THE CHANGING NATURE OF WATER SECURITY AND ITS SOCIO-ENVIRONMENTAL STRESSES

Water Security and Conflict Session, MIT Global Change Forum

March 23, 2023 Cambridge, MA

Many thanks to: Chas Fant, Xiang Gao, Cypress Frankenfeld, Andrei Sokolov, Shelli Orzach, Alyssa McCluskey, Jen Morris, Angelo Gurgel, Seb Eastham, Sergey Paltsev, Ken Strzepek, and John Reilly

HOW CAN AND SHOULD WE DEFINE AND QUANTIFY WATER "SECURITY"

- Broad diffusion of metrics across regions; scales; framing; and indicator formulation.

- Historically, definitions and interpretations have varied with geographic regions and research aims. Thus - actors (scholars, planners, managers, and stakeholders, etc.), are using the concept in widely diverging ways.

- Notwithstanding the palpable rise in use, a comprehensive understanding of how water security is conceptualized and employed in different contexts around the world is limited.

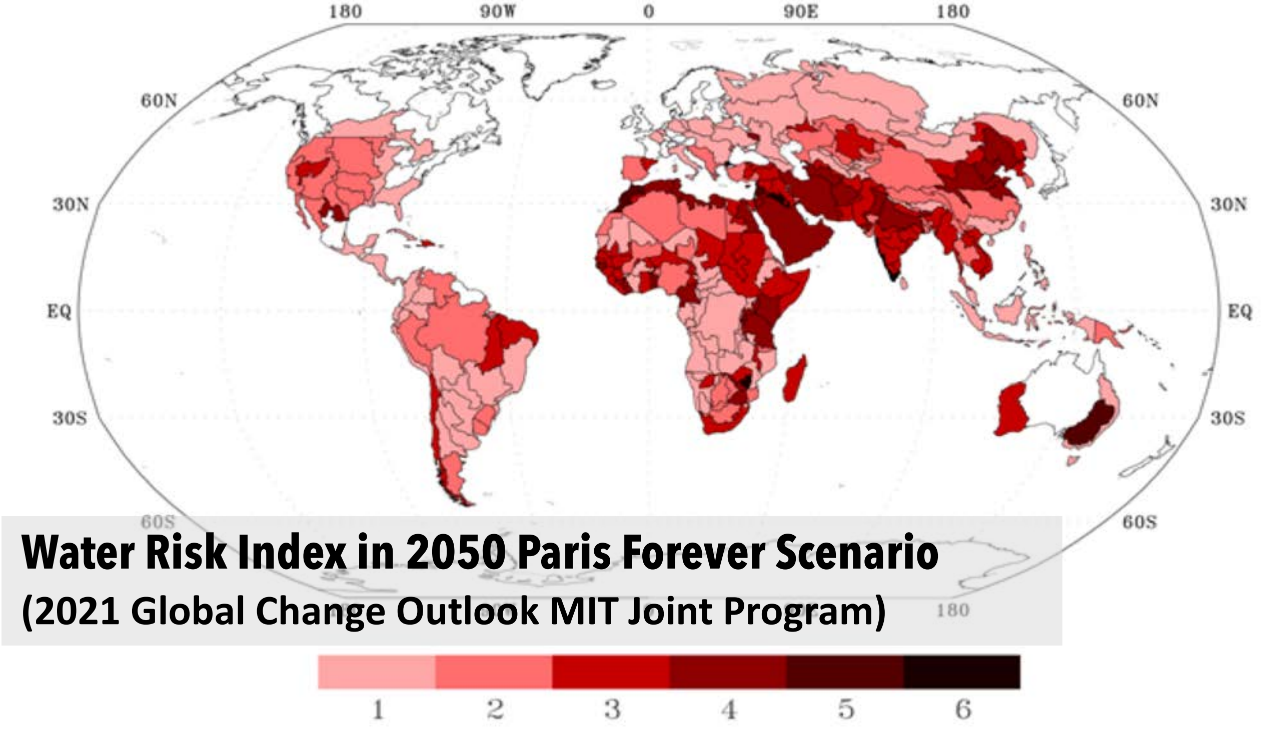
- More recently - "security" is seen more thru a lens of humans' achievement through development. Water fits within this broader definition embracing political, health, economic, personal, food, energy, environmental and other concerns and acts as a central link between them." UN-Water/United Nations

UN-Water on "water security" – define as the capacity of a population to:

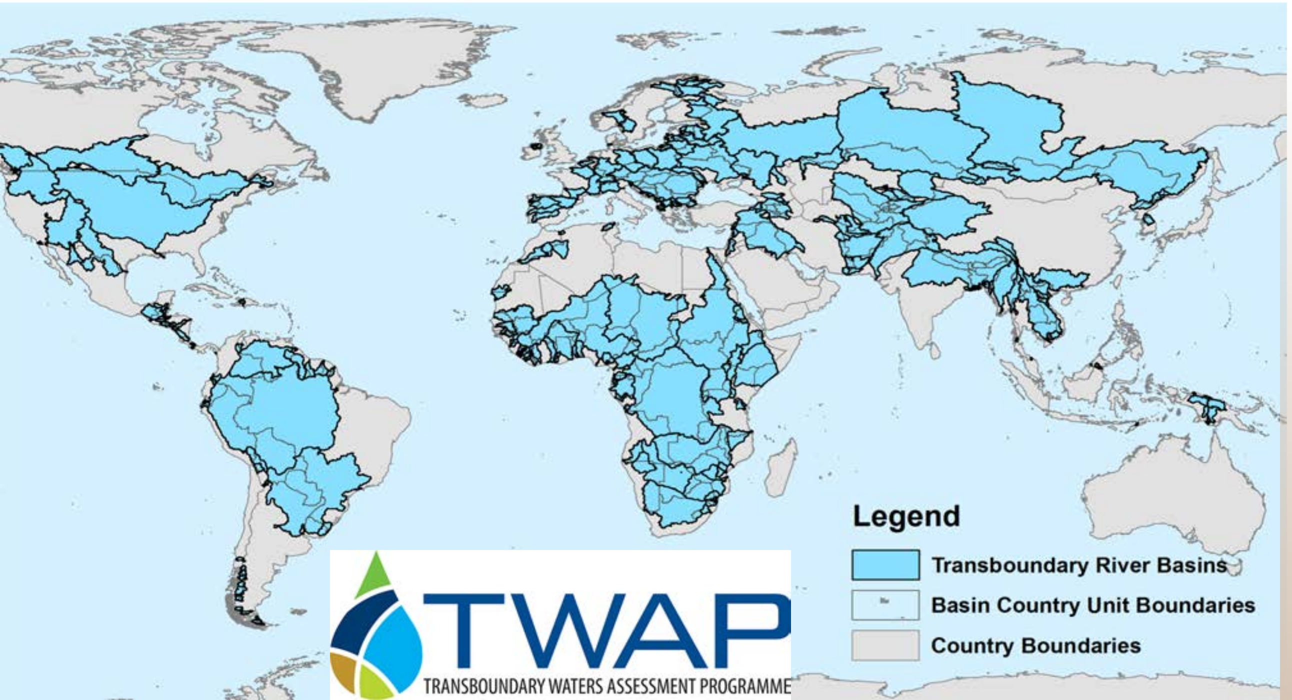
- Safeguard **sustainable access** to adequate quantities and **acceptable quality** of water.
- **Sustain** livelihoods, **human wellbeing, and socio-economic development.**
- **Protect** against waterborne **pollution** and water-related disasters.
- **Preserve ecosystems** in a climate of **peace and political stability.**

