

Potential Climate Changes and Transboundary Water Interdependencies

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OUTLINE

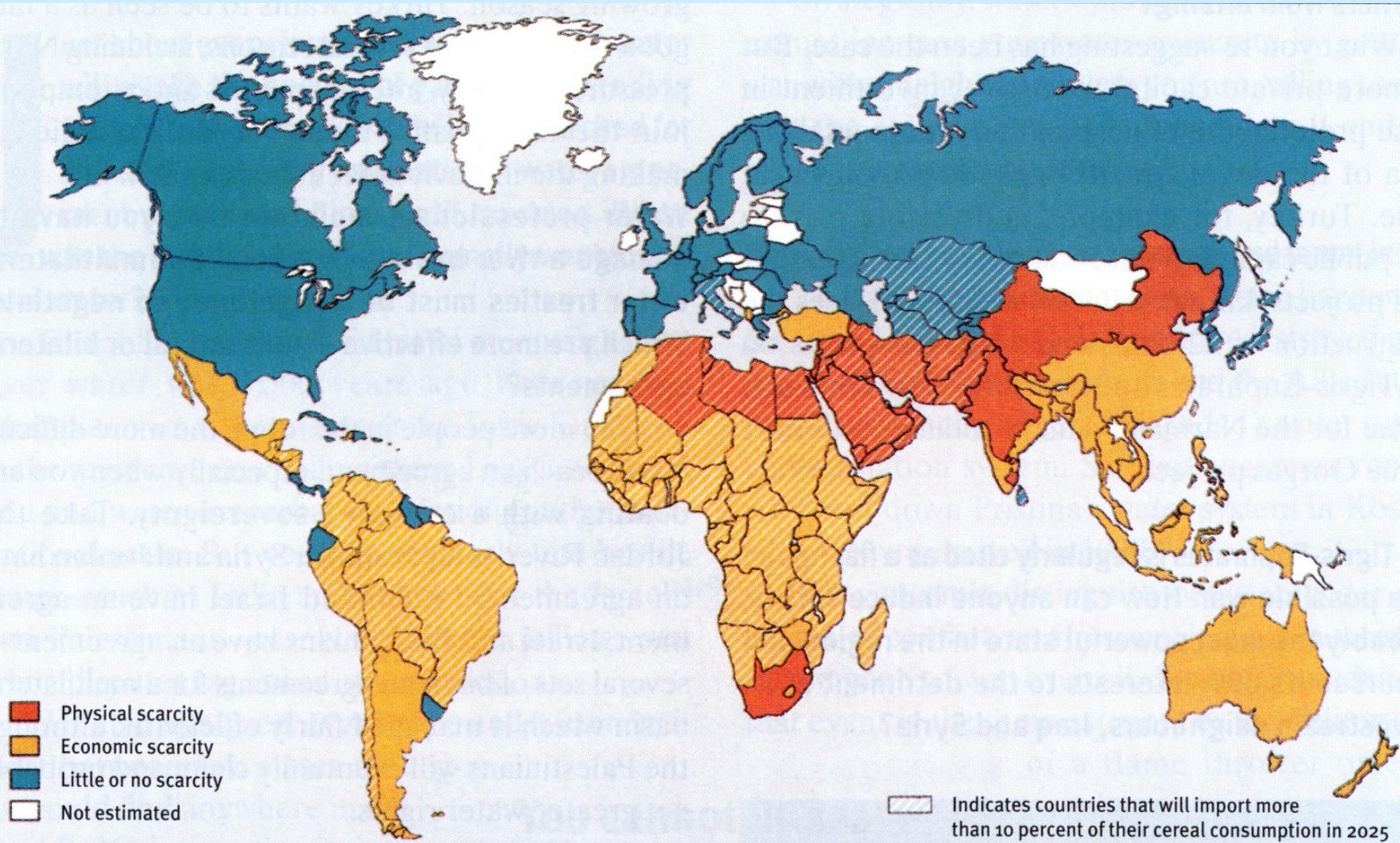
- 1.0 Challenges, Opportunities and Hydrodiplomacy**
- 2.0 Water Interdependencies, Legal Regimes and Climate Changes**
- 3.0 Increasing the Knowledge about Transboundary Aquifers: “Seen and unseen boundaries”**
- 4.0 How to Operate in Volatile and Vulnerable Environments**



“The laws of its (percolating groundwater) existence and progress cannot be known or regulated. It rises to great heights, and moves collaterally by influences beyond our apprehension. These influences are so secret, changeable, and uncontrollable, we cannot subject them to regulations of law, nor build upon them a system of rules, as has been done with streams of the surface”.

Roath v. Driscoll

Connecticut Supreme Court 1880



Projected water scarcity in 2025.

INTERLOCKING CRISES

- **CLIMATIC SHIFTS**
- **MEGARUPTURES**
- **METABOLISM**
- **SOCIO-POLITICAL CONTEXT**
- **TRANSBOUNDARY DEPENDENCIES**
- **FAST PACE OF TECHNOLOGICAL DEVELOPMENT**

The Competition for Water

- Use vs. Use
- Present vs. Future
- Region vs. Region
- Quantity vs. Quality
- Water vs. Other Natural Resources
- Water vs. Other Social Priorities

Potential Water Conflicts Arise:

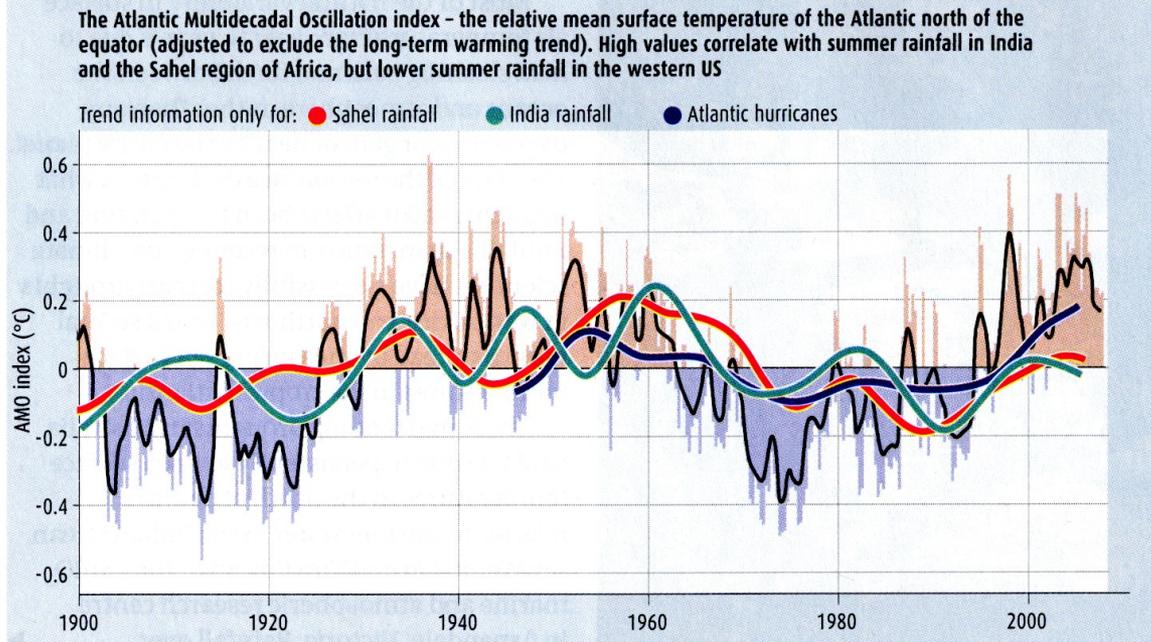
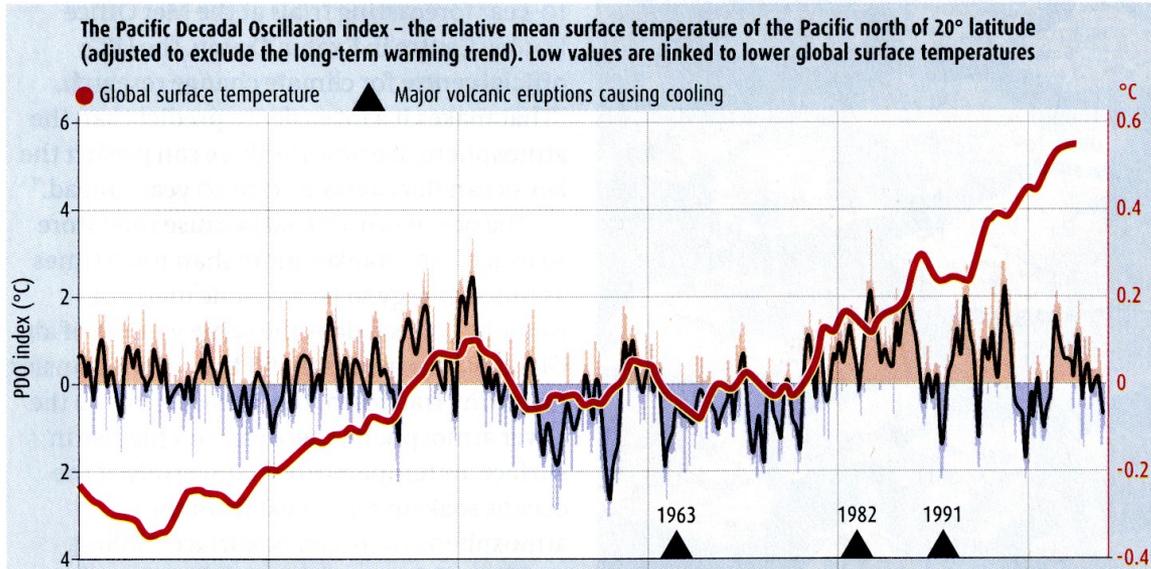
- Out of scarcity (permanent and temporary)
- Out of differences of goals and objectives
- Out of complex social and historical factors (such as pre-existing antagonisms)
- Out of misunderstandings or ignorance
- Out of skewed power between localities, regions, or nations
- Out of significant data gaps or question of validity and reliability
- Out of particular hydropolitical issues at stake (e.g. dam construction)

