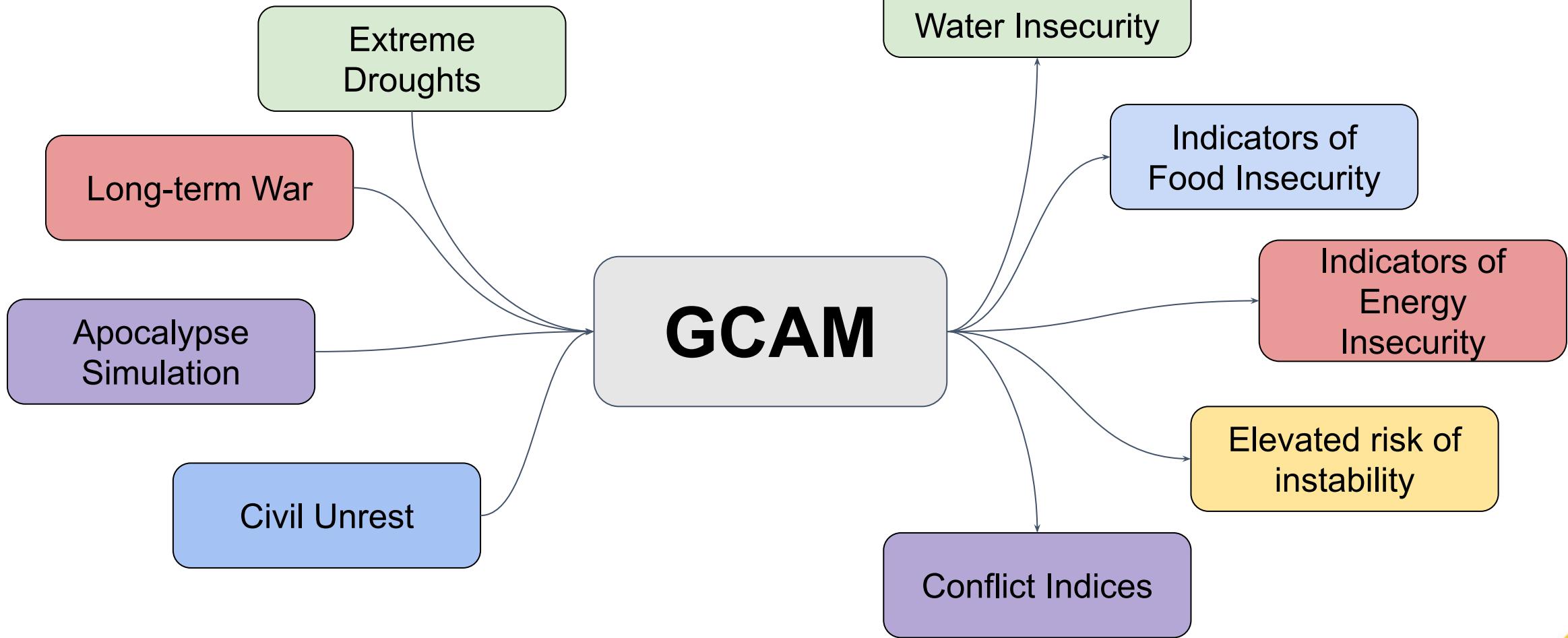
Our world rapidly evolves.... does GCAM?



Conflict and
Catastrophe Inputs to
Track Outputs

OR

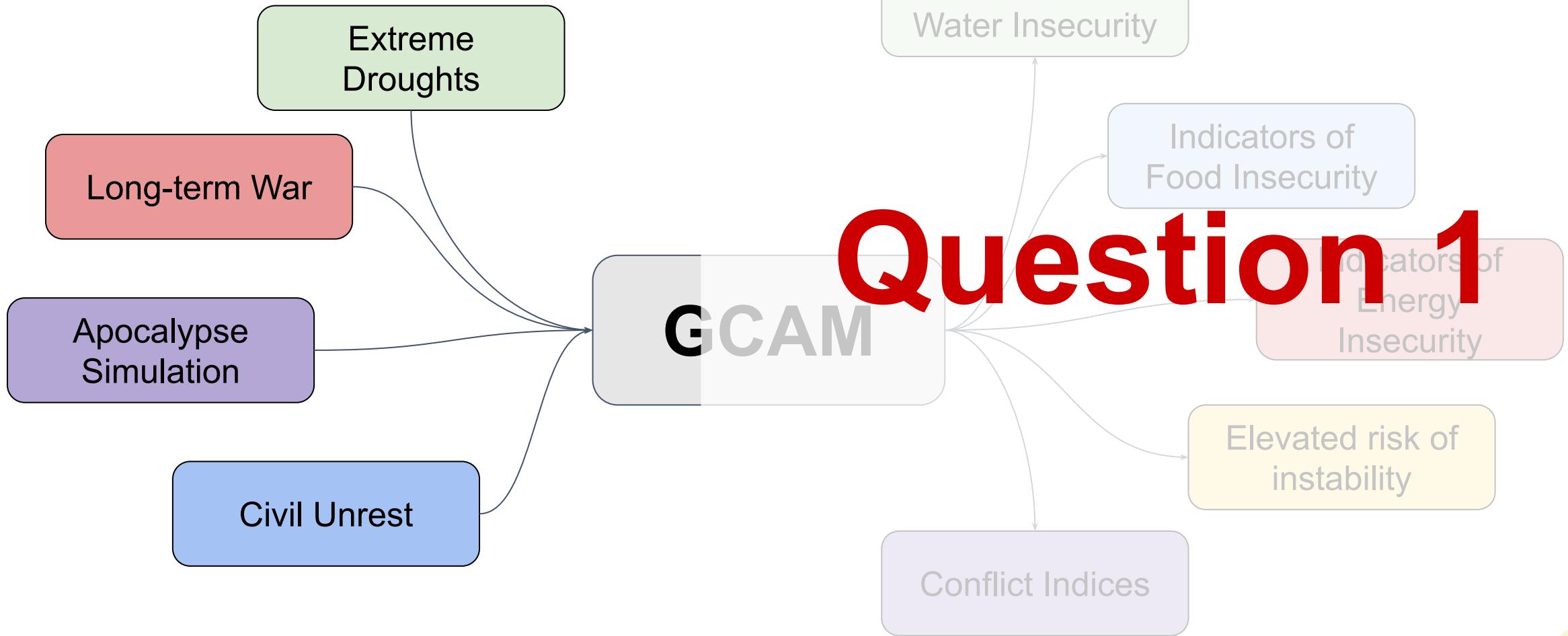
Conflict and
Catastrophe Analysis of
Outputs



Conflict and
Catastrophe Inputs to
Track Outputs

OR

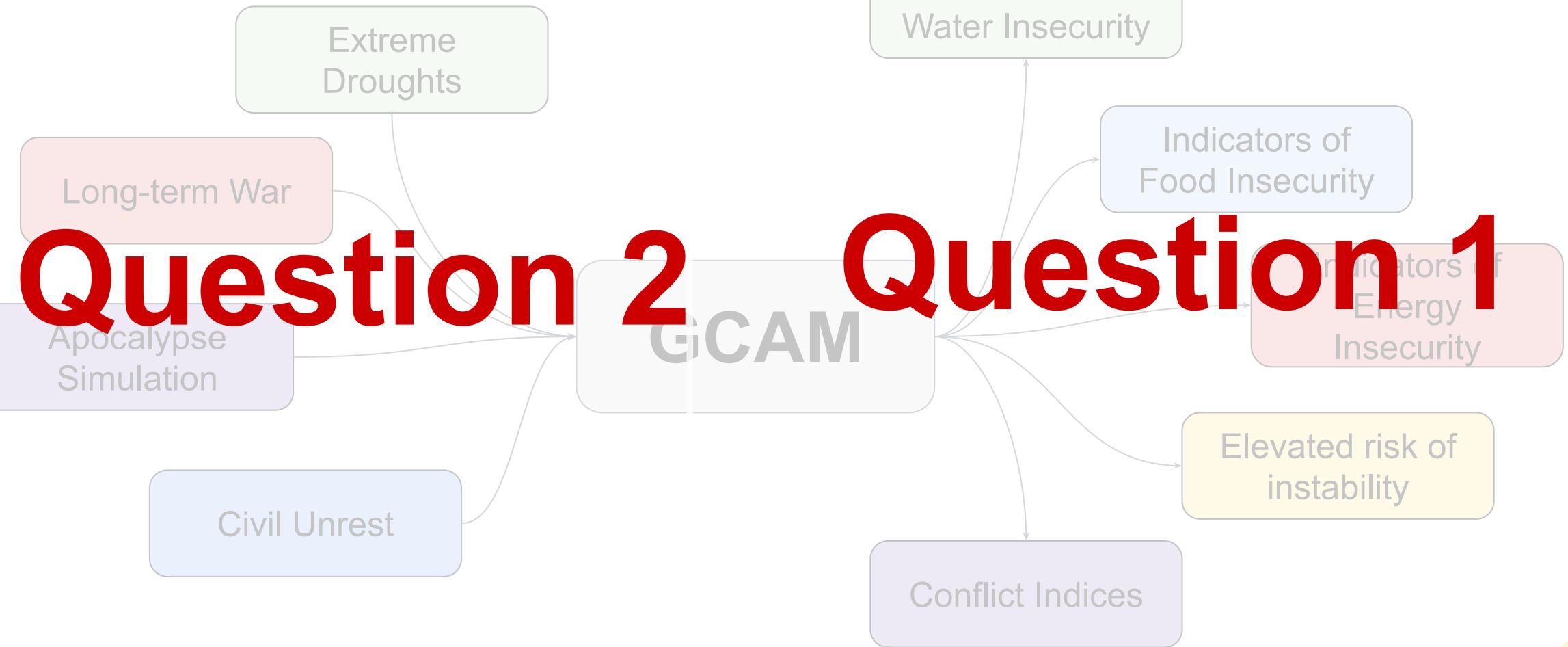
Conflict and
Catastrophe Analysis of
Outputs