In May 2018, UN Water reported that "the world is not on track to achieve SDG6" by 2030

BRINGING AND BRIDGING TOGETHER CONCEPTS OF WATER SECURITY AND CONFLICT



Water Risk Index in 2050 Paris Forever Scenario
(2021 Global Change Outlook MIT Joint Program)



- Reliability
- Quality
- Quantity
- Safe and equitable access
- Environmental provisioning of water
- Transboundary water resources
- Multitude of metrics

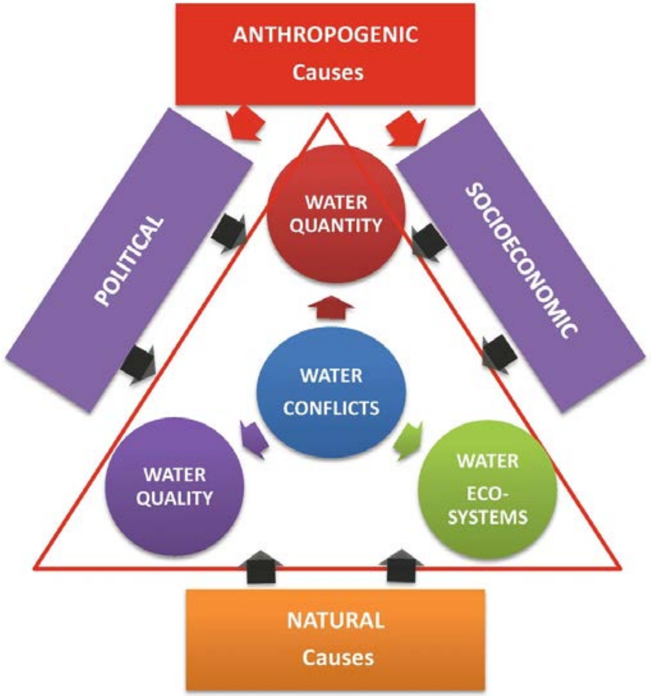
WWF, 2009; UNEP, 2009; WEF, 2011; UN-Water, 2013; UNESCO, 2013

WATER SECURTIY AND "CONFLICT"

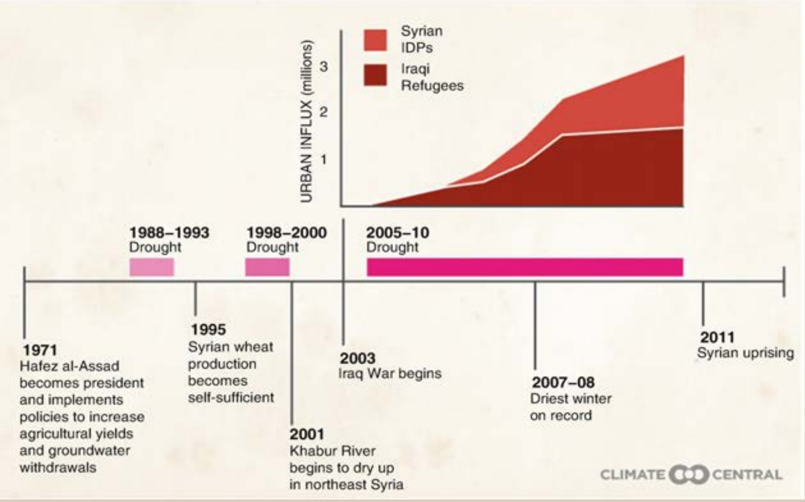
GOING BEYOND "WATER WARS"

MACRO VS. MICRO AND INTRA- VS. INTER- NATIONAL

- Early 2000s studies noted basins with potential for political stresses – within 5 to 10 years . Basins included: Kunene; Okavango; Orange; Limpopo; Incomati; Lake Chad; Sengal; Ganges, Brahmaphutra; Meghna; Mekong; Saleen and Ob. Nearly 20 years after these studies - no widespread violent conflict occurred.
- A transboundary violent conflict that did occur is in Euphrates-Tigris – but primarily precipitated by the U.S. invasion of Iraq and subsequent militia-charged political/ethnic turmoil. Powell et al. (2017) and Swain (2015)
- Sub-national "conflicts" have been on the rise and dominate the global rise in water-related "conflicts" (Water Conflict Chronology - Pacific Institute, 2022)
- Simply put, water-security conflicts are (seemingly) becoming more granular – and contexts and definitions of conflict have moved well beyond limited focus on military risks and conflicts (WMO and Gerlak et al., 2018).



Ganoulis, J., Fried, J. (2018)



<u>Thus, water-related conflicts can be categorized as follows: (Pacific Institute, 2022)</u>

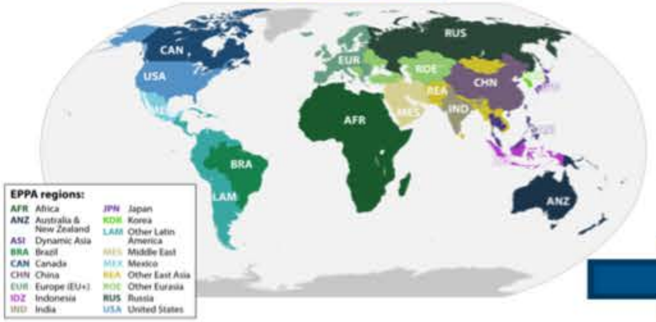
<u>Trigger</u>: Water as a trigger or root cause of conflict, where there is a dispute over the control of water or water systems or where economic or physical access to water, or scarcity of water, triggers violence.

