Water security

January 2017
Roger Bales

Topics for class

1. Definitions of water security
2. Water security assessment in a global context
3. Elements of California water security

Goals

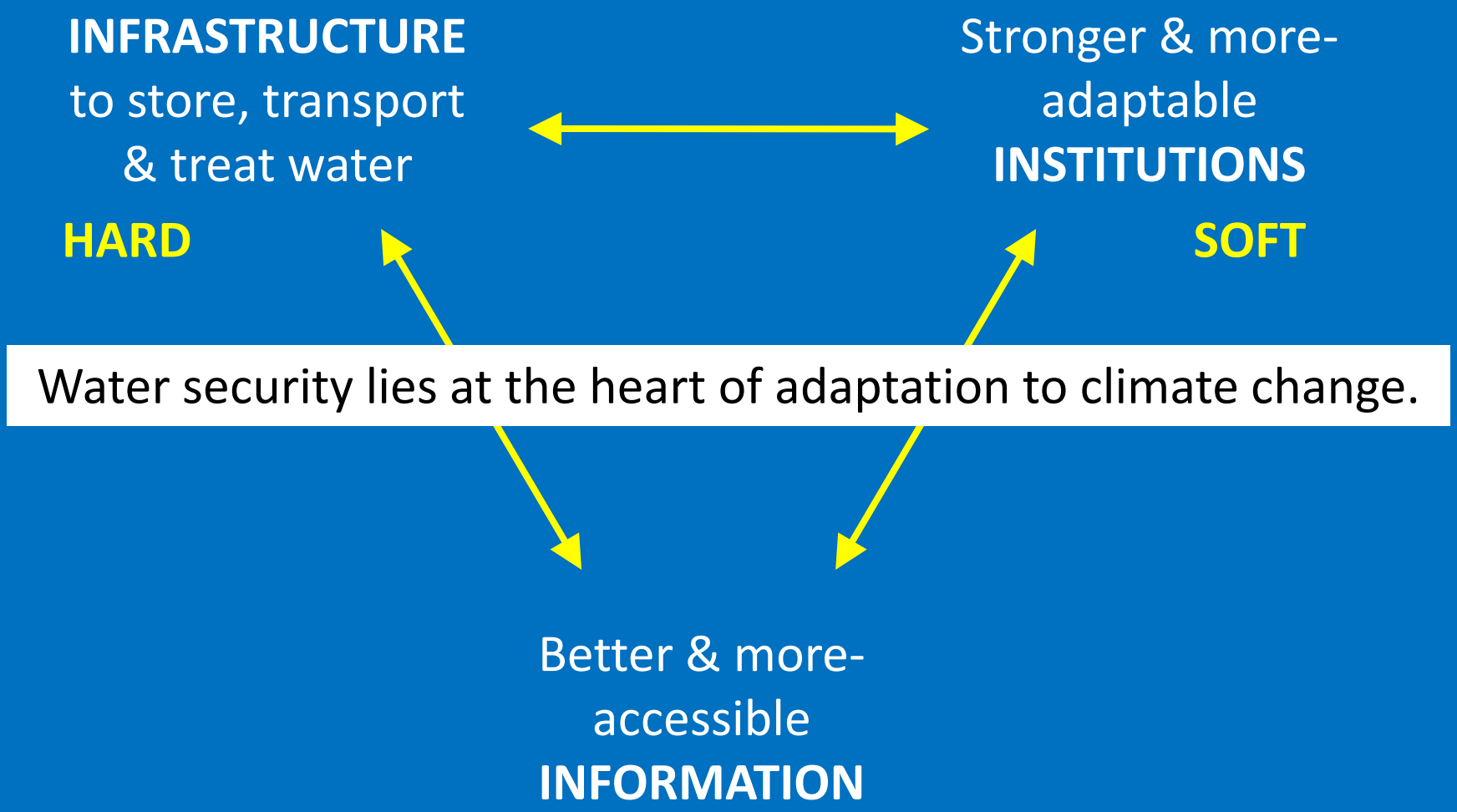
1. Develop an understanding of what elements define a region's water security
2. Place water security in a societal context
3. Begin to assess California's water security, in a historical context

Questions

1. Your definition of water security, globally & for California?
2. For California, major areas for conflict? Compromise?
3. Fundamental barriers to water security, social, political, science, engineering?

Note: In-class activities & discussion notes accompany these slides

Making a water-secure world – the three I's



Water security: the reliable availability of an acceptable quantity & quality of water for health, livelihoods & production, coupled w/ an acceptable level of water-related risks

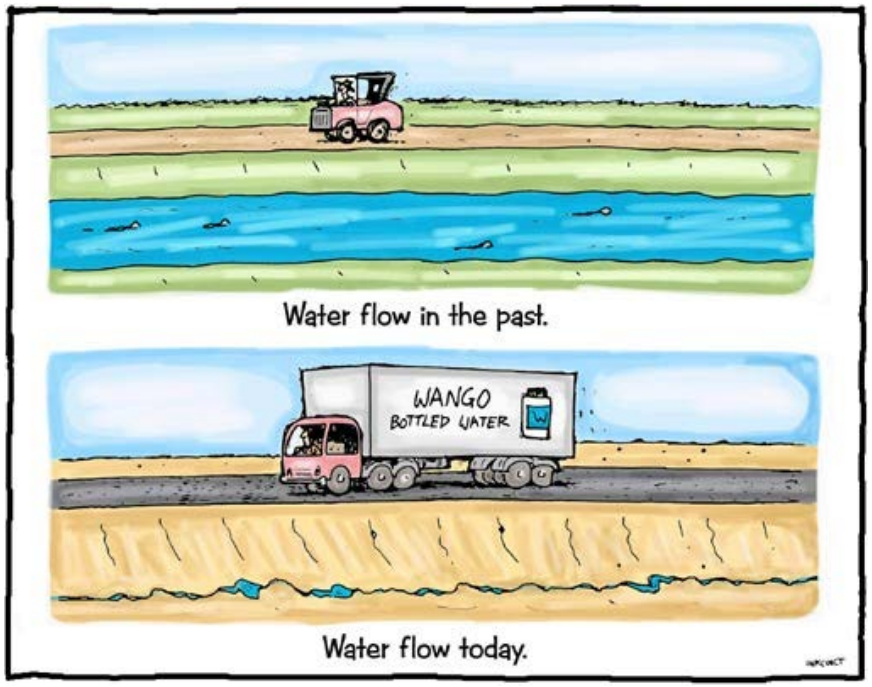
Defining water security

Water security: the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, & socio-economic development, for ensuring protection against water-borne pollution & water-related disasters, and for preserving ecosystems in a climate of peace & political stability.

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

http://www.inkcinct.com.au/

Future water security?



Water flow in the past.

Water flow today.

Defining water security

Water security

the capacity of a population to safeguard sustainable access

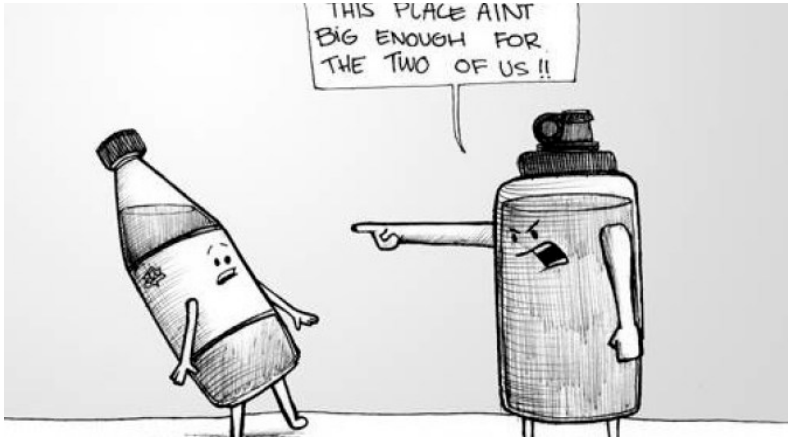
to adequate quantities of acceptable quality water

for sustaining livelihoods, human well-being, & socio-economic development

for ensuring protection against water-borne pollution & water-related disasters

for preserving ecosystems

in a climate of peace & political stability.



Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

Defining water security

Water security encapsulates complex and interconnected challenges

& highlights water's centrality for achieving a larger sense of security, sustainability, development & human well-being.

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

Defining water security

Many factors contribute to water security – many of which lie outside the water realm. → ranging from biophysical to infrastructural, institutional, political, social & financial

In this respect, water security lies at the centre of many security areas → each of which is intricately linked to water.

Addressing this goal therefore requires collaboration across sectors, communities & political borders, → so that the competition or potential conflicts over water resources, between sectors & between water users or states, is adequately managed.

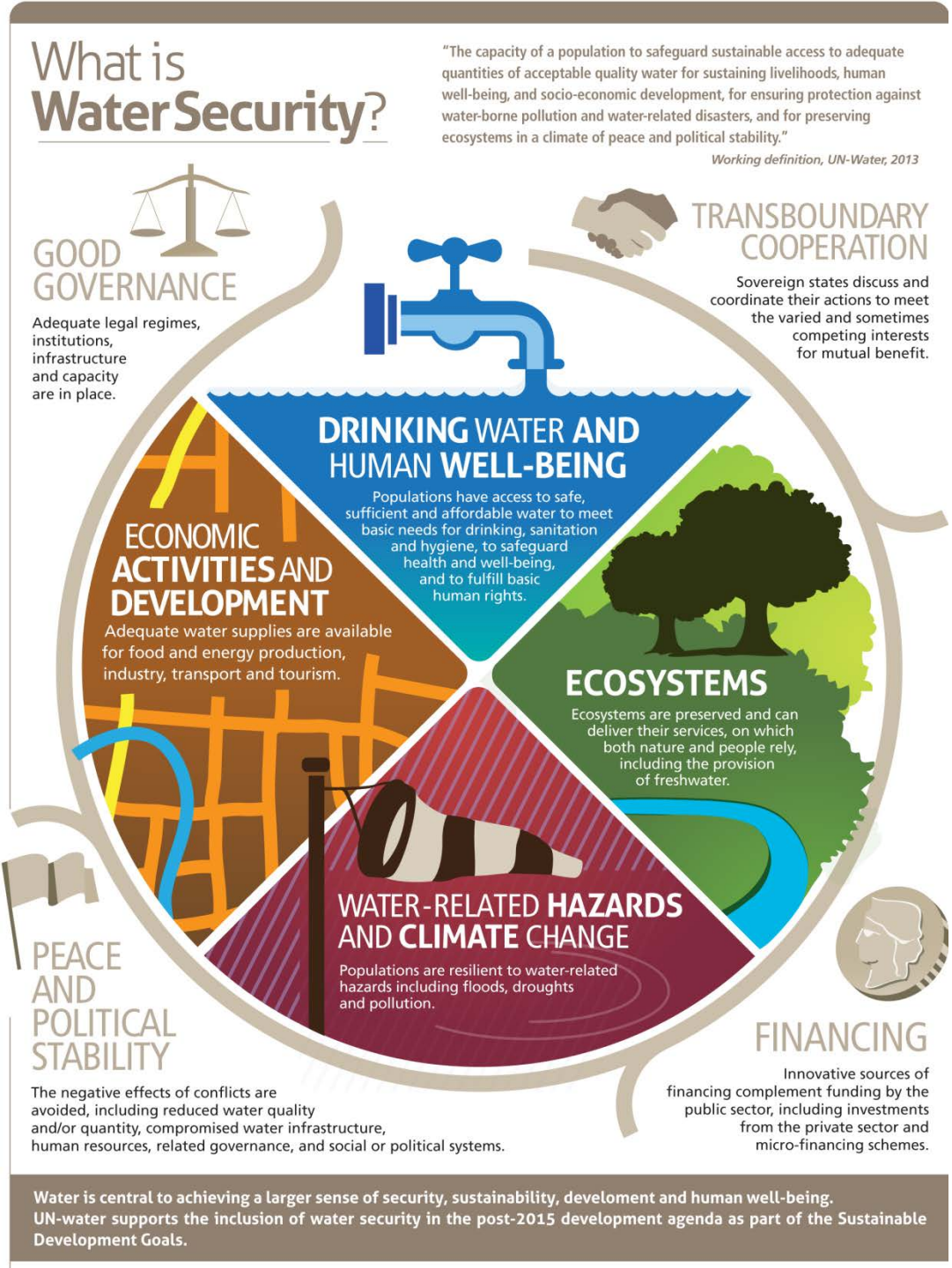
In recognition of its security implications on tensions & conflicts, → UN-Water supports the inclusion of water security on the agenda of the UN Security Council.

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

Key Aspects of Water Security, as found in a broad range of published definitions

- Access to safe and sufficient drinking water at an affordable cost in order to meet basic needs, which includes sanitation and hygiene, and the safeguarding of health and well-being;
- Protection of livelihoods, human rights, and cultural and recreational values;
- Preservation and protection of ecosystems in water allocation and management systems in order to maintain their ability to deliver and sustain the functioning of essential ecosystem services;
- Water supplies for socio-economic development and activities (such as energy, transport, industry, tourism);
- Collection and treatment of used water to protect human life and the environment from pollution;
- Collaborative approaches to transboundary water resources management within and between countries to promote freshwater sustainability and cooperation;
- The ability to cope with uncertainties and risks of water-related hazards, such as floods, droughts and pollution, among others; and,
- Good governance and accountability, and the due consideration of the interests of all stakeholders through: appropriate and effective legal regimes; transparent, participatory and accountable institutions; properly planned, operated and maintained infrastructure; and capacity development.

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013



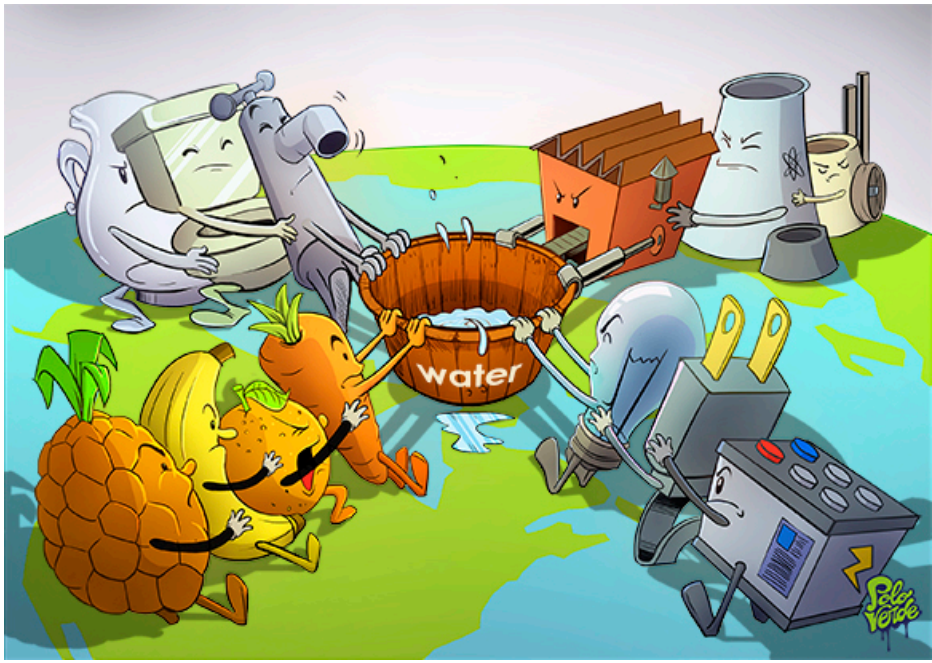
How will climate warming, population growth & land-use change stress the 4 components of water security?

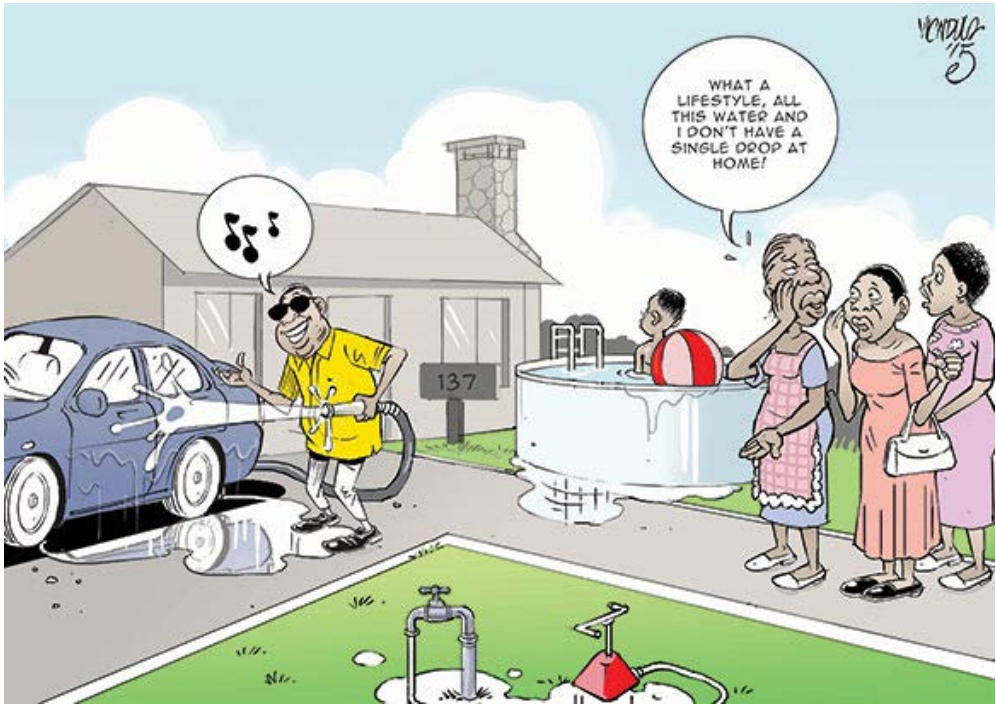
How can the 4 determinants of water security respond as climate warms to maintain or enhance water security in California? In a semi-arid developing area of Africa?

IC-1

Achieving water security requires collaboration across sectors, communities, disciplines and political borders, to reduce the risk of potential conflicts over water resources, between sectors and between water users or states.

