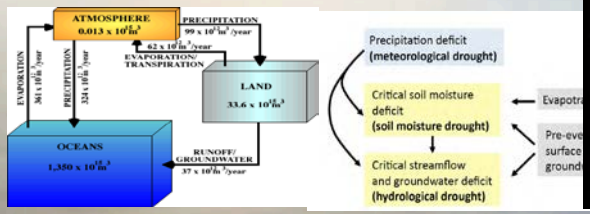
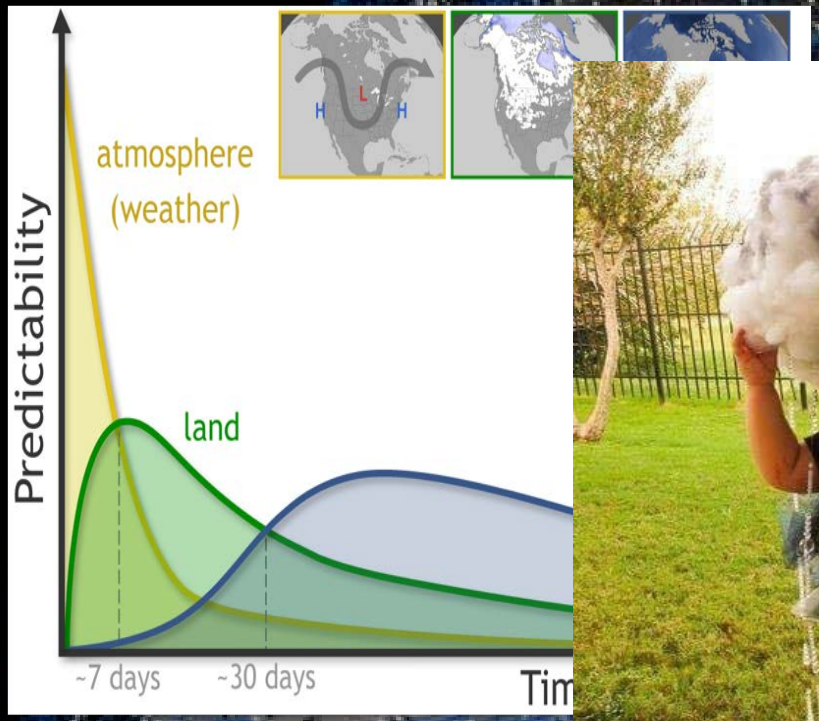
Modernizing the view of drought: from risk to resilience

Roger S. Pulwarty
Senior Scientist
National Oceanic and Atmospheric Administration

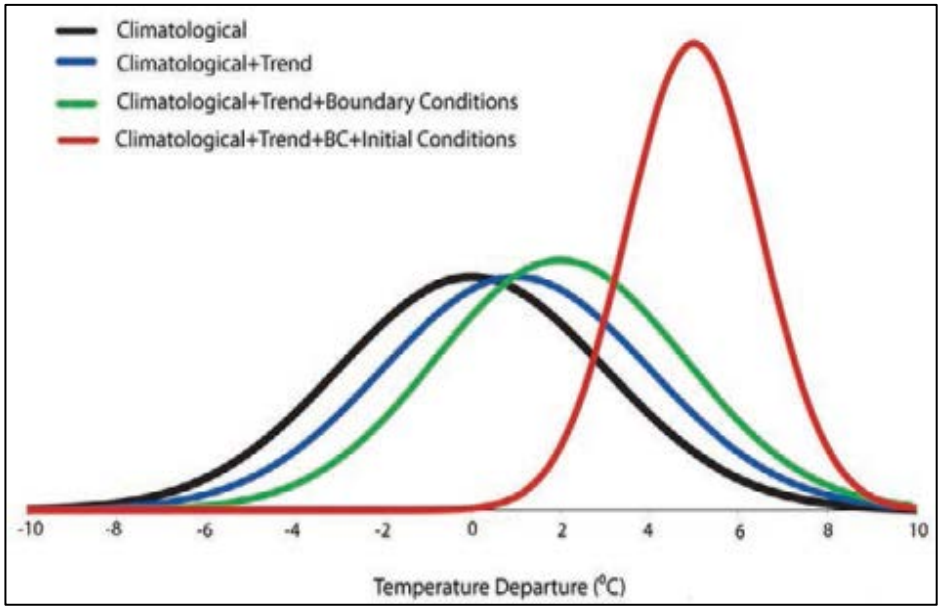



Predictability
atmosphere
(weather)
land
~7 days
~30 days
Tim


Costume-Works.com

Typical El Niño Winters
Drier
Colder
Wetter
Warmer

The Making of an Extreme Event: Putting the Pieces Together (Dole et al 2014)



Climatological

Climatological + Trend

Climatological + Trend + Boundary conditions

Climatological + Trend + Boundary +Initial conditions

Pathways to Drought Monitoring and Predictability

Key Phenomena, variables

Ocean Temp anomalies

Global-Scale Atmospheric Changes

Regional Forcing and land feedbacks

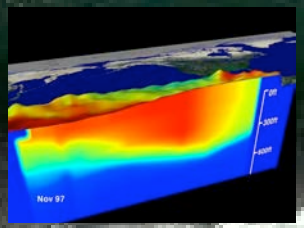
Local Impacts, Info needs

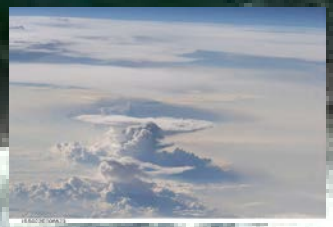
ENSO, PDO, AMO, warm pool variability, climate change,

planetary waves, hydrological cycle, monsoons, Hadley Cell, Walker Circulation

precipitation, soil moisture, snow, low level jets, dust, vegetation, land/atmosphere contrasts, changes in weather