The Problem is Global

The Solution is Possible



Long-term fluctuations in sea surface temperatures have a huge impact on surface temperatures and rainfall around the globe



SOURCE: NOAA, GISS, ZHANG 2006

SPECIAL REPORT GLOBAL WARMING

TIME

**BE
WORRIED.
BE **VERY**
WORRIED.**

Climate change isn't some vague future problem—it's already damaging the planet at an alarming pace. Here's how it affects you, your kids and their kids as well

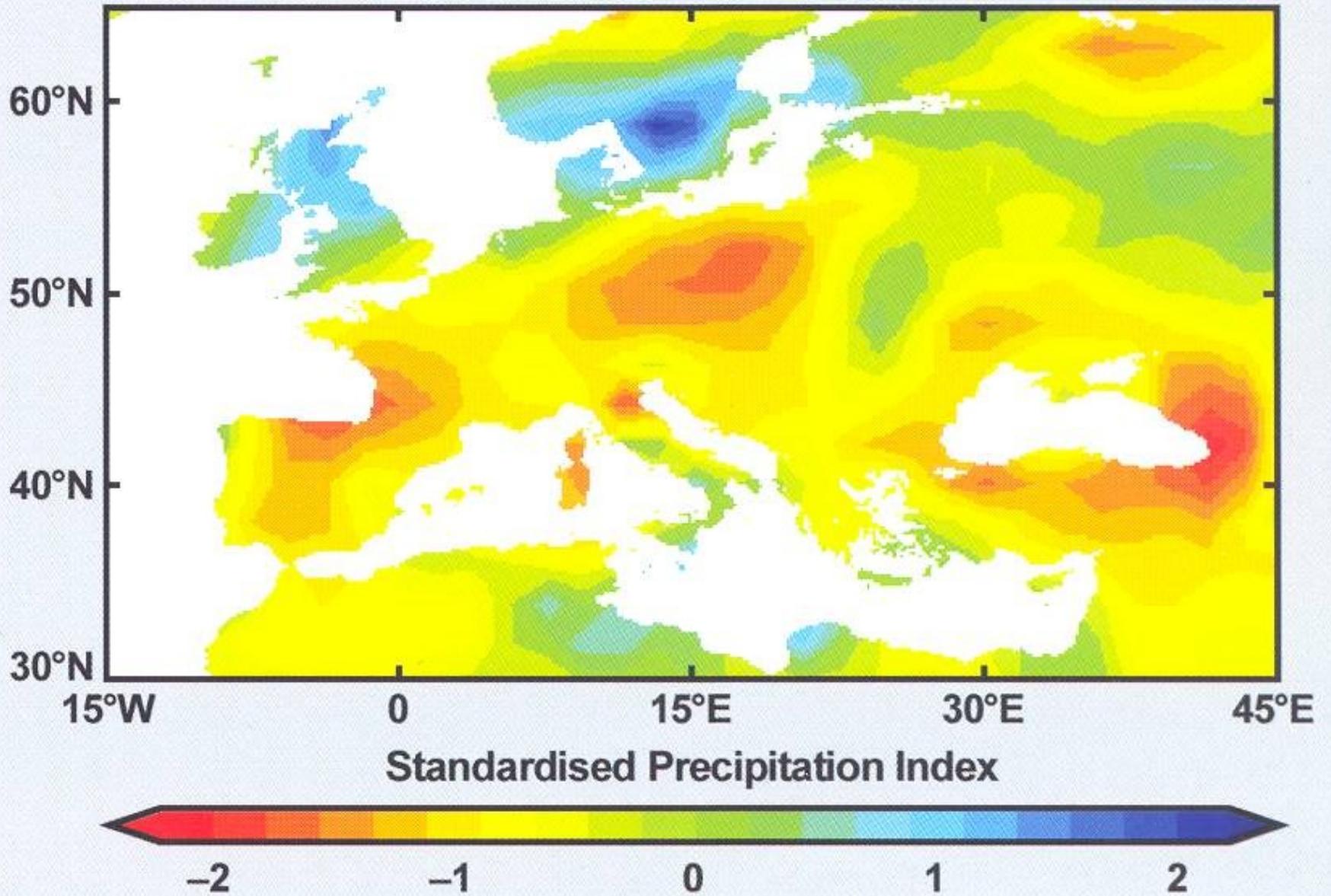
EARTH AT THE TIPPING POINT

HOW IT THREATENS YOUR HEALTH

**HOW CHINA & INDIA CAN HELP
SAVE THE WORLD—OR DESTROY IT**

THE CLIMATE CRUSADERS





Extent and severity of the 2003 drought

CLIMATE

Nary a Drop to Spare

Drought grips the West

Three generations of the Messner family have farmed the land near Twin Falls, Idaho, but none had ever seen it get this dry. It's worse even

Growing Thirst

Population growth is exploding in western states. The driest of all, Nevada, leads the way with a 86 percent increase from 1990 to 2000.

Urban Drain In eastern metropolitan areas, water consumption—for manufacturing, drinking, cleaning, flushing, and sprinkling—rivals that of farmers in the West.

Parched Earth

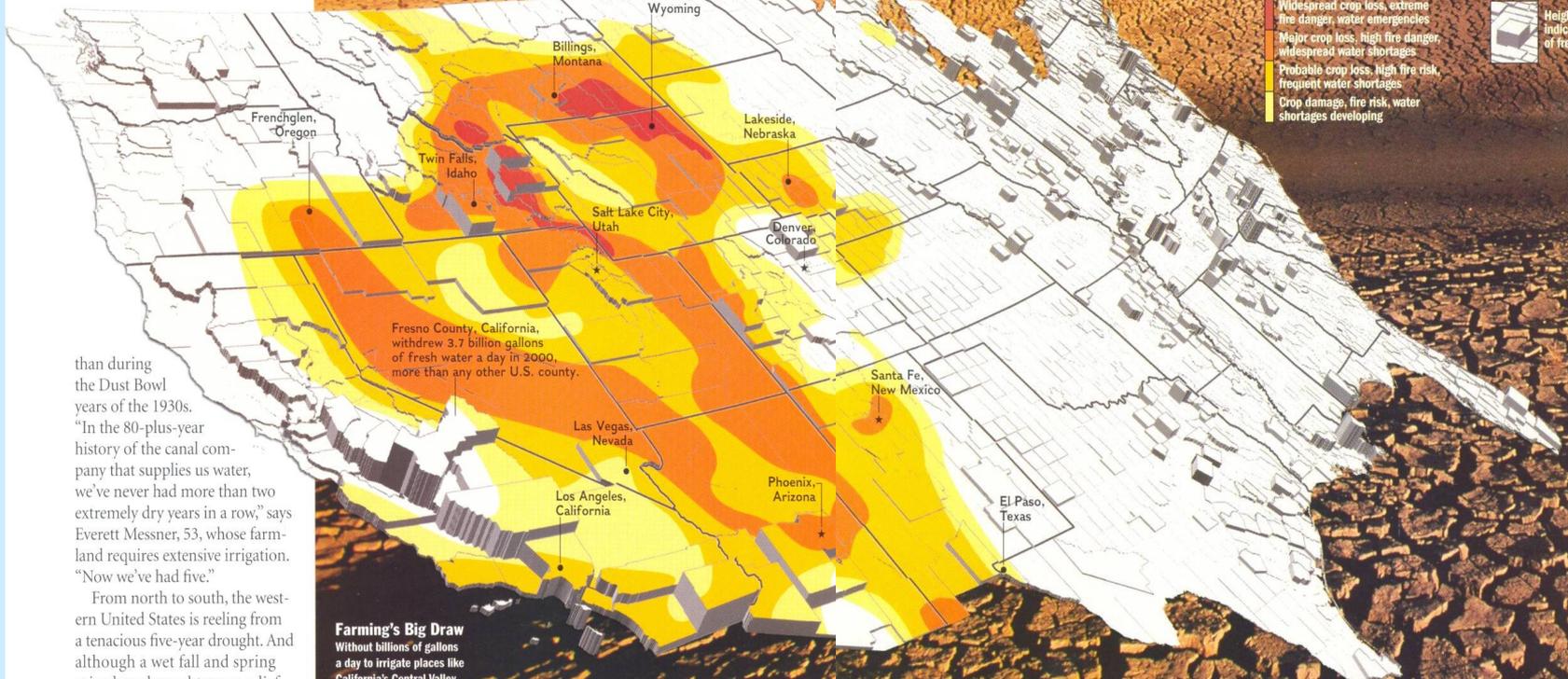
Five years into a severe drought, there's not enough water to meet the diverse needs in the western United States. Farmers are leaving dry fields fallow, cities are imposing water-use restrictions on residents, and hydroelectric plants are scaling back power production.