Defining water security

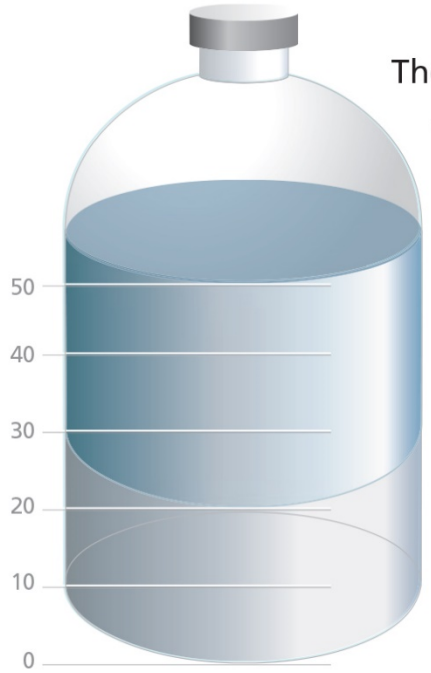




Global policy relevance of water security

Example: water security and human rights

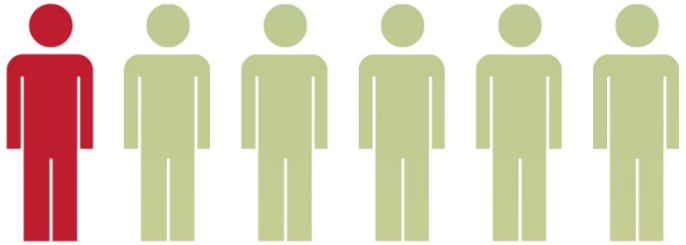
Water requirements for our basic needs



The UN suggests that each person needs **20-50 litres** of water a day to ensure their basic needs for drinking, cooking & cleaning

Source: World Water Assessment Programme (WWAP)

Access to improved drinking water



One in 6 people worldwide - 783 million - don't have access to improved drinking water sources.

Source: World Health Organization (WHO) and United Nations Children Fund (UNICEF) Joint Monitoring Programme on Water Supply and Sanitation (JMP)

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

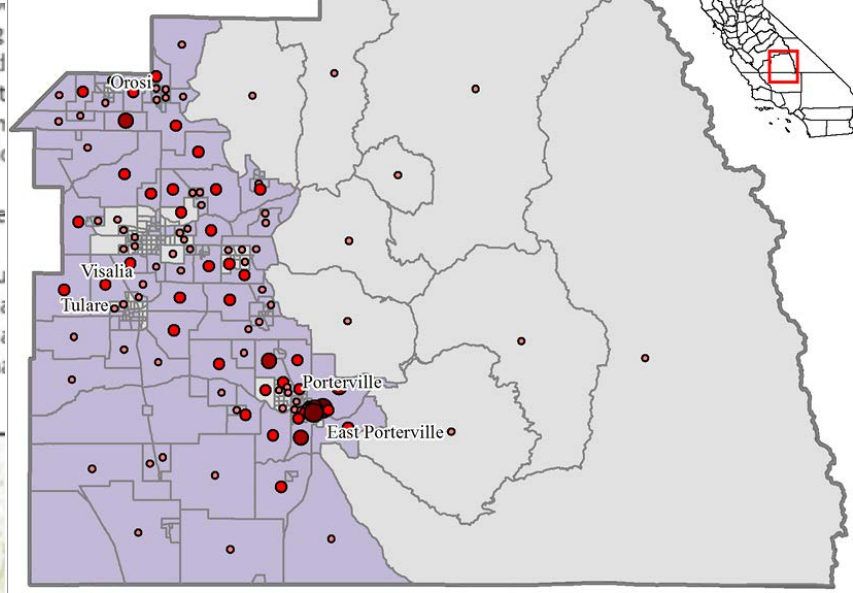
Households w/o water during drought

include active outages, active water supply problen
resolved outages, and outages where interim soluti
have been implemented. Currently only eleven
counties report interim and/or permanently resolve
outages. Water supply shortages for agriculture,
livestock, or other non-household uses are not inclu
in these counts. Missing information or no data for
given county does not necessarily mean that there
no household water shortages in the county only th
none have been reported to the State.

Number of Reports by County

- No Reports
- 1 to 9
- 10 to 99
- 100 to 999
- 1000+

Esri, HERE, DeLorme, FAO, NOAA, USGS, ...

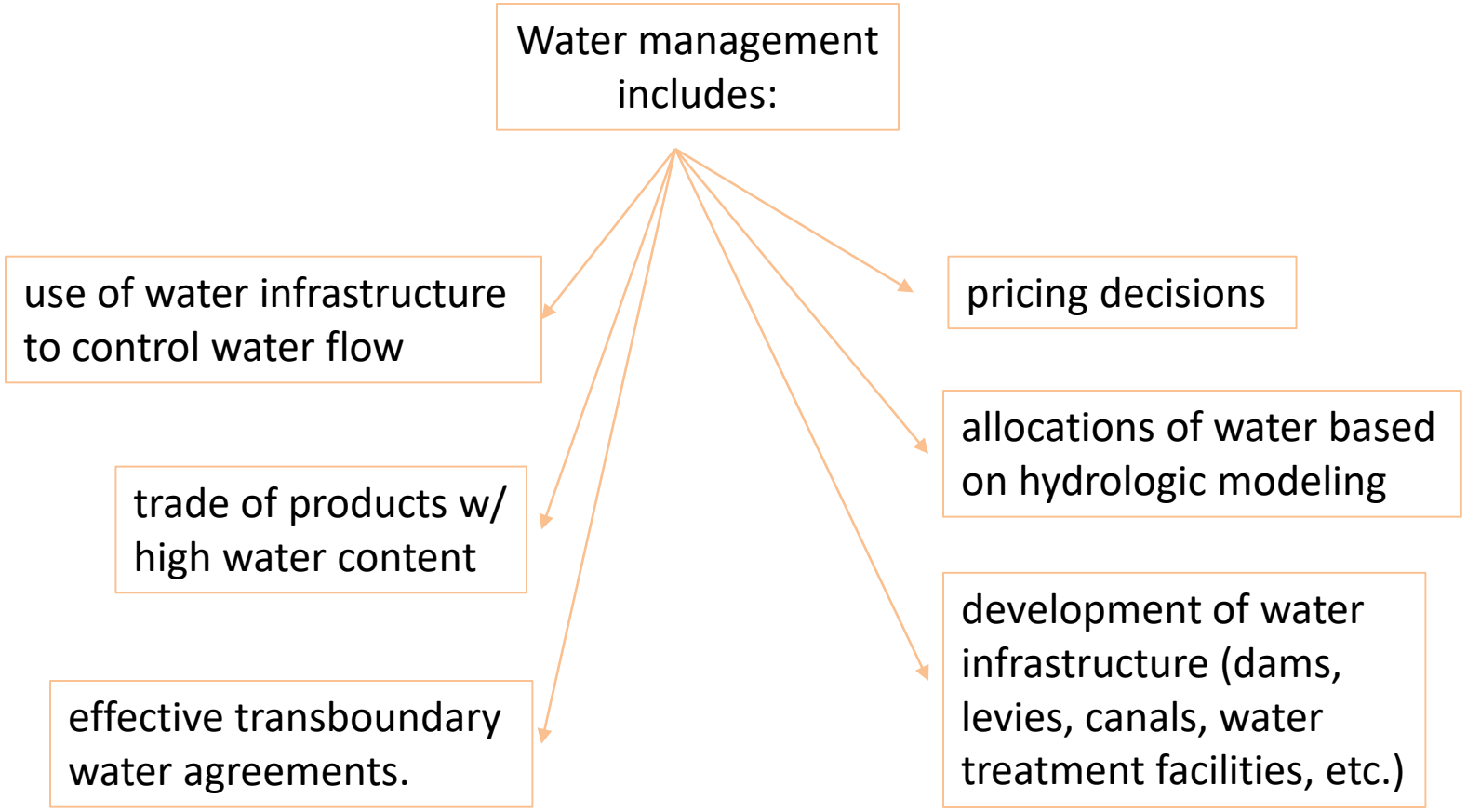


Tulare County

Pacific Institute, 2017

Global water security – a Defense Intelligence Agency Assessment

How will water problems (shortages, poor water quality, or floods) impact US national security interests over the next 30 yr?



Global Water Security – a Defense Intelligence Agency assessment, 2012

Global water security – a Defense Intelligence Agency Assessment

How will water problems (shortages, poor water quality, or floods) impact US national security interests over the next 30 yr?

Assumptions:

1. Water-management technologies will mature along present rates

→ no far-reaching improvements will develop and be deployed over the next 30 yr

2. For several states, we assume that present water policies—pricing & investments in infrastructure—are unlikely to change significantly

→ Cultural norms often drive water policies & will continue to do so despite recent political upheavals

3. States with a large & growing economic capacity will continue to make infrastructure investments

→ & apply technologies to address their water challenges.

Global Water Security – a Defense Intelligence Agency assessment, 2012

Key judgments – global water security

Our Bottom Line:

During the next 10 yr, many countries important to the U.S. will experience water problems

shortages, poor water quality, floods →

that will risk instability & state failure, increase regional tensions, & distract them from working with the U.S. on important policy objectives

Between now and 2040, fresh-water availability will not keep up w/ demand →

absent more-effective management of water resources

Water problems will hinder the ability of key countries to produce food & generate energy →

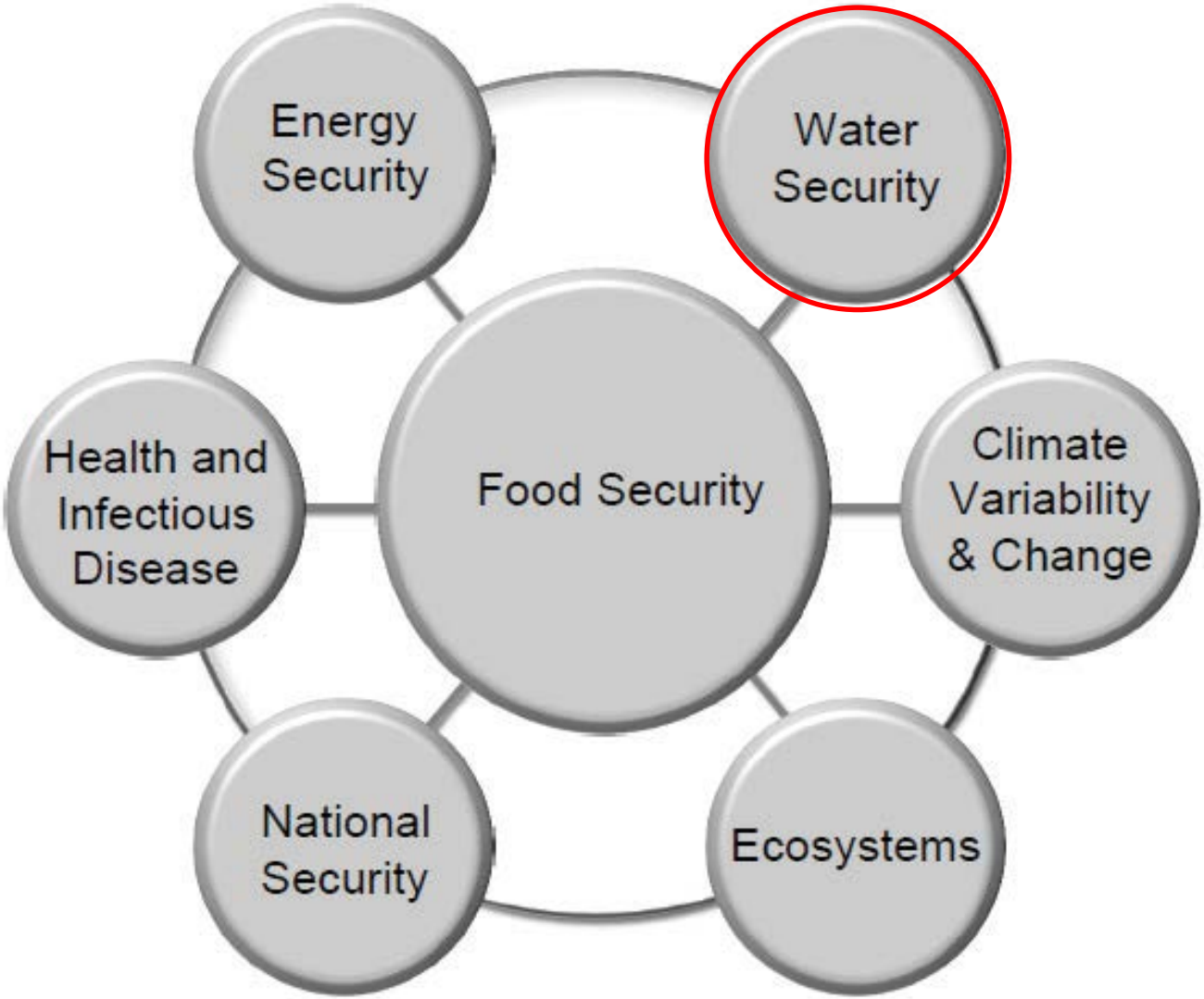
posing a risk to global food markets & hobbling economic growth

As a result of demographic & economic-development pressures →

North Africa, Middle East, & South Asia will face major challenges coping w/ water problems