Conflict and
Catastrophe Inputs to
Track Outputs

OR

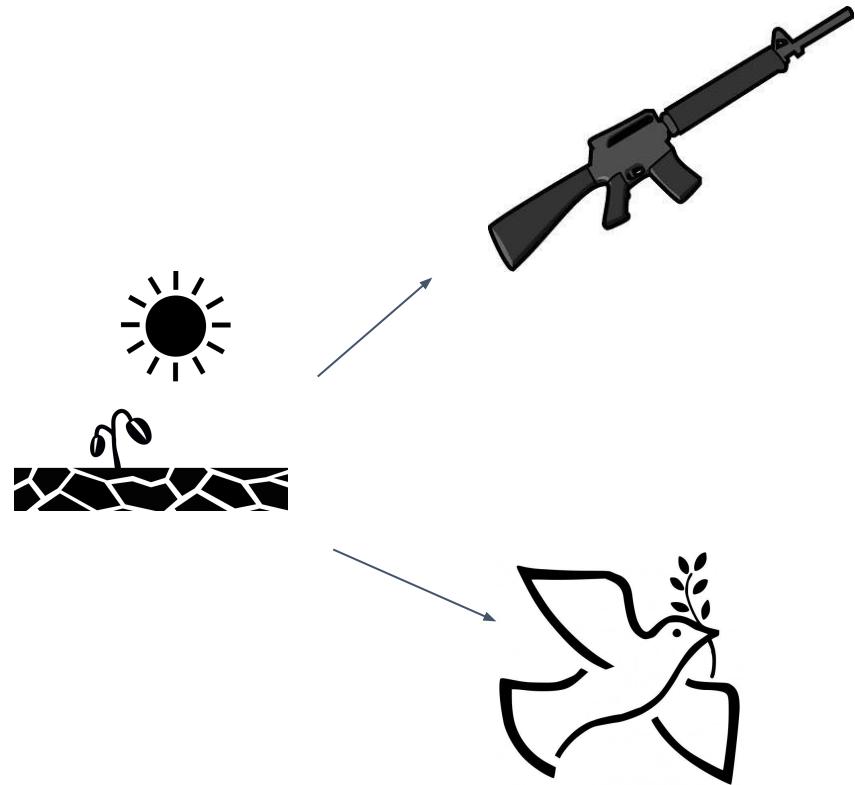
Conflict and
Catastrophe Analysis of
Outputs



Motivation and Framing

- Numerous studies have explored the climate-conflict linkages
 - These pathways are complex: studies struggle to come up with a set list or linear relationship
 - For example, U-curve of water scarcity and cooperation
- However, these relationships can be used to assess ‘risk’ of instability or conflict, acknowledging that they are not perfect predictors
- GCAM offers similar FEW- related outputs to many of these indicators
- Can we combine methods to map FEW-scarcity indicators onto a GCAM ensemble to assess where and when conflict risk in specific regions may occur?
 - What does this mean in the context of GCAM? How realistic are these results?
 - Are these useful? -> outputs highly dependent on inputs

Motivation and Framing



Can we combine methods to map FEW-scarcity indicators onto a GCAM ensemble to assess where and when conflict risk in specific regions may occur?

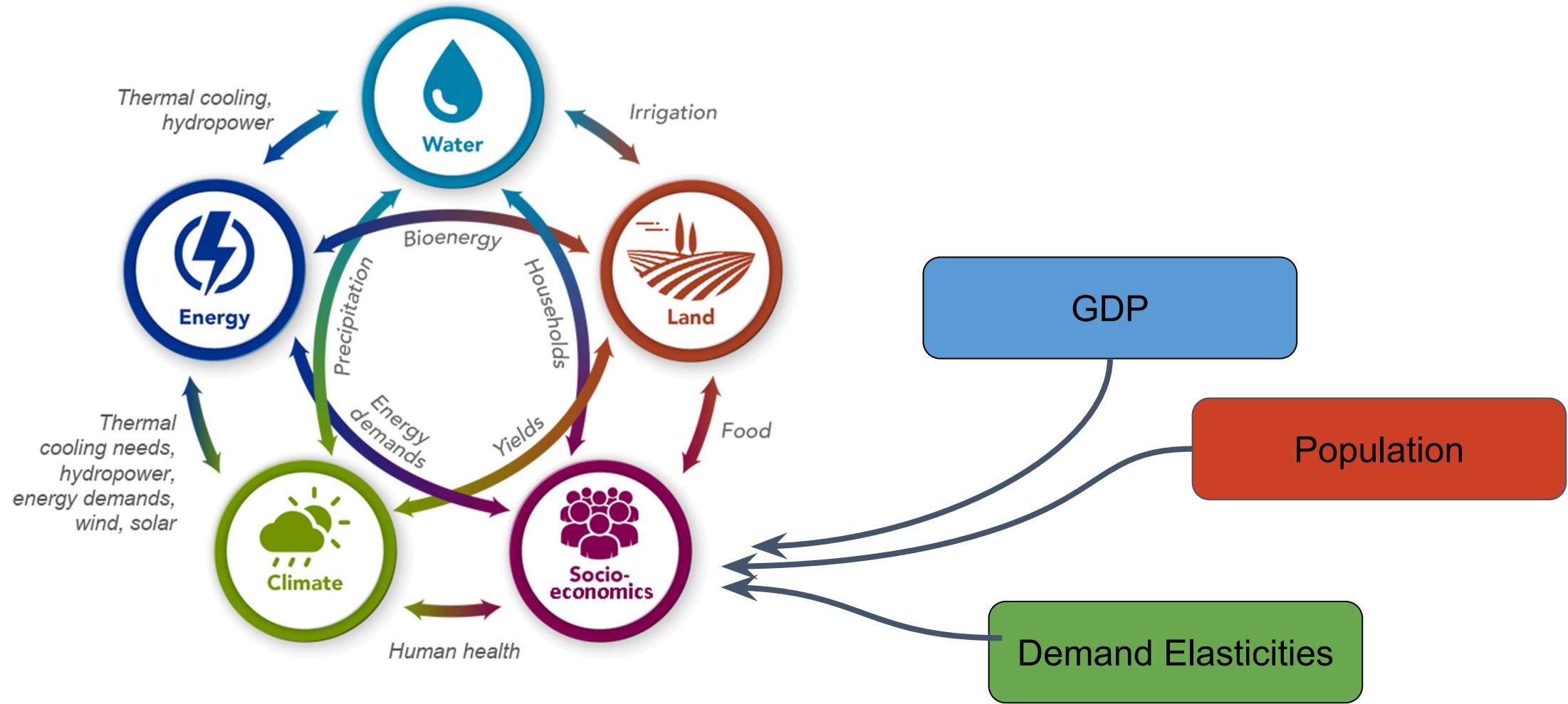
What does this mean in the context of GCAM? How realistic are these results?

Are these useful? It is a good index?

Indicator	Pardee-RAND FEW Insecurity Index	GCAM	Sub-indicator
1	Domestic Food Price Level Index	Price staple foods/GDP per capita	Food
2	Share of Dietary Supply from Non-starchy Foods	Supply non-staple to staple	Food
3	Supply of daily dietary calories Relative to Minimum Dietary Requirement	Supply to some baseline per person	Food
4	log of per capita electricity to the log of the per capita electricity consumption required to meet basic needs	Per capita electricity consumption/4000	Energy
5	Geometric mean of percentage of population with access to electricity	Price electricity/GDP	Energy
6	percentage of population using modern fuels for cooking and heating.	Traditional Biomass/total energy	Energy
7	total water withdrawals for municipal uses with the country-wide water requirements	Water Consumption/Min Daily Requirement	Water
-	proportion of the population that uses an improved source of drinking water and the proportion of the population using improved sanitation facilities.	Not applicable	-
8	total per capita internally available renewable water.	Groundwater vs run-off	Water

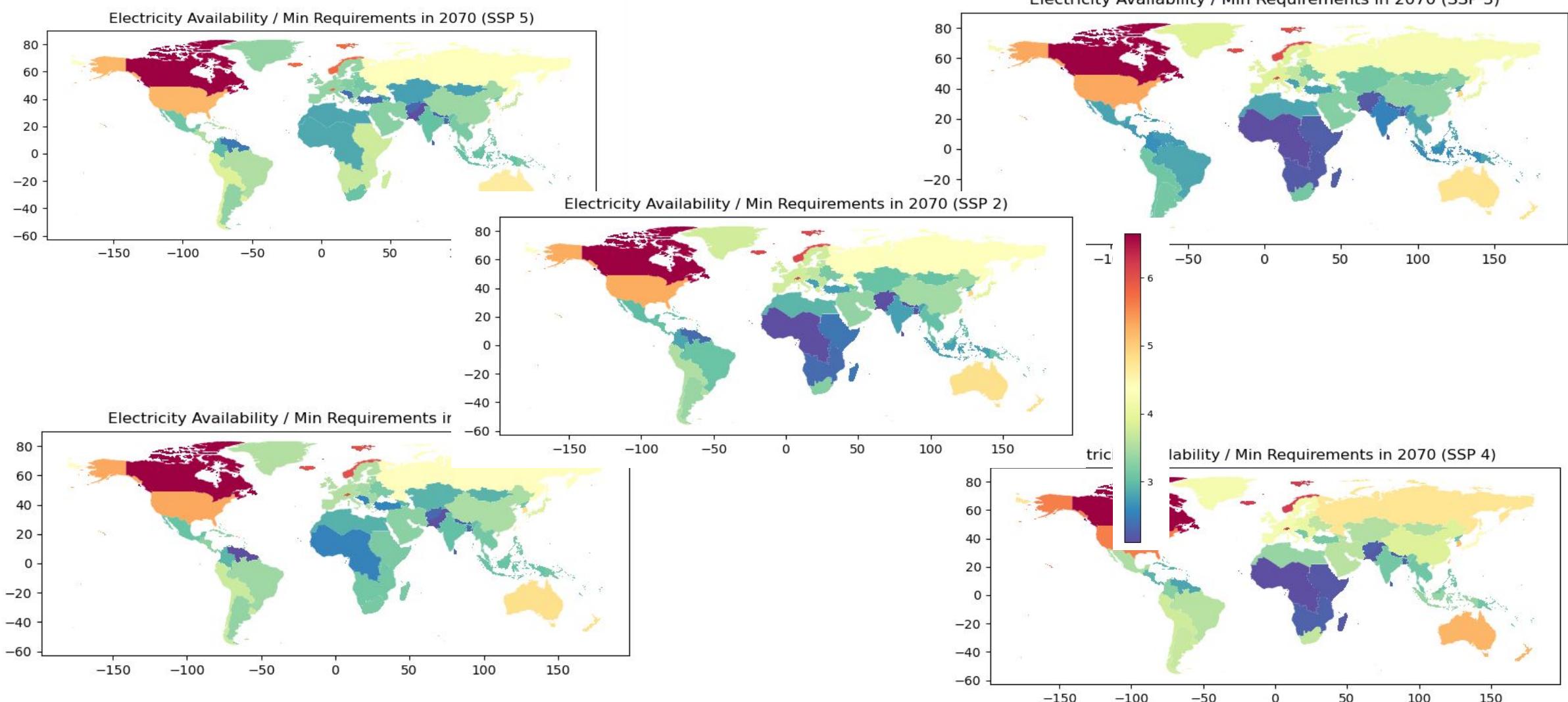
Willis, Henry H., David G. Groves, Jeanne S. Ringel, Zhimin Mao, Shira Efron, Michele Abbott, Zohan Hasan Tariq, and Michael W. Robbins, Interactive Pardee RAND Food-Energy-Water Security Index. Santa Monica, CA: RAND Corporation, 2024. <https://www.rand.org/pubs/tools/TLA2942-1.html>.