Drought condition, early fall 2004 (prior to October rains)
Categories based on multiple indicators

- Widespread crop loss, extreme fire danger, water emergencies
- Major crop loss, high fire danger, widespread water shortages
- Probable crop loss, high fire risk, frequent water shortages
- Crop damage, fire risk, water shortages developing

Fresh water use, 2000 (most recent U.S. Geological Survey data)

Height of county indicates volume of fresh water use.



than during the Dust Bowl years of the 1930s. "In the 80-plus-year history of the canal company that supplies us water, we've never had more than two extremely dry years in a row," says Everett Messner, 53, whose farmland requires extensive irrigation. "Now we've had five."

From north to south, the western United States is reeling from a tenacious five-year drought. And although a wet fall and spring rains have brought some relief to sections of the Southwest, the drought is far from over, says

Farming's Big Draw

Without billions of gallons a day to irrigate places like California's Central Valley, the supply of fruits and vegetables stocking U.S. grocery stores would wither.

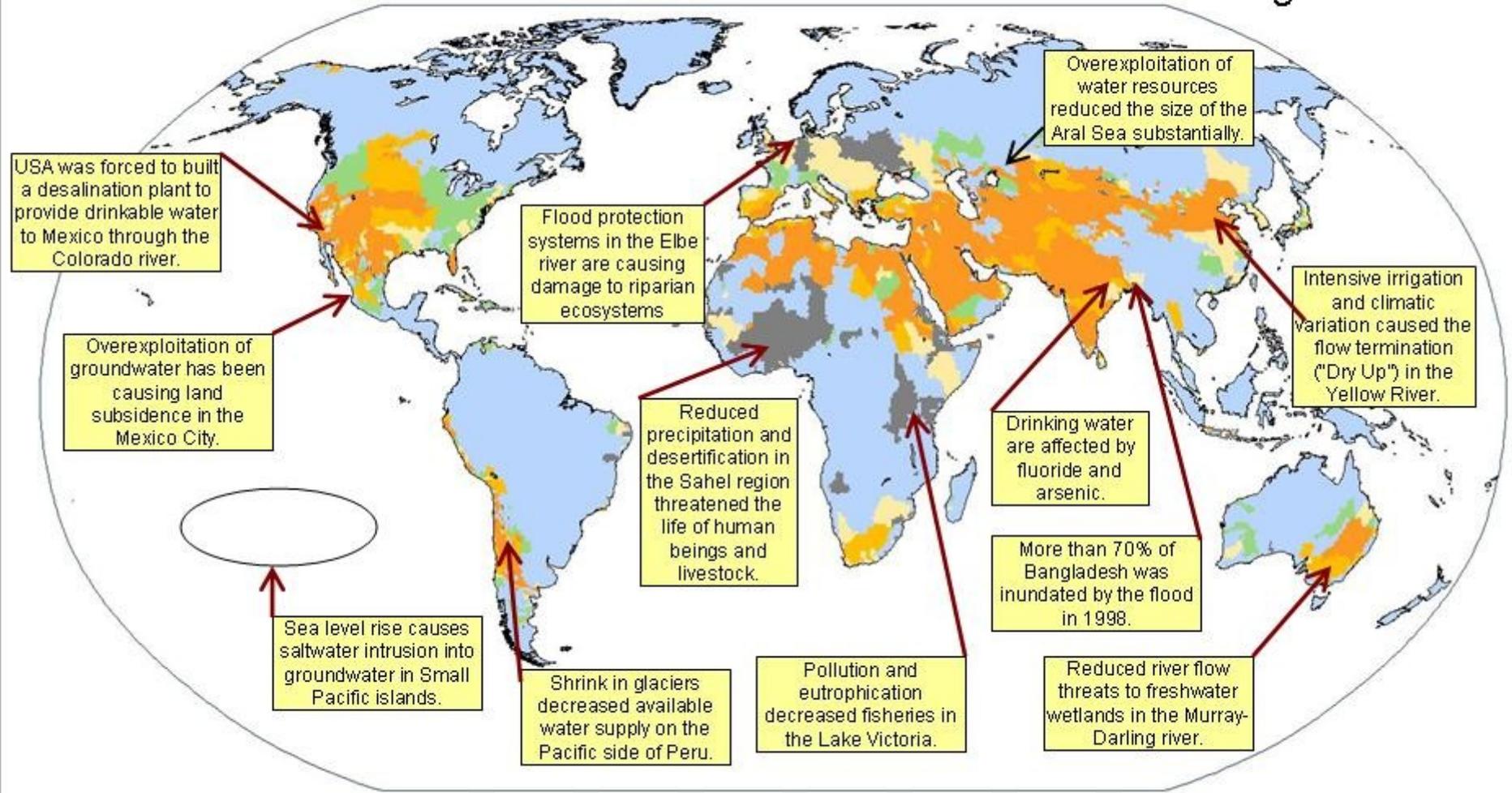
PHOTO: SMITH RESERVOIR NEAR ALAMOSA, COLORADO BY JOHN EASTCOTT AND YVA MAMATIUK

SOURCES: (DROUGHT) "U.S. DROUGHT MONITOR," COMPILED BY NATIONAL DROUGHT MITIGATION CENTER; NOAA; USDA; WATER USES; NATIONAL GEOGRAPHIC MAPS

Borders and structure of GIWA subregion 22: Black Sea

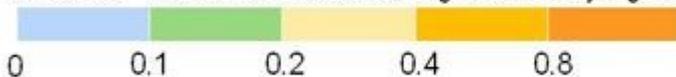


Current Vulnerabilities of Freshwater Resources and their Management



Water Stress Indicator: Withdrawal-to-Availability Ratio

No Stress Low Stress Mid Stress High Stress Very High Stress



no/low stress and per capita water availability <math>< 1700 \text{ m}^3/\text{year}</math>

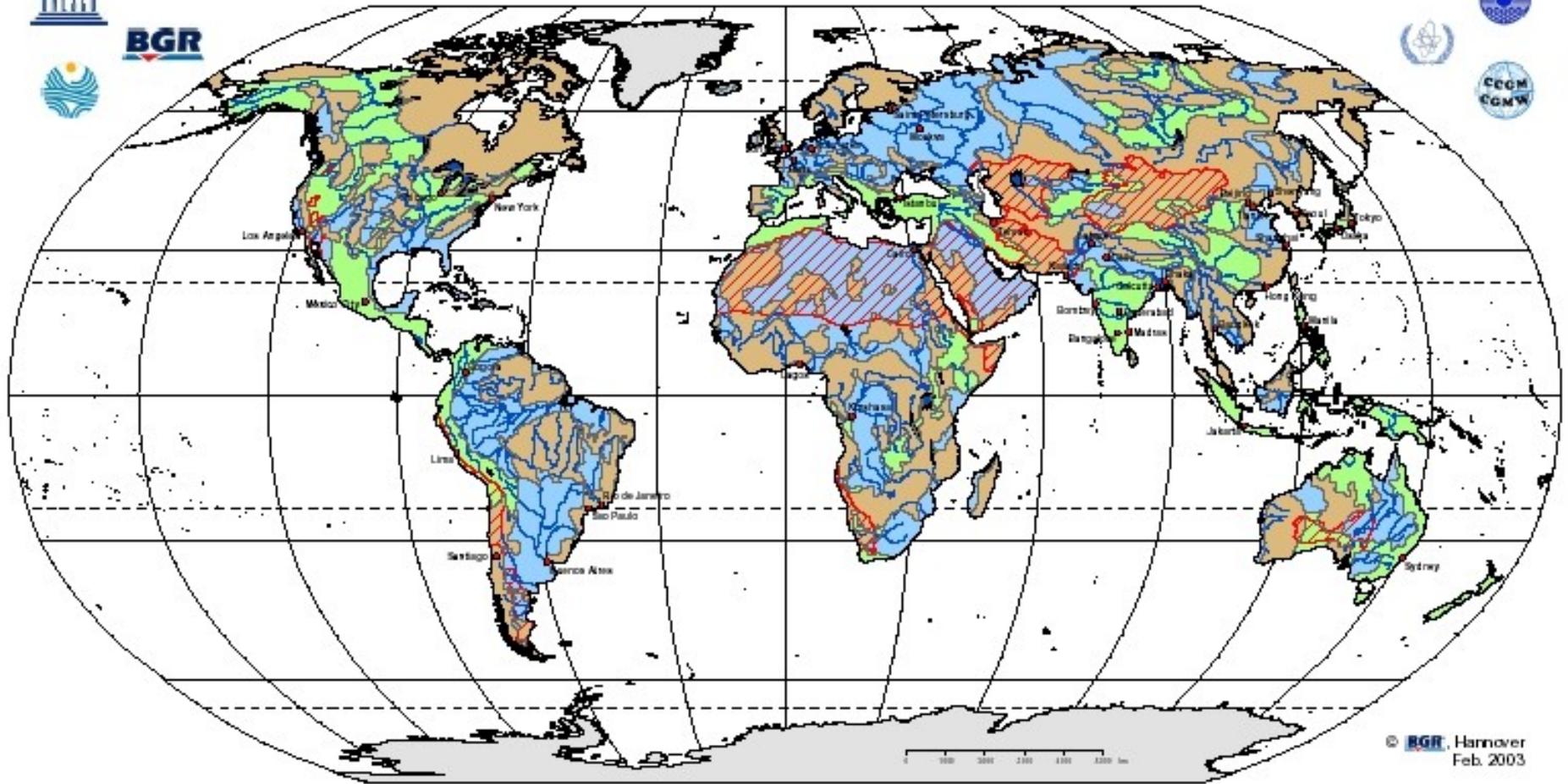
Water withdrawal: water used for irrigation, livestock, domestic and industrial purposes (2000)