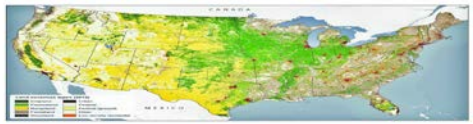
soil moisture, stream flow, precipitation, ground water, lakes, reservoirs

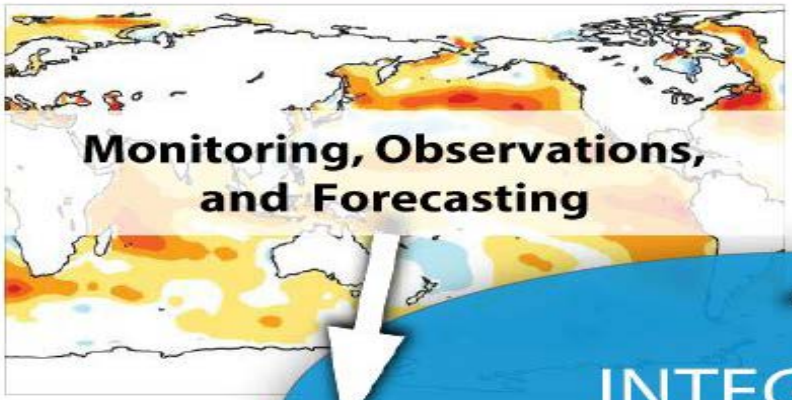


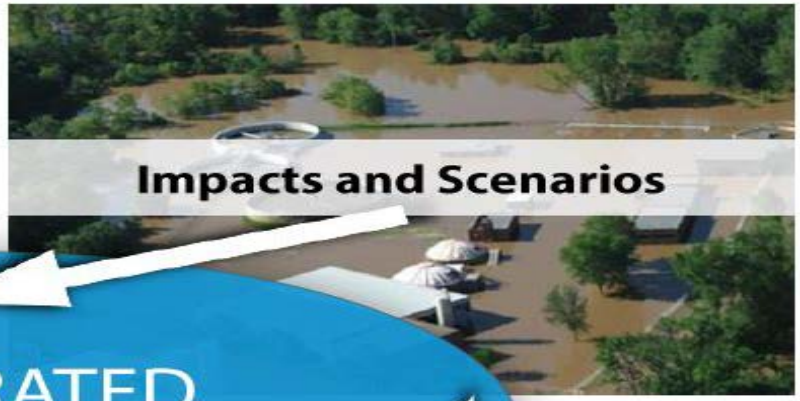


National Integrated Drought Information System

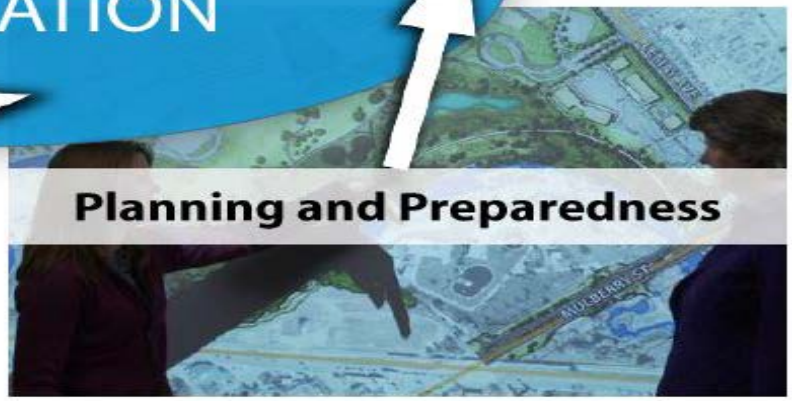


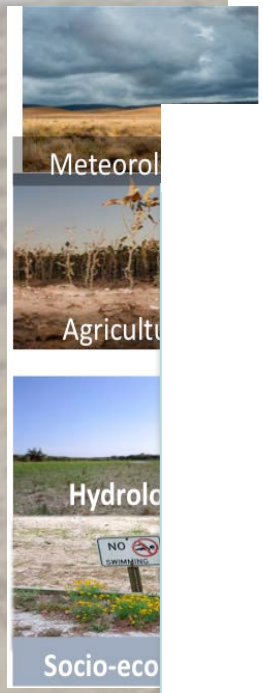







INTEGRATED INFORMATION





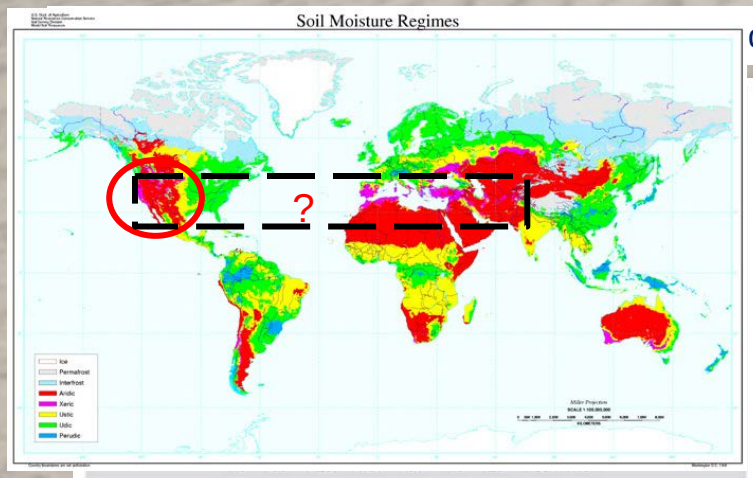
NIDIS Drought Early Warning Systems

Regional

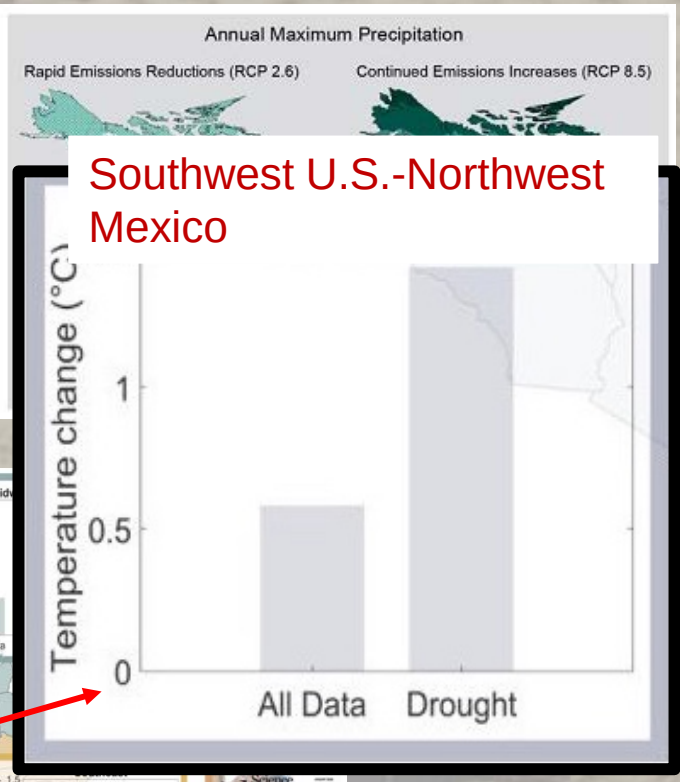
Research and Stakeholder Collaborative network:
Colorado Basin Early Warning Information System example

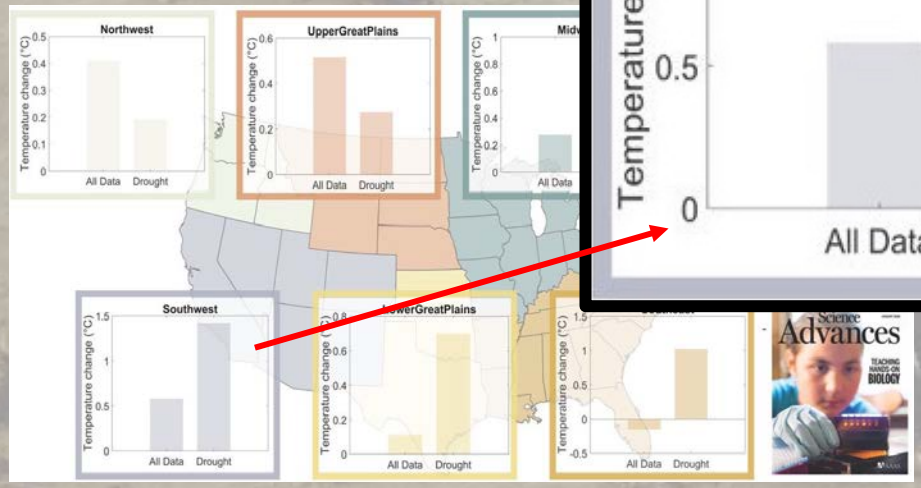
- Colorado Division of Water Resources (CDWR)
- Colorado State Climatologist
- Colorado River Water Conservation District (CRWCD)
- Colorado Water Conservation Board (CWCB)
- CU – Western Water Assessment, CIRES, and CADSWES
- Denver Water Board
- Northern Colorado Water Conservancy District (NCWCD)
- Wyoming State Engineer
- Wyoming State Climatologist
- Utah State Climatologist
- Western Regional Climate Center
- Mexico CNA
- National Center for Atmospheric Research (NCAR)
- National Drought Mitigation Center (NDMC)