But...these indicators are highly dependent on inputs

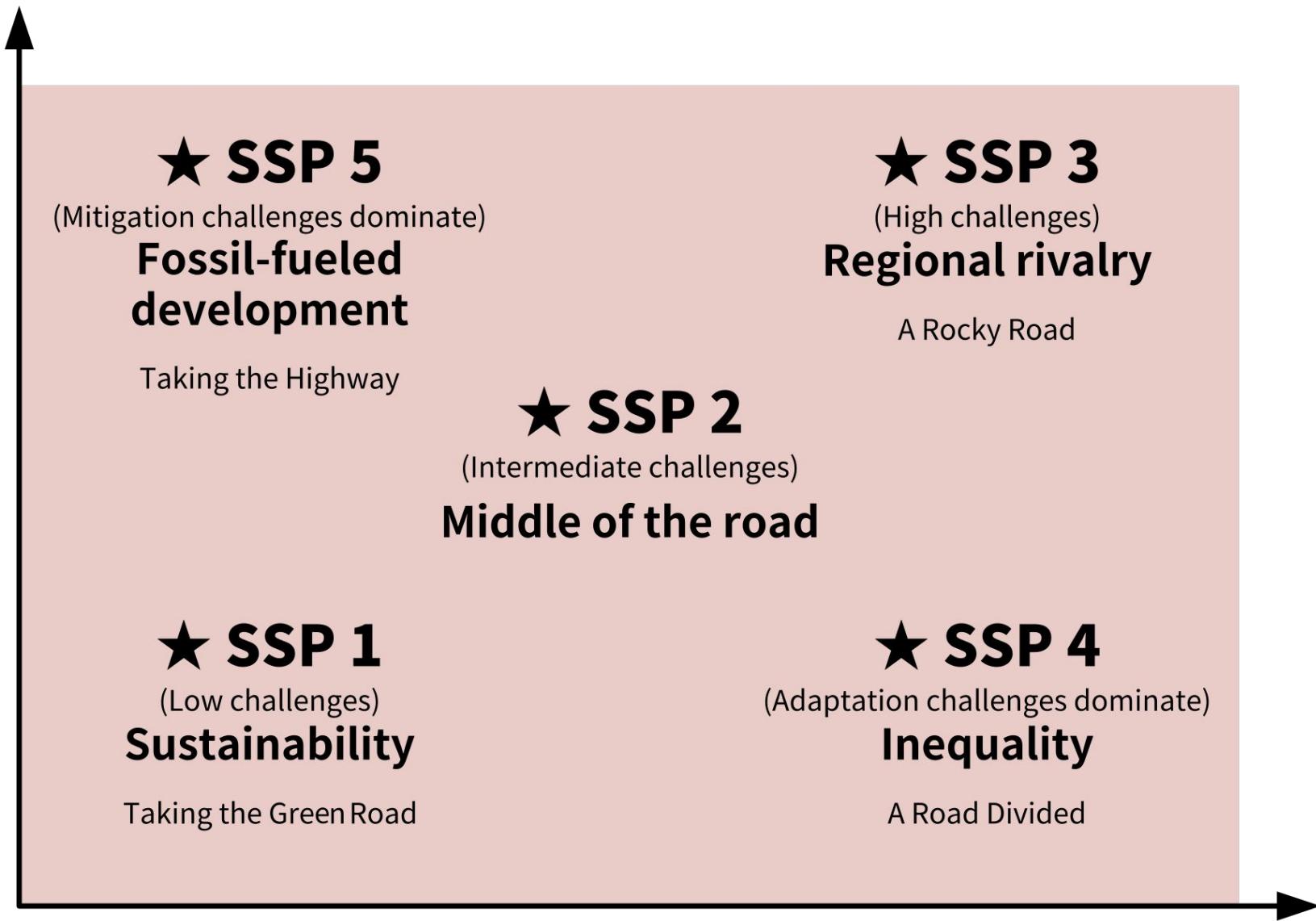


Calvin, et al. (2019)

Step 1: Track individual indicators across scenarios

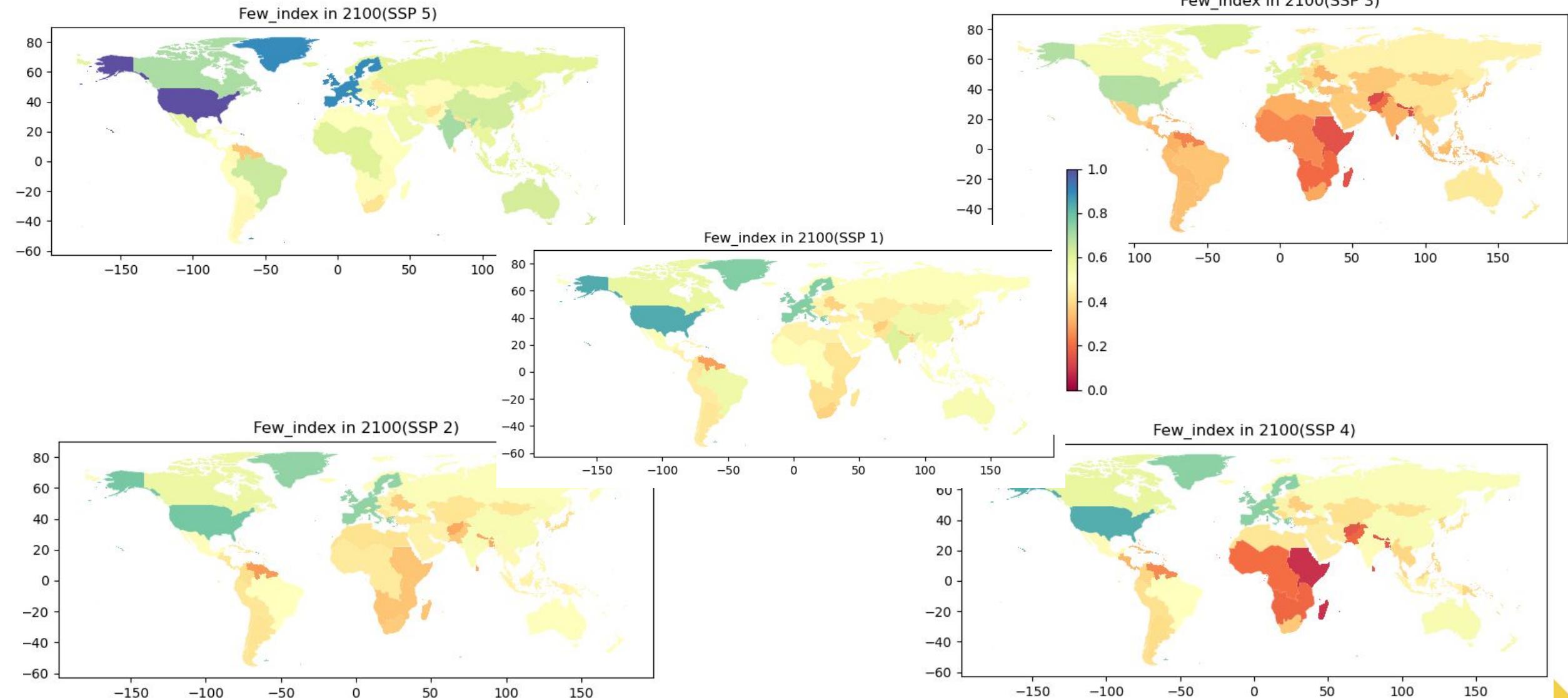


**Socio-economic challenges
for mitigation**

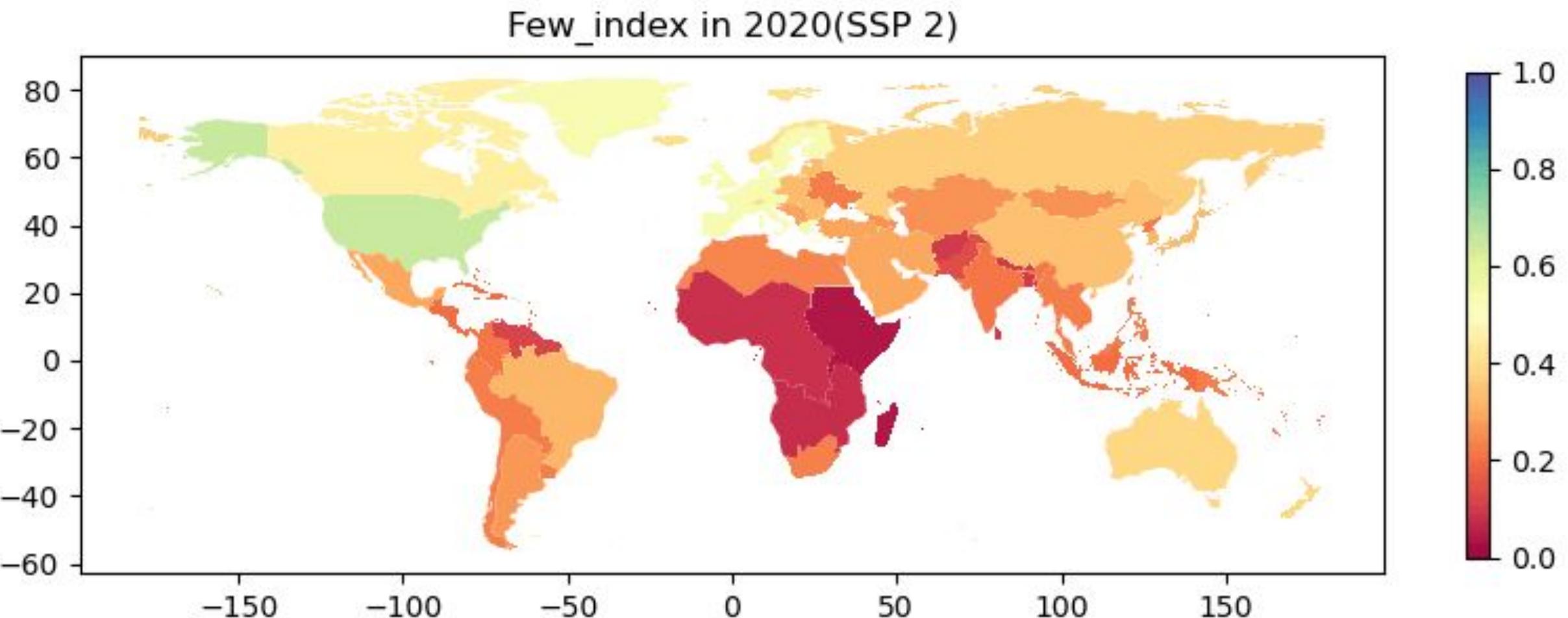


**Socio-economic challenges
for adaptation**

FEW Index at 2100 Across Scenarios - We get results that make sense!