Water availability: Average annual water availability based on the 30-year period 1961-90

Groundwater Resources of the World



BGR



© BGR, Hannover
Feb. 2003

Hydrogeology

- major groundwater basin with highly-productive aquifers
- area with complex structure including some important aquifers
- area with generally poor aquifers, locally overlain by river-bed aquifers

Surface Water

- polar ice
- large freshwater lake
- major river

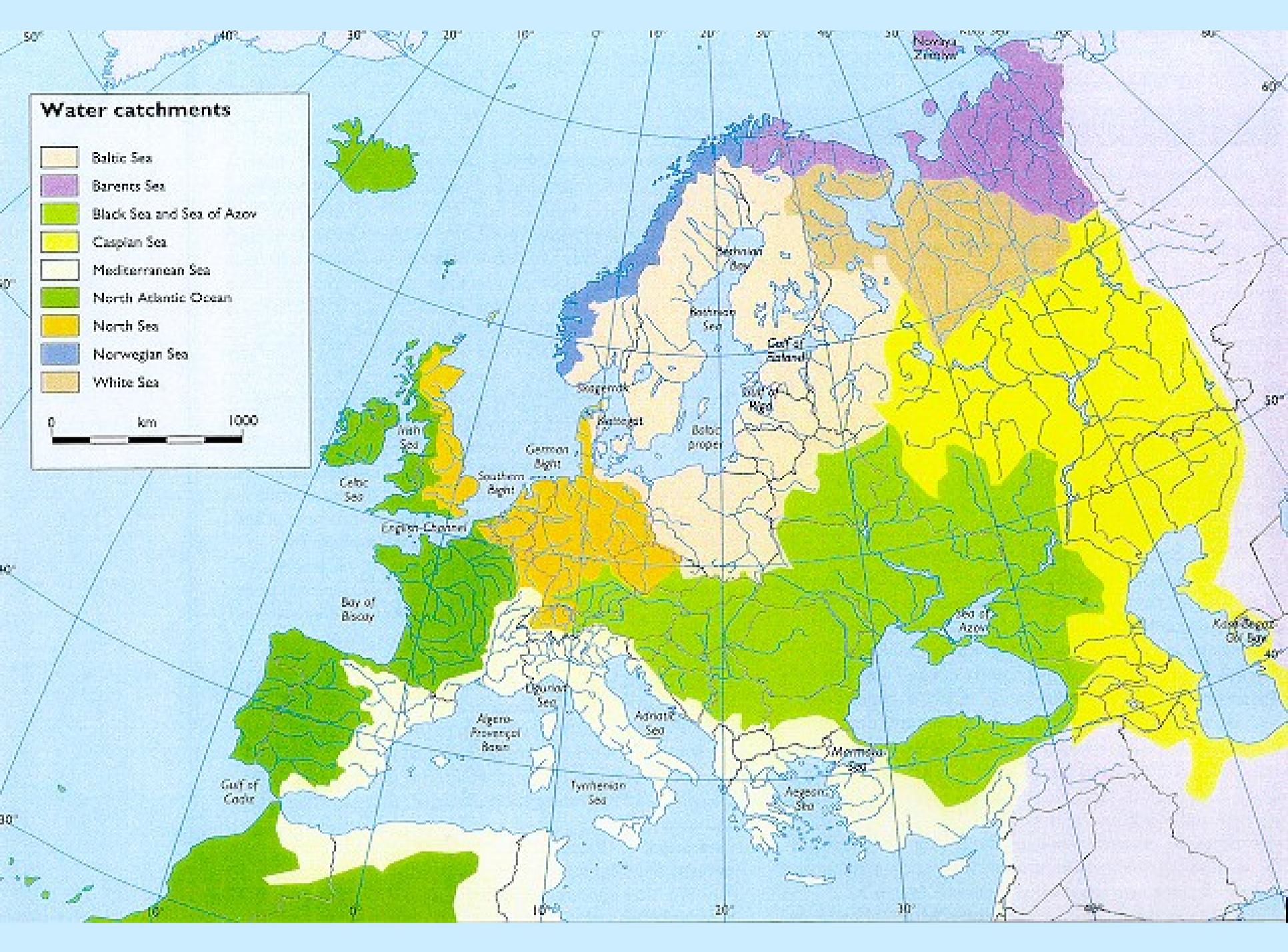
Other Geographic and Climate Features

- selected megacity
- non-renewed groundwater resources (rainfall < 200 mm/yr)

reprinted from: BGR, Hannover, 2003, "Groundwater Resources of the World", BGR 110, 1-100, 100-105, 105-106

Water catchments

- Baltic Sea
- Barents Sea
- Black Sea and Sea of Azov
- Caspian Sea
- Mediterranean Sea
- North Atlantic Ocean
- North Sea
- Norwegian Sea
- White Sea



Why is IWRM Needed?

- Water is becoming increasingly scarce, more competition among uses, increased demands
- Need more efficient mgmt within each sector
- Social needs, values evolve - need comprehensive, multiobjective approaches (envir, SusDev, equity)
- Set priorities for investment strategy;
- Put water to best use, greatest social value
- Strategies for emergencies-mitigate worst impacts of floods, droughts

Integrated WRM

- Integration is an IDEAL which can be approached through better coordination and restructuring
- Integration of policies, institutions, sectors, planning, management & regulatory decisions
- Modern water resources management requires constant adaptation to new needs, ideas, technologies and societal preferences
- New flexible organizations, reconfigured agencies are needed to accomplish new mgmt objectives

The “Three Paradigms”

[NEPA] National Environmental Policy Act/1970

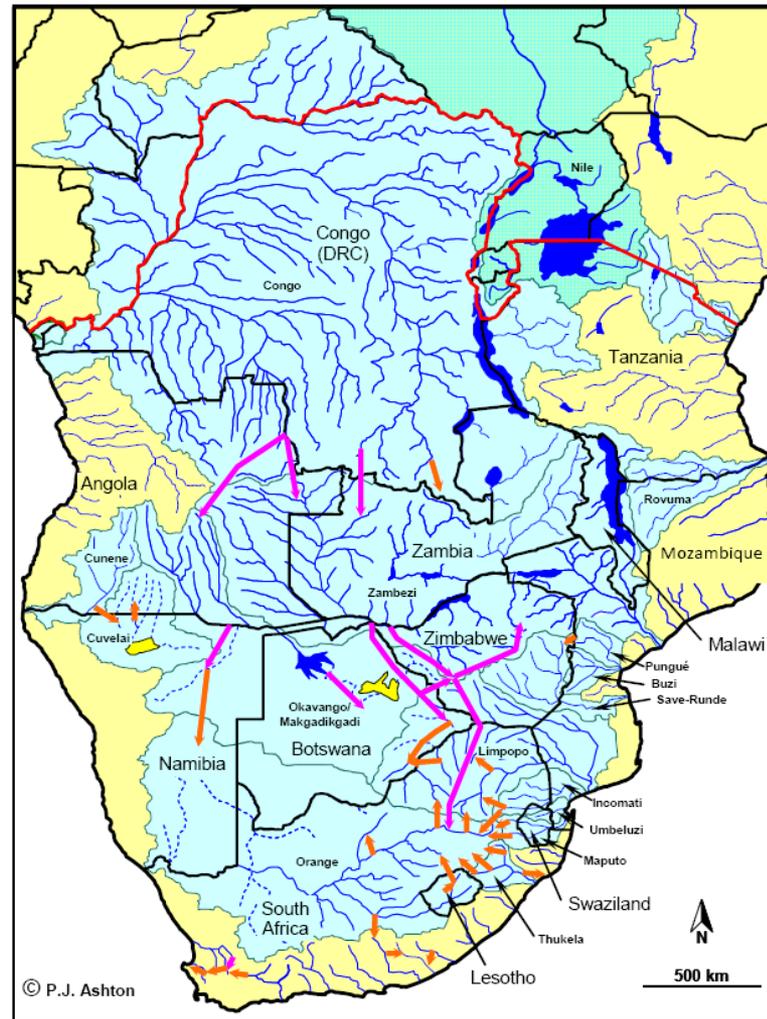
[WFD] Water Framework Directive/2000

[MDGs] Millennium Development Goals/2000

SOME EXAMPLES OF PARADIGM SHIFT

- From extrapolative to anticipatory thinking and planning
- From elitist to participatory water planning and management
- From supply-driven to demand-driven water policies
- From economic emphasis to water as public good
- Recognition of various types of water such as “Blue Water,” “Green Water,” “Virtual Water,” etc.