- USDA: Natural Resources Conservation Service
- USFS: Region 2
- USBR: Eastern Colorado Area Office, Great Plains Region, Office of Policy and Programs, Research and Development
- USGS: Colorado Water Science Center, Central Region, Grand Canyon Monitoring and Research Center
- NOAA: Earth System Research Laboratory, National Centers for Environmental Prediction, National Climatic Data Center, National Weather Service

Netw g, risk
asse
Drou



during drought (1965-2014 minus 1902-1951)





(NC4 2018, Aghakouchak et al 2018)

(NC4 2018, Aghakouchak et al 2018)

NCEI, 2020)

From Jan**1980**-Jun**2020**, the U.S. has experienced 273 distinct billion-dollar weather & climate events - each causing at least $1 billion in direct losses

- **Total, direct losses** from these **273 events** exceeds **$1.79 trillion** (CPI-adjusted, 2020)

DISASTER TYPE	EVENTS	PERCENT FREQUENCY	TOTAL COSTS	PERCENT OF TOTAL COSTS	COST/EVENT	DEATHS
Drought	27	9.9%	$252.7B CI	14.1%	$9.4B	3,865†
Flooding	33	12.1%	$150.4B CI	8.4%	$4.6B	617
Freeze	9	3.3%	$30.6B CI	1.7%	$3.4B	162
Severe Storm						
Tropical Cyclone						
Wildfire						
Winter Storm						
All Disasters						

