Potential Climate Changes and Transboundary Water Interdependencies

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OUTLINE

1.0 Challenges, Opportunities and Hydrodiplomacy

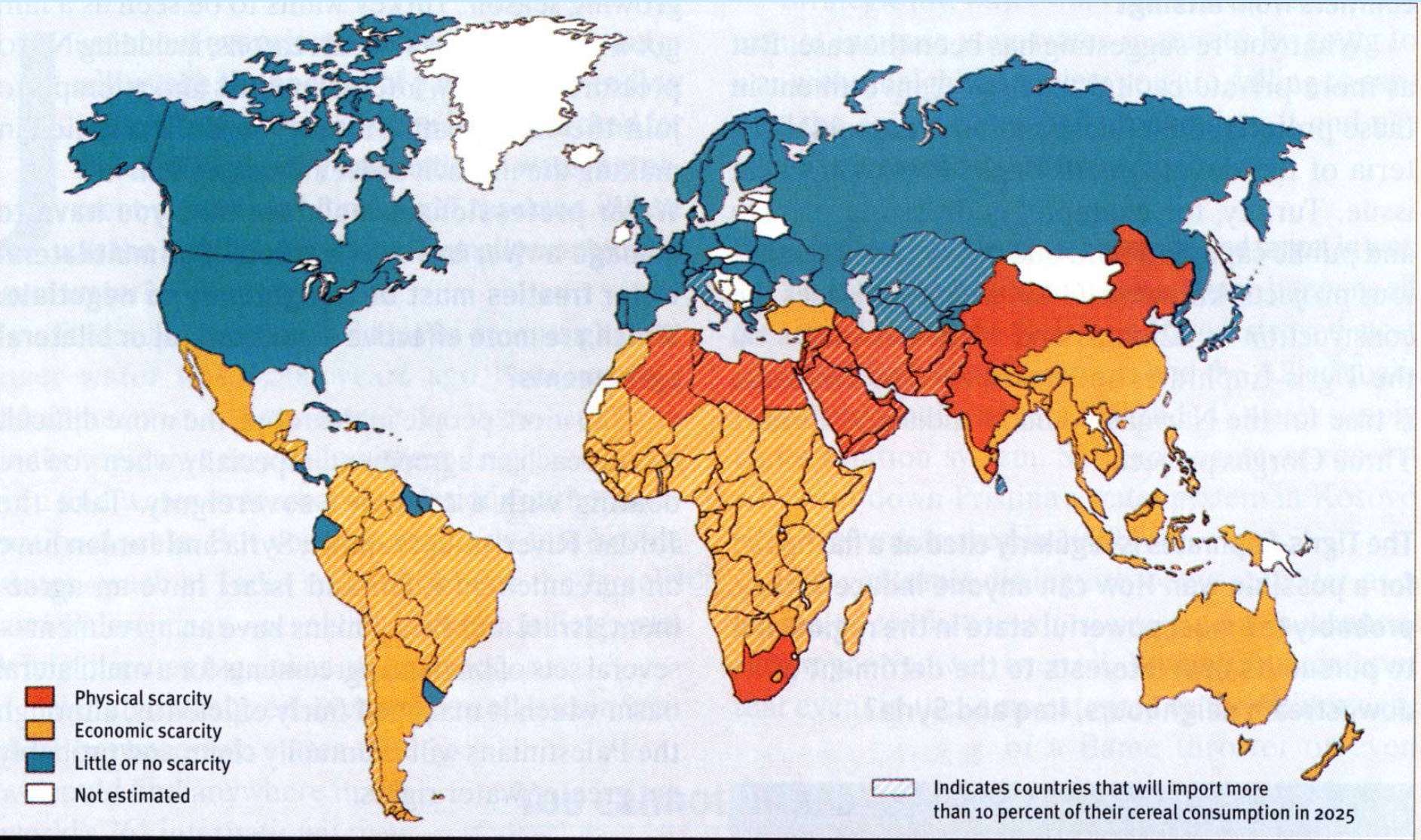
2.0 Water Interdependencies, Legal Regimes and Climate Changes

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.