Figure 3. Inter-basin transfers (IBTs) and the SADC regional integration (image, courtesy of Peter Ashton).



THE PROPOSED BENEFIT-SHARING APPROACH

The proposed benefit-sharing approach is based on nine key elements, which differ fundamentally from the traditional paradigm as elucidated below.

A comparison of the traditional paradigm and the proposed benefit-sharing approach, based on the nine key elements developed in this paper, is presented in table 1.

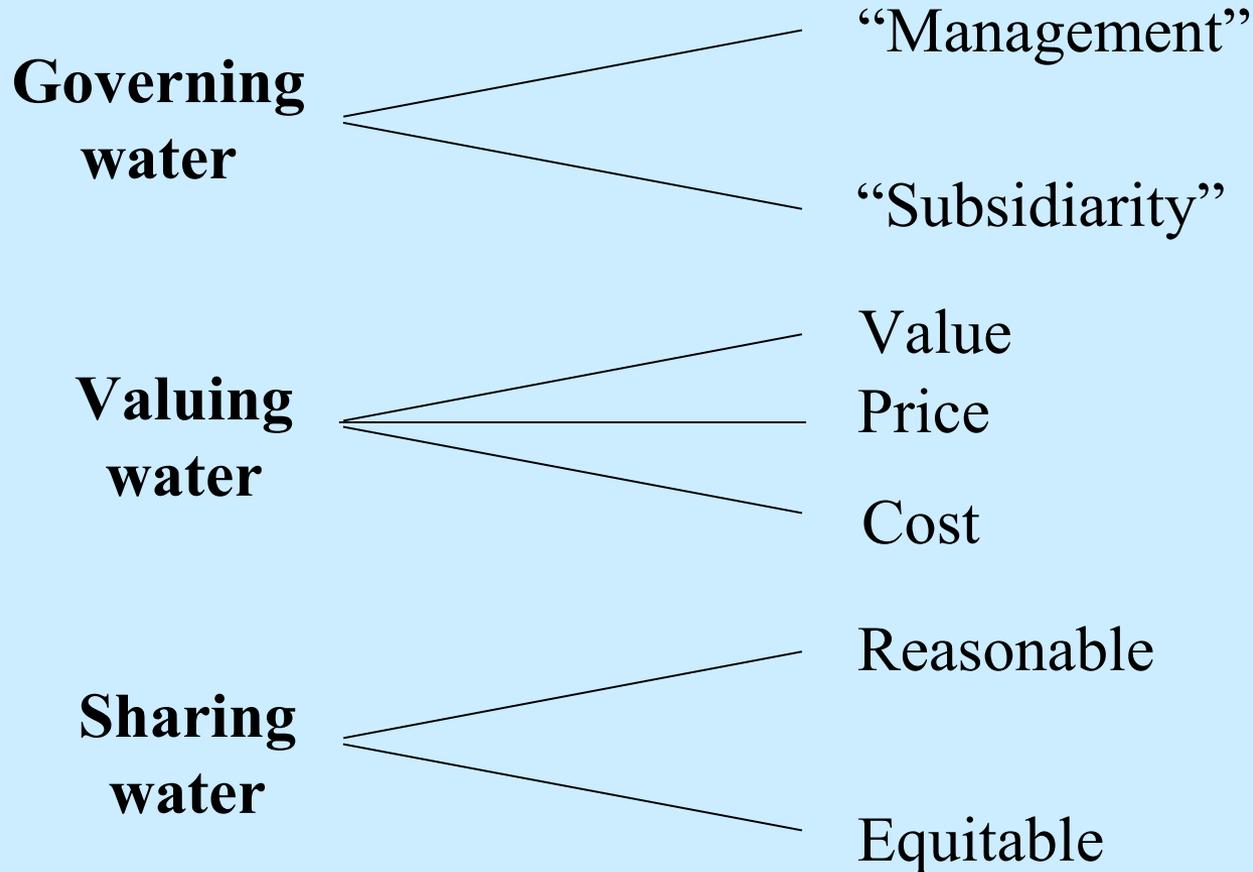
Table 1. Comparison of the traditional paradigm and the proposed benefit-sharing approach.

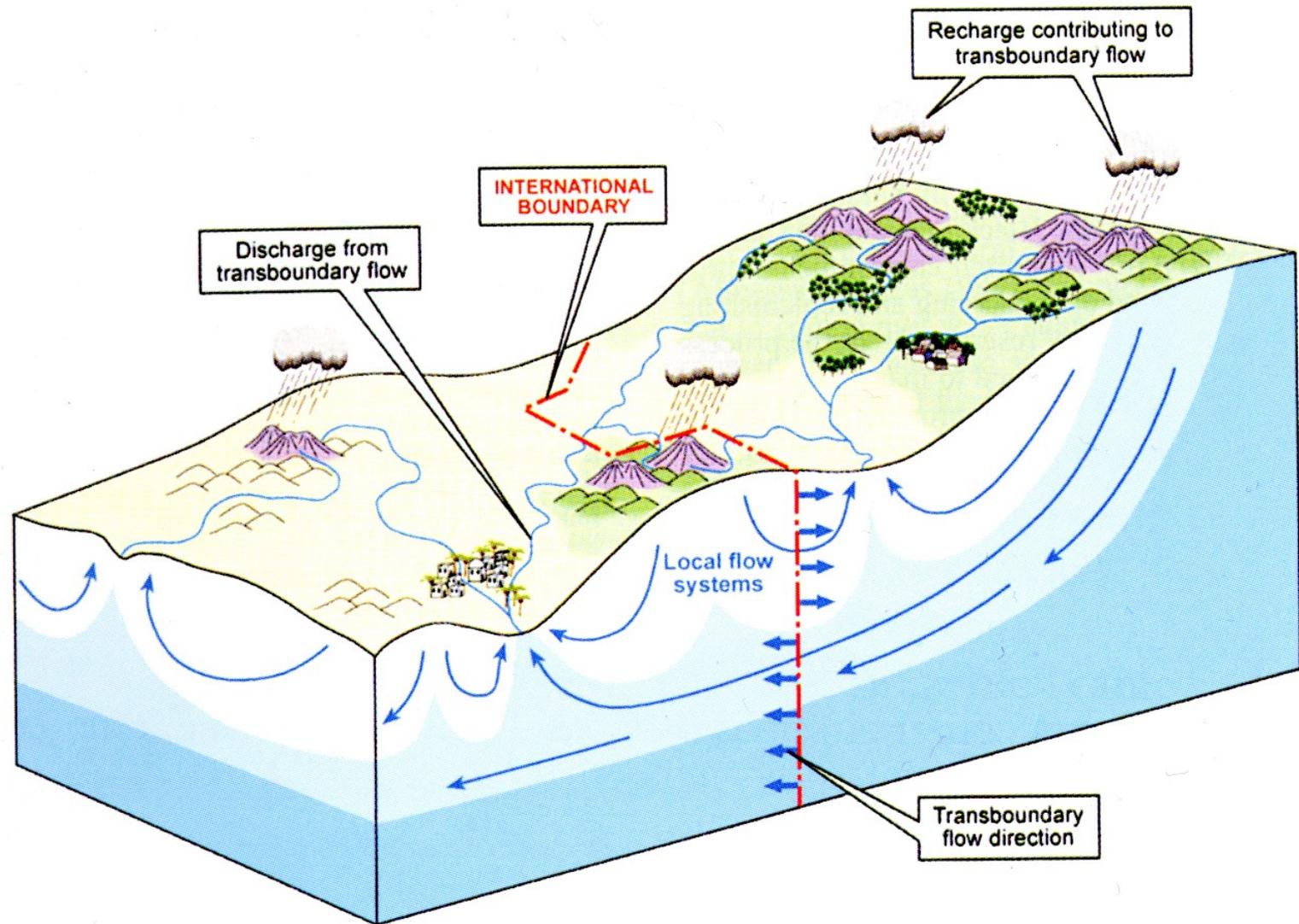
Element	Traditional paradigm	Benefit-sharing paradigm
Perspective on water	Water is treated as a finite stock.	Water is treated as a less finite flux with technological capacity becoming a key variable (Homer-Dixon, 2000).
National sovereignty	Fear of the erosion of sovereignty stunts institutional development (Turton, 2002).	Sovereignty is never eroded by agreement potentially using a PNA model (Nielsson, 1990).
Institutional architecture	Centralized decision-making and hierarchical structure within the context of a negotiated regime (Conca, 2006).	Decentralized decision-making in a matrix-styled structure potentially within the context of a PNA model (Nielsson, 1990; Turton, 2008b).
National security	Water resource management is subsumed to national security concerns, trying to cascade security from the top down.	Human security generates many types of benefits that can be shared, building security from the bottom up.
Scale of optimization	Level of the state within the context of a river basin results in a smaller range of potential solutions.	Level of the hydro-political complex above the state and basin results in a larger range of potential solutions (Ashton and Turton, 2008a; Turton and Ashton, 2008; Turton, 2008b).
Basket of options	Limited by viewing water as a stock with the scale of optimization being the state and basin.	Broader in focus, because water is viewed as a flux, with the scale of optimization being the hydro-political complex.
Scale and remedy	The potential impact of the remedy is limited by the lower scale of optimization.	The remedies to water constraints are sourced outside of the water sector (Allan, 2000) in a hydro-political complex.
Data	Sometimes classified, generally not freely shared and usually contested (Warner, 1996; Phillips et al., 2006).	Declassified, freely shared, institutionalized and usually uncontested (Turton, 2003b; 2008b).
Decision-making	Centralized and hierarchical designed to protect against the erosion of sovereignty, but always taken against a background of imperfect knowledge and mediated by the prevailing threat-perception (Turton, 2003a).	Decentralized and matrix-styled with fears of the potential erosion of sovereignty attenuated by a possible PNA model (Nielsson, 1990). Institutionalized data attenuates the background of imperfect knowledge.
Resulting configuration of hydro-political dynamics	Zero-sum, competitive and unstable in its fundamental configuration, with a high potential for conflict (Phillips et al., 2006).	Positive-sum and stable in its fundamental configuration, with a growing incentive for cooperation (Turton et al., 2008b).