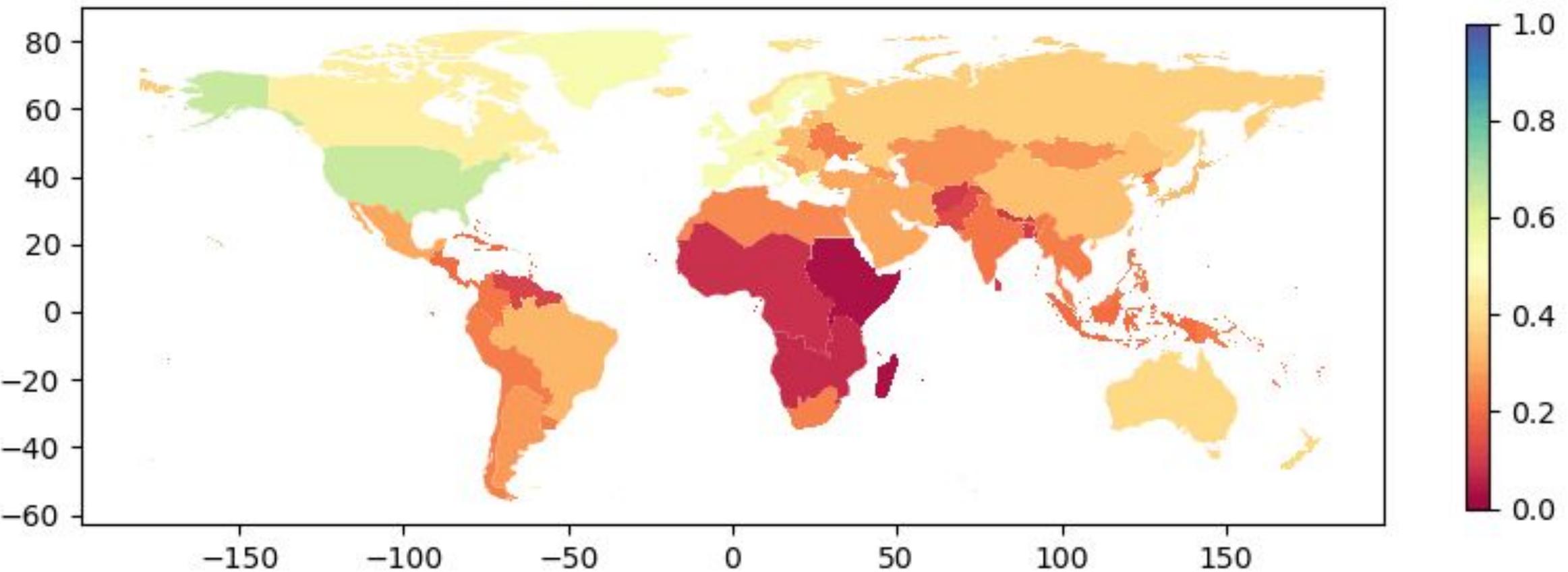


Step 3: Track FEW Index Changes Over Time (SSP 2)

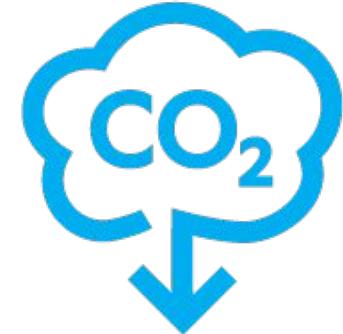


Track FEW Index Changes Over Time (SSP 4)

Few_index in 2020(SSP 4)



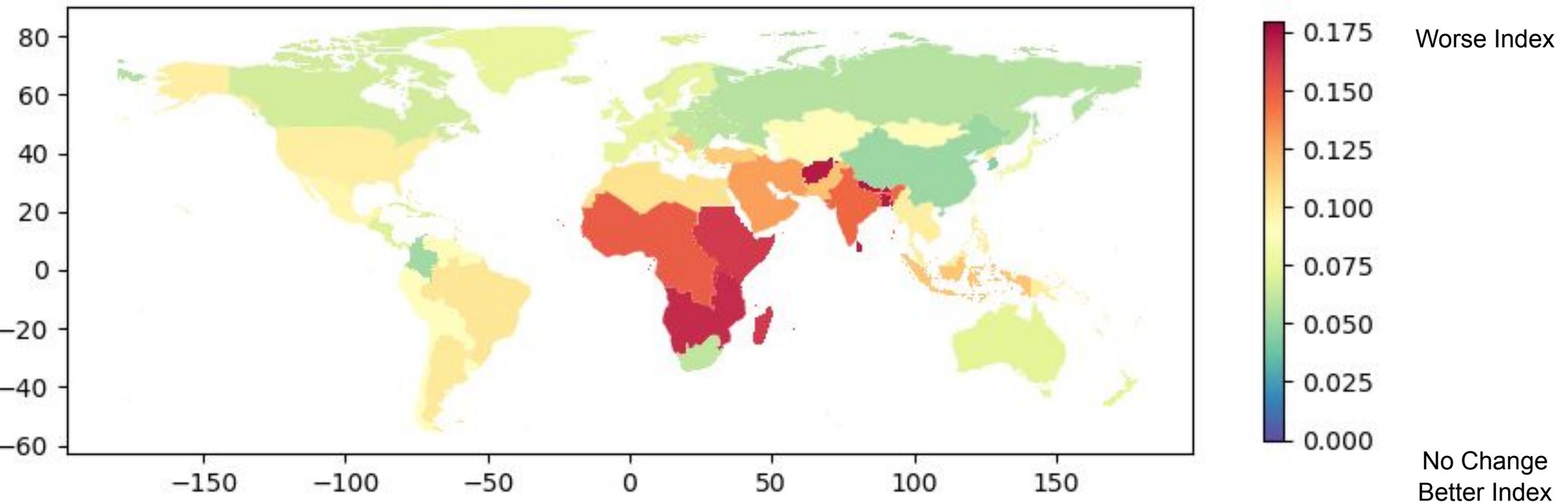
Now that we proved the concept, what happens if we change the scenario to the same mitigation scenario as the previous group?



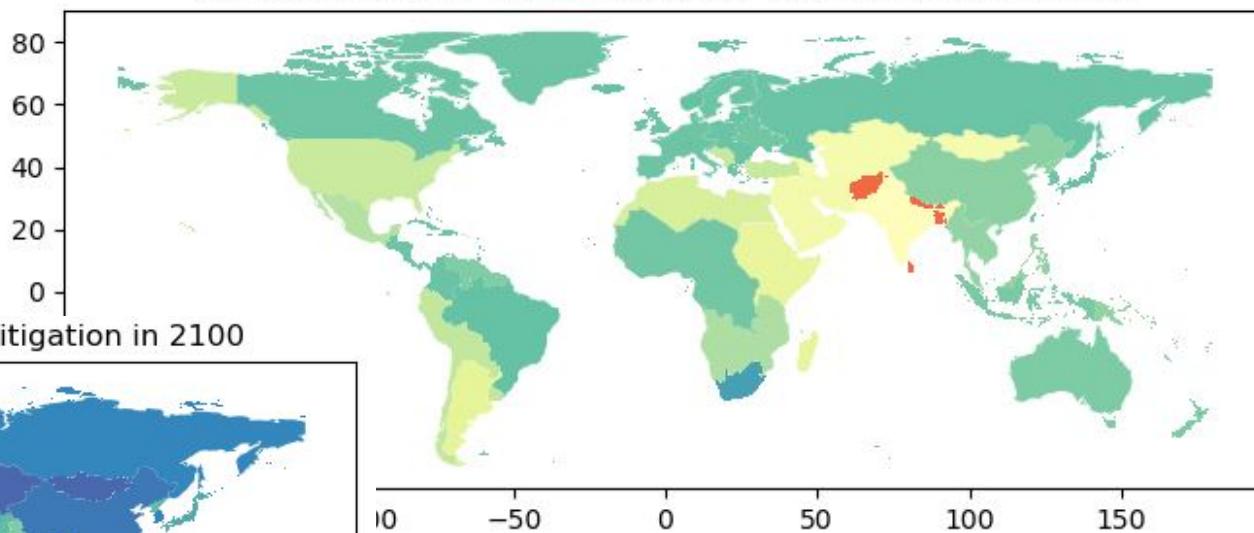
SSP2: Middle of
the Road

Reduced Carbon
Emissions

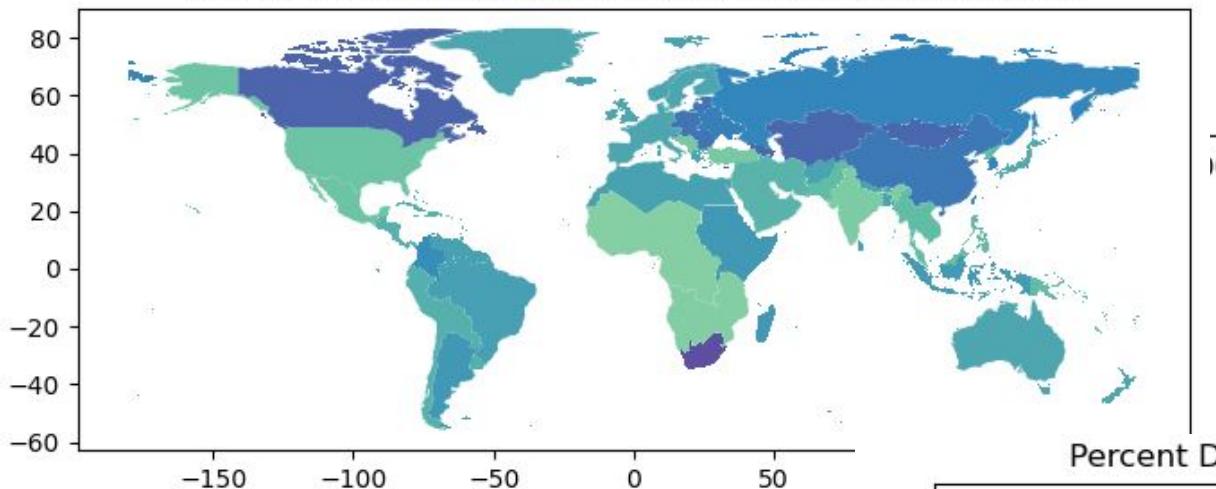
% Worsening of FEW Index with Mitigation - Tradeoffs