nature climate change

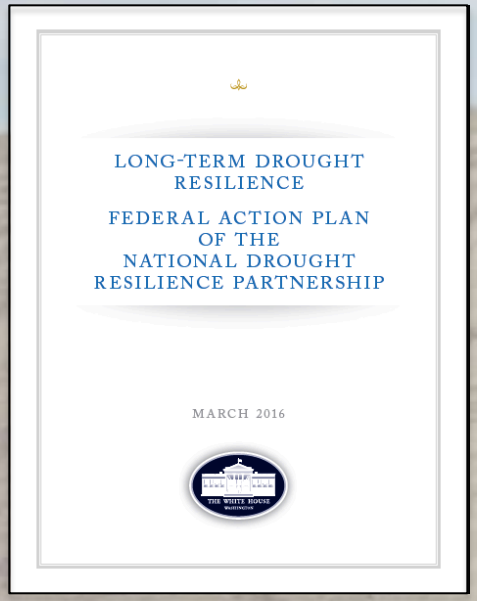
PERSPECTIVE

https://doi.org/10.1038/s41558-020-0709-0

Check for updates

Flash droughts present a new challenge for subseasonal-to-seasonal prediction

Angeline G. Pendergrass[1]✉, Gerald A. Meehl[1], Roger Pulwarty[2], Mike Hobbins[2,3], Andrew Hoell[2], Amir AghaKouchak[4], Céline J. W. Bonfils[5], Ailie J. E. Gallant[6,7], Martin Hoerling[2], David Hoffmann[6,7], Laurna Kaatz[8], Flavio Lehner[1], Dagmar Llewellyn[9], Philip Mote[10], Richard B. Neale[1], Jonathan T. Overpeck[11], Amanda Sheffield[12], Kerstin Stahl[13], Mark Svoboda[14], Matthew C. Wheeler[15], Andrew W. Wood[1] and Connie A. Woodhouse[16]

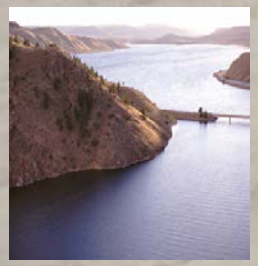


National Drought-Resilience Partnership Goals

Goal 1: Data Collection and Integration –key data platforms, modeling and prediction

Goal 2: Communicating Drought Risk on Critical Infrastructure

Goal 3: Drought Planning and Capacity Building



Goal 4: Coordination of Federal Drought Activity

Goal 5: Market-Based Approaches for Infrastructure and Efficiency

Goal 6: Innovative Water Use, Efficiency, and Technology

CRITICAL INFRASTRUCTURE SECTOR IMPACTS DUE TO DROUGHT HAZARD

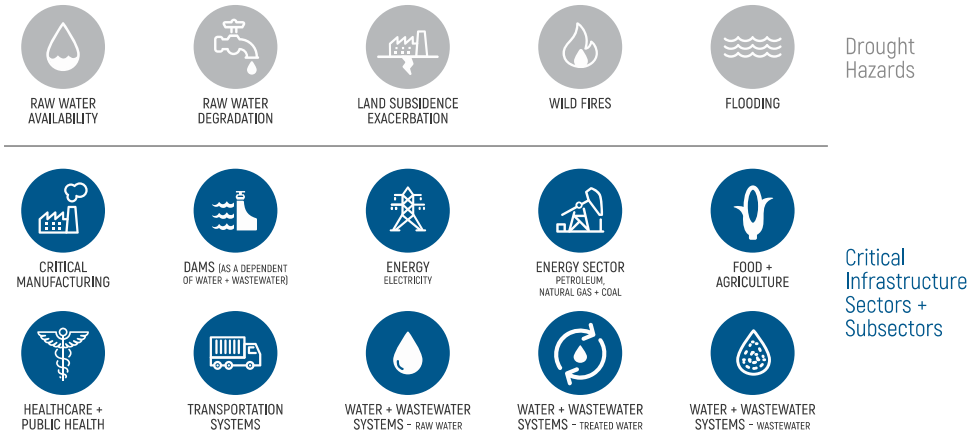
National Protection and Programs Directorate Infrastructure Development and Recovery (IDR) | February 2018

Homeland Security

SCOPE

Critical Infrastructure Sector Impacts Due to Drought Hazard

Existing resources from NIDIS, EPA, USDA, DOI, DHS, FEMA, HHS-CDC, and other sources were compiled to create a risk analysis of drought hazard impacts to critical infrastructure sectors. The analysis reflects summaries of identified vulnerabilities of critical infrastructure sectors to direct exposure of drought hazards, operational impacts to each sector that contributes to slow down or stoppage of essential goods and services to meet demand needs, and indirect/cumulative impacts of dependent sectors and communities when supply needs cannot be met. Ten critical infrastructure sectors and subsectors were investigated in the context of five drought hazards.



KEY FINDINGS

Direct Impacts to Critical Infrastructure from Drought Hazards

DROUGHT HAZARDS, DIRECT IMPACTS

SERVICE PROVIDER CRITICAL INFRASTRUCTURE SECTOR	Raw Water Availability	Raw Water Quality Degradation	Dust Storms	Flooding	Land Subsidence Exacerbation	Wild Fires
Critical Manufacturing	●	●		●*	●*	●
Dams						
Energy - Electricity	●	●	●	●		●
Energy - Petroleum, Natural Gas + Coal	●	●		●		●
Food + Agriculture	●	●		●	●*	●
Healthcare + Public Health		●		●*		●
Transportation Systems	●	●		●	●	●
Water + Wastewater Systems - Raw Water		●	●	●	●	●
Water + Wastewater Systems - Treated Water	●	●	●	●	●	●
Water + Wastewater Systems - Wastewater		●	●	●	●	●

Critical Infrastructure Dependencies + Interdependences

SERVICE RECEIVER (DEPENDENT) CRITICAL INFRASTRUCTURE SECTOR

SERVICE PROVIDER CRITICAL INFRASTRUCTURE SECTOR	Crit. Manf.	Dams	Energy – Elect.	Energy - Petro, NG, Coal	Food + Ag.	HC + Public Health	Trans	RW	TW	WW
Critical Manufacturing	●	●*	●	●	●		●	●	●	●
Dams	●*	-	●	●	●		●	●	●	●
Energy - Electricity	●	●	-	●	●	●	●	●	●	●
Energy - Petroleum, Natural Gas + Coal	●	●	●	-	●	●	●	●	●	●
Food + Agriculture	●	●*		●	-	●	●	●	●	●
Healthcare + Public Health	●	●	●	●	●	-	●	●	●	●
Transportation Systems	●	●	●	●		●	●	●	●	●
Water + Wastewater Systems - Raw Water	●	●	●	●	●		●	-	●	●*
Water + Wastewater Systems - Treated Water	●		●	●		●	●		-	
Water + Wastewater Systems - Wastewater	●	●	●	●	●	●	●	●		-

* *Dependency understood but not identified specifically by reference*

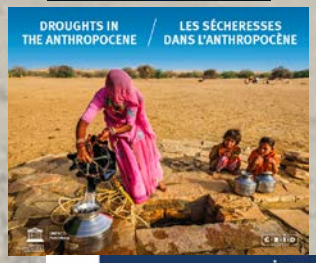
This example is generally based on products provided by the Office of Cyber and Infrastructure Analysis, NPPD, list document.