Basics of the New Paradigm

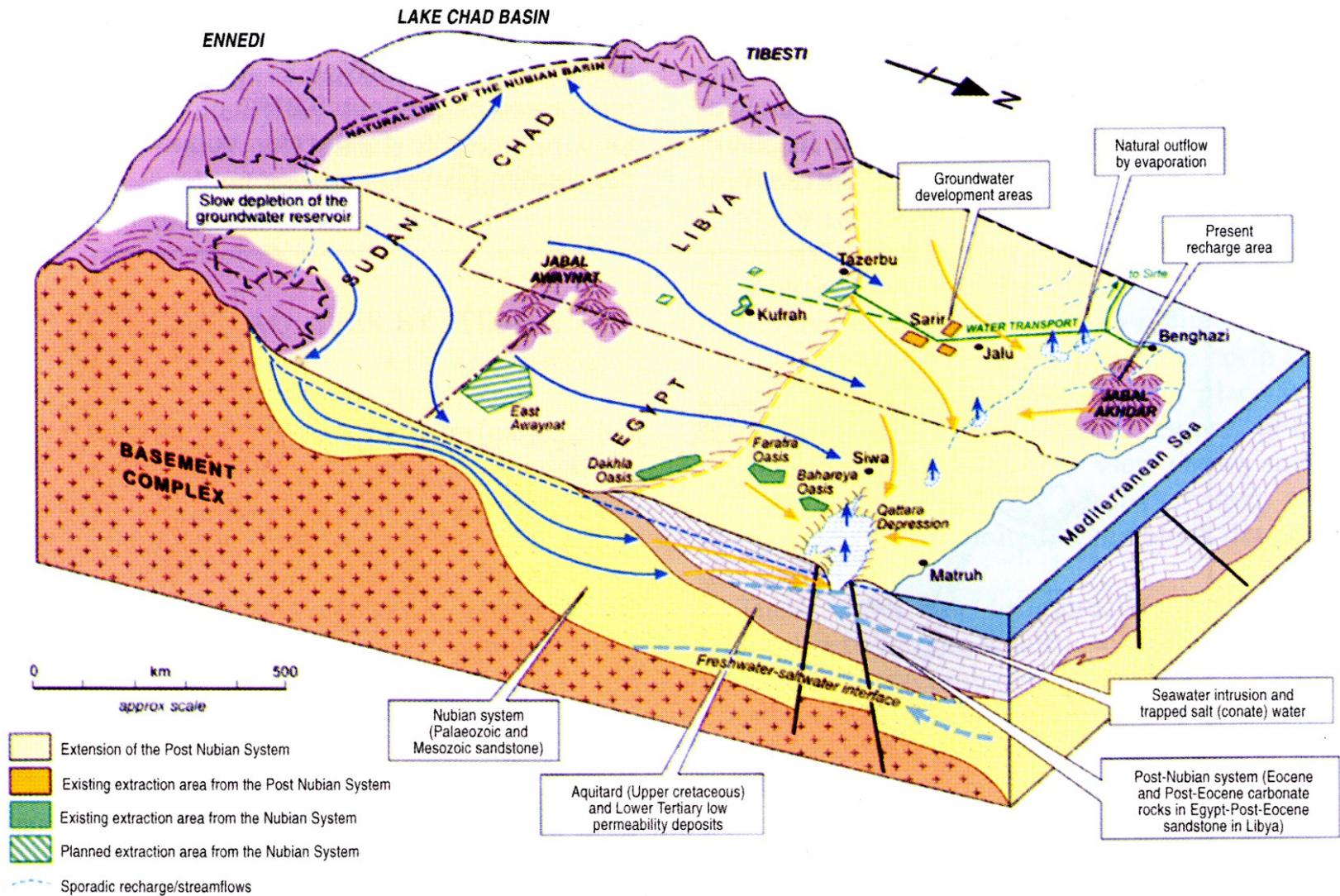
- Duty to Cooperate
- Conjunctive Management
- Integrated Management
- Equitable Utilization
- Sustainable Use
- Minimization of Environmental Harm

THREE KEY ISSUES IN COMPREHENSIVE WATER RESOURCES PLANNING & MANAGEMENT

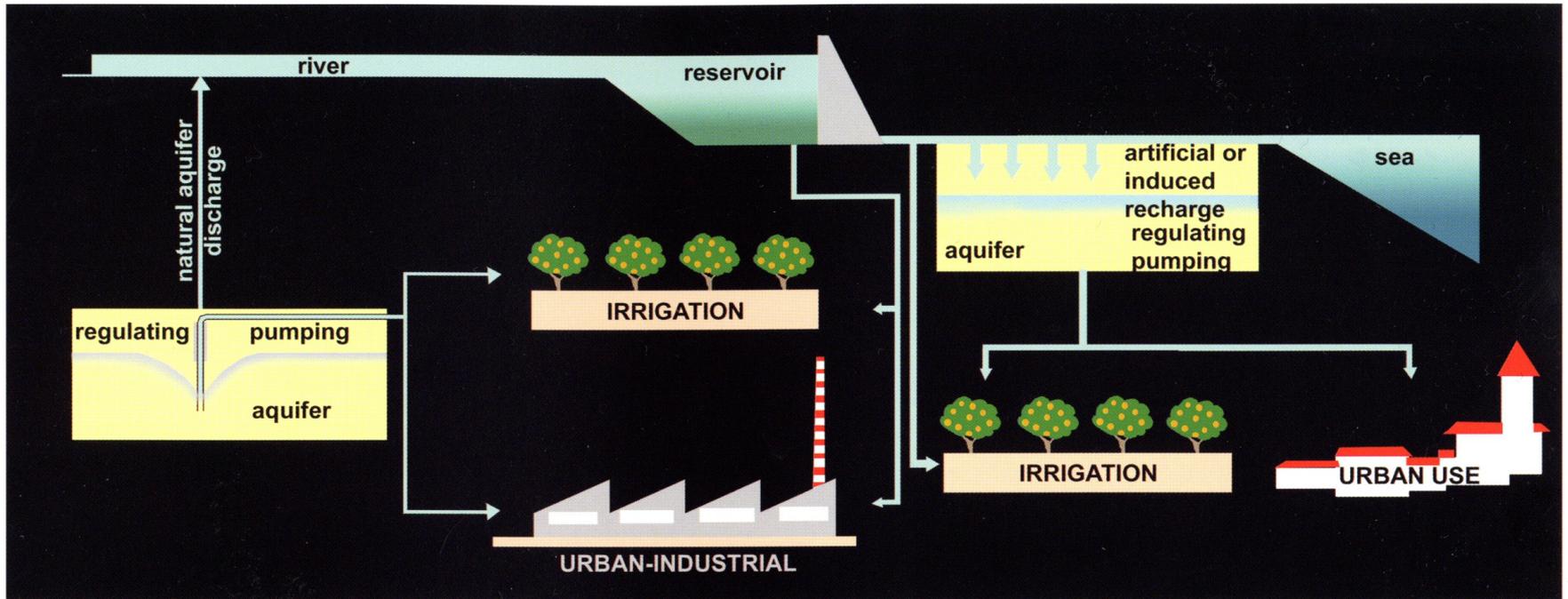




Puri, S. & El Naser, H. (2003). Schematic of a transboundary aquifer. In "Intensive use of groundwater. Challenges and opportunities"