Weapon: Water as a weapon of conflict, where water resources, or water systems

Integrated Global System Model Framework

Project risks in the natural, managed, and built environments

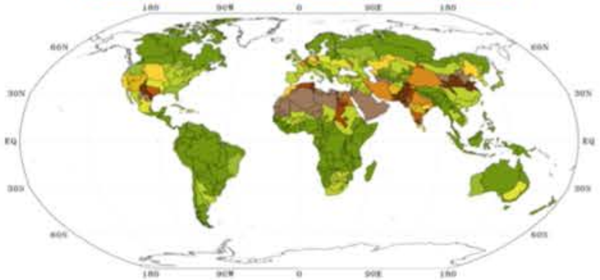
EPPA Regions

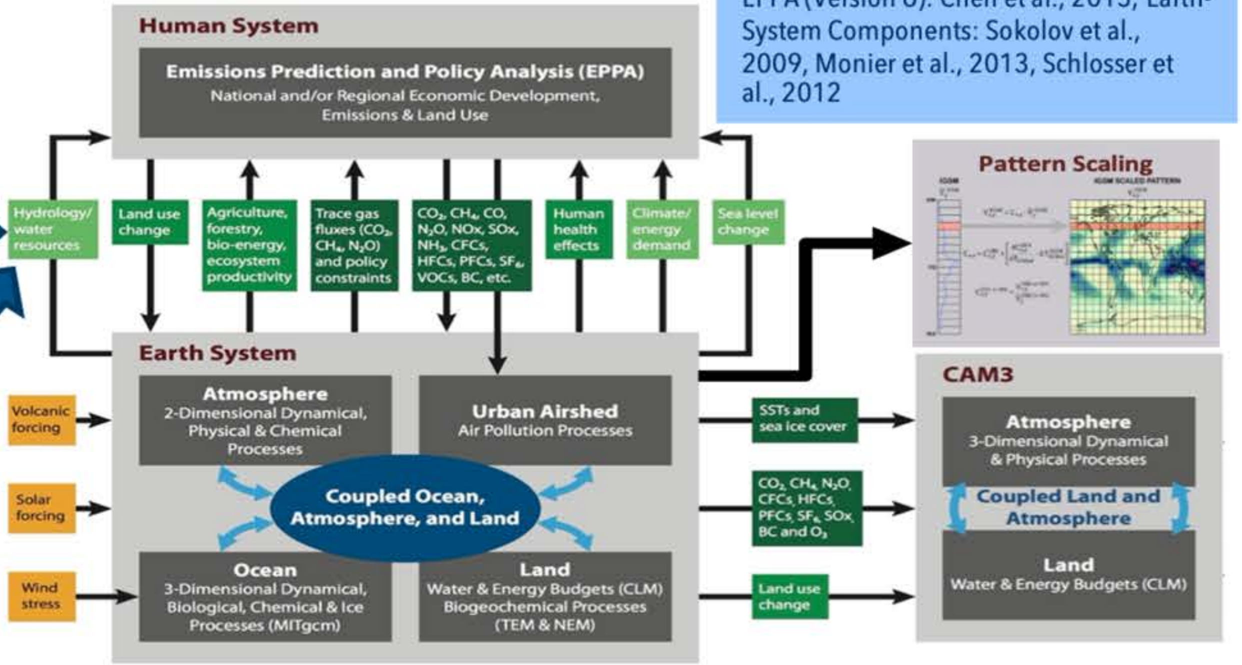


Managed Water System

IGSM-WRS: Strzepek, K., C. A. Schlosser, A. Gueneau, X. Gao, C. Fant, E. Blanc, and, B. Rasheed, and H. Jacoby (JAMES, 2013).

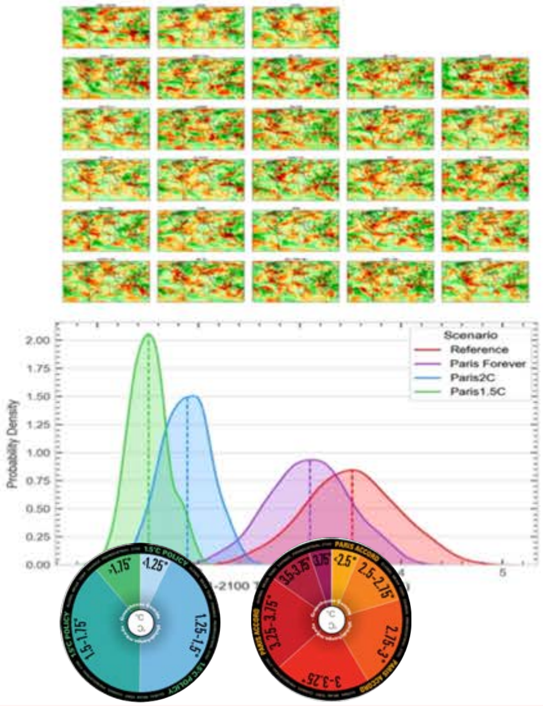
Assessment Sub-Regions (ASRs)



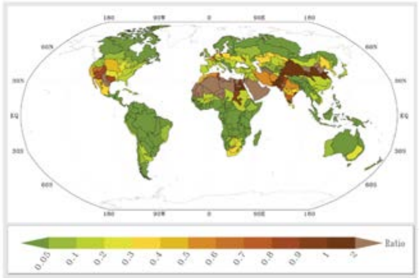


EPPA (Version 6): Chen et al., 2015; Earth-System Components: Sokolov et al., 2009, Monier et al., 2013, Schlosser et al., 2012

Distribution of Plausible Regional Outcomes

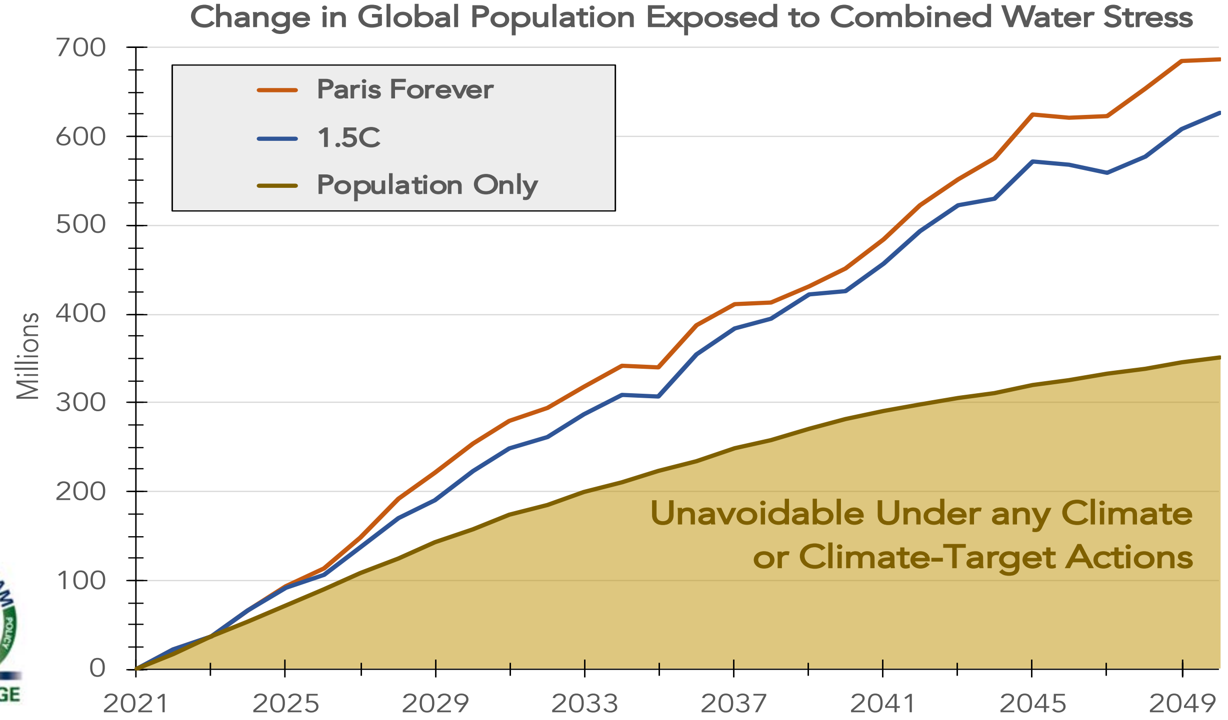


Multi-Sector Human and natural forces and their changes.
How much does mitigation help? Where do we adapt and sustain?