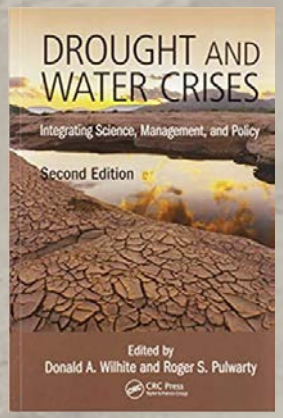
UNDRR GAR 2021 Special Report on Drought

Section I. Modernizing our understanding of drought

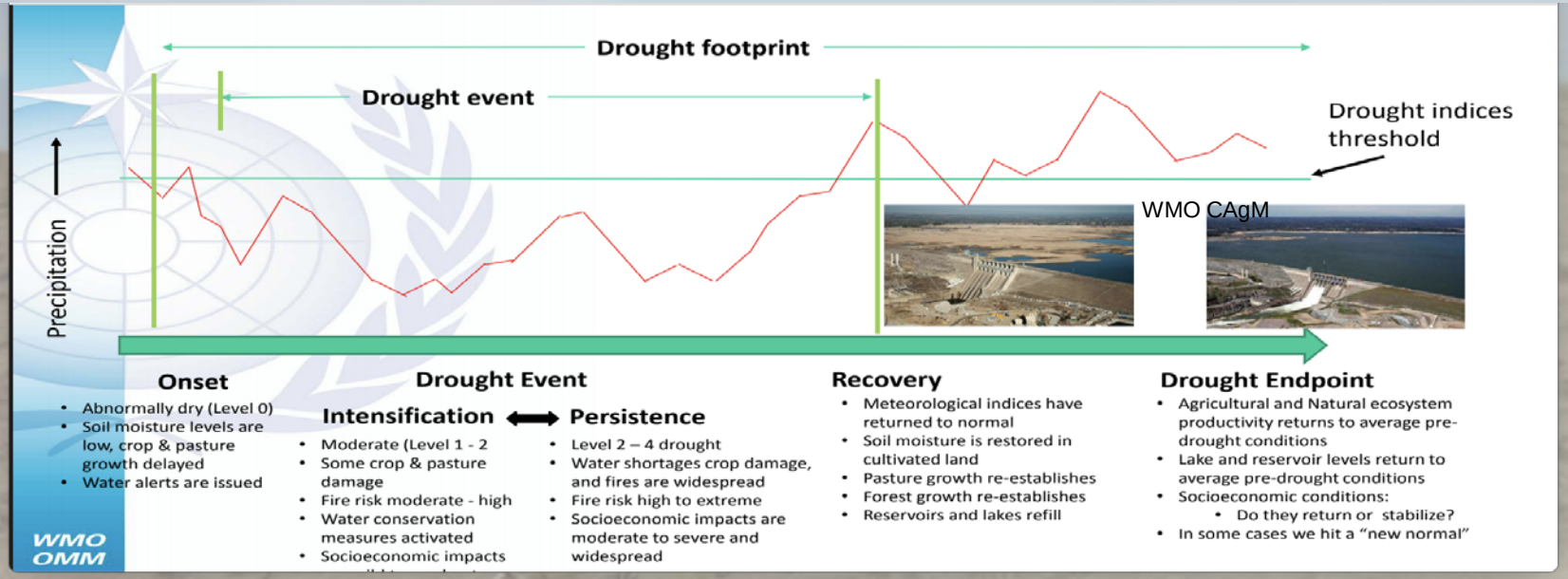
Section II. Cases: The economic, social, cultural, environmental aspects of drought assessment, response, mitigation