Puri, S. & El Naser, H. (2003). Block diagram of the Nubian aquifer system. In "Intensive use of groundwater. Challenges and opportunities"



A system of conjunctive use of surface water and groundwater, comprising a surface reservoir and two aquifers, one of which is located upstream from the surface reservoir. The diagram also shows the different areas of water demand (urban, industrial and irrigation). Depending on the availability of water in the reservoir, a certain level of demand is met either from surface reserves, or jointly with groundwater, or exclusively by the latter. This system can be complemented with artificial recharge operations so that river water may be stored in the aquifer

Five Major Legal Principles that are Shaping and Will Further Affect the Practice of “Hydrodiplomacy”

1. The Principle of international water and the concept of an international “watercourse;”
2. The Principle of reasonable and equitable utilization, a principle that has generated interminable debates and interpretations as to “reasonableness” and “equity;”
3. Obligation not to cause significant harm and the exercise of due diligence in the utilization of an international watercourse;
4. The Principle of notification and negotiations on planned measures; and
5. The Duty to cooperate, including regular exchanges of data.

Revised and Augmented by
ROBERT D. HAYTON and ALBERT E. UTTON

**TRANSBOUNDARY
GROUNDWATERS:
THE BELLAGIO DRAFT TREATY**

**AGUAS SUBTERRANEAS
TRANSFRONTERIZOS:
ANTEPROYECTO DE TRATADO
"BELLAGIO"**

CiRT

International Transboundary Resources Center
Centro Internacional de Recursos Transfronterizos



Groundwater in
international law
Compilation of treaties
and other legal instruments

ISSN 1014-6679

FAO
LEGISLATIVE
STUDY

86



The Legal Assessment Model

Data Collection Tools

Relevant Factors Matrix: Provides format and method for collection of requisite data & information

Legal Audit: Method for reviewing existing law at international and national levels

Glossary of Terms: Defines terms used in LAM from Interdisciplinary perspective

**Phase I
Data
Collection**

Assesses the quality and quantity of available of the data collected in Phase I

**Phase II
Data
Analysis**

Determine most appropriate method of evaluation based on Phase II data analysis

**Phase III
Evaluation**

Apply most appropriate method of evaluation to determine whether current utilisation of a TWS is consistent with "equitable and reasonable utilisation"

Final Phase

Options for securing legal entitlement based on legal assessment carried out through Phases I-III

Sources of Uncertainty in the Water Management Process

1. Data

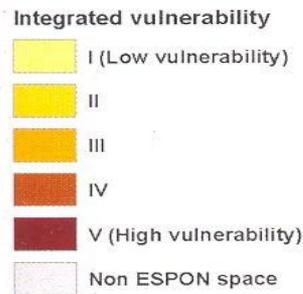
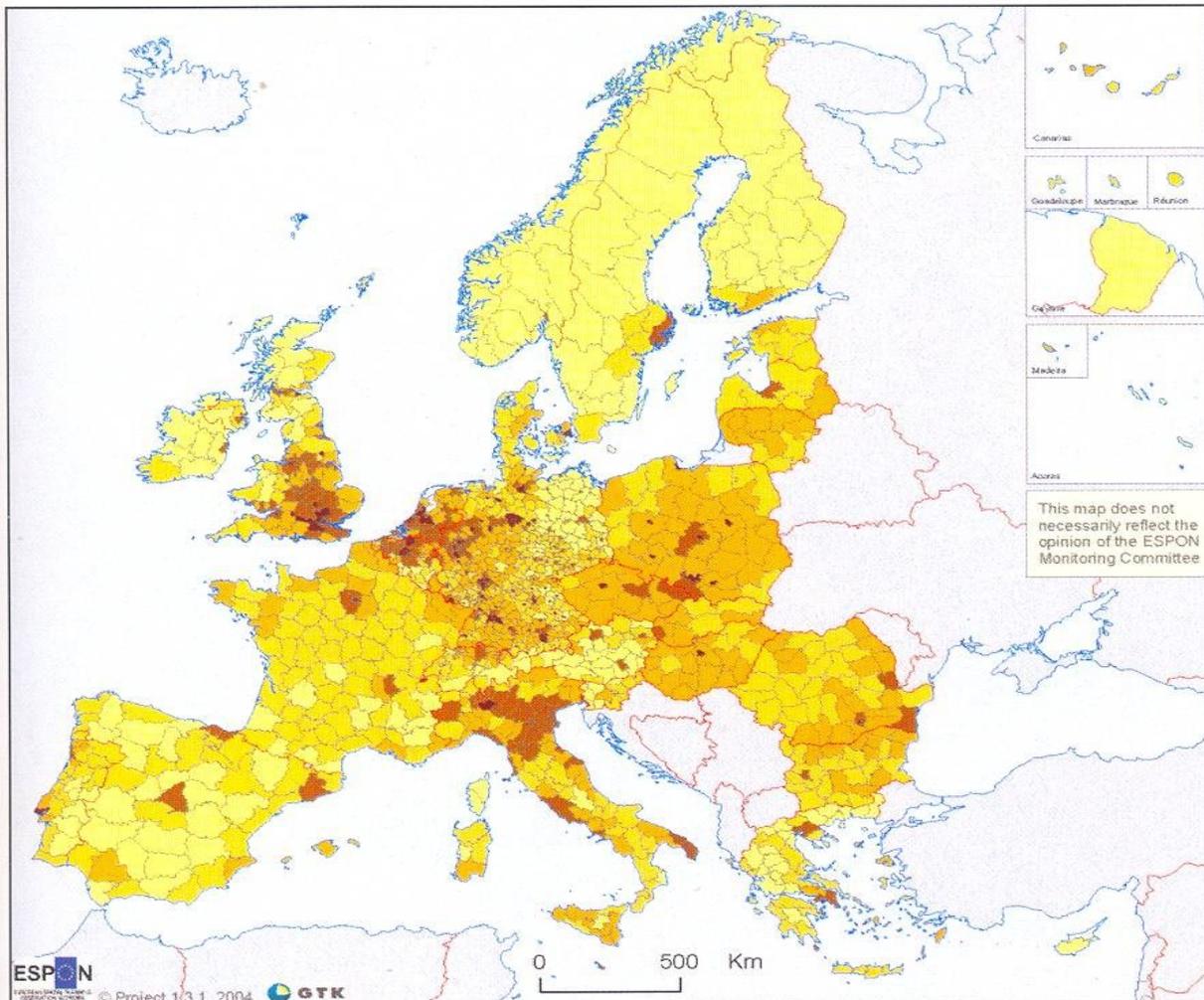
- physical, chemical, biological, etc.
- scale problems (temporal and spatial)