Mid-Century Water Stress: Climate Mitigation Can Reduce - But not Eliminate - Heightened Risks of Global Population with increased "Water Stress"

1) **"Environmental water-stress"** index: basin use of water has exceeded one-third of its natural replenishment
2) **"Societal water-stress"** index: basin where 15% (or higher) of the basin's annual water demands cannot be met



2021 Global Change Outlook - MIT Joint Program

High-priority basins or regions include: the Arabian Peninsula, Brahmaputra, Danube, Huang He, Indus, Ganges, Murray-Darling, Niger, Nile, Rio Grande, Southern Mediterranean, Volta and the Zambezi.

5.8 billion people in basins exposed to societal water stress (water-supply shortfall). More than half of the world's population will be exposed to stresses on its water supply by 2050

3.6 billion people in basins exposed to environmental water stress (withdrawal burden).

3.2 billion people in basins exposed to societal and environmental water stress conditions.

3 out of every 10 people worldwide will live in basins where societal *and* environmental pressures on water resources will be experienced.

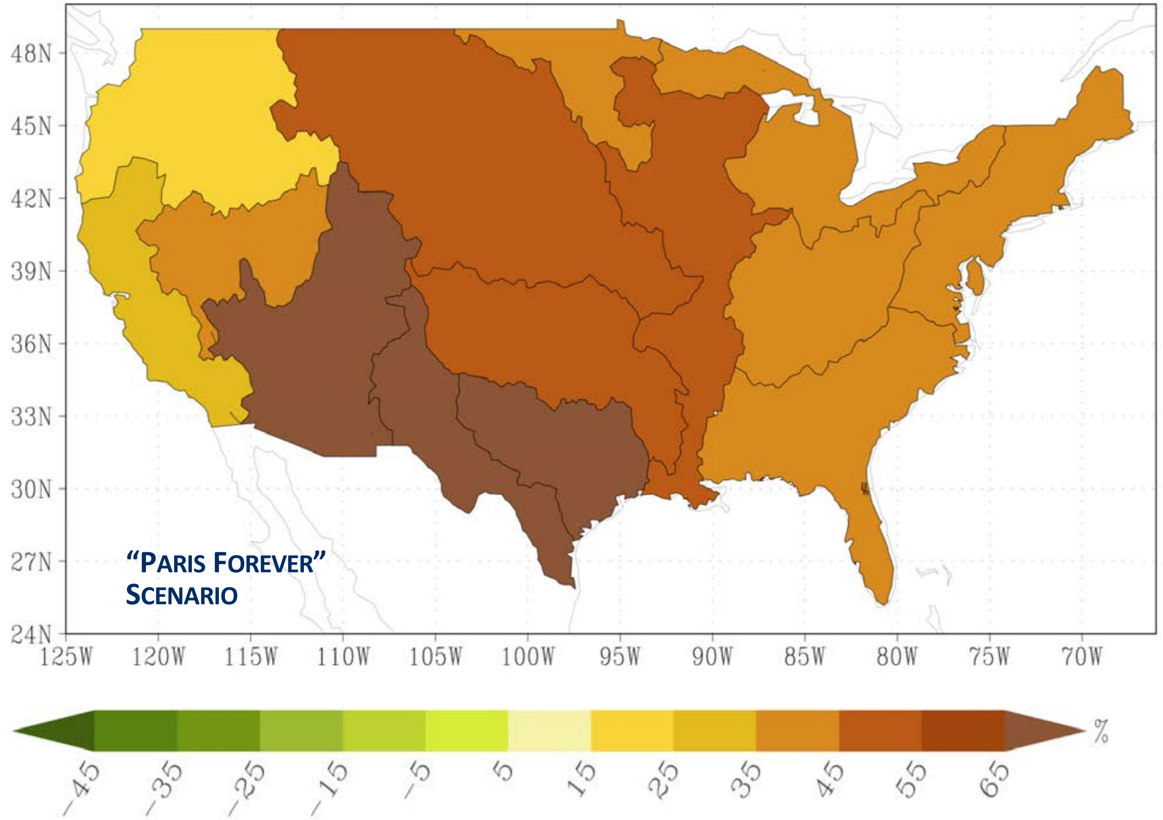
Aggressive climate mitigation reduces midcentury population-under-stress increases by ~10%.

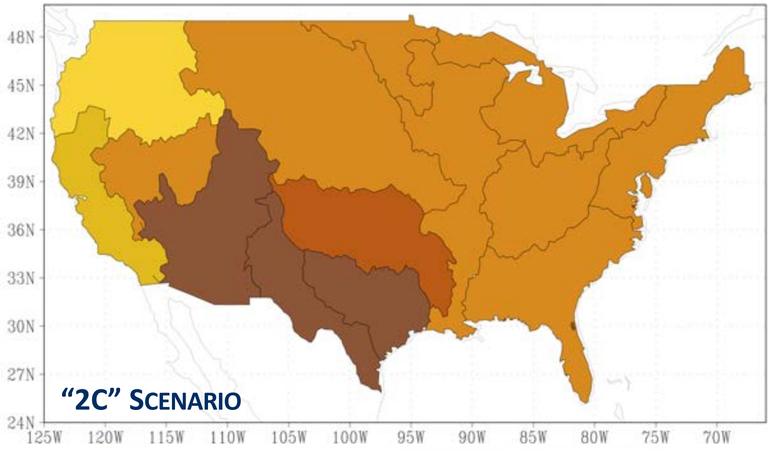
Conservative outlook – Lacks water quality considerations (stay tuned).

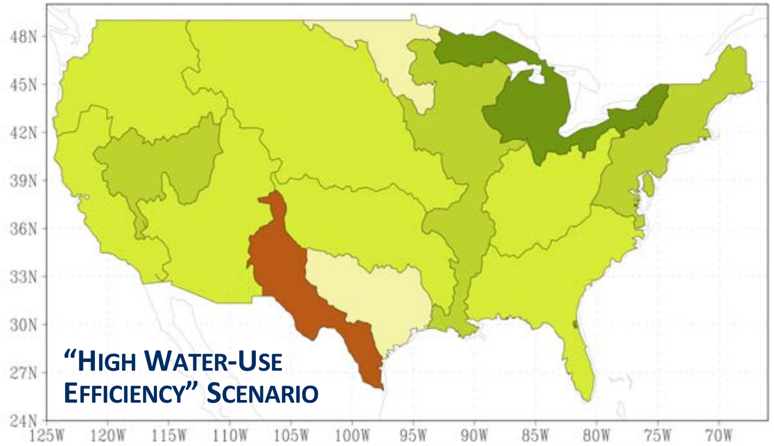
Change in Water Stress Risks (unmet demand)