SECTION III Drought: From Risk to Resilience

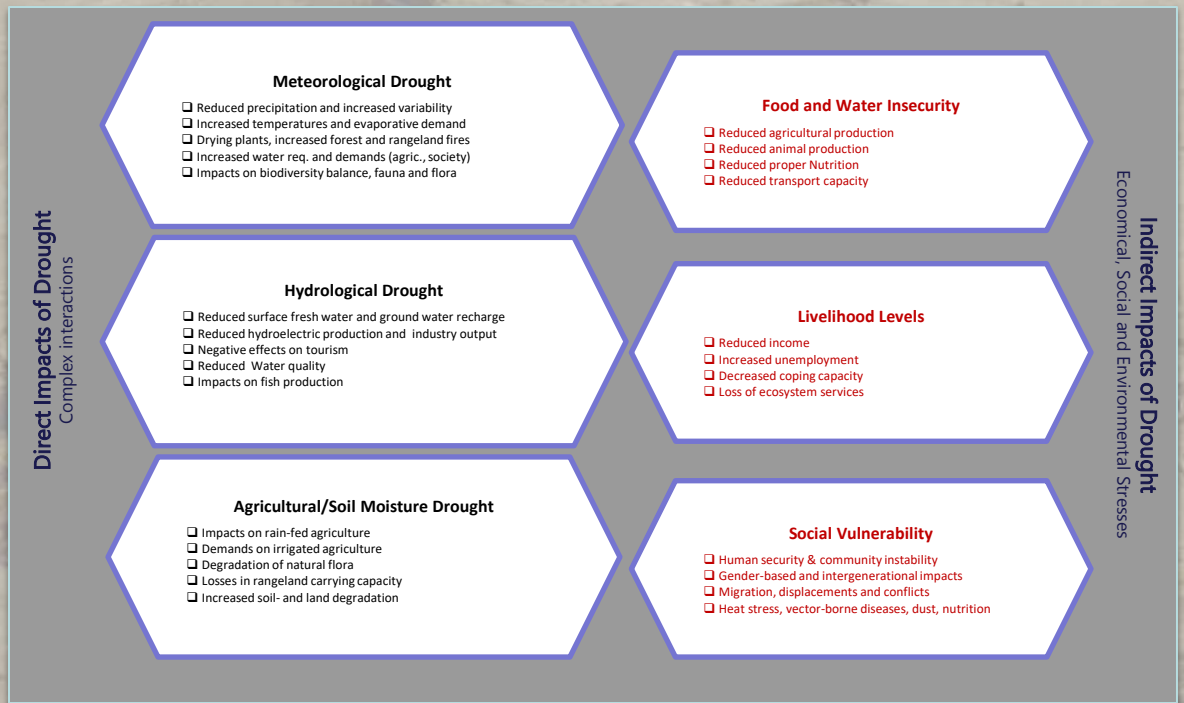




March 2021



Section I: Complexity of drought staging and drought impacts



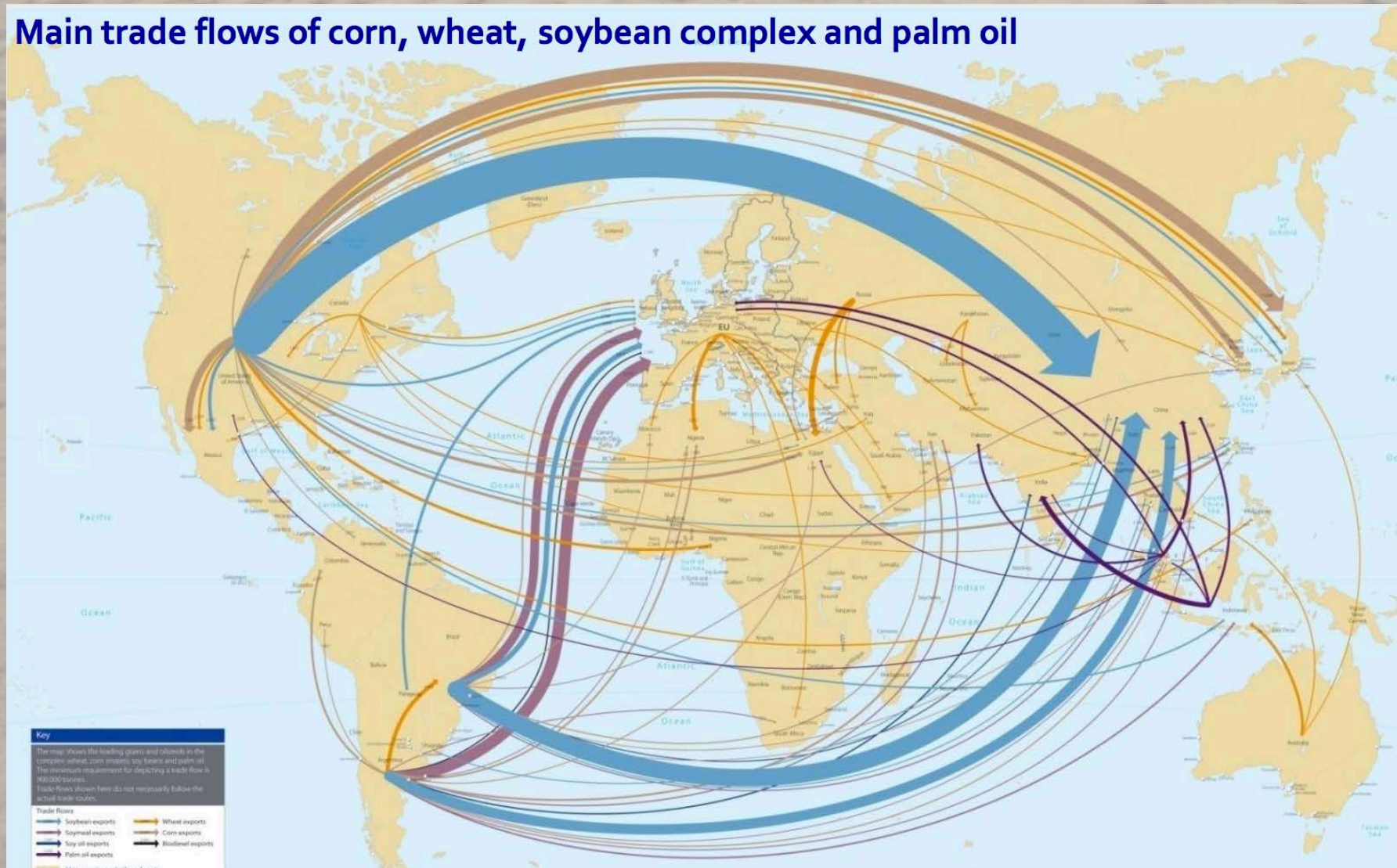
Section II
Across cases…….