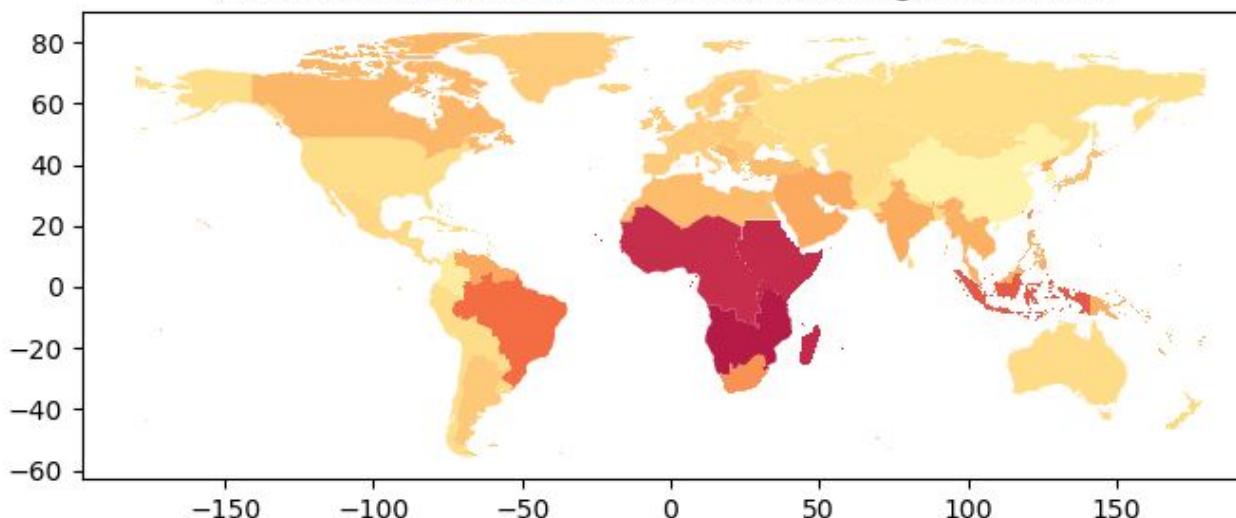
Percent Decrease Water Sub-Index with Mitigation in 2100



Percent Decrease Energy Sub-Index with Mitigation in 2100

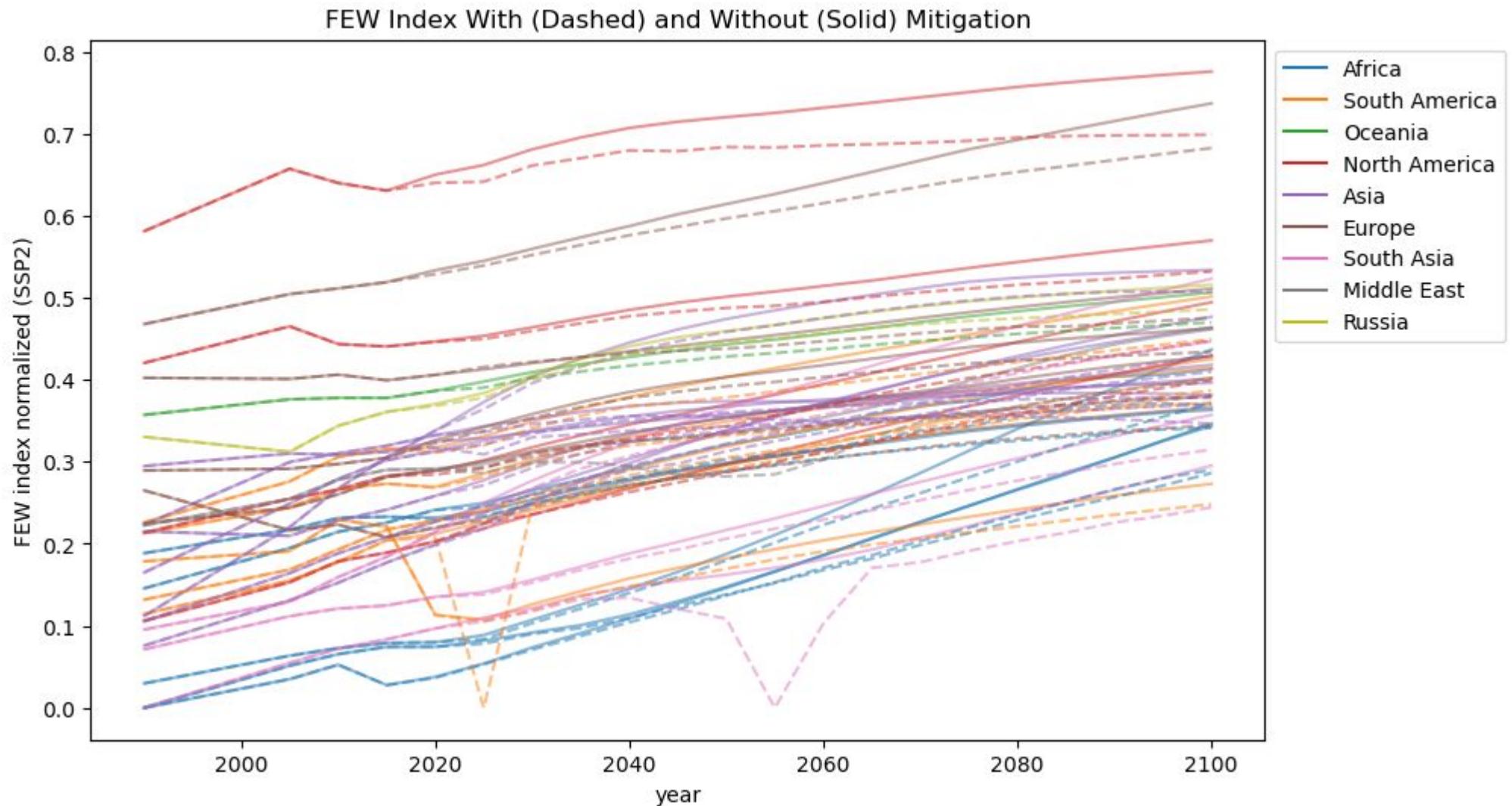


Percent Decrease Food Sub-Index with Mitigation in 2100



Worse Index
No Change
Better Index

Index illustrates increased risk of FEW-related conflict, particularly in Global South



Conclusions of the FEW-Index Experiment



- Captured Pardee-RAND FEW Index
- Tested index **across scenarios**
- Demonstrated use in **policy comparisons**



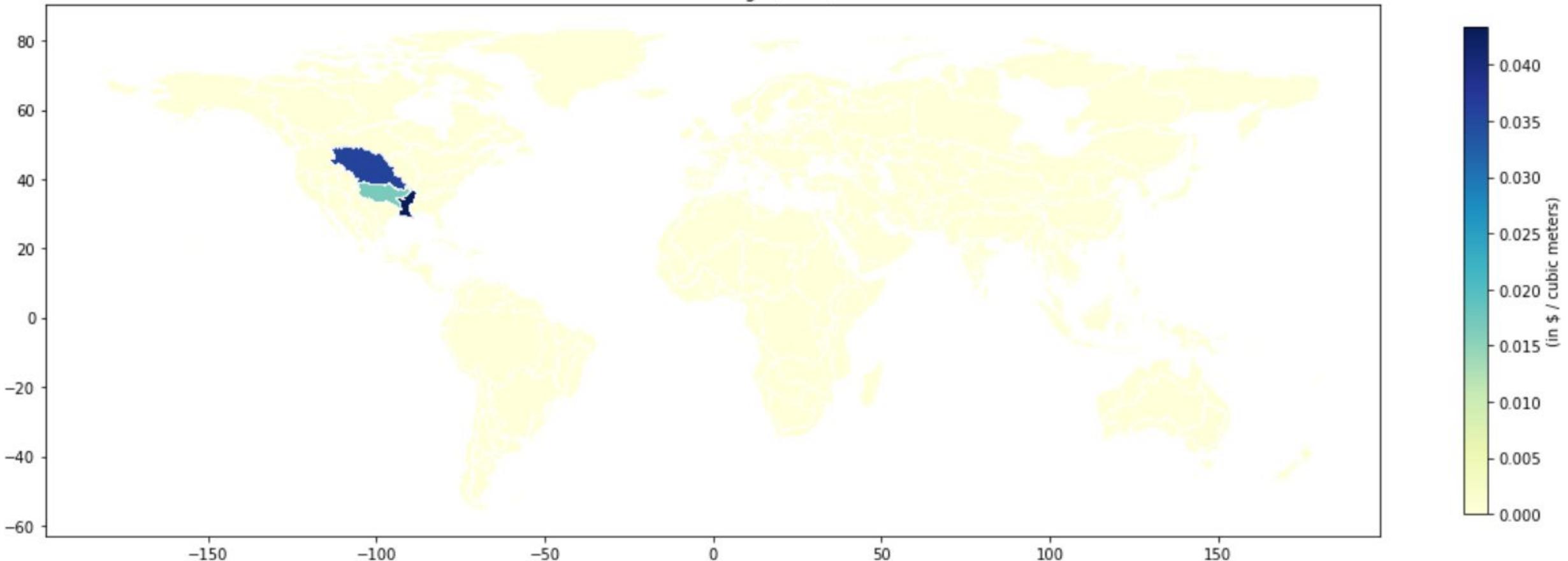
- Accuracy and **meaning**
- Benefit (?) of **singular indicator**
- Impact of **local context** and institutions on mitigating conflict risk

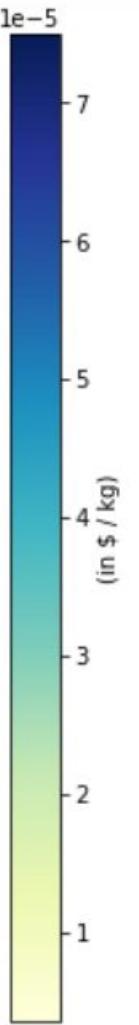
Can we cause short-term catastrophe's in GCAM?