Global Water Security – a Defense Intelligence Agency assessment, 2012

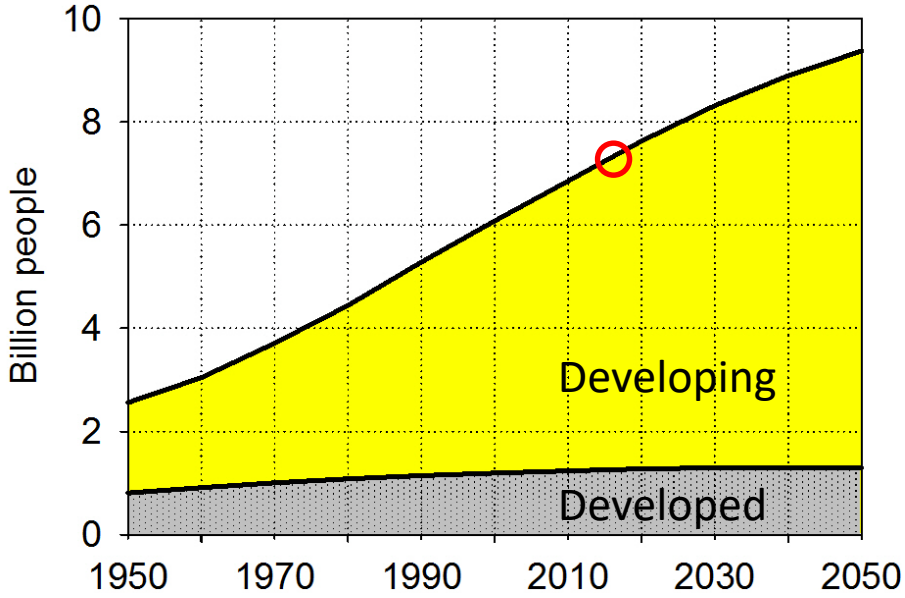
Water security in context

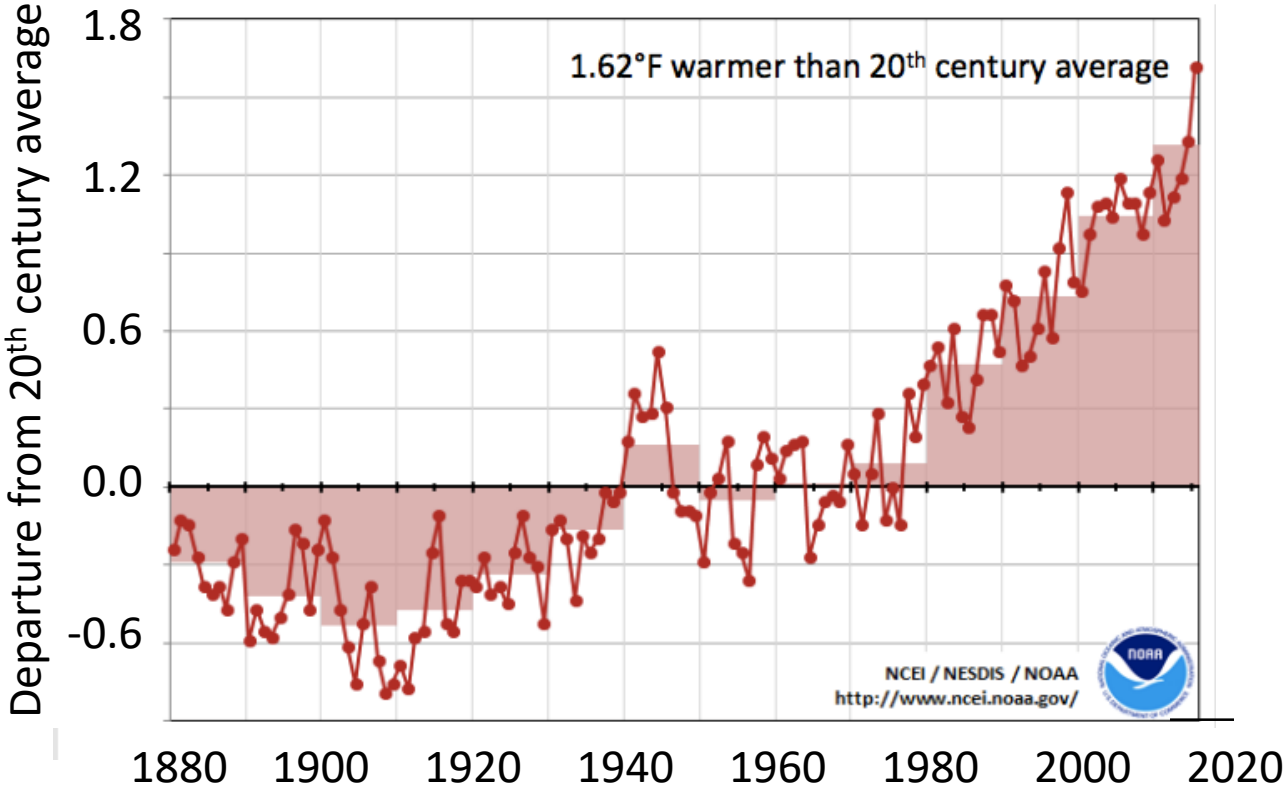


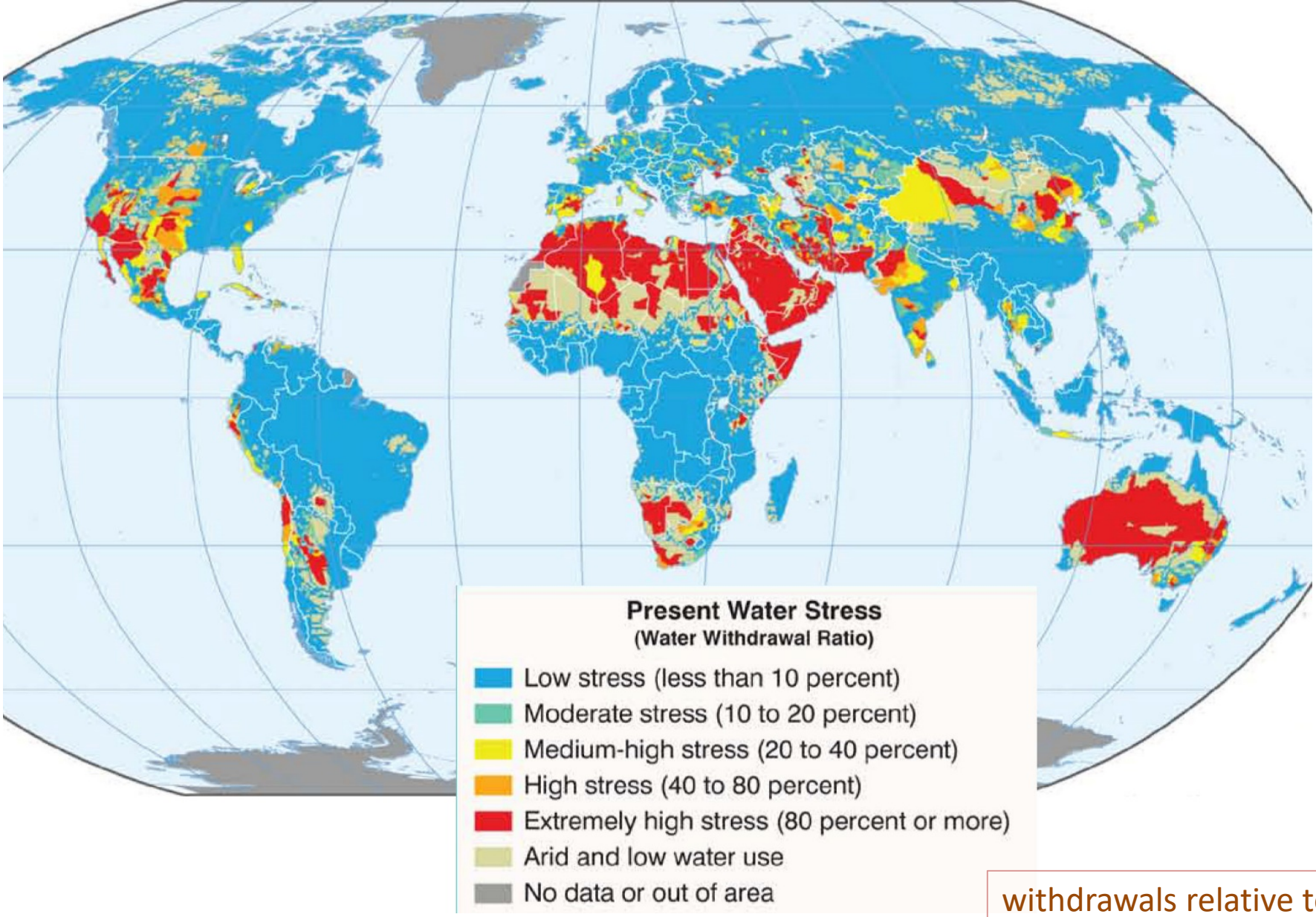
The nexus of food security & factors that affect it, as an example of interactions among resource domains. National Academy Report 23533, 2016.

Trends & stresses

A warming climate & growing global population are placing unprecedented stress on critical food, water, energy & ecosystem resources around the world







withdrawals relative to renewable supplies w/ upstream consumptive use removed

http://www.wri.org/our-work/project/aqueduct/aqueduct-atlas

Global Water Security – a Defense Intelligence Agency assessment, 2012

Adapted from World Resources Institute

Average annual applied water use for California

Precip: 200 MAF
Applied: 80 MAF
Ag: 33 MAF
Urban: 8 MAF

31% Wild & Scenic Rivers

2% Managed Wetlands

9% Instream Flows

49% Aquatic Environment

7% Required Delta Outflow

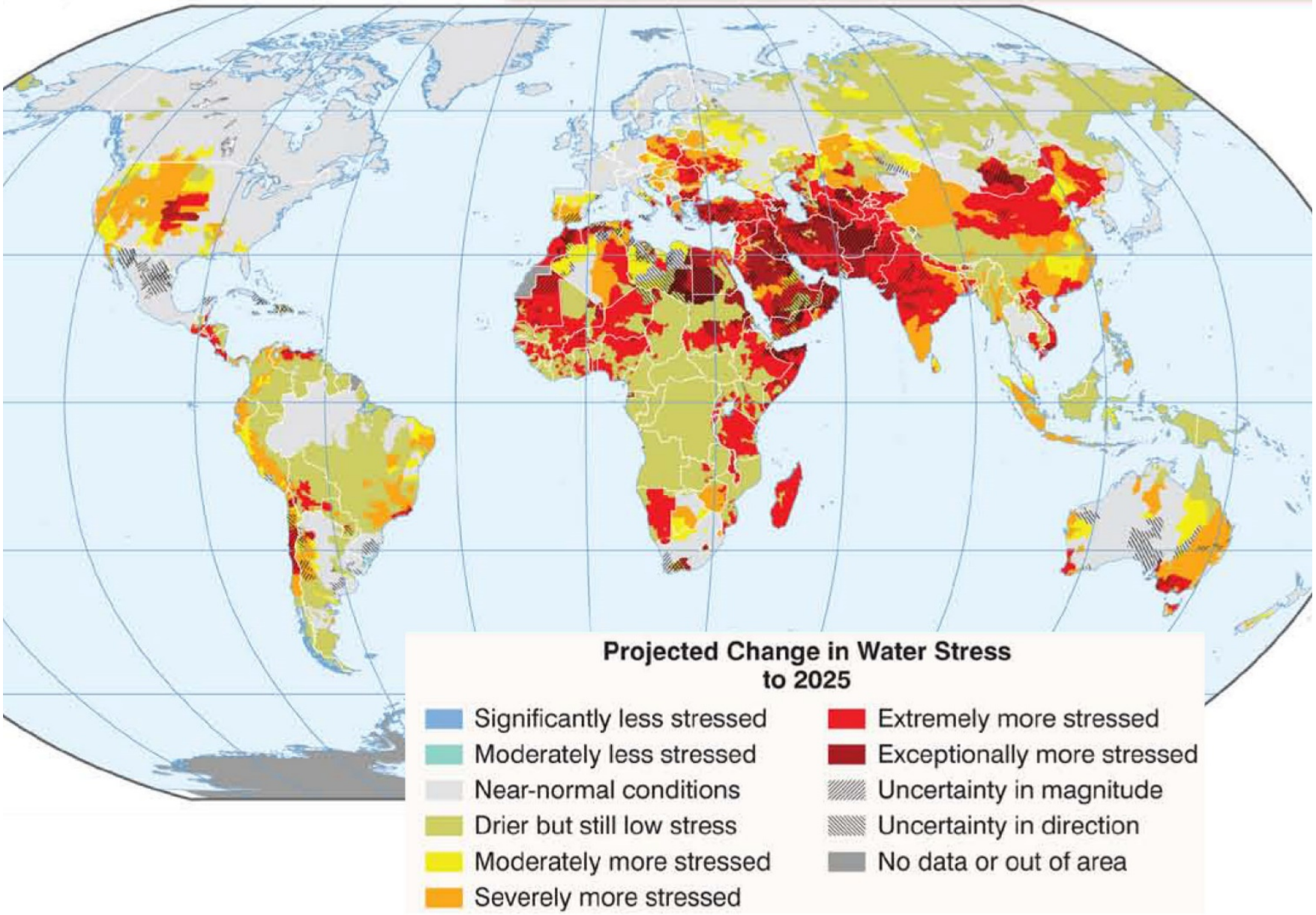
41% Irrigated Agriculture

This water produces food for consumption in urban areas while also providing terrestrial and aquatic habitat for a multitude of species.

10% Urban

Water supplies:
Agriculture: 80%
Urban 20%

Data from DWR, adapted from Nor. Cal. Water Assn.



Global Water Security – a Defense Intelligence Agency assessment, 2012
Adapted from World Resources Institute

Key judgments (cont.)

A. We assess that during the next 10 years, water problems will contribute to instability in states important to US national-security interests.

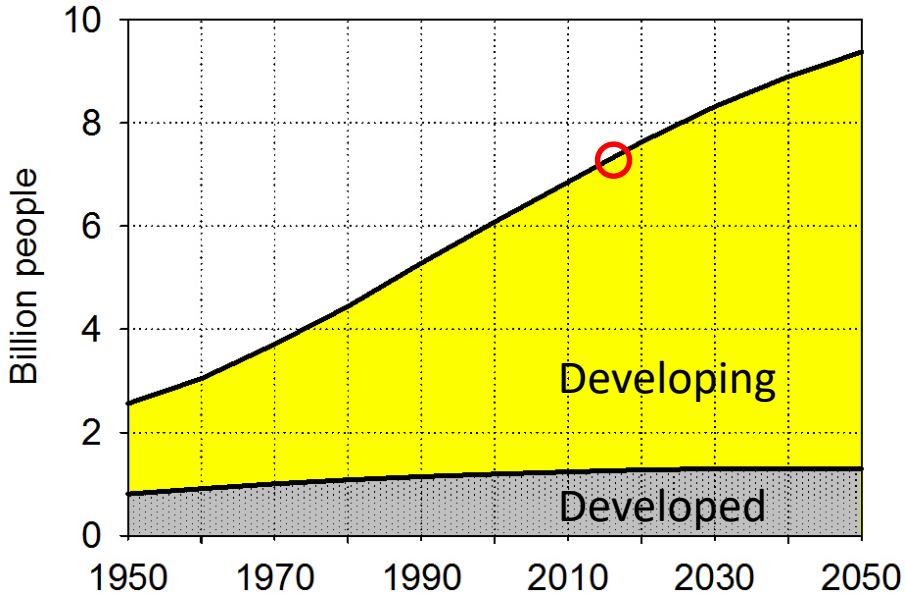
Water shortages, poor water quality & floods by themselves are unlikely to result in state failure.

However, water problems …

when combined w/ poverty, social tensions, environmental degradation, ineffectual leadership & weak political institutions …

contribute to social disruptions that can result in state failure

Population increases, migration & changing human consumption patterns resulting from economic growth will be key drivers of rising fresh-water demand. World population is projected to grow by about 1.2 billion between 2009 & 2025—from 6.8 billion to near 8 billion people.



Global Water Security – a Defense Intelligence Agency assessment, 2012

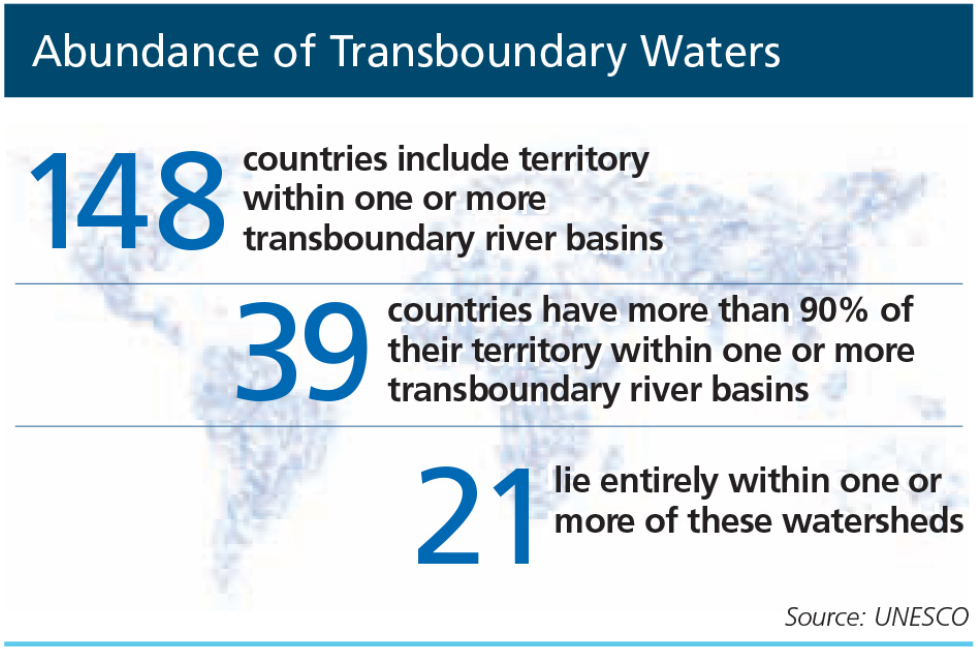
Key judgments (cont.)

B. We assess that a water-related state-on-state conflict is unlikely during the next 10 yr.

Historically, water tensions have led to more water-sharing agreements than violent conflicts.

However, we judge that as water shortages become more acute beyond the next 10 yr, water in shared basins will increasingly be used as leverage …

the use of water as a weapon or to further terrorist objectives also will become more likely beyond 10 yr.



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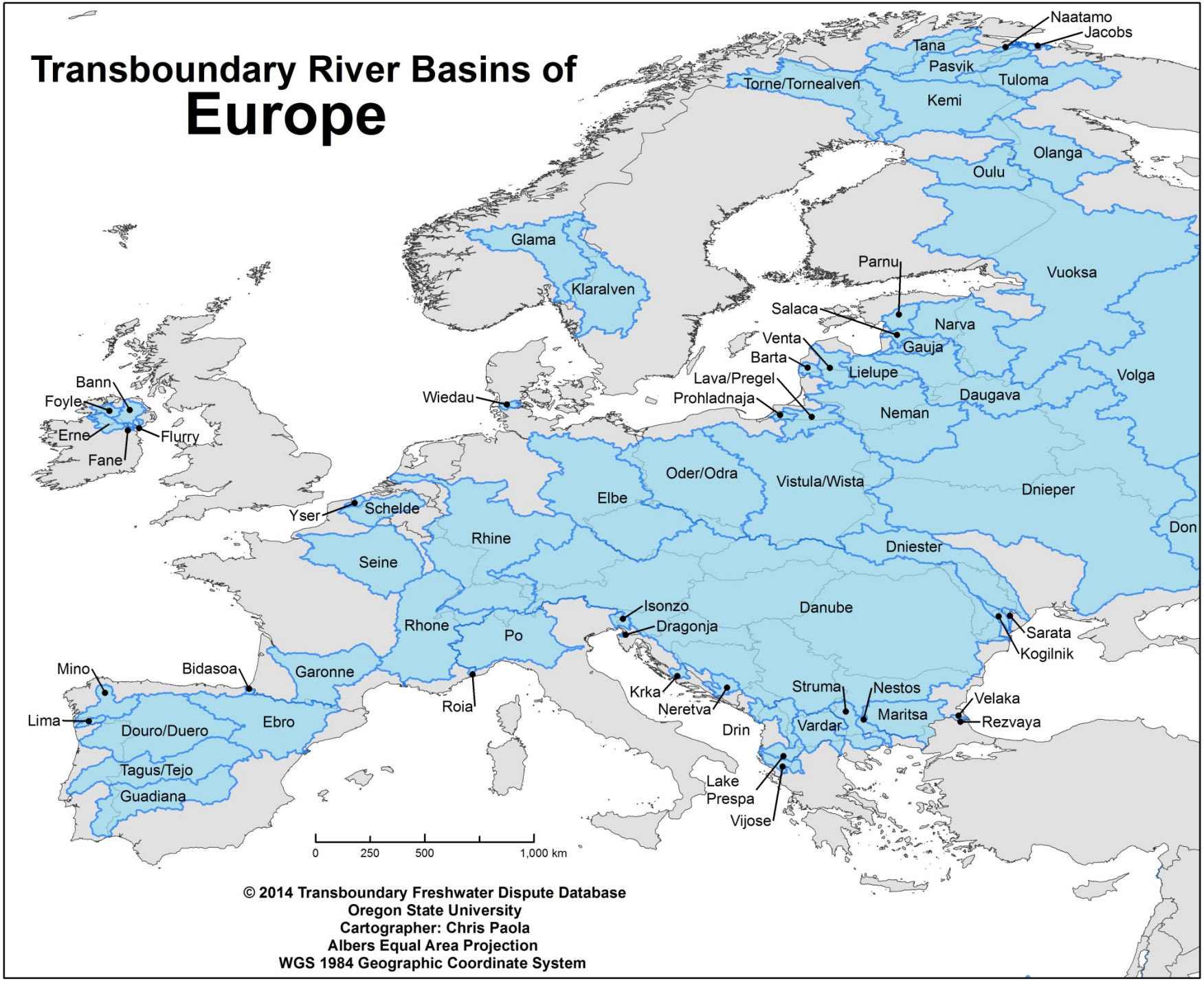
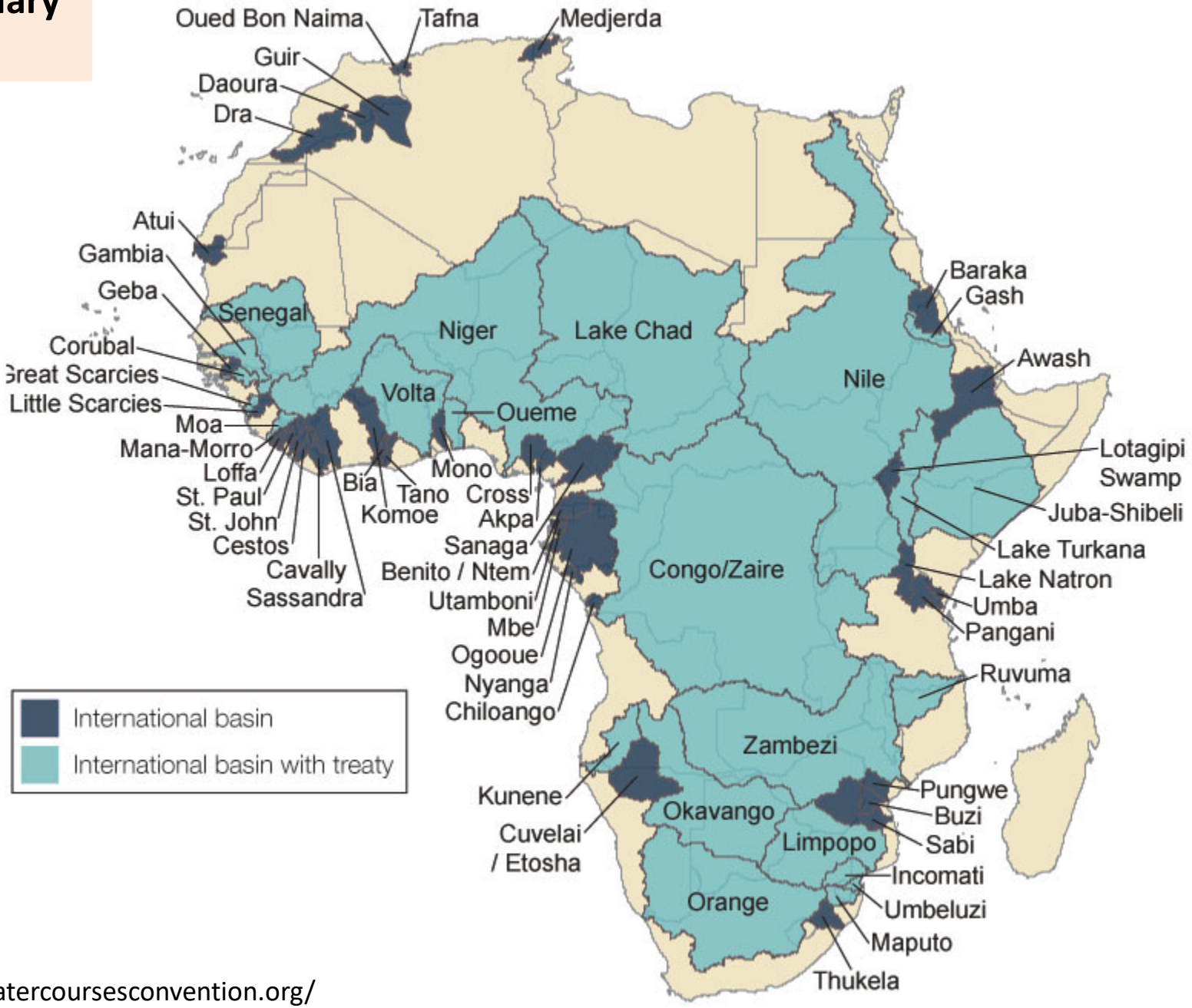