Highlighting six areas of concern and opportunity:

1. Risk assessment (sectoral and multi-hazard)
2. Uncertainties associated with a c
   and local levels)
3. The increasingly complex pathwa
   Water-Energy-Food nexus

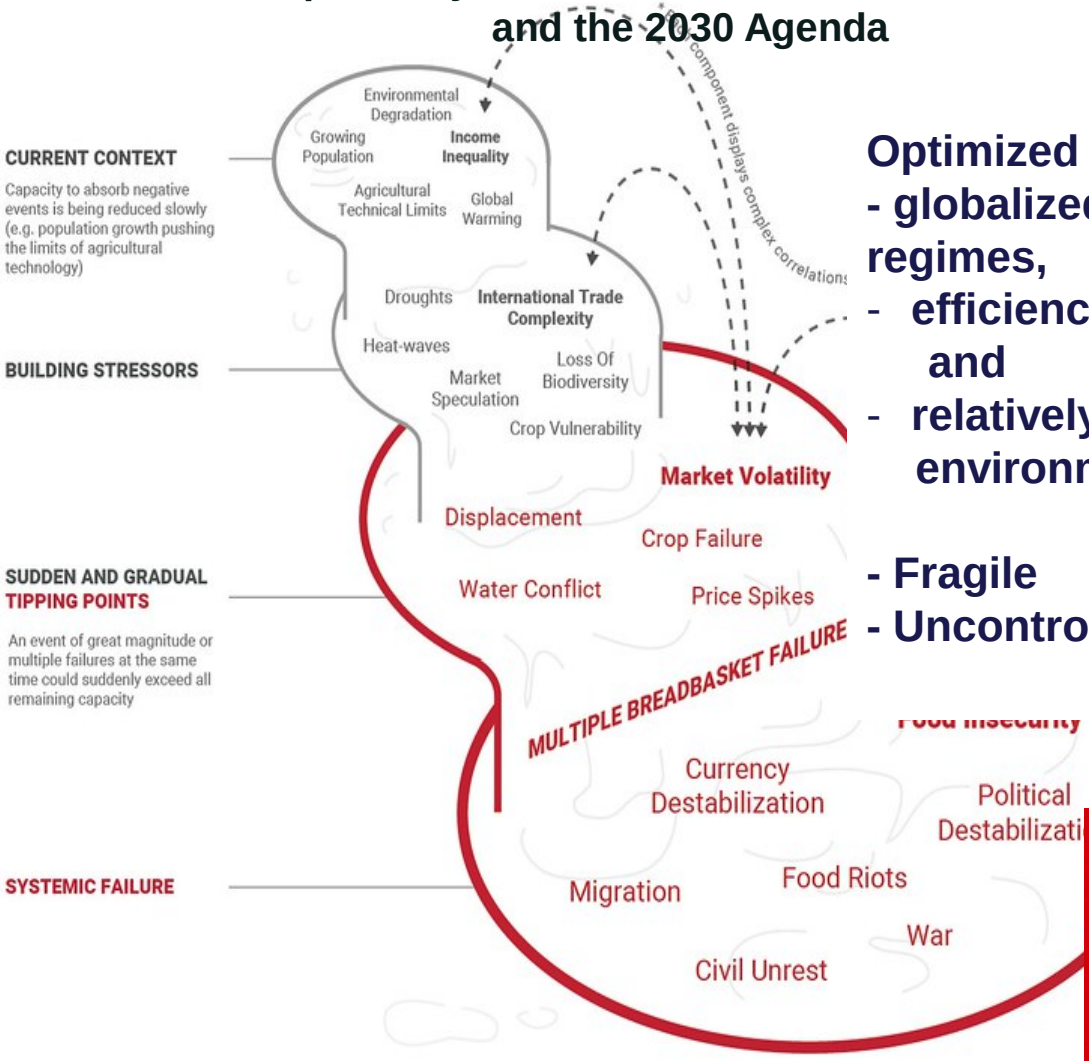
4. Benefits of action and costs of inaction
5. Transboundary coordination on drought: shared visions, shared implementation
6. The role of technology, efficiency and policy
7. Links to human security and conflict

Globally networked risks:
e.g. modern food systems highly dynamic, complex, formal and informal –
fundamentally important to food security



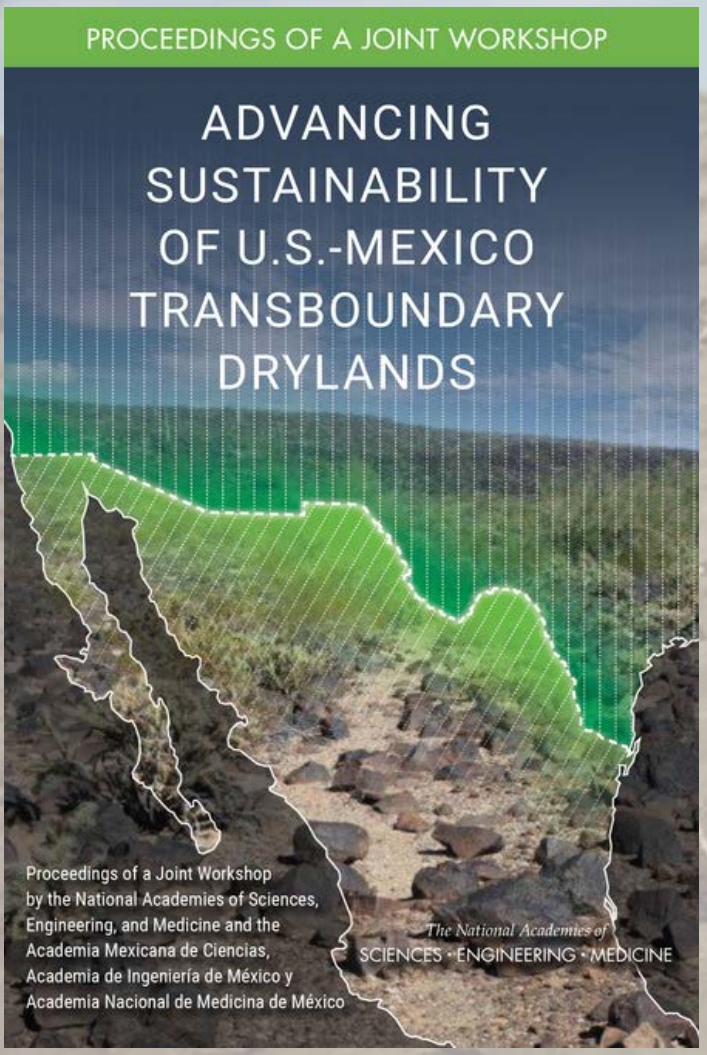
Globally networked risks (example)
e.g. modern food systems are highly dynamic, complex, formal and informal – fundamentally important to food security