Maps show 75th Percentile (1-in-4 chance of higher change) at 2050

Beneficial Impacts of efficient municipal and industrial consumption





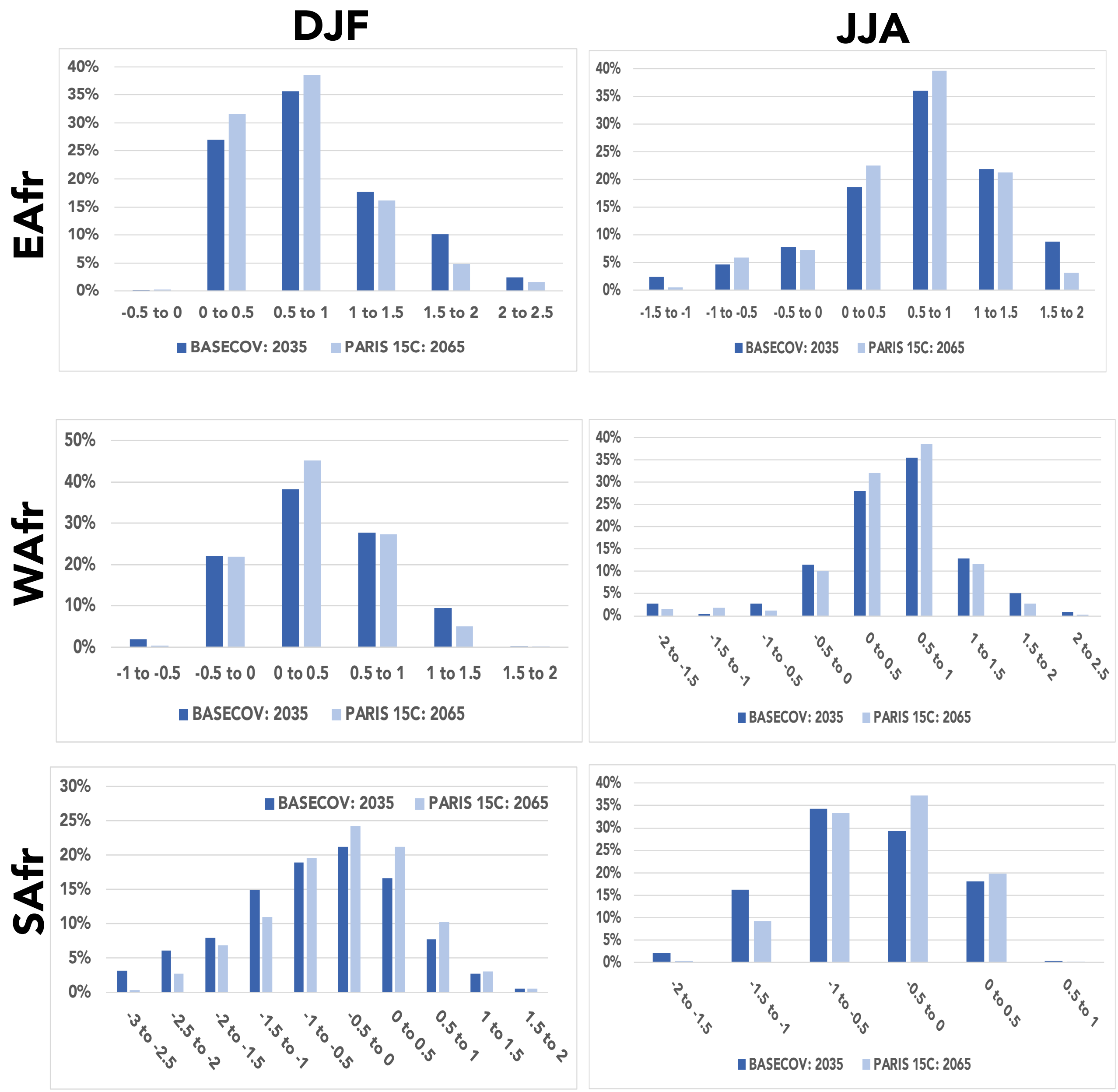


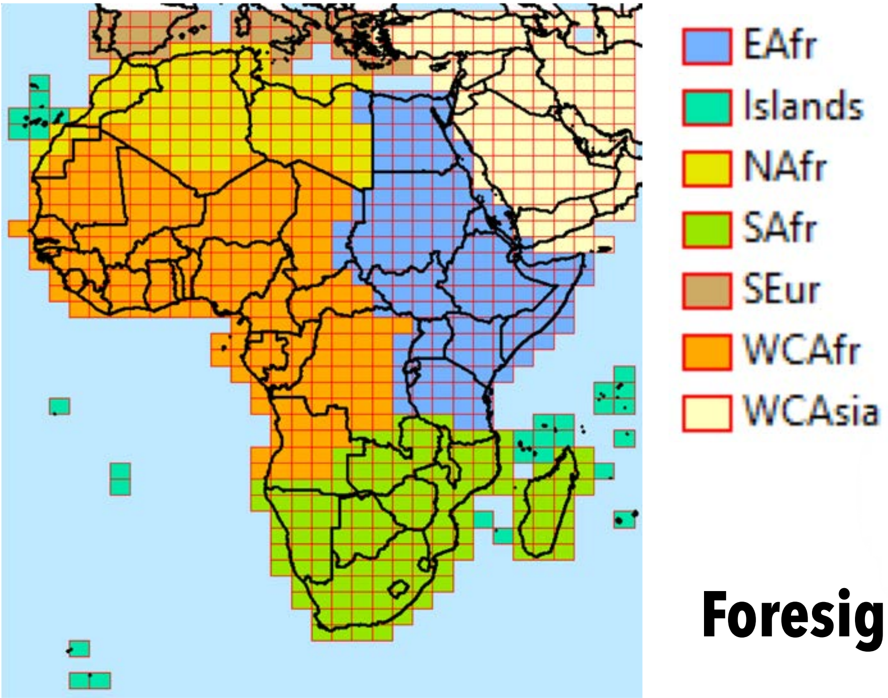
Based on 2021 Global Change Outlook - MIT Joint Program

- At Mid-Century – Water stress is up across the contiguous U.S. – regardless of climate action.
- Widespread municipal and industrial efficiencies adaptation can turn the tide of risk.

Unavoidable Yet (at least) Delayable Risks

Seasonal Precipitation Change from 2020 (mm/decad)