Oregon State University
Cartographer: Chris Paola
Albers Equal Area Projection
WGS 1984 Geographic Coordinate System

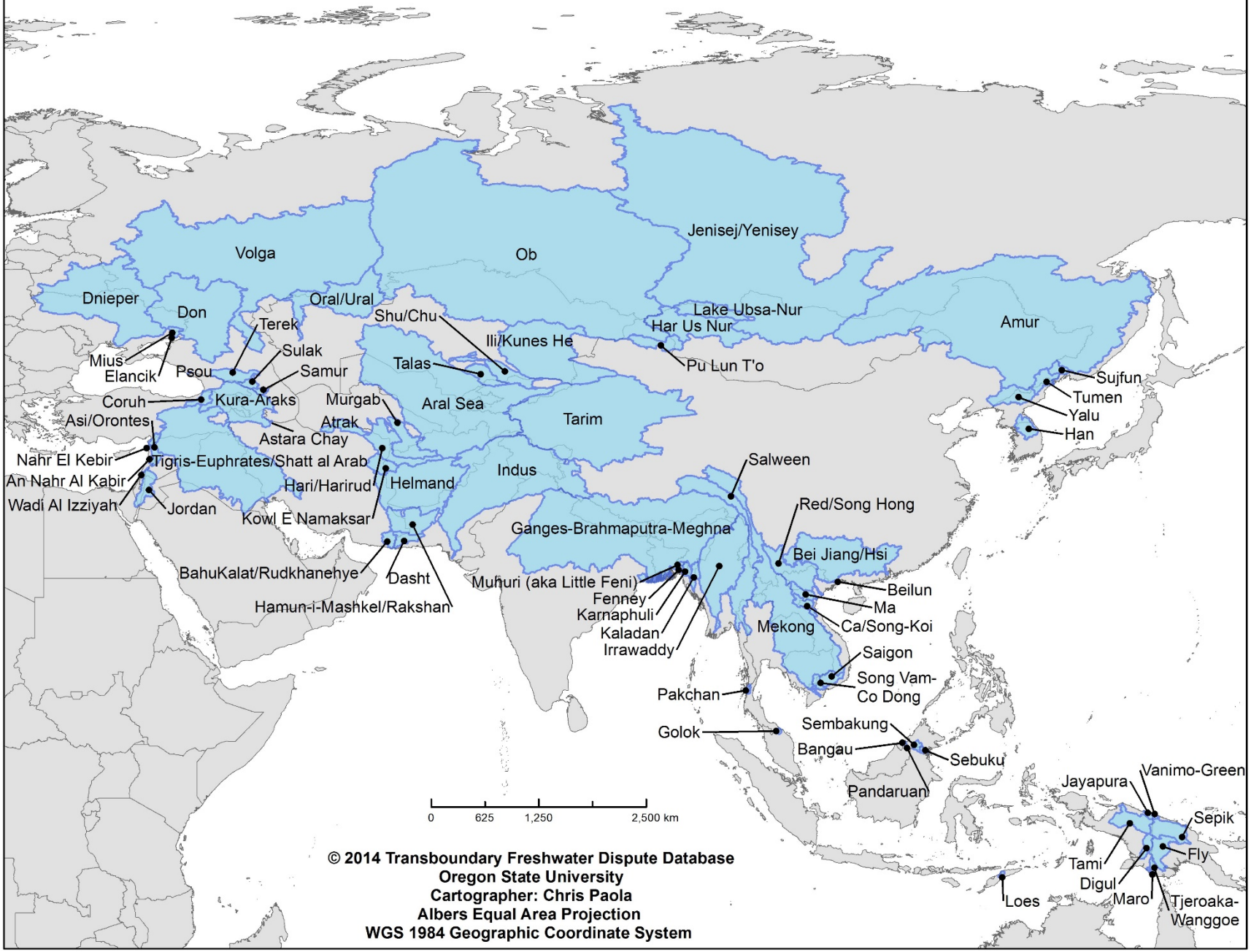

BOSNIA AND HERZEGOVINA
Beograd
Sarajevo
SERBIA
MONTENEGRO
Sofia
BULGARIA
Podgorica
Lake Skadar
Lake Bilečko
Neretva
Trebižat
Morača
Beli Drim
Drin
Crni Drim
Vardar
Bregalnica
Skopje
FORMER YUGOSLAV REPUBLIC OF MACEDONIA
Tiranë
Lake Ohrid
Prespa Lakes
Crna
Axios
Lake Dojran
Thessaloniki
ALBANIA
GREECE
Vjosë
Drino
Aoos
AEGEAN SEA
ADRIATIC SEA
ITALY
Ramsar Sites
1 Lake Skadar/Shkoder and Buna/Bojana River
2 Prespa Park Wetlands
40°
20°
Kilometres
0
50
100
150
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.
UNEP/DEWA/GRID-Geneva 2011

Trans-boundary river basins



http://www.unwatercoursesconvention.org/

Transboundary River Basins of Asia



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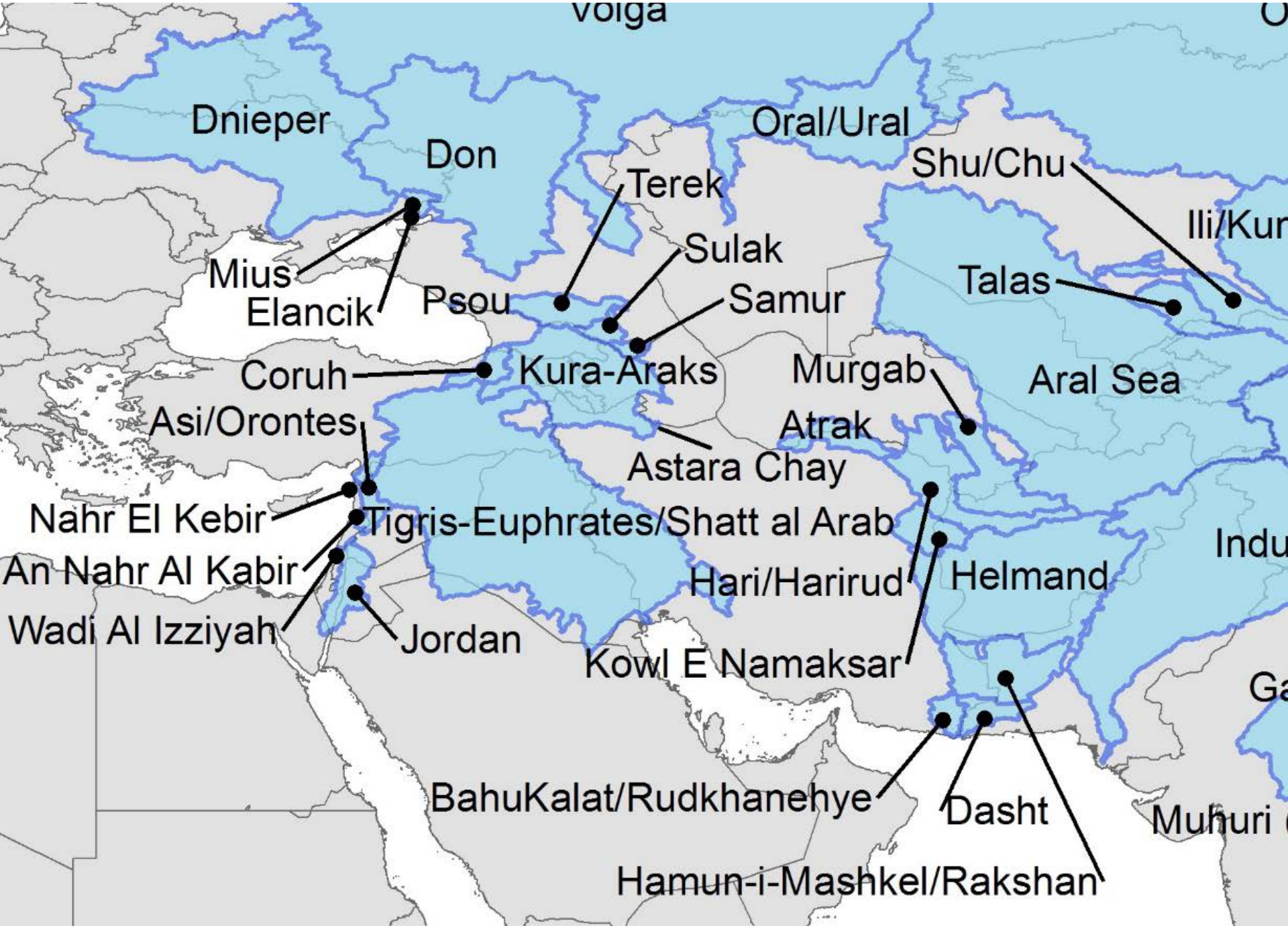
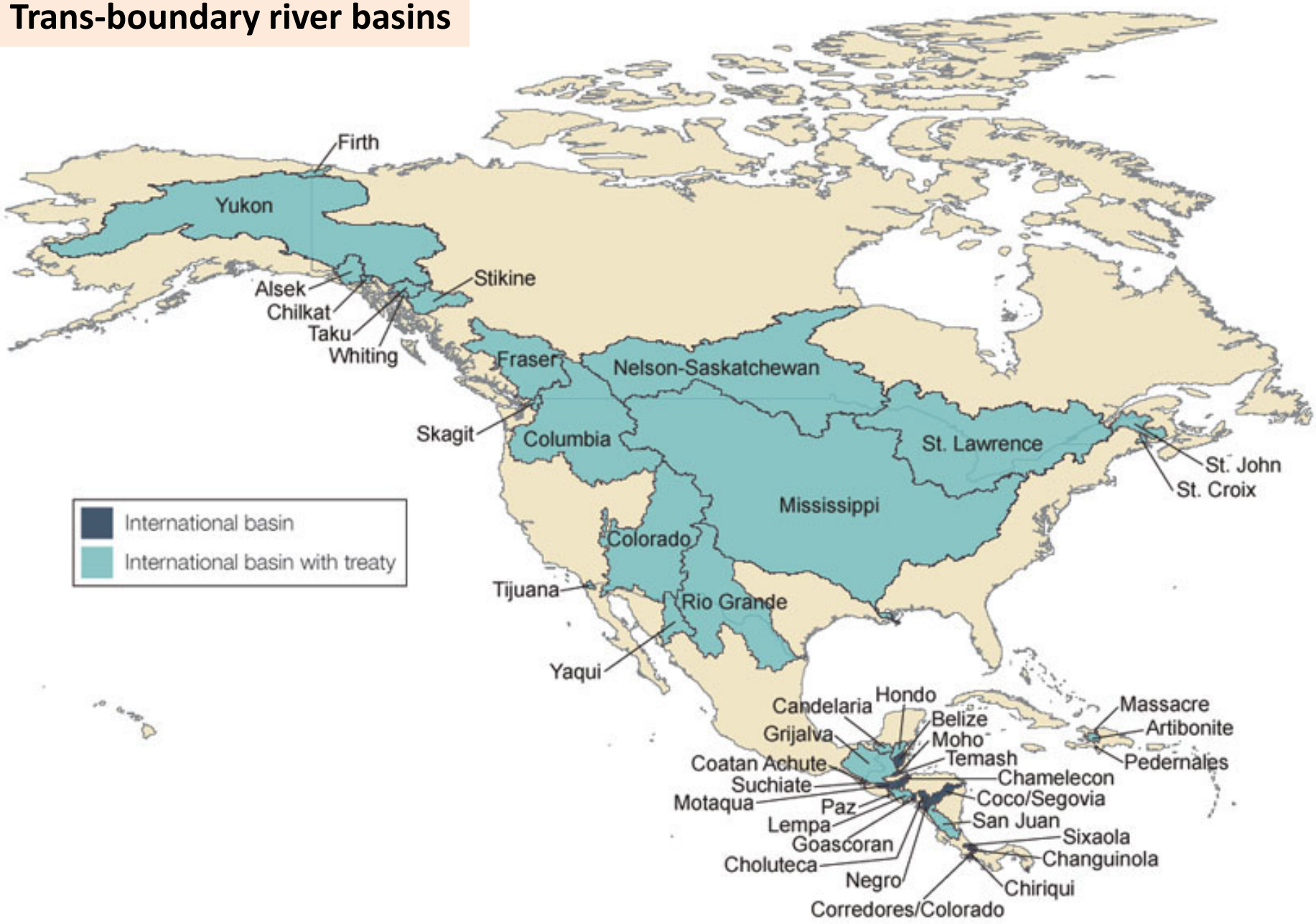

Volga
Dnieper
Don
Oral/Ural
Shu/Chu
Terek
Ili/Kur
Sulak
Mius
Elancik
Psou
Samur
Talas
Coruh
Kura-Araks
Murgab
Aral Sea
Asi/Orontes
Atrak
Astara Chay
Nahr El Kebir
Tigris-Euphrates/Shatt al Arab
Indu
An Nahr Al Kabir
Hari/Harirud
Helmand
Wadi Al Izziyah
Jordan
Kowl E Namaksar
BahuKalat/Rudkhanehye
Dasht
Muhuri
Hamun-i-Mashkel/Rakshan


Barima
Amacuro
Catatumbo
Corantijn/Courantyne
Jurado
Orinoco
Essequibo
Oiapoque/Oyupock
Maroni
Mataje
Patia
Mira
Zarumilla
Tumbes
Chira
Amazon
Lake Titicaca-Poopo System
Cancoso/Lauca
Zapaleri
La Plata
Lagoon Mirim
Chuy
Valdivia
Puelo
Yelcho
Palena
Aysen
Baker
Pascua
Seno Union/Serrano
Gallegos/Chico
Cullen
San Martin
Rio Grande (S. America)
Aviles
Lake Fagnano
Carmen Silva/Chico
Transboundary River Basins of
South America
0
500
1,000
2,000 km
© 2014 Transboundary Freshwater Dispute Database
Oregon State University
Cartographer: Chris Paola
World Cylindrical Equal Area Projection
WGS 1984 Geographic Coordinate System

Trans-boundary river basins



http://www.unwatercoursesconvention.org/

Key judgments (cont.)

B. We assess that a water-related state-on-state conflict is unlikely during the next 10 yr.

Water as a Driver for Peace

- Water challenges have often brought divergent actors together to resolve a common problem.
- Once cooperative water agreements are established through treaties, they are often resilient over time & produce peaceful cooperation, even among other existing hostilities & contentious issues.

The Mekong Committee, established by Cambodia, Laos, Thailand & Vietnam in 1957 exchanged data & information on the river basin throughout the Vietnam War.

Israel & Jordan held secret "picnic table" talks to manage the Jordan River starting in 1953, even though they were officially at war from 1948 until 1994.