Chapter 2 Systemic risks, the Sendai Framework and the 2030 Agenda



Optimized for
- globalized trade regimes,
- **efficiency, peace time and**
- **relatively stable environment**

- Fragile
- Uncontrollable



Sustainability Partnerships in the U.S. – Mexico Drylands Region US and Mexico Academy of Sciences 2020

Integration mechanisms

Characterized by scope (single issue, multilateral, or comprehensive) and then by the level authority and formality within each category

Single issue Informal networks: Policy networks that emerge from local interactions for joint ventures, service contracts to address externalities, dry-year options

Multilateral: Multipurpose districts with a consolidated set of public services within geographic territory for example drought response by watershed or regional organizations

Comprehensive: Regional integration through embedded norms created by overlapping ventures, agreements and contracts and coordination across multiple policy domains governed by statutory framework e.g. water quality planning by a joint river basin authority

Section III. From risk to resilience

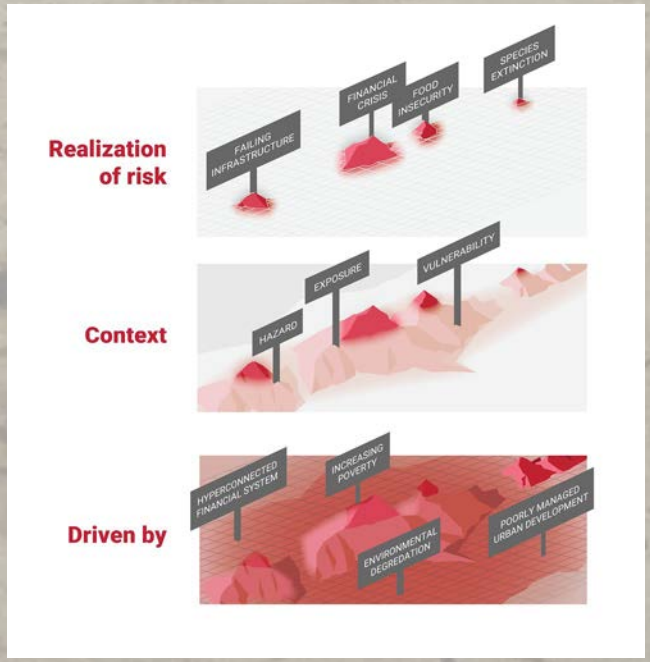
An agenda to strengthen a collaborative framework between research and management that:

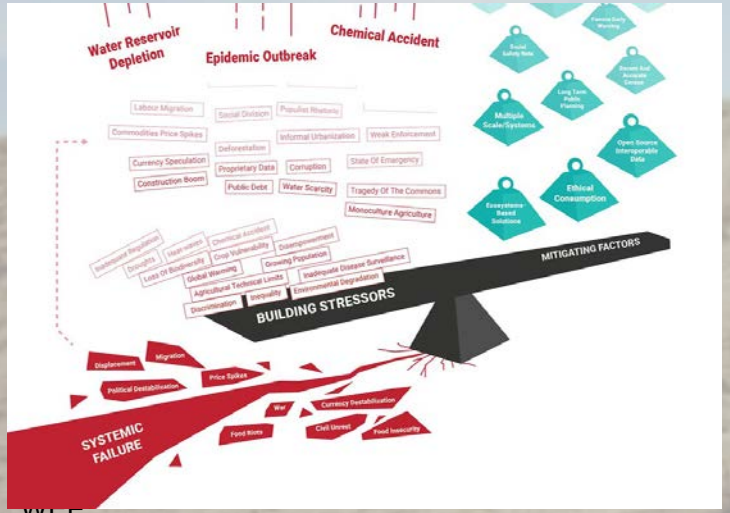
Creating a compelling narrative/vision for a better future:

- Maximises the value of existing assets for drought-related security and resilience
- investments in resilience within communities and countries

Section III From risk to resilience

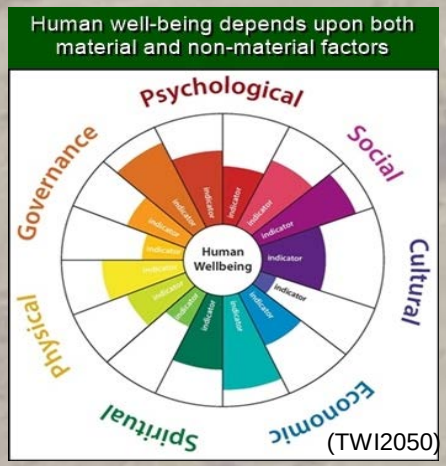
1. **Characterizing systemic risks**
2. **Systemic risk stability domains, disruptions and opportunities/entry points (food security, health, drought to desertification, transboundary watersheds)**
3. **Being proactive:** Knowing better (research products, technology barriers/opportunities)
4. **Governance and financing : Networks, capabilities and implementation in a changing environment**





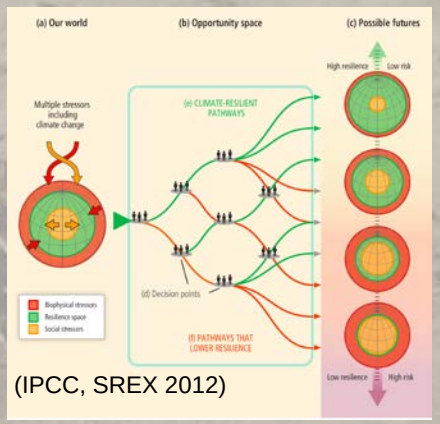
WEF

Governance, Coherence and Pathways to 2030



(TWI2050)

Risks AND Capabilities Pathways



(IPCC, SREX 2012)

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