Source: World Water Forum 2000

INTERLOCKING CRISES

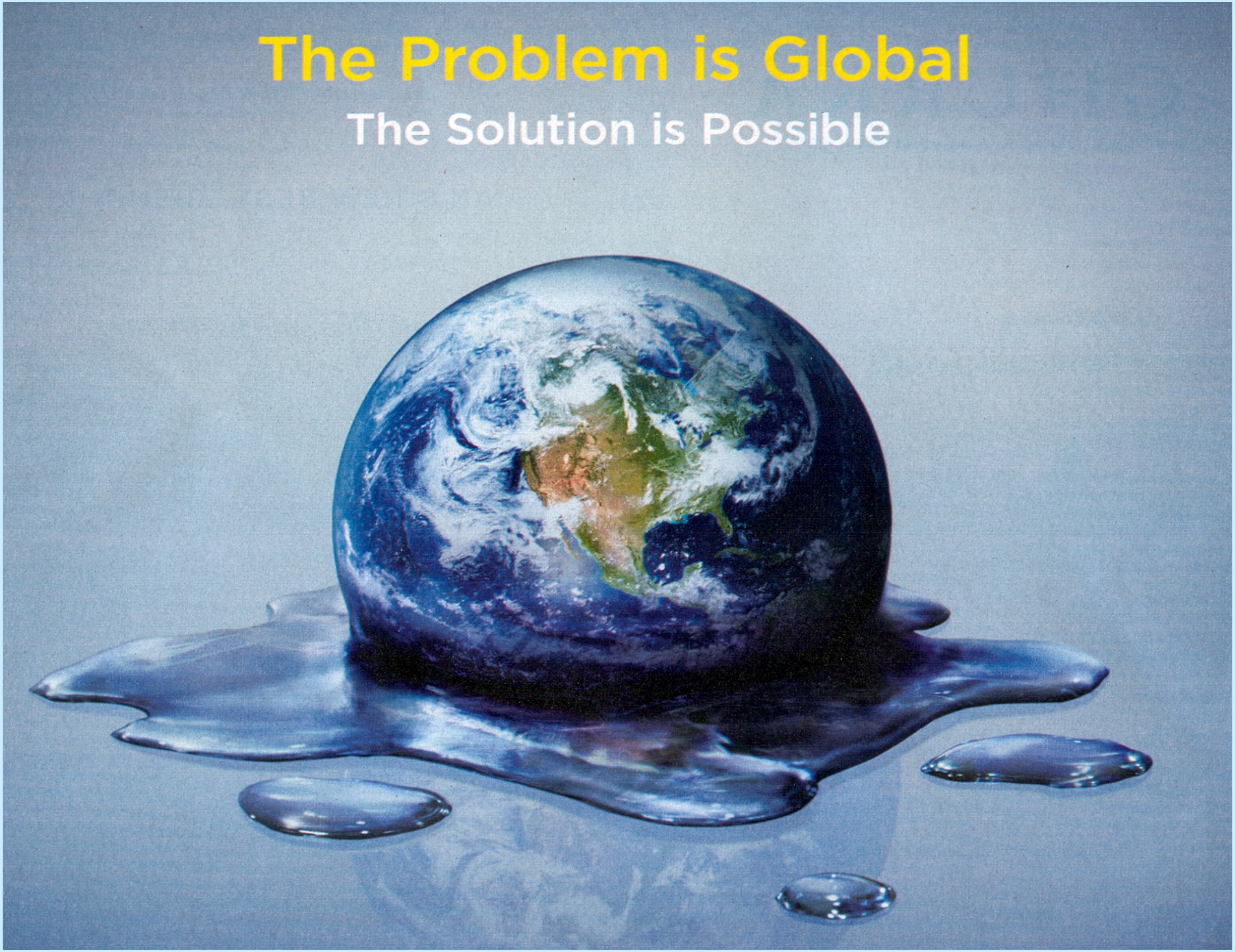
- **CLIMATIC SHIFTS**
- **MEGARUPTURES**
- **METABOLISM**
- **SOCIO-POLITICAL CONTEXT**
- **TRANSBOUNDARY DEPENDENCIES**
- **FAST PACE OF TECHNOLOGICAL DEVELOPMENT**