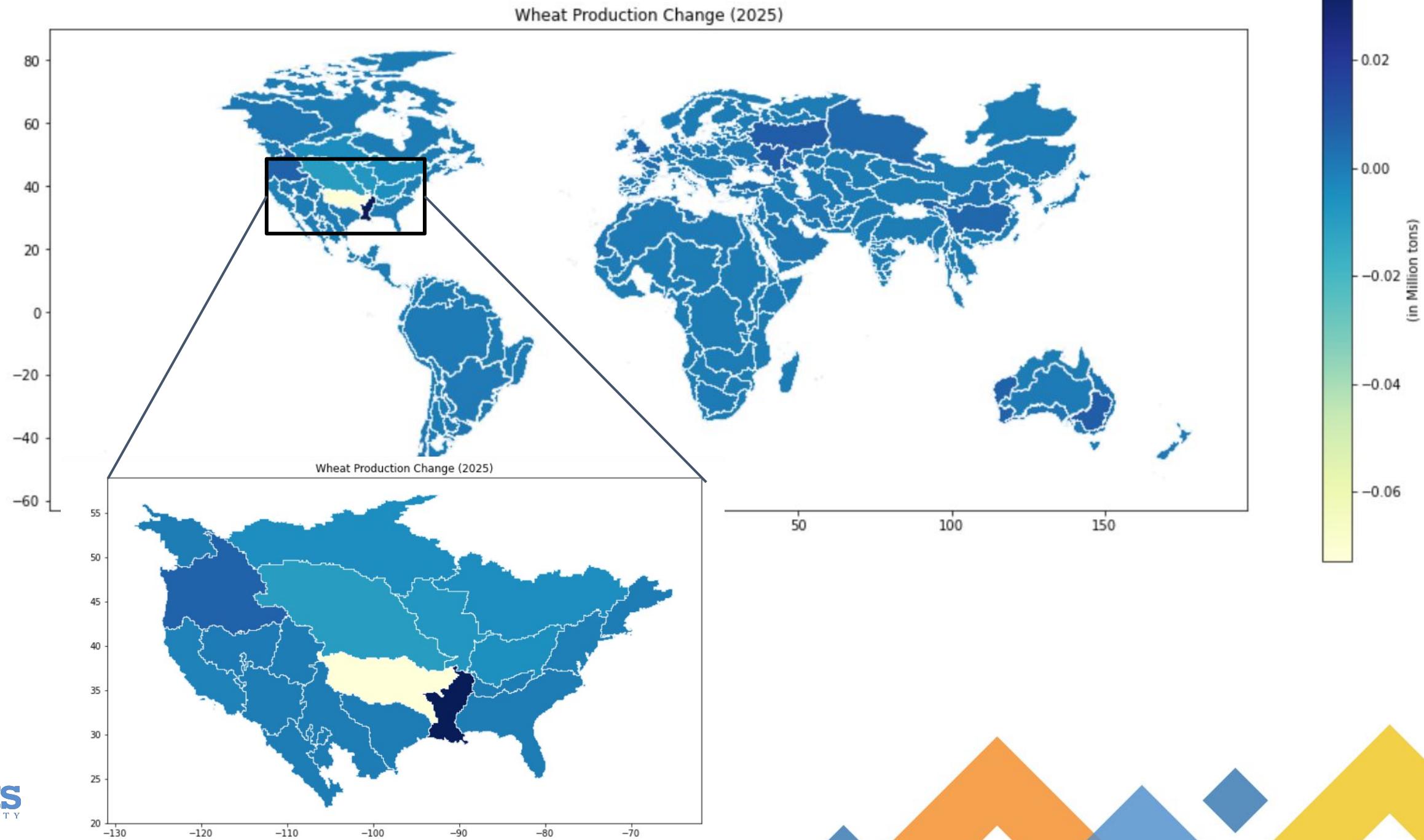
Motivation and Framing

- As an **equilibrium** model, GCAM is primarily designed to analyse long-term impacts on global systems.
- This project aims to explore if **short-term catastrophic climatic shocks** can be modelled using GCAM.
- We modelled a **decade-long severe heatwave** in the American midwest by **decreasing runoff** in the Arkansas, Missouri, and South Mississippi river basins by **70%**
- To what extent can a **climate shock** (drought) affect **agriculture production**, and prices in the US and beyond?

Water Price change (2025)





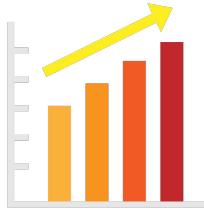


Conclusion



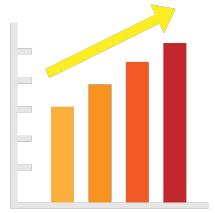
1. GCAM can incorporate behavioral responses and adaptation strategies **to some extent**

Conclusion



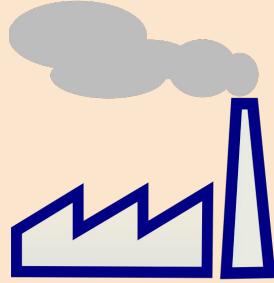
1. GCAM can incorporate behavioral responses and adaptation strategies **to some extent**
2. It is limited by its **underlying assumptions** and modeling framework

Conclusion



1. GCAM can incorporate behavioral responses and adaptation strategies **to some extent**
2. It is limited by its **underlying assumptions** and modeling framework
3. Since it is an equilibrium model, it adapts to these catastrophic shocks by **reallocating** wheat production across nations and regions, but may not always be practically feasible because of difference in **geography, climatic, political, cultural and economic factors**.

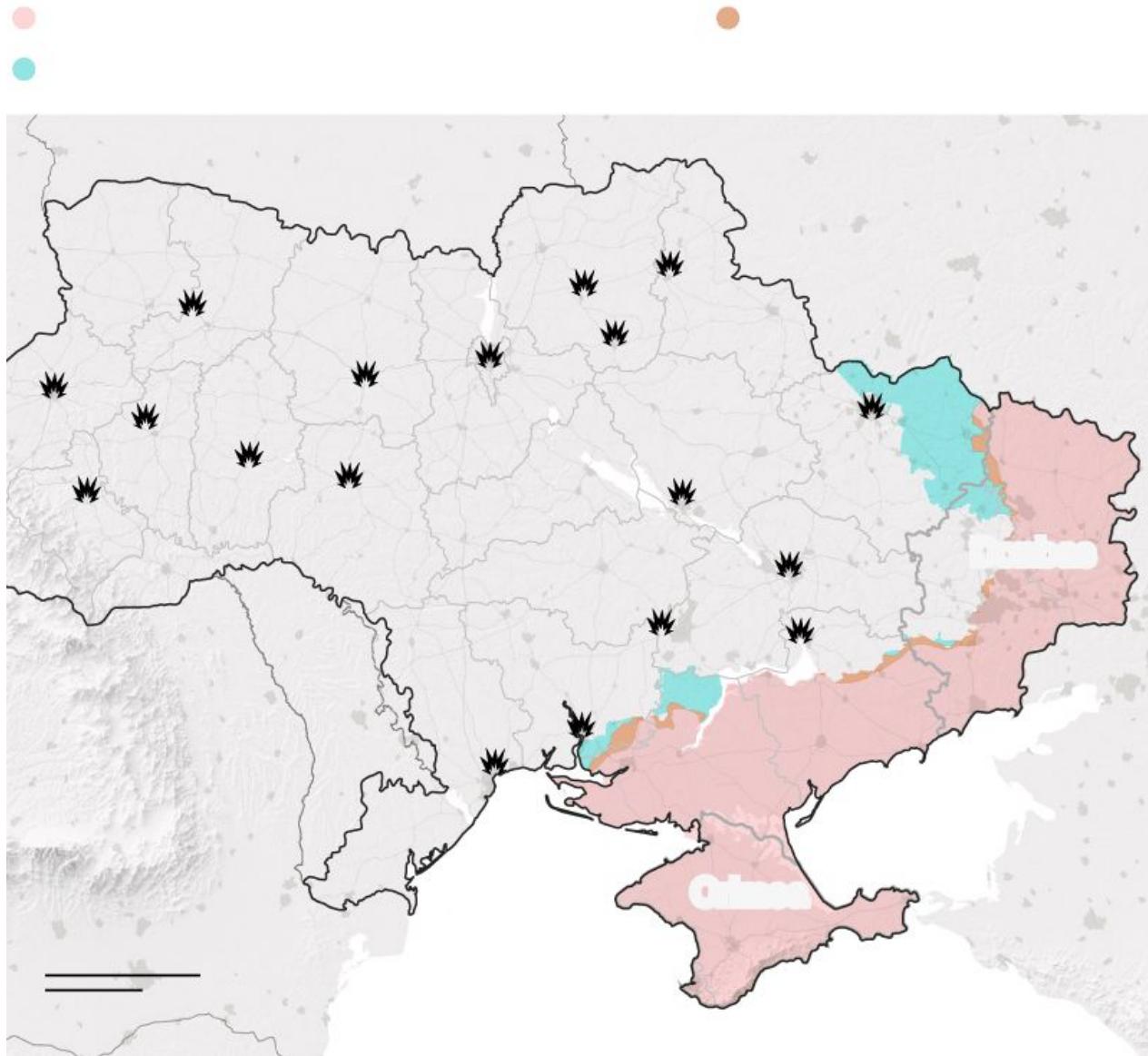
Conflict as Reduced Land Availability



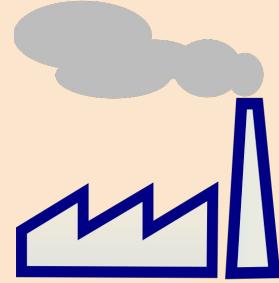
During conflict,
production shifts
(increase in
weaponry, decrease
in other things)



Of particular interest
within GCAM, large
scale conflict takes
farmland out of
production



Conflict as Reduced Land Availability



During conflict,
production shifts
(increase in
weaponry, decrease
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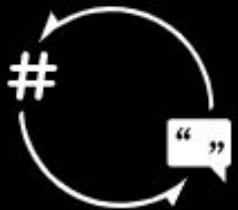
Of particular interest
within GCAM, large
scale conflict takes
farmland out of
production



We tried to take
farmland out of
production but saw no
effect on outputs
Why?

Conflict + Catastrophe Group Conclusion

- GCAM, when used properly, can be a powerful tool
- Challenges of using GCAM - nature of equilibrium models
- GCAM can begin to illustrate how climate mitigation policies could increase regional risk of instability or unrest
- GCAM cannot be used to **predict** conflict



Connecting Numbers and Narratives

We investigated multiple ways that IAMs can be integrated with narratives around conflict and catastrophe.



Learning How to Learn

We focused on pushing the model beyond its use to a point of failure. We searched for implications of model rather than model itself.



Embracing Complexity

No such thing as prediction within complex systems- we learned when these models can be a powerful tool and when they are not.

How should we approach and use
GCAM, given the complexities of the
systems it represents?

Exploring GCAM's Capabilities and Limitations

GCAM's Equilibrium Focus:

- Designed for analyzing **long-term** environmental, economic, and energy trends.
- Limited in addressing **rapid changes or shocks** like sudden climate events or economic crises.

Implications for Policy:

- Crisis Management: May not capture **immediate impacts** of sudden events, presenting challenges in crisis response planning.
- Policy Adaptation: Essential for policymakers to understand these **limitations**

Exploring GCAM's Capabilities and Limitations

Communicating with Policymakers:

- Clear Communication: Simplify complex model outcomes into actionable insights that can be readily used in decision-making processes.
- Relevance to Policy: Tailor communication to highlight how GCAM's projections align with or inform specific policy goals, especially in areas like long-term climate strategy and energy planning.
- Engagement Strategies: Facilitate workshops and briefings that allow policymakers to interact directly with model outputs, enhancing their understanding and ability to utilize the information effectively.