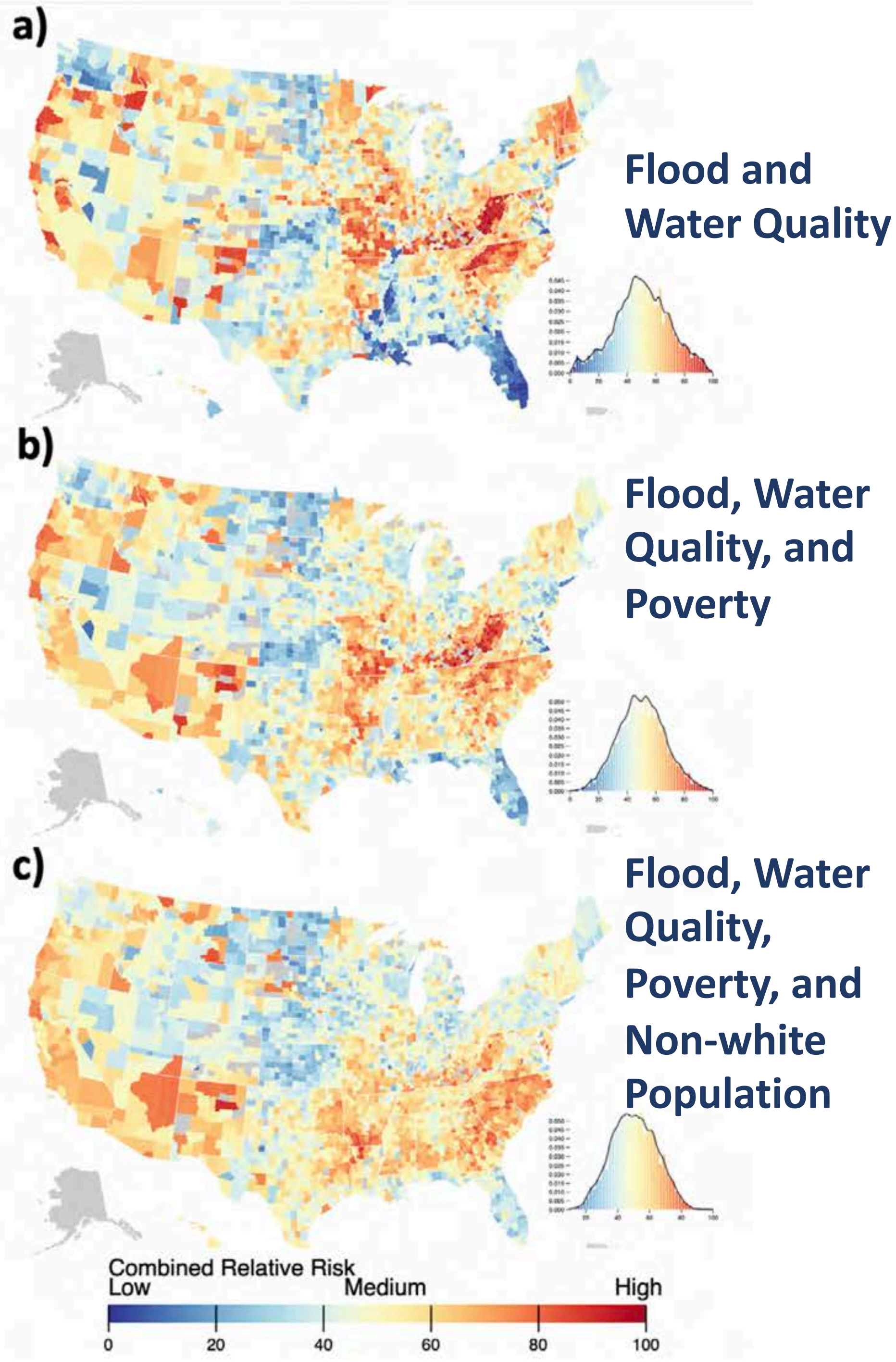


CGIAR

Foresight Initiative

- Risk of change in 2035 under weak mitigation (dark blue bars) is comparable to that in 2065 with aggressive mitigation (light blue bars).
- **An aggressive climate target gives time to prepare for (unavoidable) risks. For large sub regions of Africa – up to 30 additional years.**

Schlosser et al., 2021 (Climatic Change and 2023 (forthcoming)



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The intersection of physical stressors, socio-economic vulnerabilities, and inequities affect the "hotspot" landscapes of overall water "security".

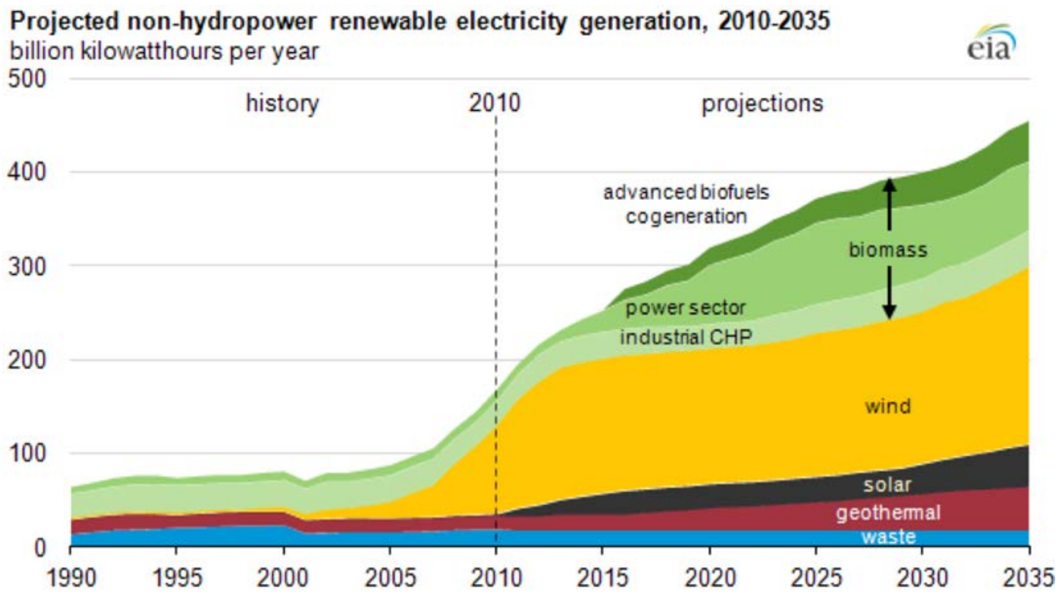
Table 4. Summary of results from the combinatory risk metrics considering: 1) flood and water quality; 2) flooding, water quality, and poverty; and 3) flooding, water quality, poverty, and nonwhite population. The table presents the top-five ranked states (listed highest to lowest in the column) with the combined risk based on the percentage of counties of the state that are in the top 10% among the nationally-pooled county values.

Rank	Flood and Water Quality		Flood Risk, Water Quality and Poverty		Food Risk, Water Quality, Poverty, and Non-white Population	
1	West Virginia	67%	West Virginia	60%	North Carolina	62%
2	Vermont	50%	Kentucky	54%	South Carolina	51%
3	New Hampshire	50%	North Carolina	48%	Arizona	40%
4	North Carolina	45%	Arkansas	35%	West Virginia	31%
5	Kentucky	40%	Arizona	33%	Kentucky and Georgia	30%