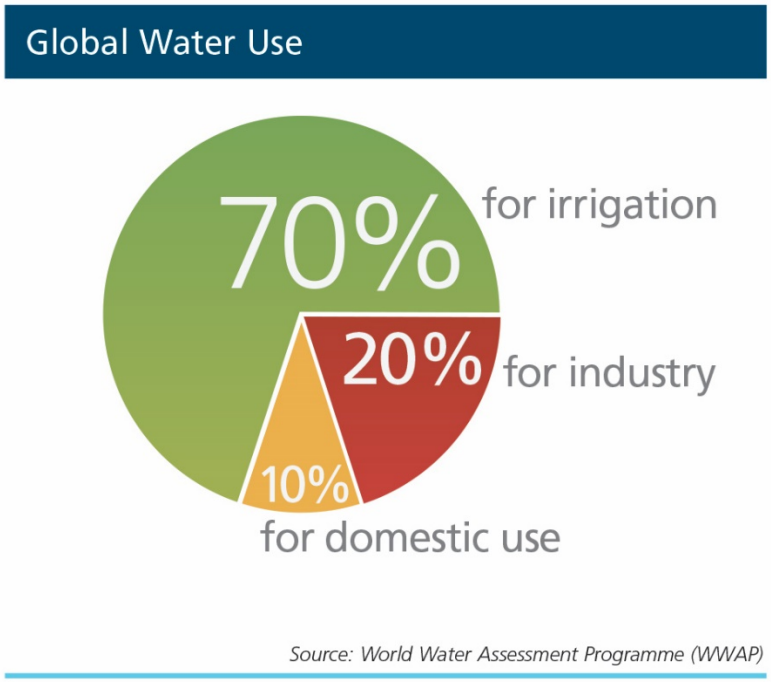
The Indus River Commission survived two major wars between India & Pakistan.

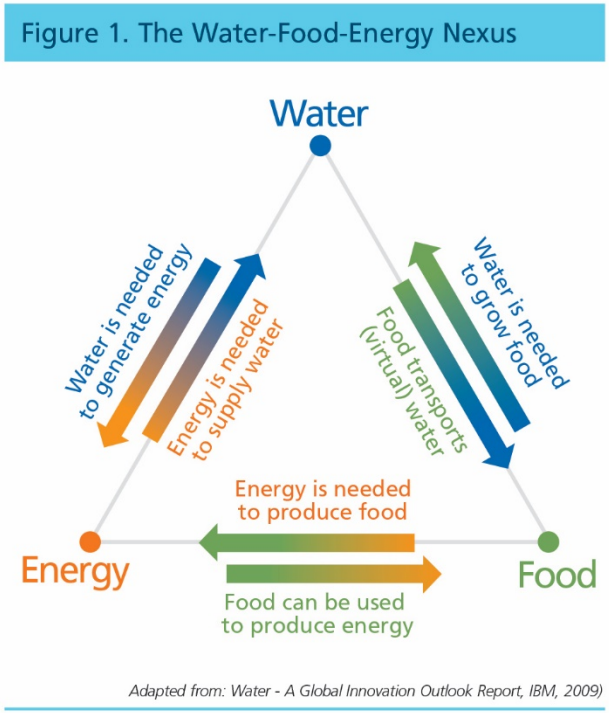
Global Water Security – a Defense Intelligence Agency assessment, 2012

Key judgments (cont.)

C. We judge that during the next 10 yr the depletion of groundwater supplies in some agricultural areas—owing to poor management—will pose a risk to both national & global food markets.

- Many advances in agricultural production have been due to the unprecedented use of finite groundwater reserves
- About 2 billion people rely on groundwater as their sole source of water

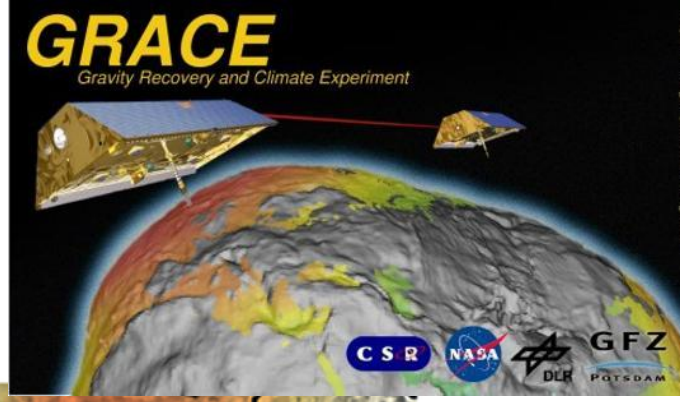


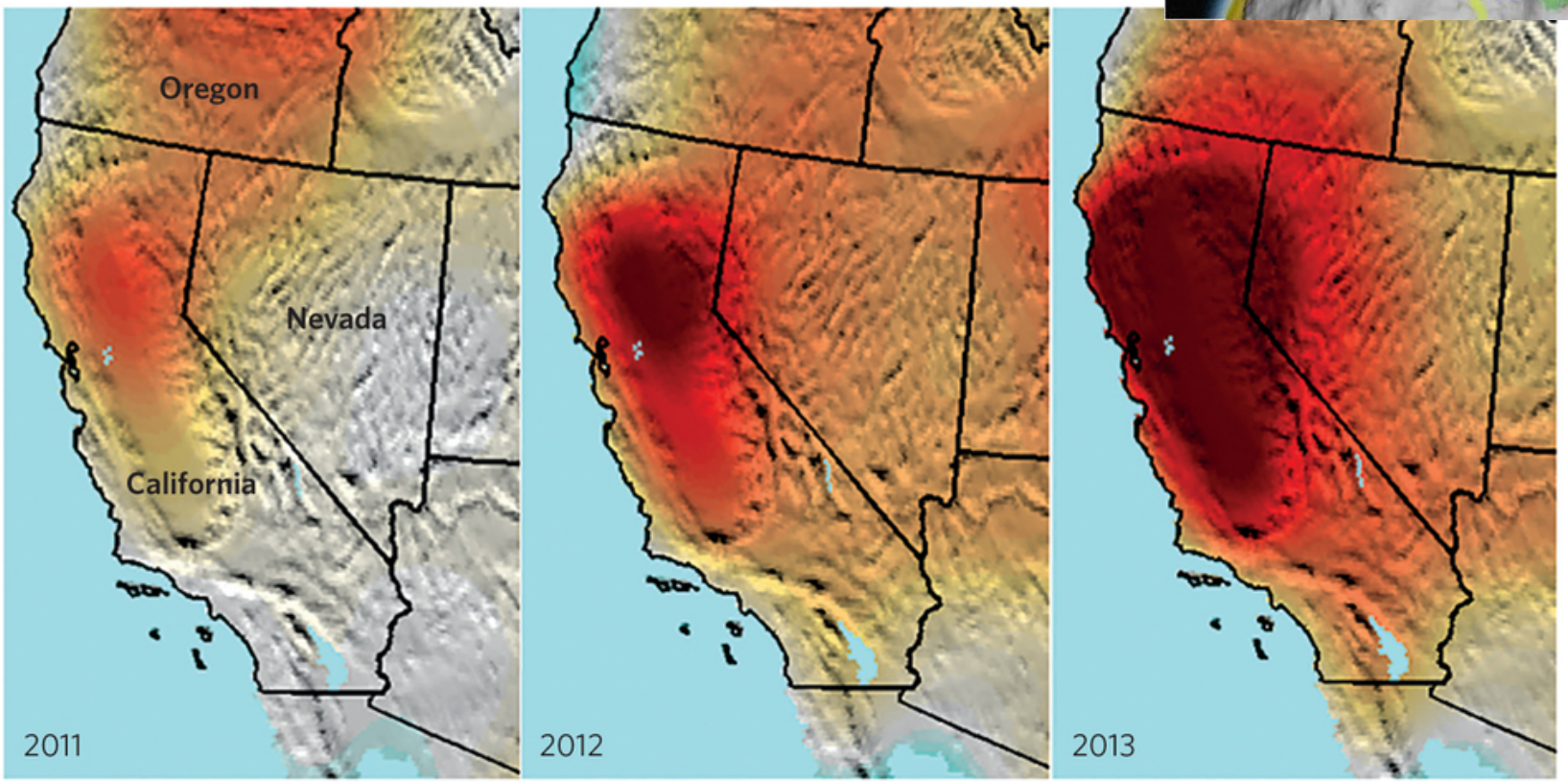


Global Water Security – a Defense Intelligence Agency assessment, 2012
Figures from UN-Water Analytical Brief, 2013

IC-2

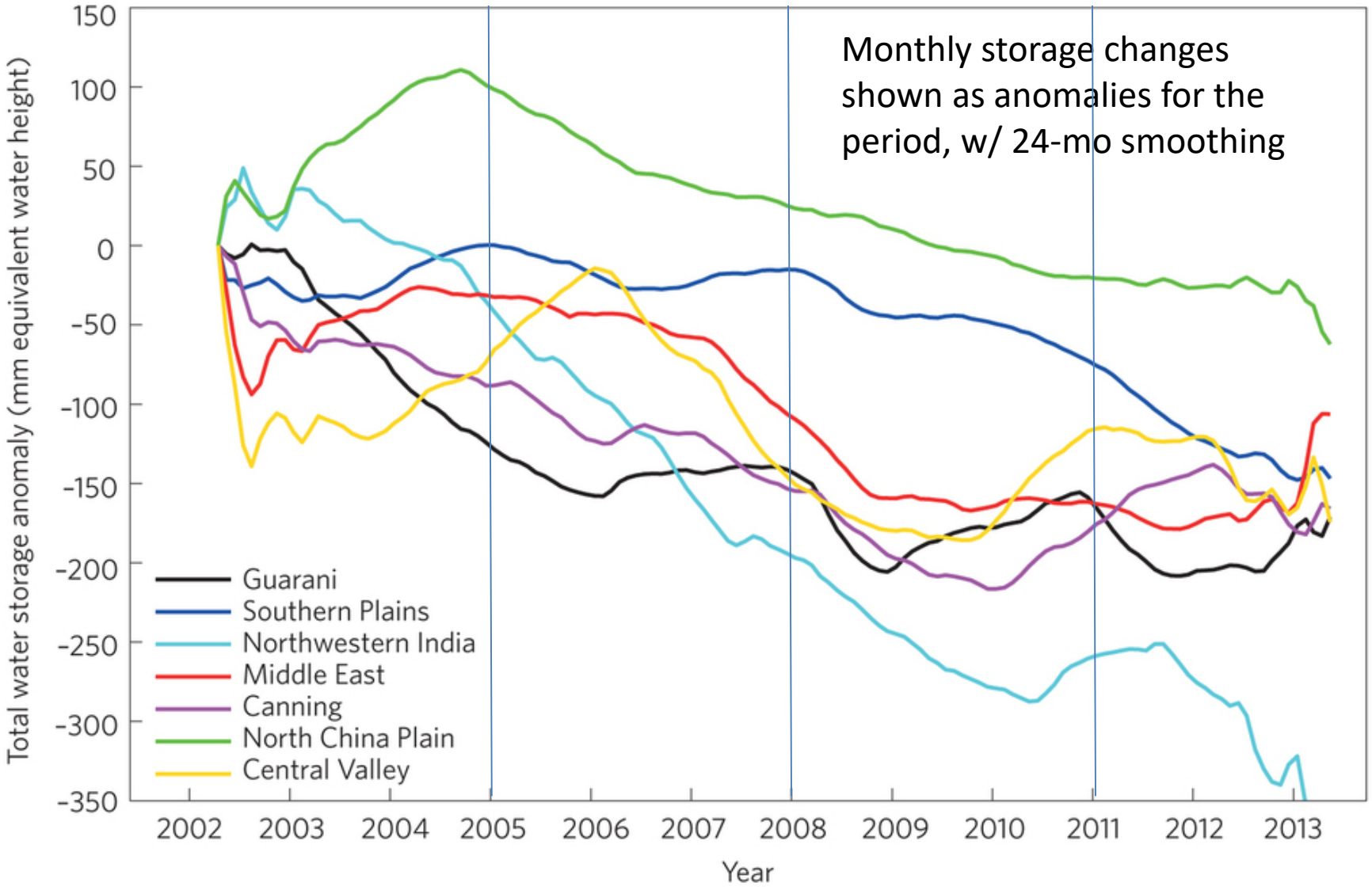
NASA's Gravity Recovery & Climate Experiment (GRACE) satellite mission is providing new, space-based insights into the global nature of groundwater depletion





J. Famigletti, The global groundwater crisis, *Nature Climate Change*, Nov 2014.

Water-storage declines in several of the world's major aquifers in Earth's arid and semi-arid mid-latitudes, derived from the GRACE



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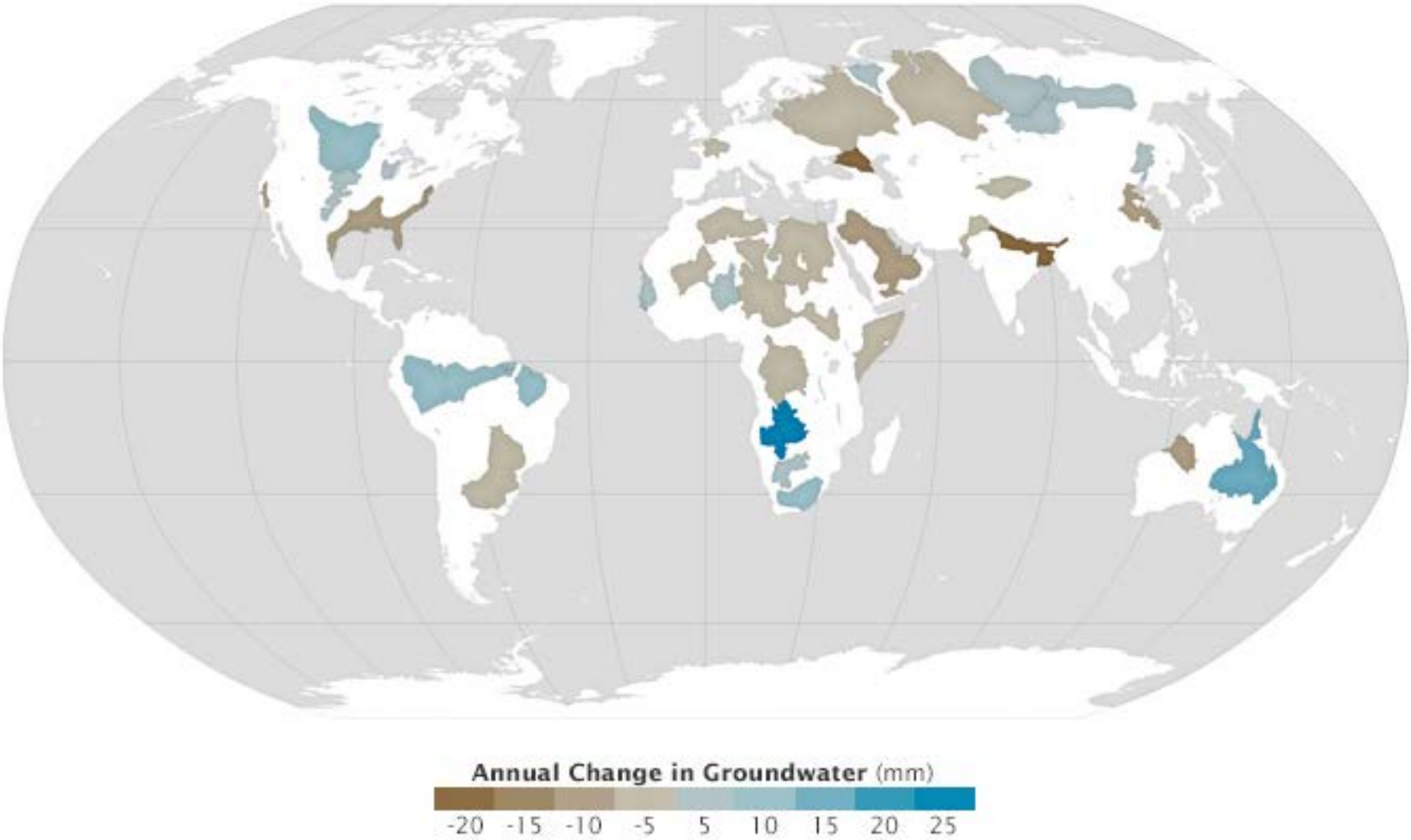
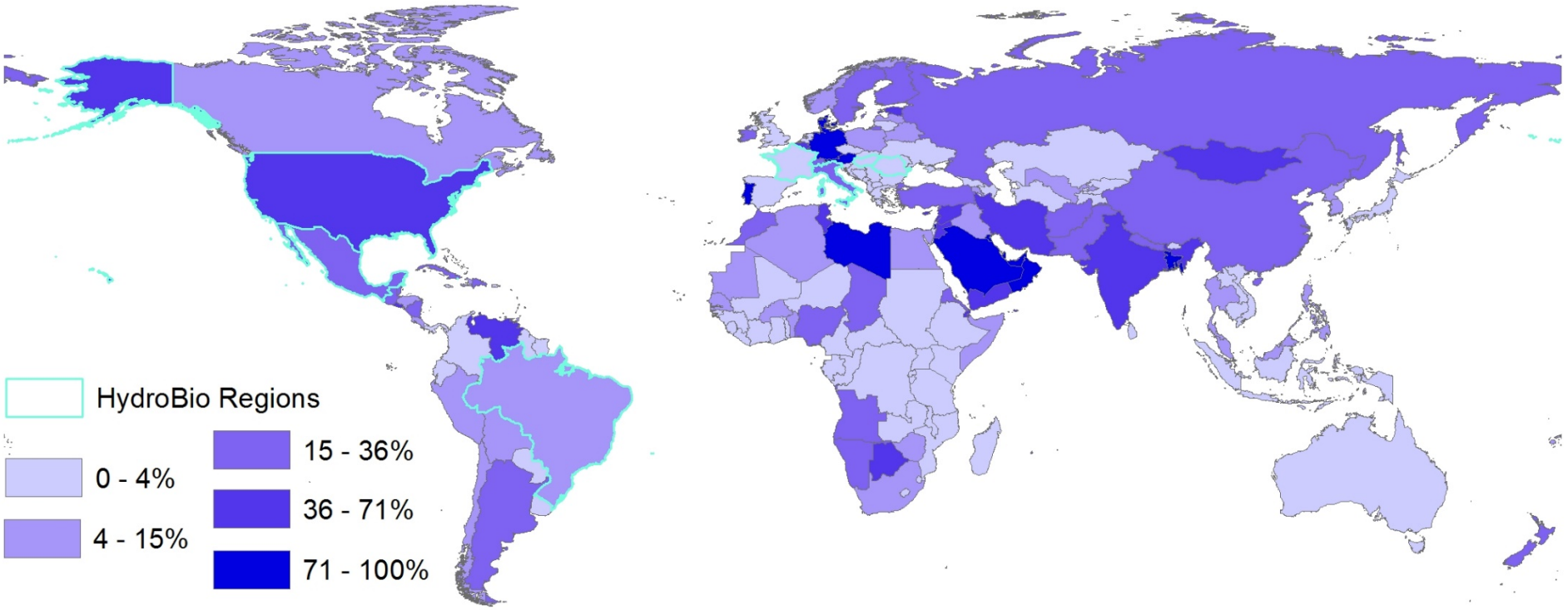
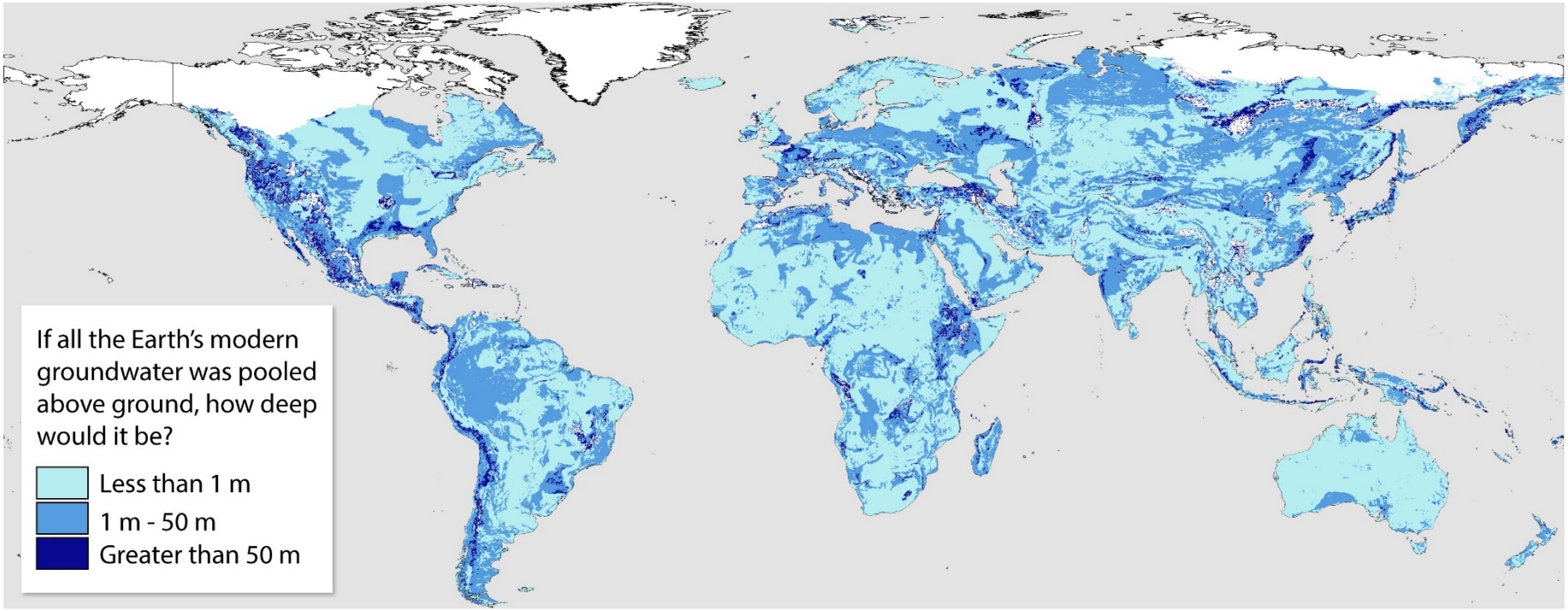