Exploring GCAM's Capabilities and Limitations: Policymaking



1. Clear Communication: Simplify complex model outcomes into actionable insights



2. Relevance to Policy: Tailor communication to highlight how GCAM's projections align with or inform specific policy goals



3. Engagement strategies: Facilitate workshops and briefings that allow policymakers to interact directly with model outputs

Enhancing IAM Engagement and Communication

Stakeholder Engagement

- **Objective:** Broaden stakeholder involvement across **all climate models**
- **Strategies:** Conduct more inclusive **community consultations**, integrate diverse **local and indigenous knowledge**, **actively include marginalized communities**.

Science Communication

- **Challenges:** Communicating complex results from climate models to **non-expert audiences**.
- **Solutions:** Employ **simplified narratives**, utilize visual tools, and engage through interactive platforms to **enhance understanding** and drive actionable insights.

PFI 1 Takeaways: Numbers and Narratives in the Context of IAMs

- GCAM works in a very narrow way (some parameters are local without interconnections) -> missing work for inferences later
- Some of the other factors are so interconnected that we get impractical results -> ie wheat production being completely mobile (practically infeasible due to contexts in other places)
- Issue of model accessibility -> if we don't know how the model works, we need to be very careful about using them for policy development -> in some cases, the best we can do is to use them as a discussion tool
- Our assumptions in modelers (narratives) affect model outcomes (numbers) -> this is an all modeling problem
- GCAM is not predictive- this is a very different kind of model due to lack of hypotheticals
- role of uncomfortability -> nothing is just going to work, we need to work around it

PFI 3: Numbers and Narratives in IAMs

*Models must be
accessible for
equitable policy
development.*



PFI 3: Numbers and Narratives in IAMs

Models must be accessible for equitable policy development.



The scales at which we run our models is an important decision. Global models should be used in conjunction with local models.

PFI 3: Numbers and Narratives in IAMs

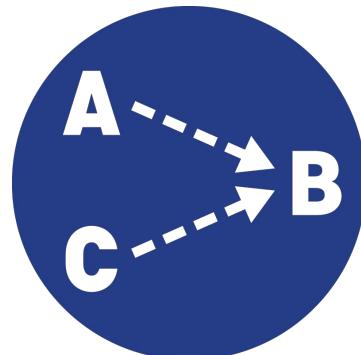
Models must be accessible for equitable policy development.



It is important to use and frame these models as ‘potential futures,’ rather than communicating about them as predictive.



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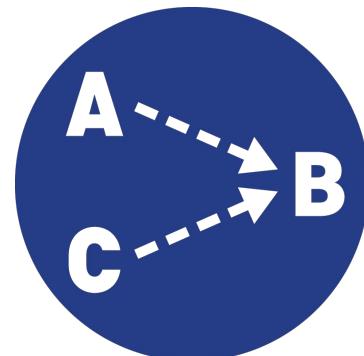
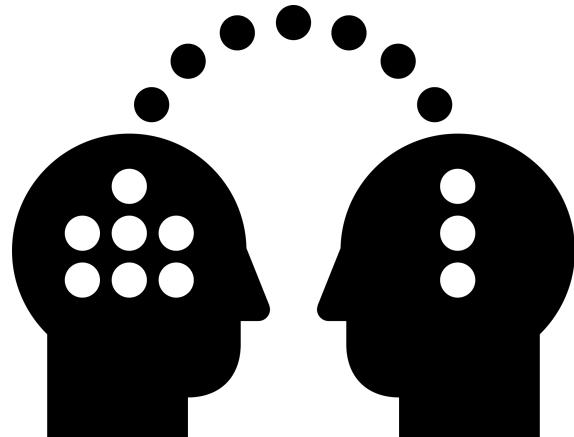
PFI 3: Numbers and Narratives in IAMs

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Assumptions drive outputs (numbers) which feeds our narratives. Our narratives then drive what assumptions we make in a cyclical pattern.

The Dark Arts of Data Science

PFI 2023-2024

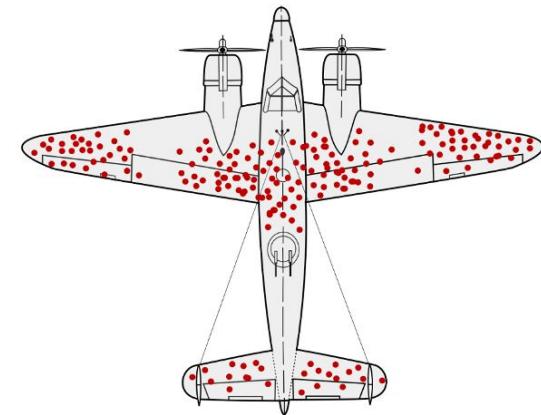
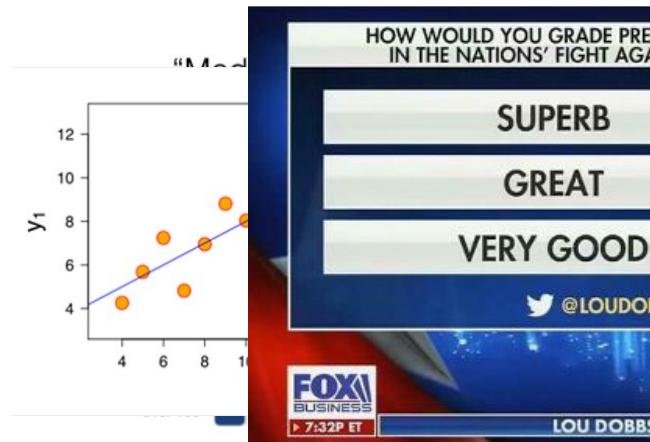
Starting Goals

Practical Wisdom

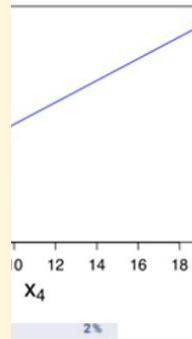
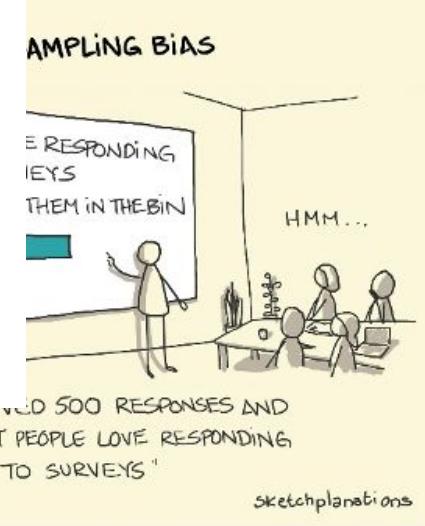
- Become conscientious data scientists
 - How data science works
 - How it persuades
 - Connecting numbers to narratives
 - How it can be abused

Formal Knowledge

How can Data and Statistics Mislead?



aircraft shows locations where they can sustain damage and still return home. Source:
https://en.wikipedia.org/wiki/Survivorship_bias



Formal Knowledge

How can Data and Statistics Mislead?

- Scientific fraud
 - p-Hacking
 - HARKing
 - Multiple Comparisons
- Tests
 - GRIM
 - Benford's Law

FOOD FOR THOUGHT

Cornell Food Researcher's Downfall Raises Larger Questions For Science

SEPTEMBER 26, 2018 · 3:07 PM ET

By Brett Dahlberg

FROM **WXXI**



Brian Wansink demonstrates his "bottomless bowl of soup" — used to show that people eat more when served in a bowl secretly replenished from the inside — after he was awarded a 2007 Ig Nobel Prize in 2007 at Harvard University. Wansink made a name for himself producing pithy, palatable studies that connected people's eating habits with cues from their environment.

Stan Honda/AFP/Getty Images

Practiced Techniques

Can We Replicate this Fox Article Analysis?



TRENDING COVID ORIGINS | TITLE IX | ARTIFICIAL INTELLIGENCE | DESANTIS VS BUD LIGHT

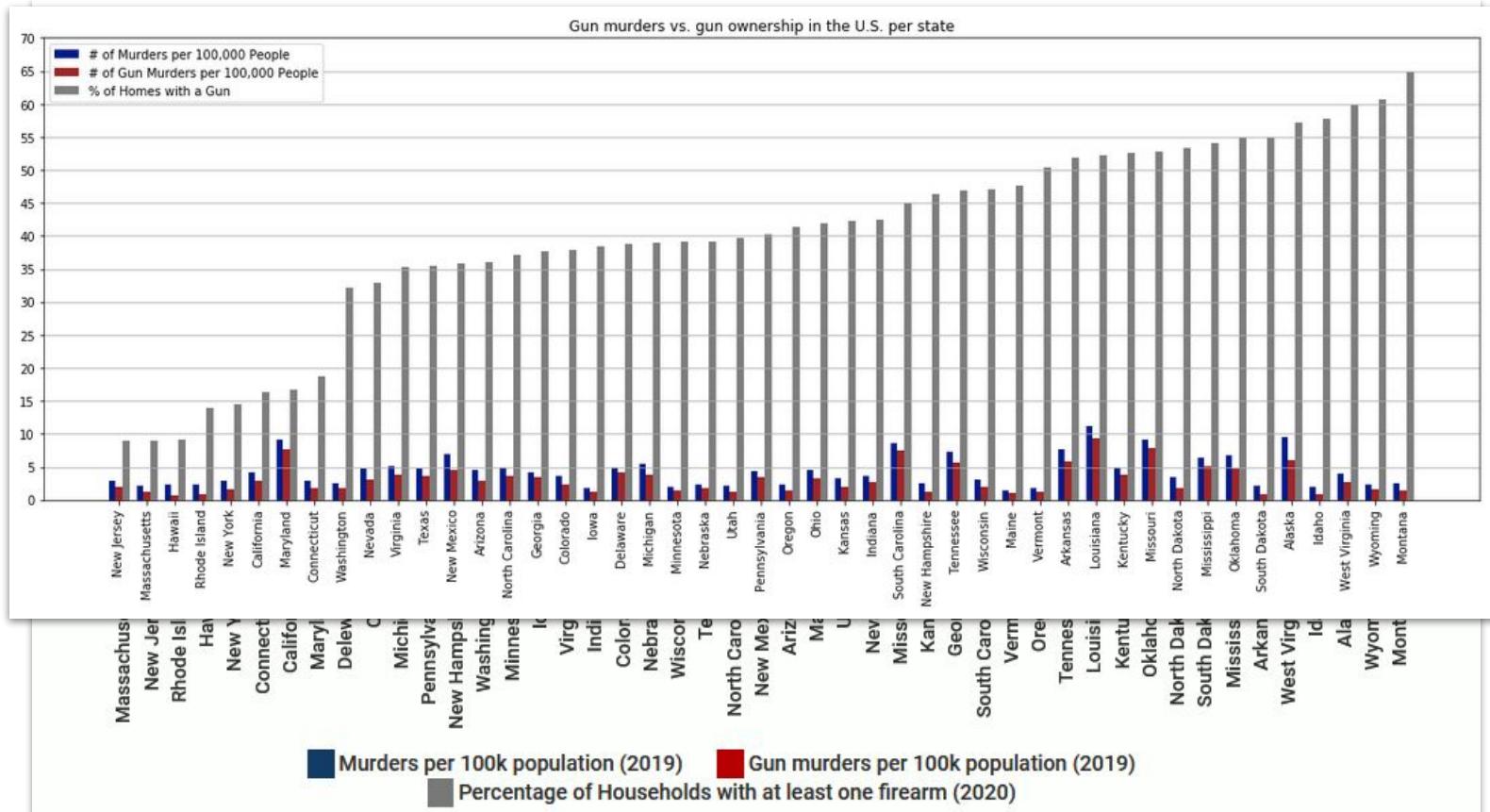
CRIME • Published June 30, 2022 2:00am EDT

States with higher rate of gun ownership do not correlate with more gun murders, data show

Lawmakers and gun control advocates are calling for stricter gun laws following a series of mass shootings

Practiced Techniques

Can We Replicate this Fox Article Analysis?