2. Model

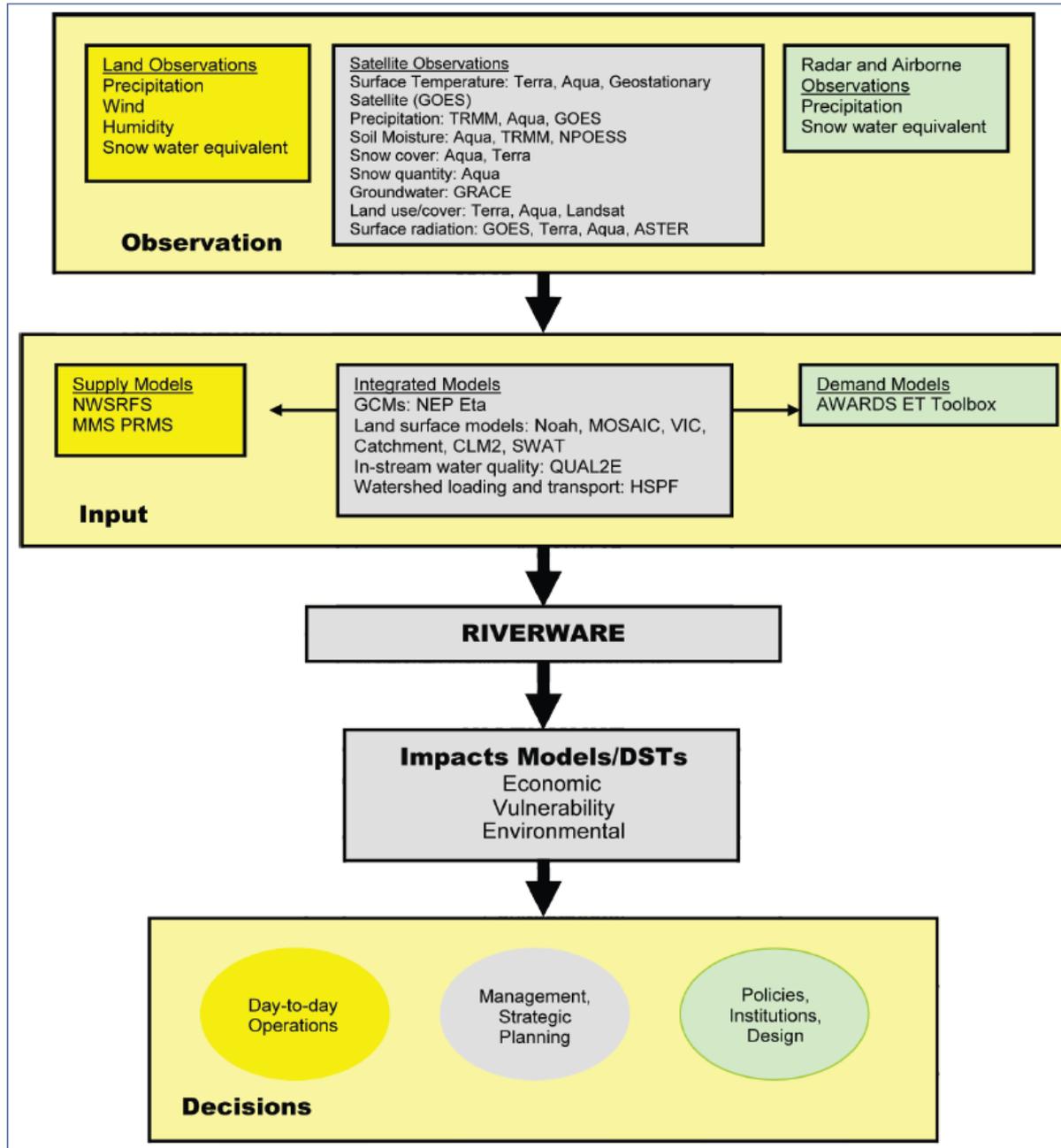
- parameter values
- numerical solution (approximations)
- bugs in the model code
- model structure (process equations, hydrogeological conceptual model)

3. Context – framing of problem

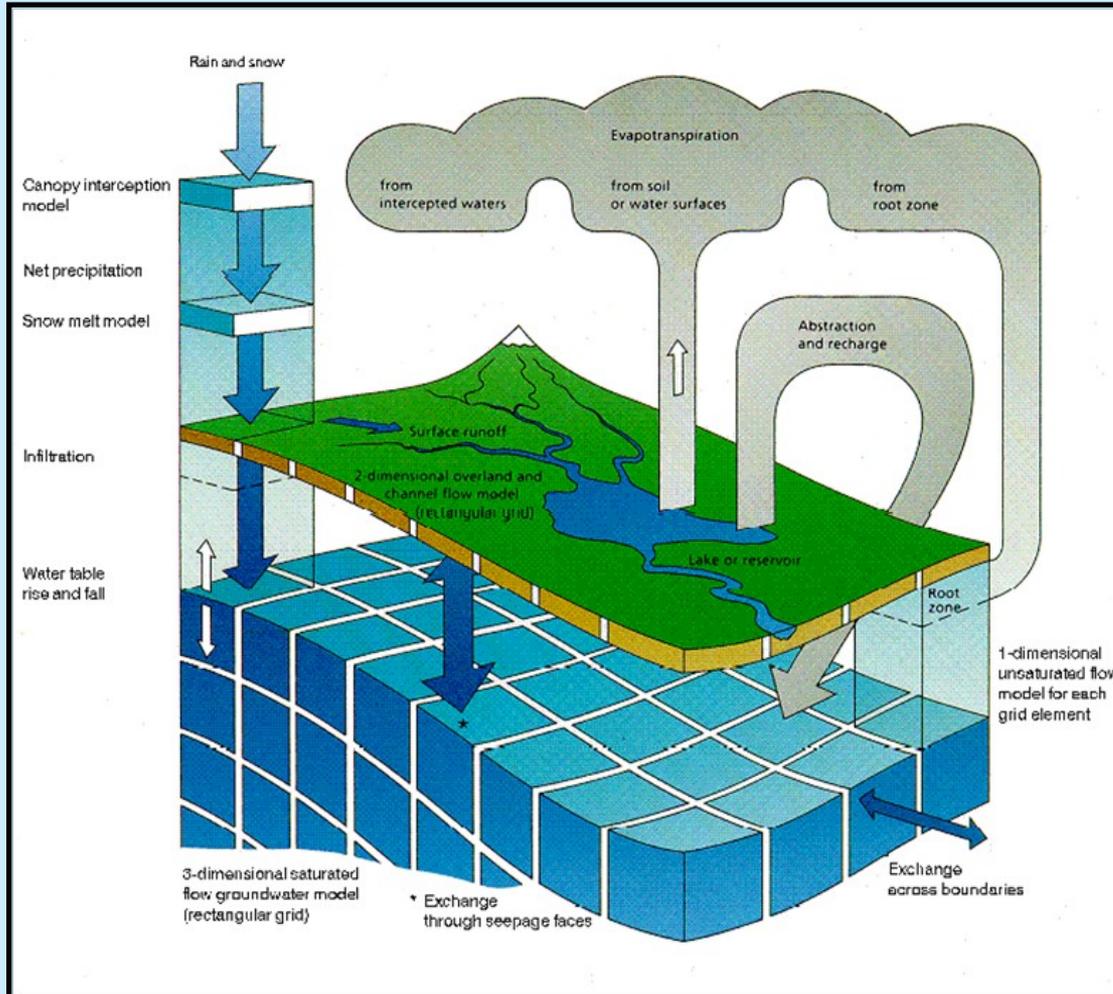
- ambiguity (multiple framing) among decision makers and stakeholders
- external factors not accounted for study
- legislation, regulatory conditions, etc.



Degree of integrated vulnerability is based on GDP per capita, population density, national GDP (inverse) and fragmented natural areas equally weighted (30:30:30:10). Remote areas, Norway and Cyprus are missing fragmented natural areas data.



MIKE SHE



COMPONENTS

ET Interception/Evapotranspiration

- Interception of rainfall by the canopy
- Drainage from the canopy
- Evaporation from the canopy surface
- Evaporation from the soil surface
- Uptake of water by plant roots and its transpiration

OC Overland and Channel flow

- Surface runoff
- Routing in rivers

UZ Unsaturated Zone flow

- Infiltration
- Moisture distribution

SZ Saturated Zone flow

- 3D groundwater flow
- Exchange with boundaries

Towards a Strategy of “Vigilance”

- **Flexible responses**, i.e., operational and strategic flexibility
- **Proactive commitment**, in terms of environmental scanning and through an emphasis on risk rather than crisis management
- **River basin focus** and robust transnational “regimes”
- **Combinations of global approaches** and national plans
- **Ecosystemic emphasis** and environmental interdependencies
- **Integrated, comprehensive management**, capacity building and organizational mobilization.

UNDERLYING TRANSFORMATIONS

VOLATILITY

- TURBULENCE AND UNCERTAINTY

VULNERABILITY

- INTERDEPENDENCIES AND RISK

VIGILANCE

- ENVIRONMENTAL SCANNING AND PREPAREDNESS

VULNERABILITY

- [a] Fragile Physical Environment
 - = environmental degradation
 - = lack of ecosystem resilience
 - = history of extreme hydrological events
- [b] Fragile Economy
 - = economic inequalities/disparities
 - = inadequate funding
- [c] Lack of Local Institutions
 - = lack of social resilience
 - = poor social protection
 - = marginalization
 - = capacity for recuperability
- [d] Lack of Preparedness
 - = inadequate warning systems
 - = lack of training
 - = lack of community mobilization

Suggested Water Sharing Indicators

- **Interdependency** indicator as exemplified by the amount of water inflow from other river basins
- **Cooperation** indicator measured by the number of significant joint projects, treaties or other formal agreements
- **Vulnerability** indicator resulting from the ratio of water demand and supply
- **Fragility** indicator “measured” in terms of environmental deterioration and social unrest (especially poverty and rivalries) within and between countries
- **Development** indicator as summarized by competence, commitment for dealing with and managing water-related conflicts

Requisites for the Transition

- The Need for New Paradigms
 - Sustainability, heterarchy, co-evolution
- The Understanding of New Contexts
 - “Raplexity,” interdependence, globalization
- The Emergence of New Methodologies
 - Cumulative, synergistic, diachronic impacts
 - Indicators, DSS, data-information, judgement
 - Computational prowess

Emerging Operational Principles

- **Envisioning**

Share the dream, share the goals

- **Empowerment**

Joint decision making, power sharing

- **Enactment**

Implementation, civic engagement

The 3 R's

Rethinking → new paradigms

Reorganizing → organizational mobilization

Retooling →
→