Annual Change in Groundwater (mm)
-20 -15 -10 -5 5 10 15 20 25

Groundwater Irrigated Area as Percent of Total Irrigated Area





Tom Gleeson, Kevin M. Befus, Scott Jasechko, Elco Luijendijk and M. Bayani Cardenas (2015).
Nature Geoscience, DOI: 10.1038/NGEO2590.

Key judgments (cont.)

C. We judge that during the next 10 yr the depletion of groundwater supplies in some agricultural areas—owing to poor management—will pose a risk to both national & global food markets.

- Many advances in agricultural production have been due to the unprecedented use of finite groundwater reserves
- About 2 billion people rely on groundwater as their sole source of water

Global Water Security – a Defense Intelligence Agency assessment, 2012
Figures from UN-Water Analytical Brief, 2013

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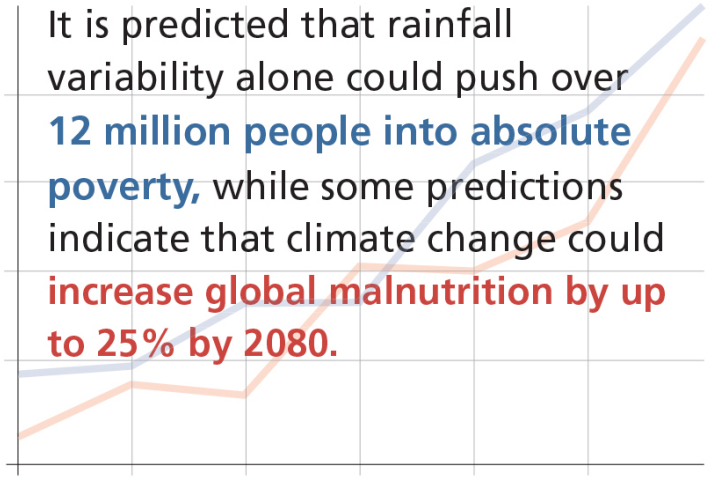
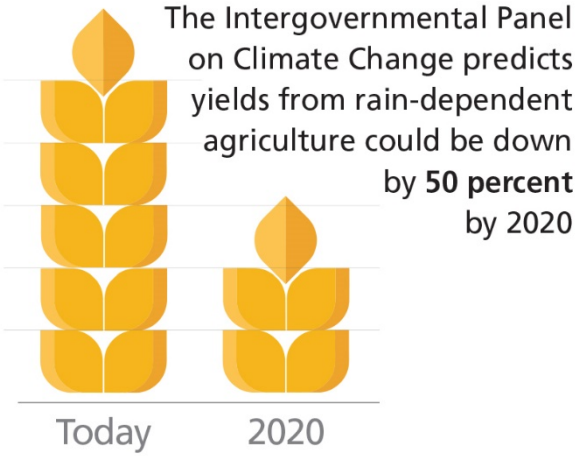
Rainfall to affect poverty figures



Source:United Nations Environment Programme (UNEP)

Daily water requirement

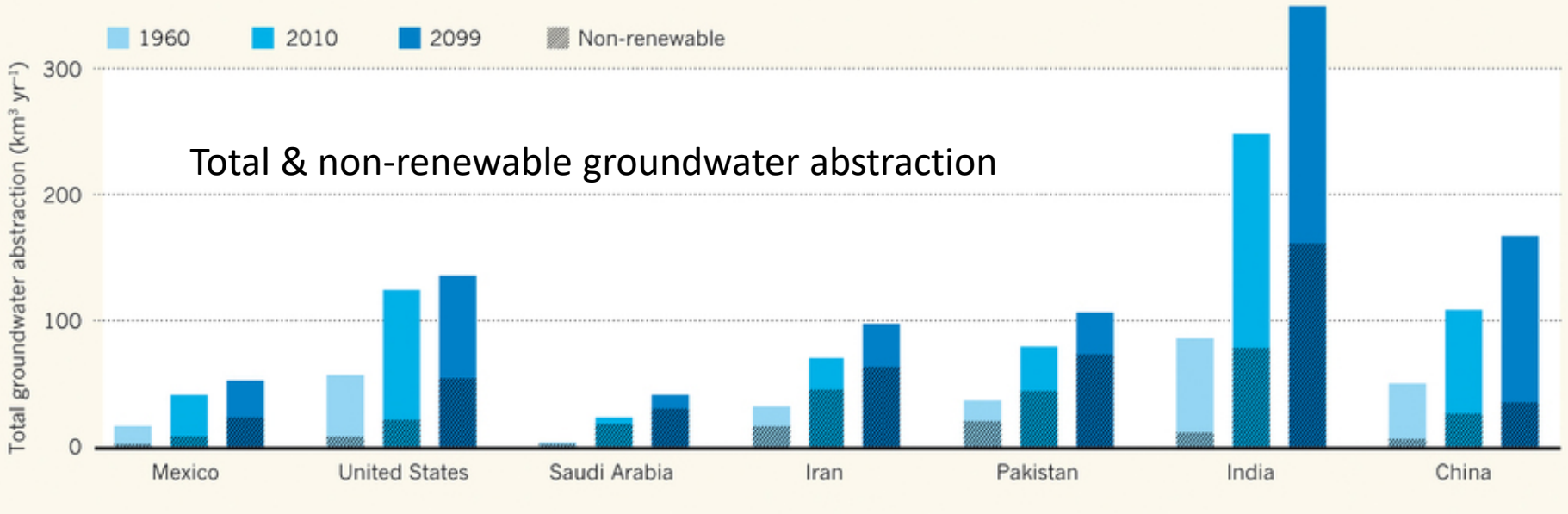


Source: United Nations Environment Programme (UNEP)

Global Water Security – a Defense Intelligence Agency assessment, 2012
Figures from UN-Water Analytical Brief, 2013

Historical & projected groundwater withdrawals in the world's major irrigating countries

These countries accounted for 74% of global groundwater withdrawals in 2010



This global analysis reveals growing societal dependence on the use of non-renewable freshwater resources that depletes groundwater reserves & undermines human resilience to water scarcity in a warming world.

IC-2a

R. Taylor, When wells run dry, *Nature*, Dec 2014.

Key judgments (cont.)

D. We assess that from now through 2040 water shortages & pollution probably will harm the economic performance of important trading partners.

Water-Energy-Industry Nexus

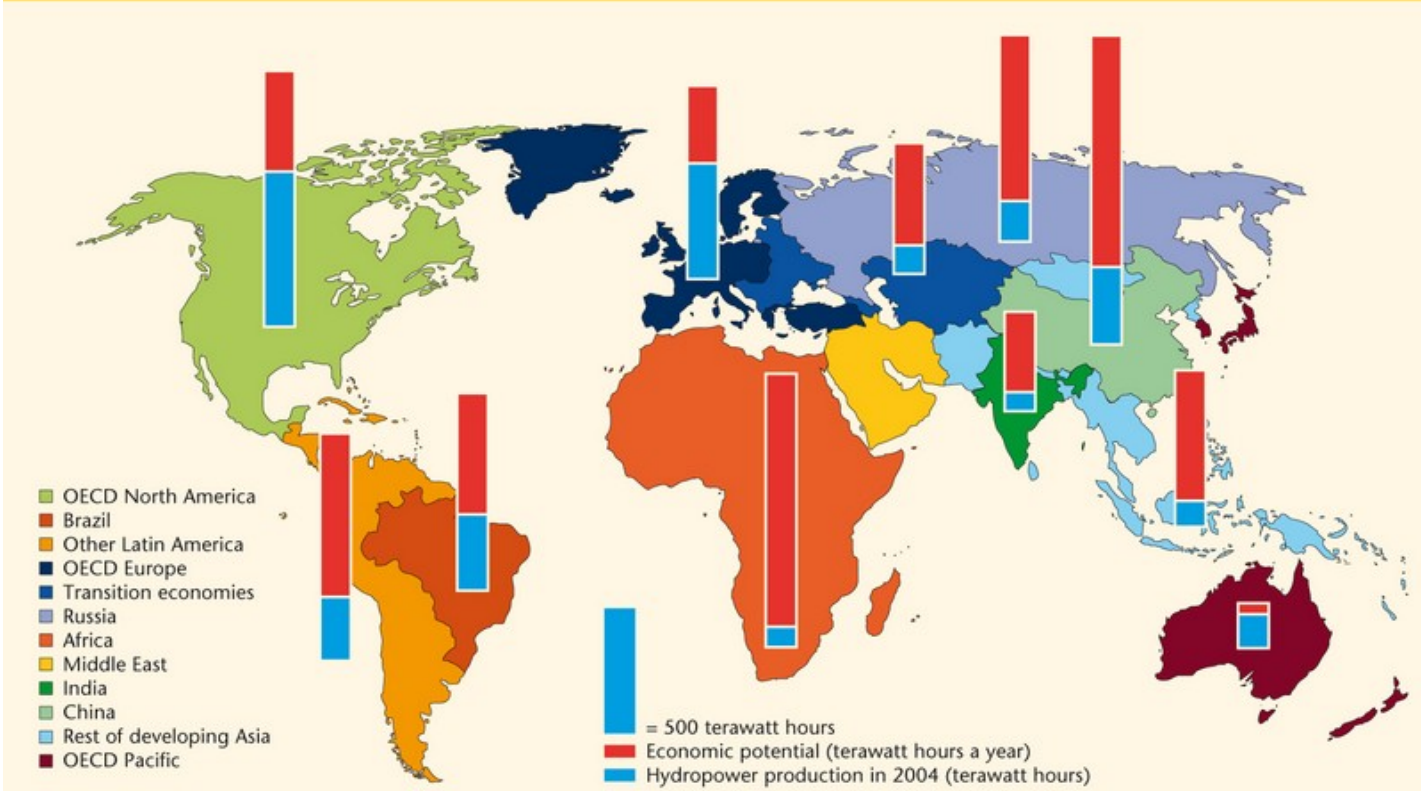
Hydropower is an important source of electricity in developing countries …

more than 15 developing countries generate 80% or more of their electricity from hydropower

… demand for water to support all forms of electricity production & industrial processes is increasing.

Global Water Security – a Defense Intelligence Agency assessment, 2012

World potential and current hydropower production, 2004

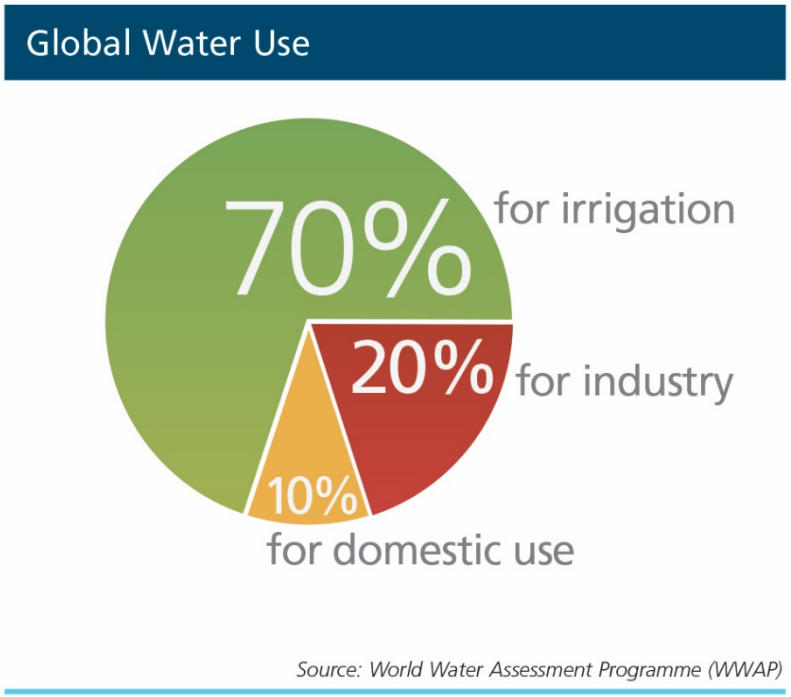


World Water Assessment Programme. 2009. *The United Nations World Water Development Report 3: Water in a Changing World.* Paris: UNESCO, and London: Earthscan. Map 7.6, page 119.

Based on data from: IEA (International Energy Agency). 2006. *World Energy Outlook 2006.* Paris

Key judgments (cont.)

E. We judge that, from now through 2040, improved water management (e.g., pricing, allocations, & "virtual water" trade) & investments in water-related sectors (e.g., agriculture, power & water treatment) will afford the best solutions for water problems.



Because agriculture uses approximately 70% of the global fresh water supply, the greatest potential for relief from water scarcity will be through technology that reduces the amount of water needed for agriculture.

Global Water Security – a Defense Intelligence Agency assessment, 2012

Key judgments (cont.)

E. We judge that, from now through 2040, improved water management (e.g., pricing, allocations, & "virtual water" trade) & investments in water-related sectors (e.g., agriculture, power & water treatment) will afford the best solutions for water problems.

Effective water management has several components

Use of an integrated water resource management framework that assesses the whole system … → & then uses technology & infrastructure for efficient water use, flood control, redistribution of water, & preservation of water quality.

Trade of products w/ high water content … → to overcome inherent local water deficiencies.

Adoption of pricing mechanisms & policies … → to encourage efficient water use & support infrastructure investments.

More robust remote-sensing/river-gauging networks & hydrologic modeling … → to support new & revised water-sharing agreements.

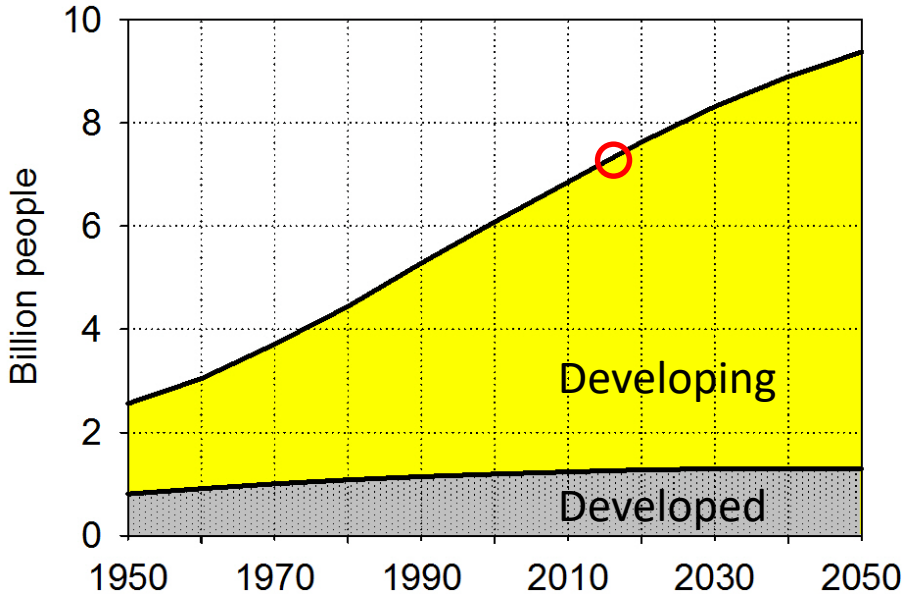
Global Water Security – a Defense Intelligence Agency assessment, 2012

Global threats to human water security & river biodiversity

Nearly 80% of the world's population is exposed to high levels of threat to water security.