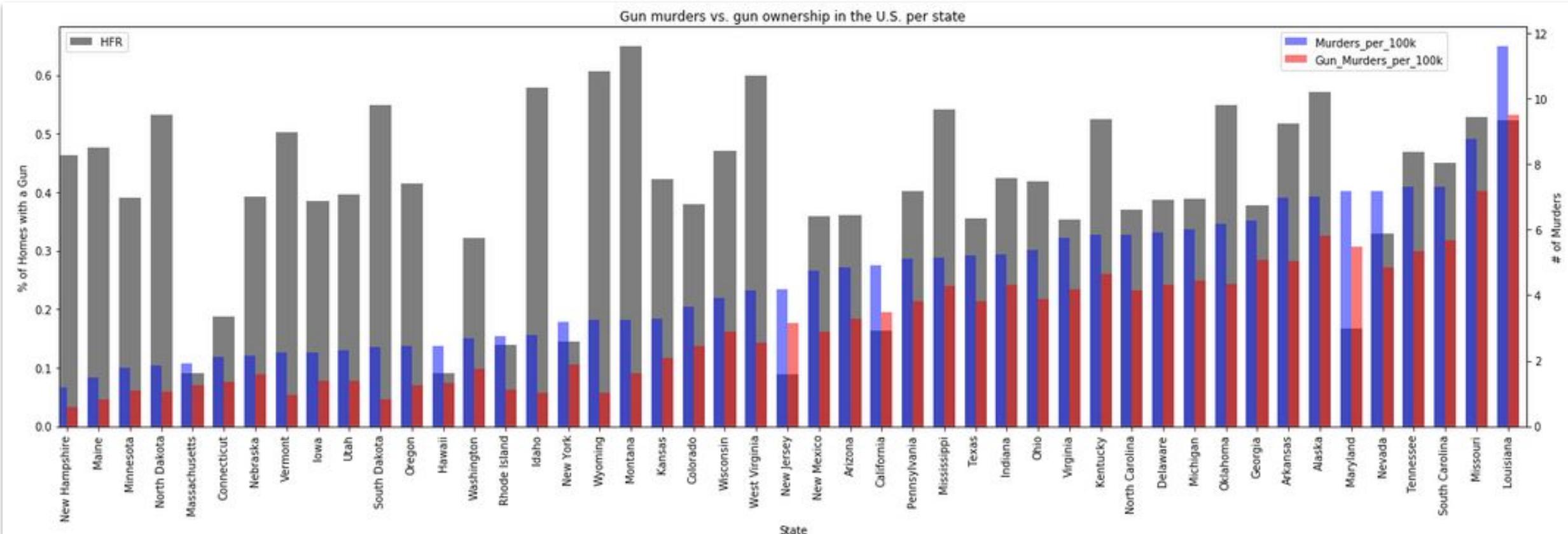
Practiced Techniques

Can We Replicate this Fox Article Analysis?

- Reasonable Sources
 - FBI
 - # Murders
 - # Murders by Firearm
 - Census Bureau
 - Population by state
 - RAND Corporation
 - Estimated percentage of homes with a gun
- Imperfect Visual
 - Bars are on the same axis
 - Slight discrepancy in values
 - Not systematic in a particular direction
 - Does not change overall pattern
 - Years of data not consistent
 - 2016 ownership estimates
 - 2019 murder and population statistics
 - Missing Data
 - Alabama, Florida, Illinois excluded
 - Incomplete reporting to the FBI
 - Bar chart
 - Not optimized for correlation analysis

Practiced Techniques

Can We Replicate this Fox Article Analysis?

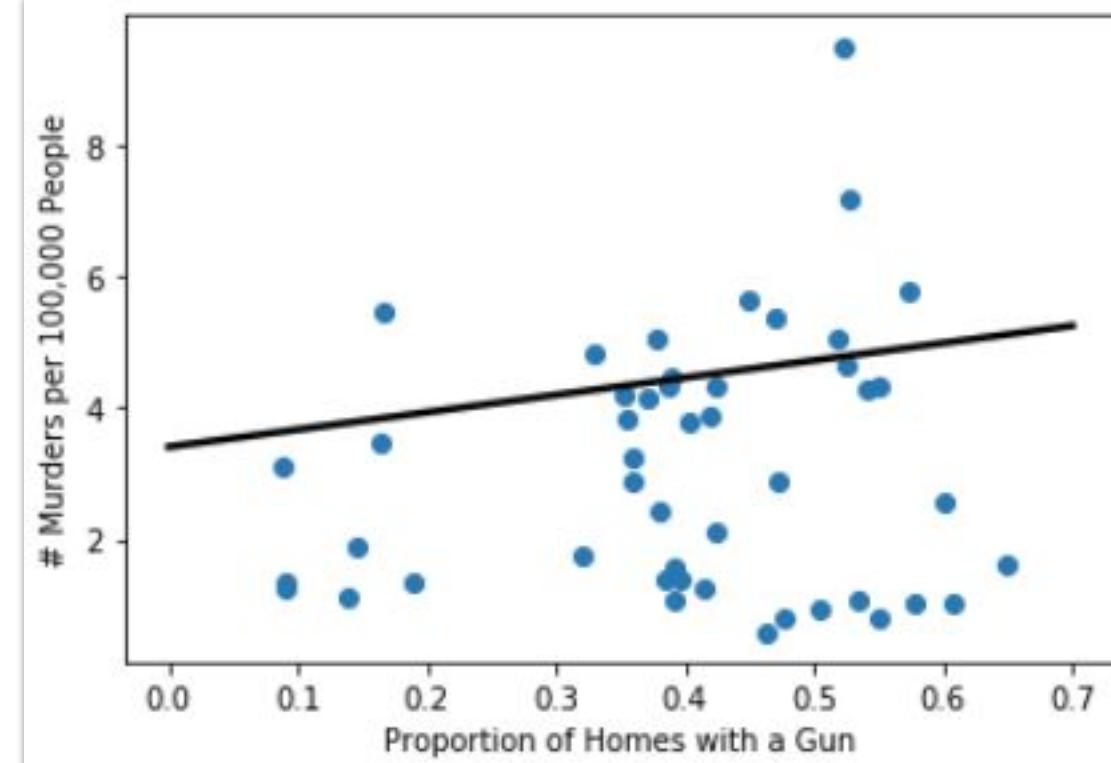


Thoughtful Practice

Can We Replicate this Fox Article Analysis?

- There does not appear to be a relationship between the proportion of homes with a gun and the number of gun murders per 100,000 people
- Fox's method was reasonable and consistent with the headline
- BUT the article did not stop at this measured, data-supported claim

Correlation Coefficient:
0.14



Thoughtful Practice

Informal Logic and Fallacies

Formal

There is a pattern of reasoning rendered invalid by a flaw in its logical structure that can neatly be expressed in a standard logic system.

E.g.

1. All humans are mammals.
2. Fido is a mammal.
3. Therefore, Fido is a human.

Informal

The source of the error is also due to the content and context of the argument. Often connected to ambiguous expressions and implicit premises

E.g.

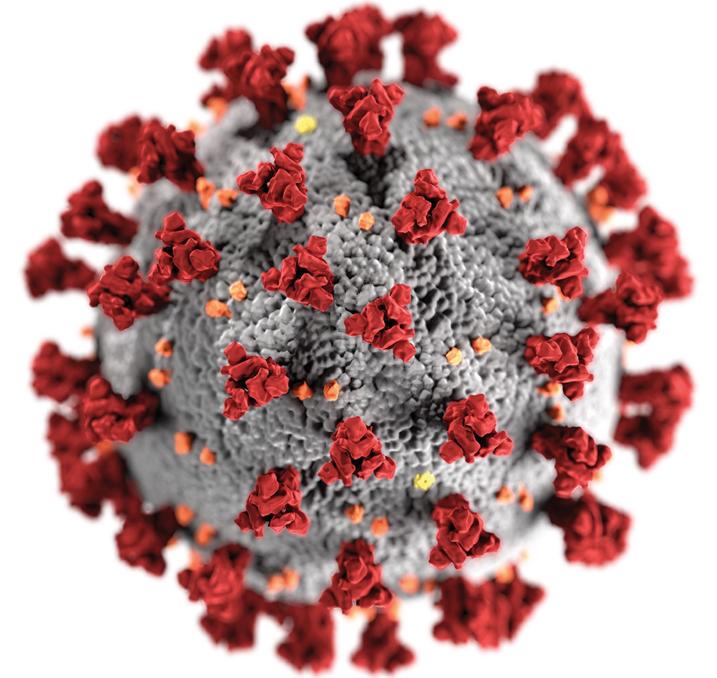
1. Feathers are light. ("light" = "not heavy")
2. Light cannot be dark. ("light" = "color")
3. Therefore, feathers cannot be dark.

Building a Corpus for Experimentation

Hypothesis: The mainstream news conducts reasonable data analysis, but there are logical leaps and fallacies in their use of those analyses to create narratives.

Building a Corpus for Experimentation

- Scrape articles from major outlets
 - Media Cloud
- Hand code disconnects
- Focus on covid case study



Future Work

- Extend to a variety of topics
 - Comparative analysis
- Expand time and source scope
- Develop new methods of computational analysis

Key Takeaways

- Learning to learn
 - Not every idea is a winner
 - Iterative research
- Finding a common language across disciplines
 - Challenging, but rewarding

PFI Presentation 2024.pptx