Many Signs point up for Bioenergy

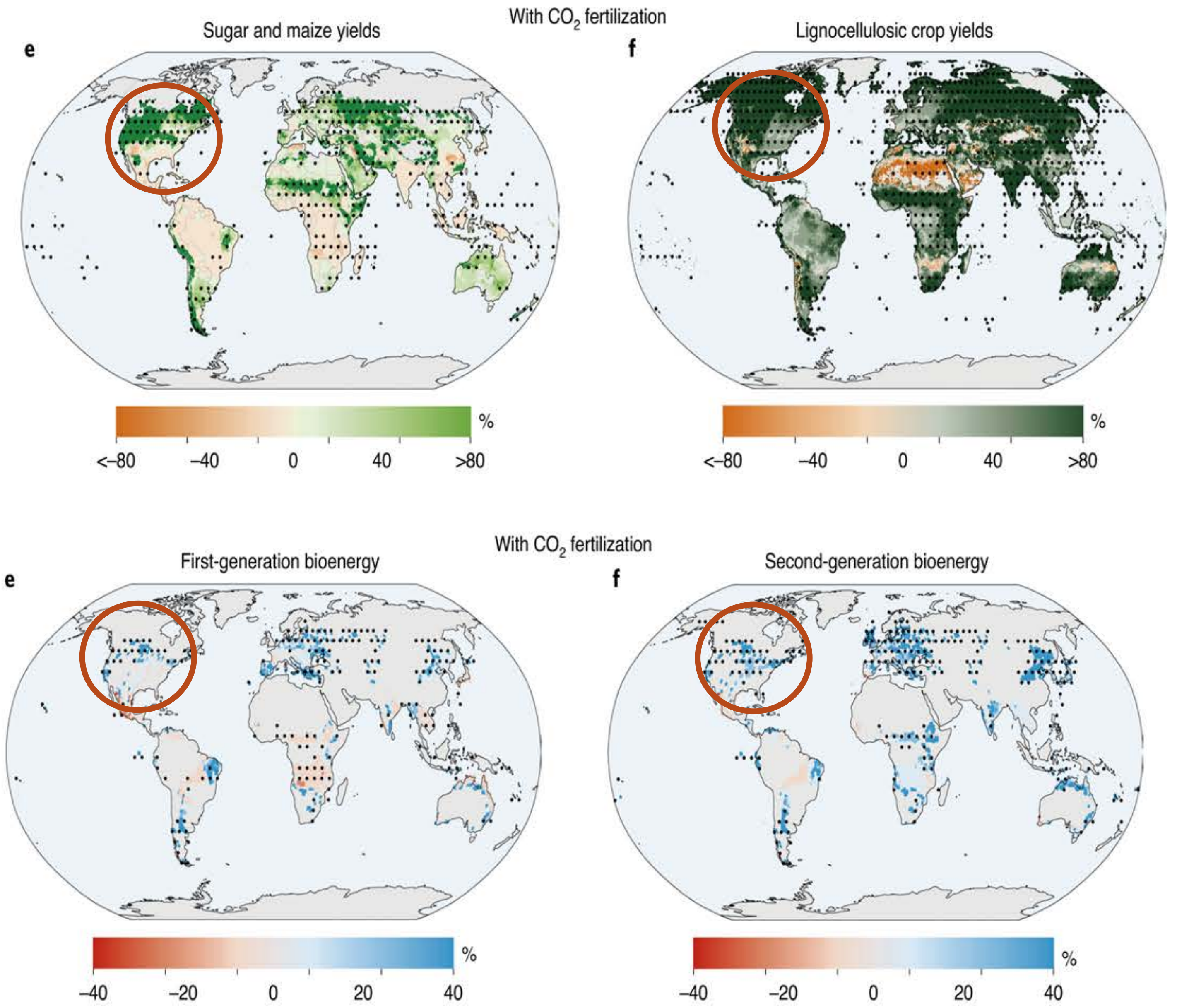
“…it would be possible to produce twenty-one times the current primary bioenergy supply and to even supply all global primary energy demand in 2050, mostly by energy crops… There would be a significant change in the composition of the bioenergy supply from today’s mostly firewood to energy crops... “

Erreraa et al. (2023, Biomass and Bioenergy)



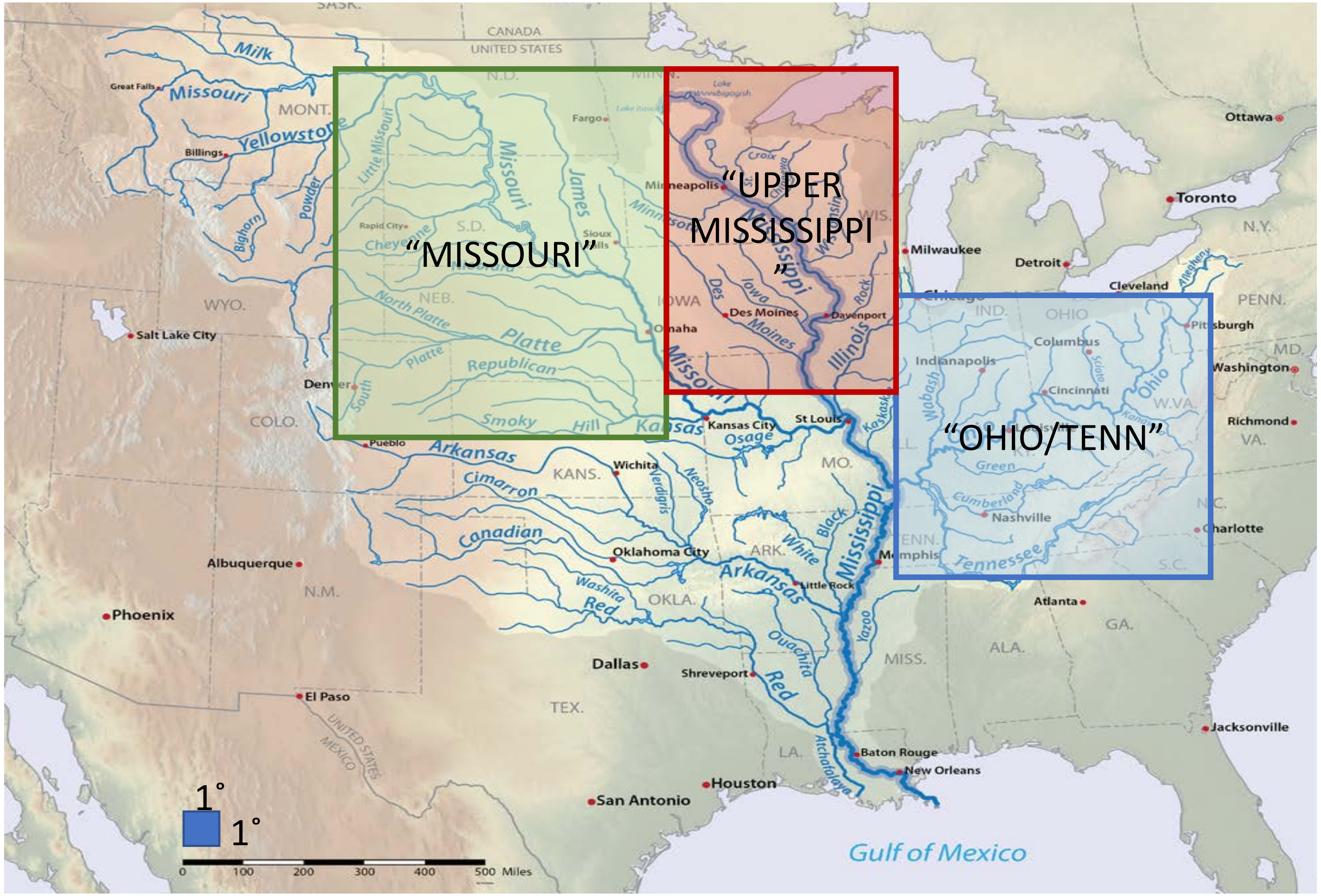
U.S. Energy Information Administration, Annual Energy Outlook

Relative Change in 2050



Gernaat et al., 2021 (Nature CC)

What are potential climate-related and land-management consequences on water quality from bioenergy expansion ?