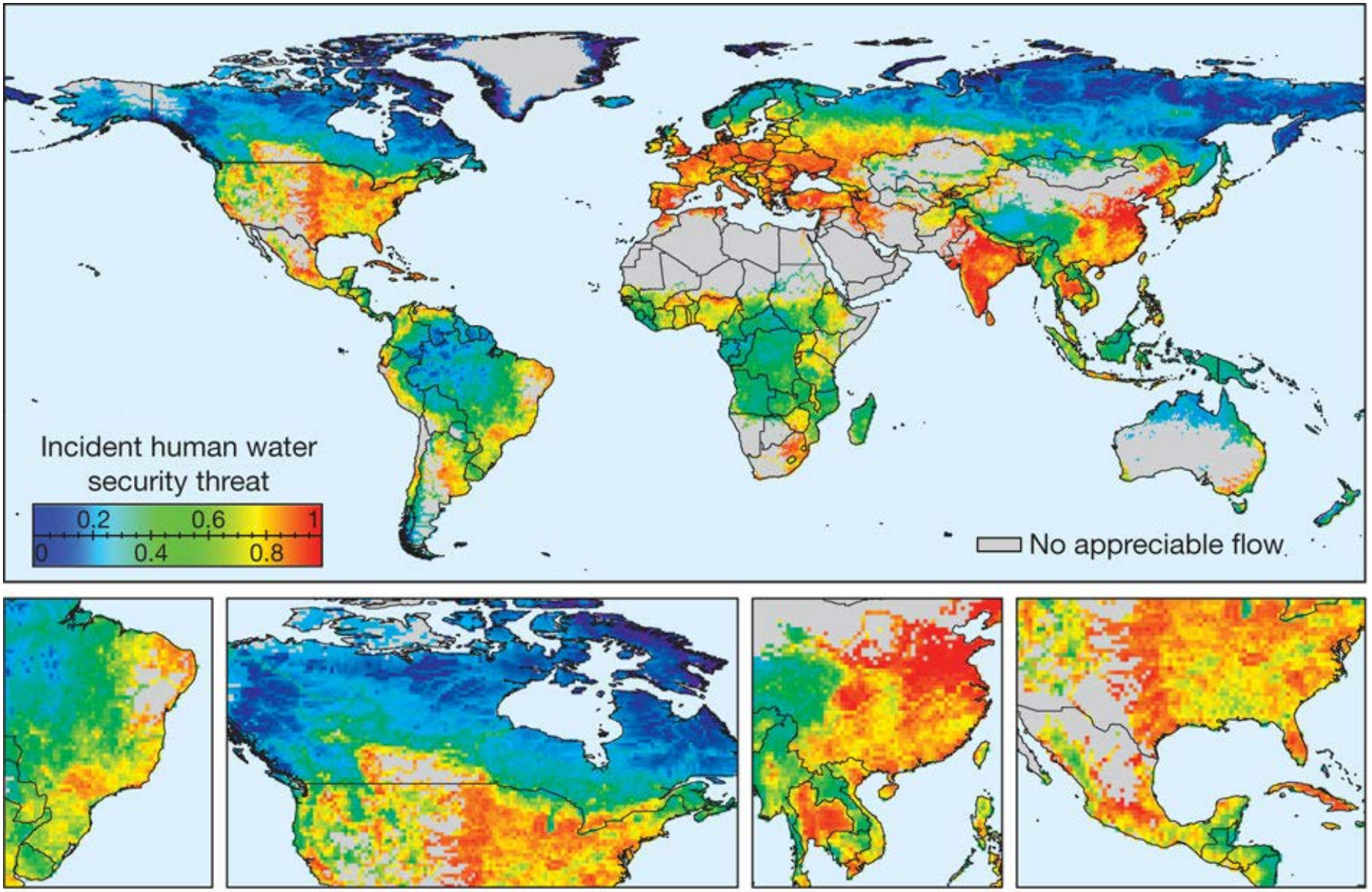
Massive investment in water technology enables rich nations to offset high stressor levels w/o remedying their underlying causes
→ whereas less-wealthy nations remain vulnerable.

A similar lack of precautionary investment jeopardizes biodiversity
→ w/ habitats associated with 65% of continental discharge classified as moderately to highly threatened.



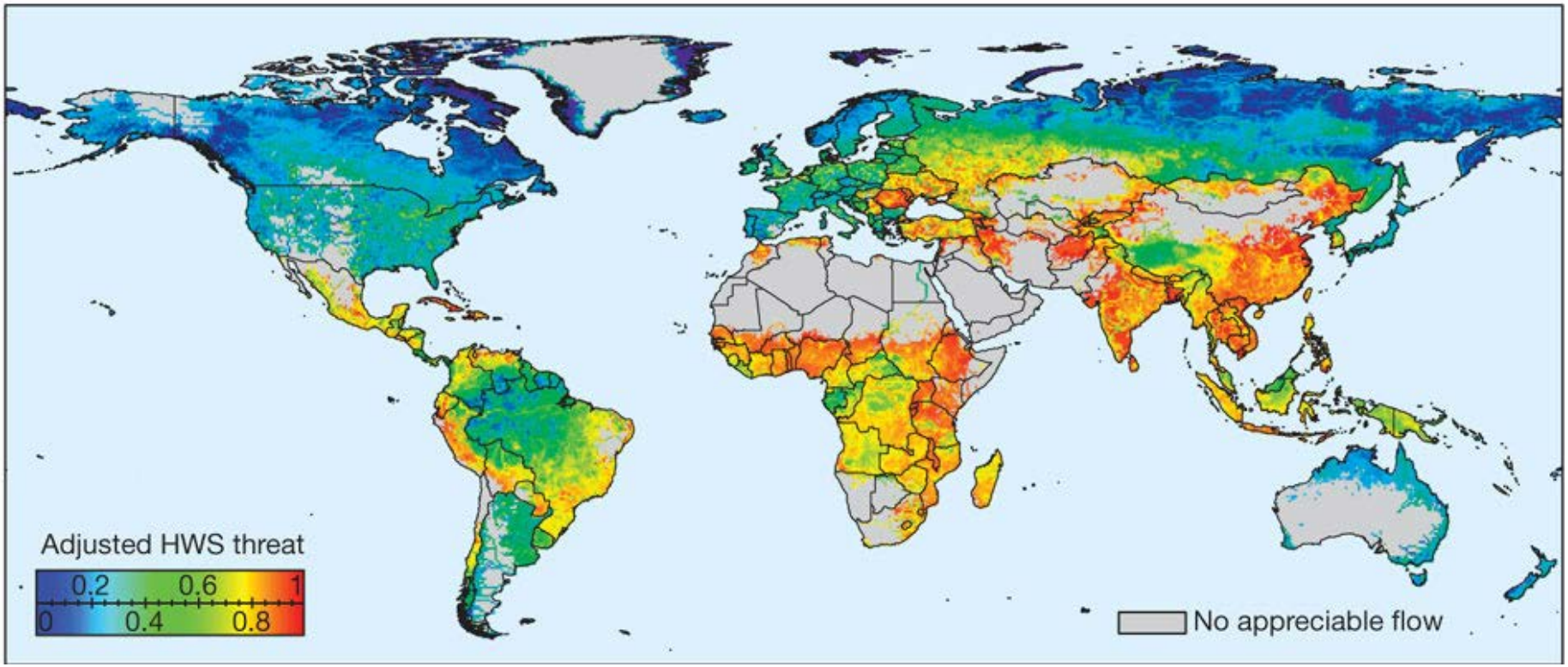
Vorosmarty, *Nature*, 2010.

Global geography of incident threat to human water security

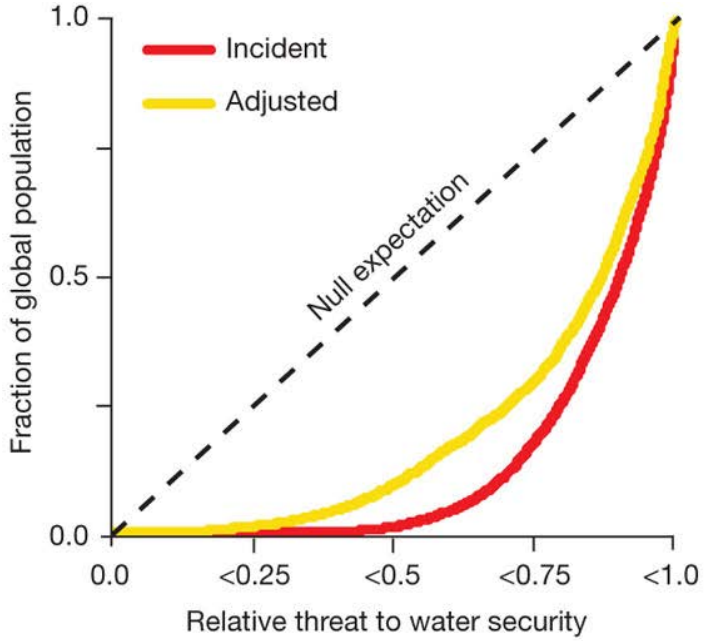


C. J. Vorosmarty, Global threats to human water security & river biodiversity, *Nature*, Sept 2010

Shifts in spatial patterns of relative human water-security threat after accounting for water-technology benefits

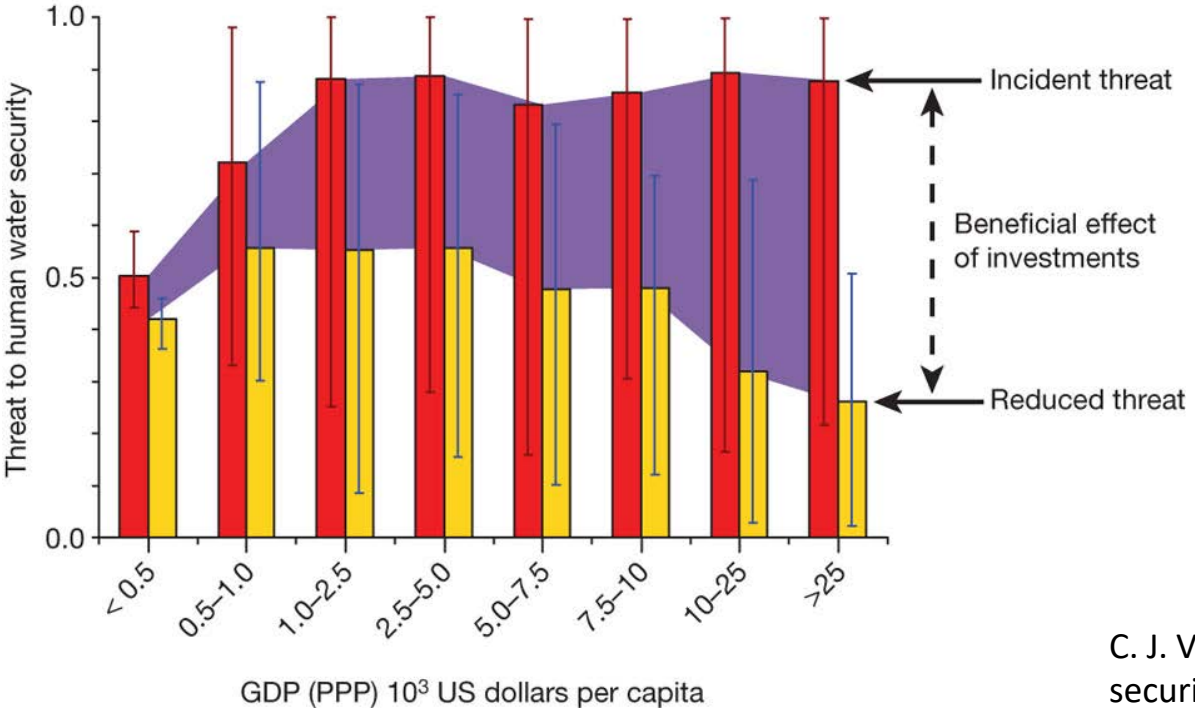


C. J. Vorosmarty, *Nature*, 2010



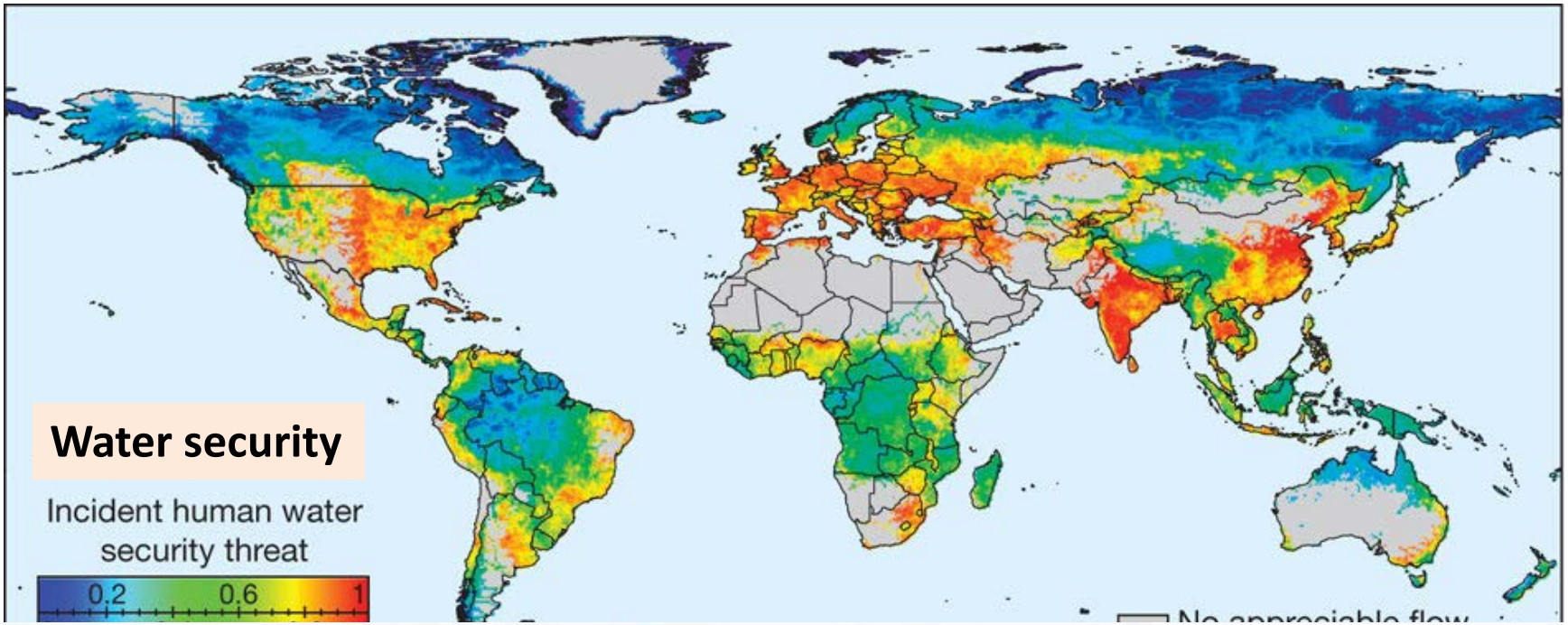
Globally aggregated human water-security threat indices linked to population & level of economic development

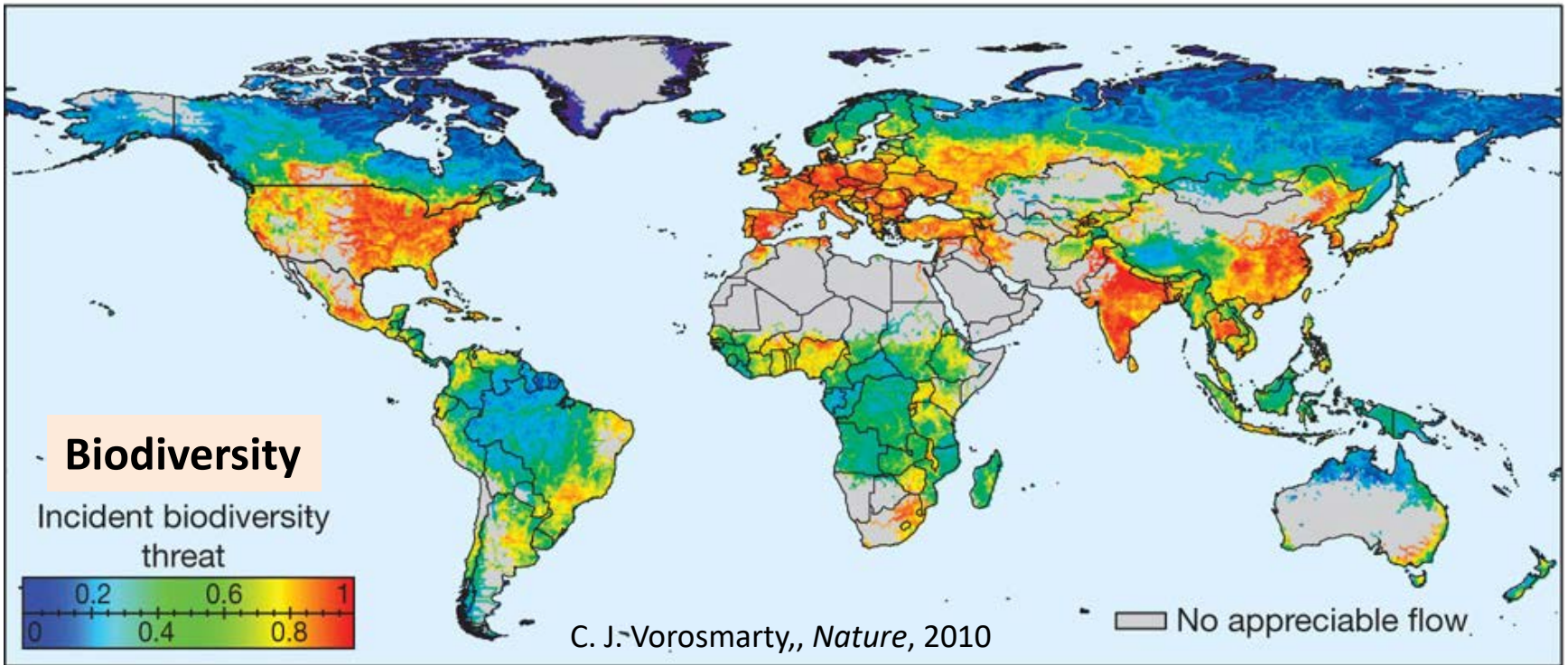
- Investments in engineering infrastructure & services improve water security, w/ their value expressed here in reduced threat units.
- Net benefits accrue to only a fraction of global population.



Technology investments greatly benefit wealthy nations, shifting them from most to least threatened.

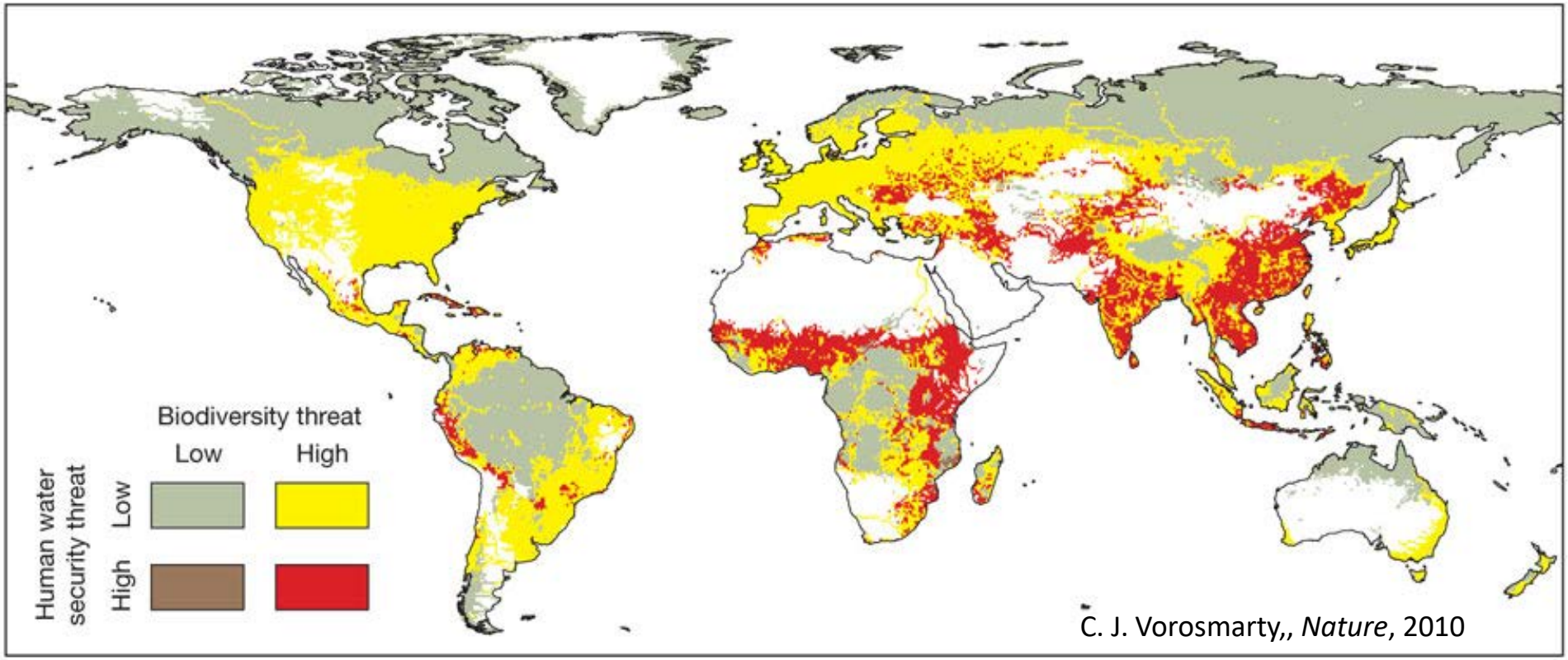
C. J. Vorosmarty, Global threats to human water security & river biodiversity, *Nature*, Sept 2010





C. J. Vorosmarty,, *Nature*, 2010

Correlation – biodiversity & water-security threats



C. J. Vorosmarty,, *Nature*, 2010

My comment: There are many pubs that identify the problem, and many that also provide the general framework for solutions. The challenge is to translate these into actual solutions!

IC-3

Water security, fresh water & ecosystem services

Freshwater resources, including rivers, lakes & wetlands, are degrading at the fastest rate compared to any other major biome

→

This poses a key threat to water security & related ecosystem services

↓

Many water-related ecosystem services are clearly related to water security for humans, e.g. drinking-water provision

←

Less-obvious services are just as important: e.g. sediment flows underpin land integrity, maintaining the resilience of coastal & delta regions to extreme weather events, such as storms & flooding

Four broad categories of services provided by fresh water & related natural systems express the close & mutually dependent relationship between ecosystems & water security:

a. Provisioning services
b. Regulating services
c. Supporting services
d. Cultural services

Examples??

IC-4

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

Water security, fresh water & ecosystem services

Four broad categories of services provided by fresh water & related natural systems express the close and mutually dependent relationship between ecosystems & water security:

a. Provisioning services or goods, which are often more visible & traded, including food, fibres & energy

b. Regulating services, such as water purification, groundwater recharge & balancing, prevention of saltwater intrusion into coastal watersheds, flood control, & sediment transport & deposition

c. Supporting services, which underpin other services, such as nutrient cycling, soil formation, primary production, habitat provision & biodiversity maintenance

d. Cultural services, ranging from recreational opportunities to aesthetic & spiritual values.

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

Increasing water security through natural infrastructure

Solutions for water security that incorporate natural infrastructure can enhance efficiency, effectiveness & equity, but also spur implementation & progress towards long-term availability of water for all. Benefits include, among others:

- Increase in drinking water supply: Watershed management saved US $5 billion in capital costs for New York City & US $300 million annually, & storage of Beijing's drinking water in Miyun watershed forests is worth US $1.9 billion annually.

http://switchboard.nrdc.org/

http://www.pmwp.org/

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

Increasing water security through natural infrastructure (cont.)

- Improved sanitation & wastewater management: The Nakivumbo swamp provides water purification for Kampala, Uganda worth US $2 million per year compared to costs of US $235,000.

pectis.files.wordpress.com

http://i.telegraph.co.uk/

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

Increasing water security through natural infrastructure (cont.)

- Increased food security: Tonle Sap lake & Mekong river fisheries supply 70-75% of people's animal protein intake in Cambodia; they are worth up to US $500 million annually & employ 2 million people.

www.svietnamtravel.com

http://d2ouvy59p0dg6k.cloudfront.net/

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

Increasing water security through natural infrastructure (cont.)

- Reliable energy security: Investment in soil conservation has significantly extended the life expectancy of the Itaipu dam in Brazil and Paraguay, & watershed management has been worth US $15-40 million for the Paute hydro-electric scheme in Ecuador

http://www.fao.org/

http://brassetravel.com/

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

Increasing water security through natural infrastructure (cont.)

- Drought management: Watershed restoration on the Loess Plateau, China has eliminated the need for drought-related emergency food aid to a region that is home to 50 million people.

en.wikipedia.org

http://arnenaessproject.org/

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

Increasing water security through natural infrastructure (cont.)

- Climate change resilience: With investment in developing skills & water institutions, people in the Pangani River basin, Tanzania, are negotiating 'environmental flows' to sustain the ecosystem services they need for climate change adaptation, food & water security.

http://www.panganibasin.com/

http://www.waterandnature.org/

Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

Increasing water security through natural infrastructure (cont.)

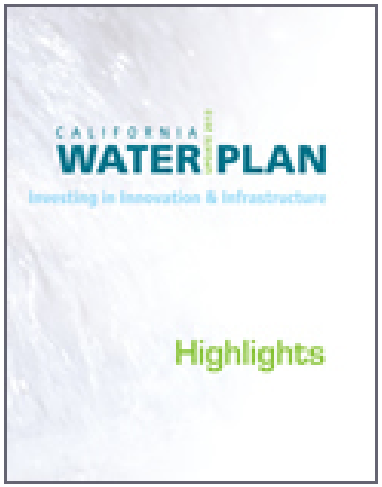
- Restored rivers: In the USA, 15 jobs are created for every US $1 million invested in river restoration.

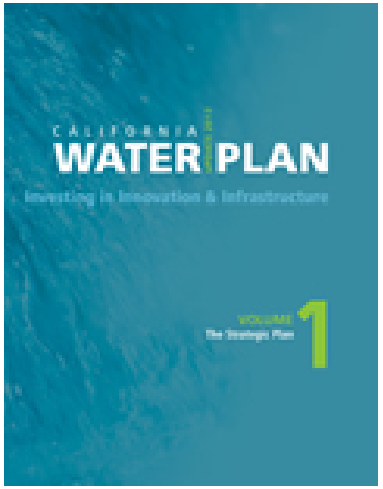
http://www.dredgingtoday.com/

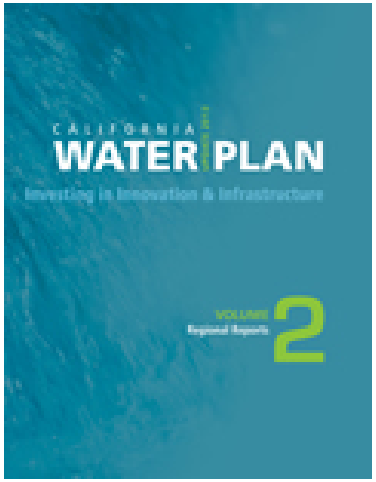
http://www.dredgingtoday.com/

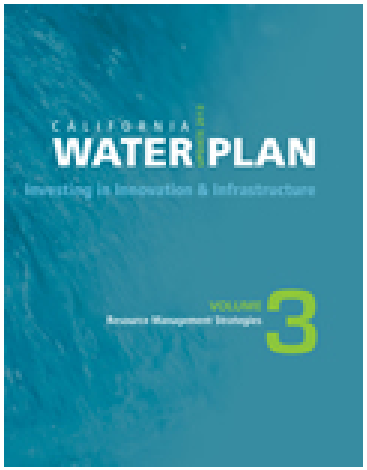
Water Security & the Global Water Agenda, A UN-Water Analytical Brief, 2013

California Water Plan, 2013









http://www.waterplan.water.ca.gov/cwpu2013/

IC-5

How Our Past Shaped the 21st Century

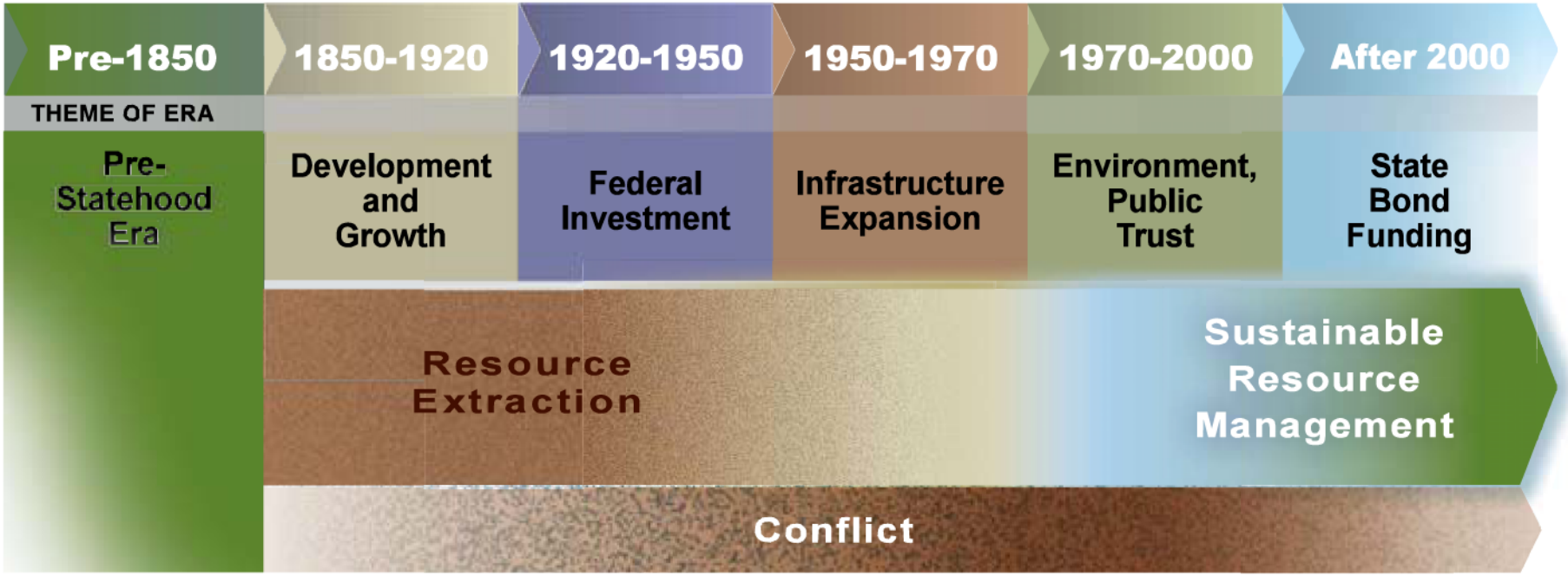
CA Water Plan, 2013

Pre-Statehood: Tribal Practices Promoted Sustainability

California's natural resources were carefully managed by Native American tribes, promoting sustainability to provide for the people for thousands of years. Tribal watershed management mimicked nature, enhancing the resources in many ways.

19th and 20th Centuries: Infrastructure Investments Promoted Growth and Economic Development

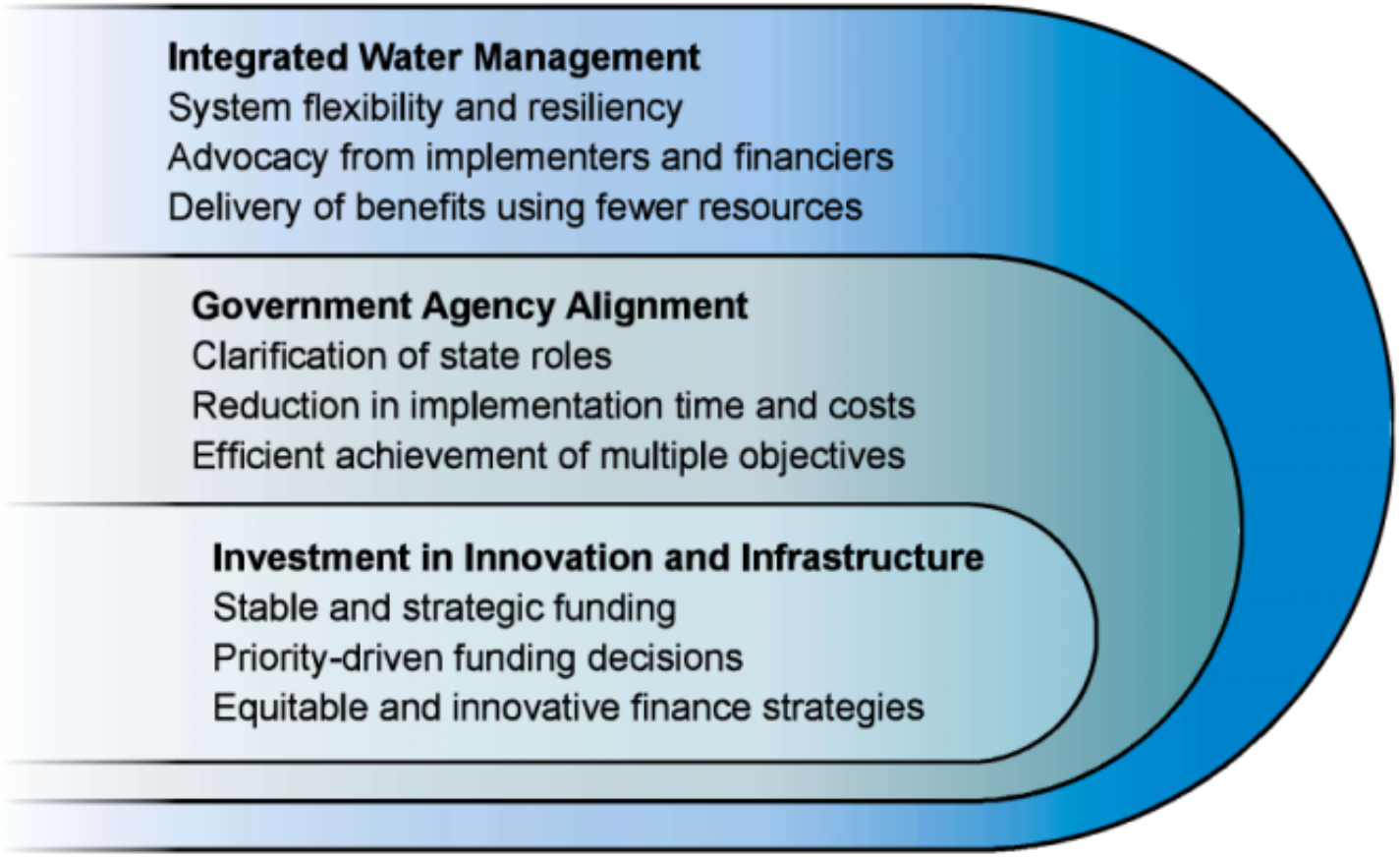
California invested in water and flood management infrastructure to promote growth and economic development in rural, suburban, and urban communities. This involved a period of resource extraction that led to a booming economy with benefits still enjoyed today, while at the same time creating a number of unintended consequences, including environmental degradation. Environmental laws and regulations were enacted in the latter part of the 20th century to help remedy the consequences and restore the environment.



California's water landscape

CA Water Plan, 2013

California Water Plan – themes



CA Water Plan, 2013

Water security

January 2017
Roger Bales

Topics for class

1. Definitions of water security
2. Water security assessment in a global context
3. Elements of California water security

Goals

1. Develop an understanding of what elements define a region's water security
2. Place water security in a societal context
3. Begin to assess California's water security, in a historical context

Questions

1. Your definition of water security, globally & for California?
2. For California, major areas for conflict? Compromise?
3. Fundamental barriers to water security, social, political, science, engineering?