<u>Considerations</u>

- Climate-related water quality issues evolve slowly across summer.
- Large sub-basin hydroclimatic changes expected (as seen from IPCC AR6/CMIP6 patterns across scenarios).
- Large potential for bioenergy

WATER QUALITY MODEL STRESS TESTING

Loading

- Nitrogen & Phosphorus loadings reduced to half of historic
- Nitrogen & Phosphorus loadings increased by half of historic

Climate

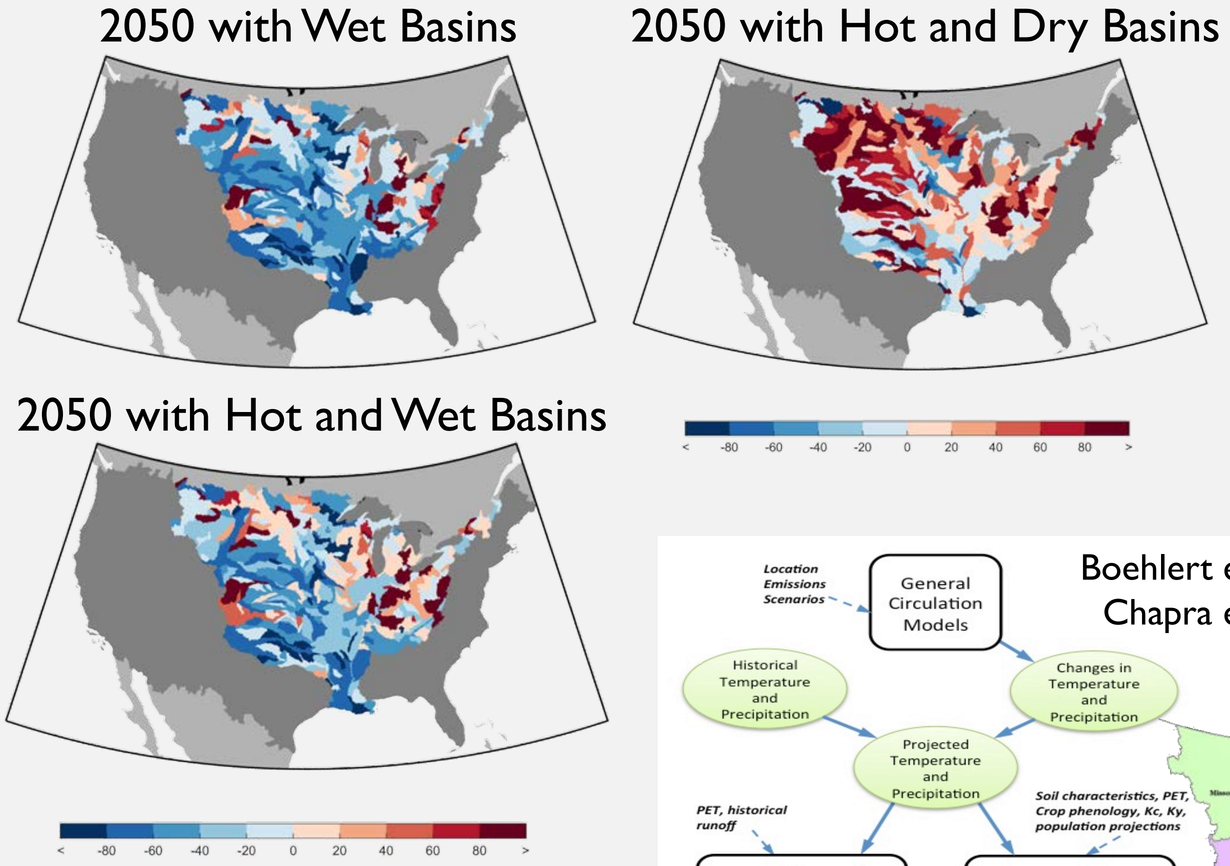
- Hot (+4C) and Warm (+2C)
- Wet (+50% flow) and dry (-50% flow)

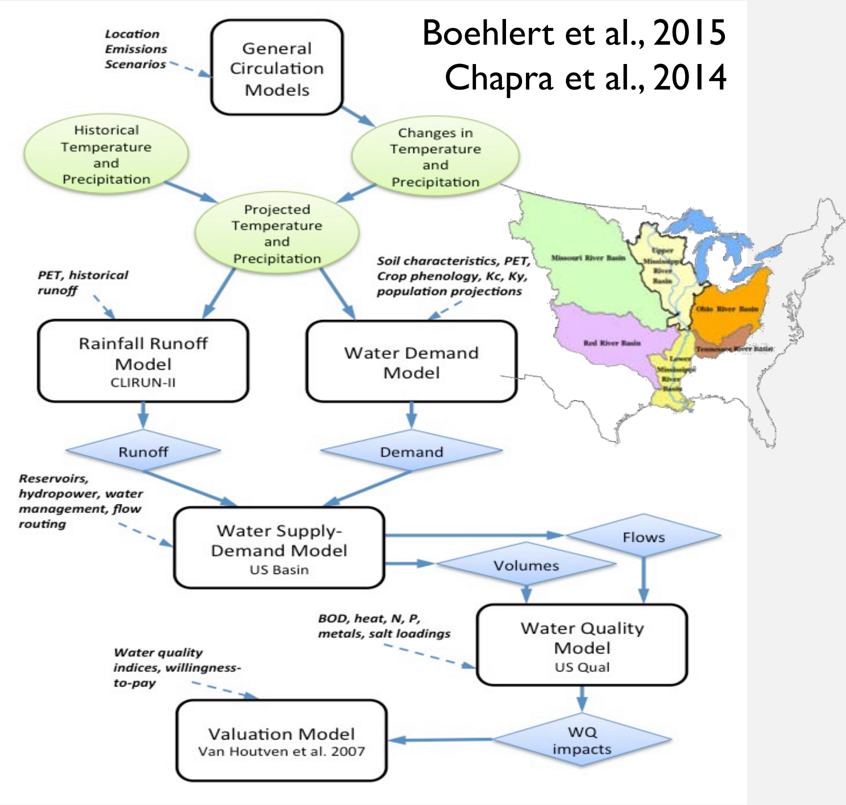
Two socioeconomic growth conditions

- 2050 and 2090
- Domestic and Industrial demands
- Population

Results relative to “Control” scenario w/ historical loading levels

Total Nitrogen Changes





- **Uniform stressors produce heterogenous and complex response cases across basins.**
  - **Cyanobacteria – resource competition**
  - **Phytoplankton (potamoplankton) response – productivity vs. mortality**
  - **Nitrogen – bacteria (de- and nitrifying), phytoplankton, organics, and oxygen**
  - **Phosphorus – hydrolysis, phytoplankton productivity/death/respiration and settling**


- Broadening the scope of “security” and “conflict” – necessary yet nebulous
- Metrics, metrics, metrics – flexible, combinatory methods and diagnostics
- Security and conflict – sector specific and granular
- Complexity abounds – not an exercise in deterministic response.
- Emerging climate-related risks can be delayed.
- Solutions to water ”security” and avoiding “conflicts” – a case of minimized consequences?

Thank you!