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

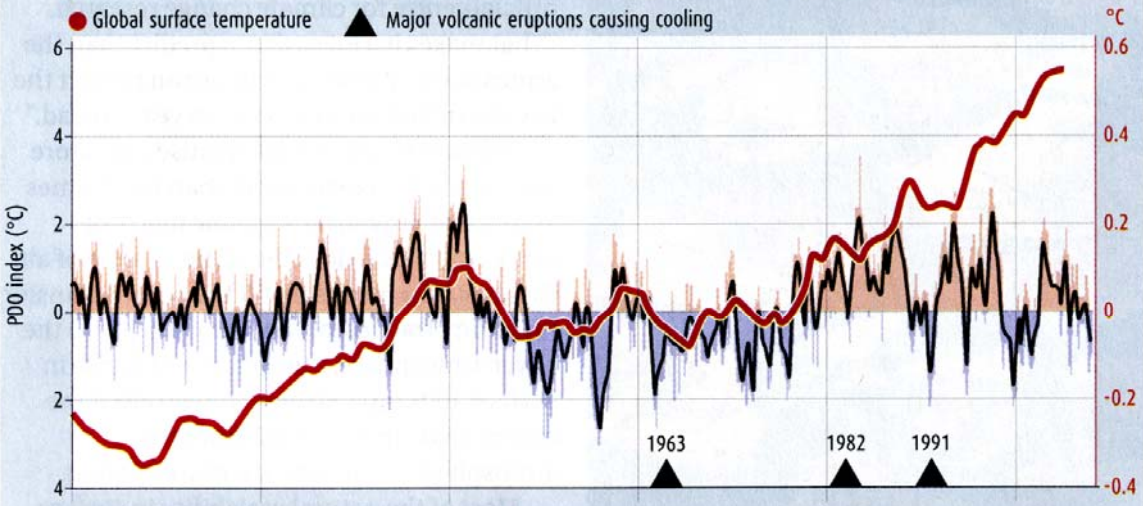
Potential Water Conflicts Arise:

- 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)

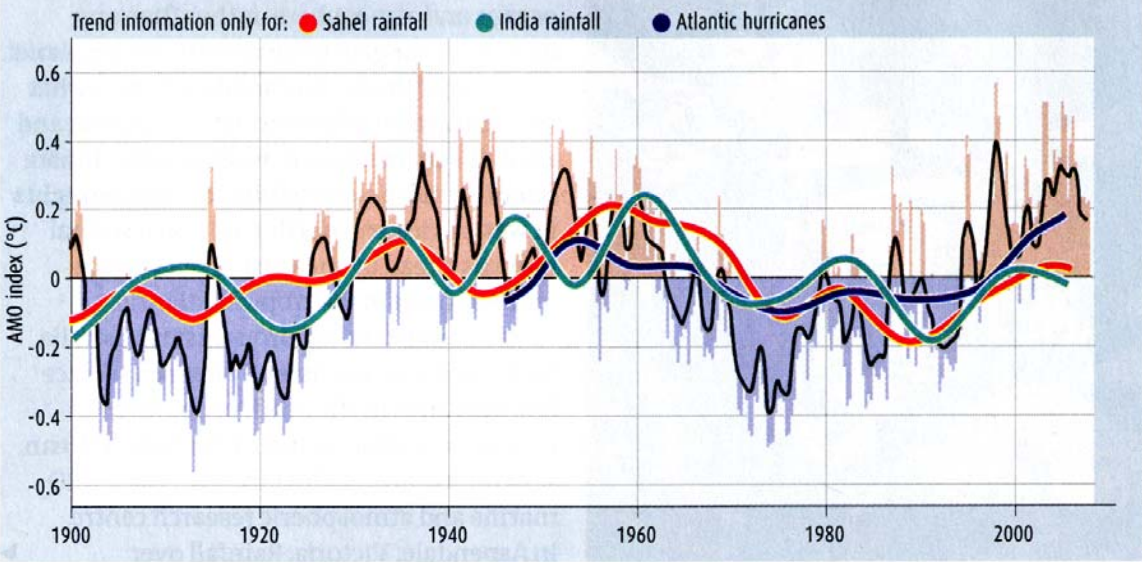

The Problem is Global
The Solution is Possible

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

The Pacific Decadal Oscillation index – the relative mean surface temperature of the Pacific north of 20° latitude (adjusted to exclude the long-term warming trend). Low values are linked to lower global surface temperatures



The Atlantic Multidecadal Oscillation index – the relative mean surface temperature of the Atlantic north of the equator (adjusted to exclude the long-term warming trend). High values correlate with summer rainfall in India and the Sahel region of Africa, but lower summer rainfall in the western US



SOURCE: NOAA, GISS, ZHANG 2006

APRIL 3, 2006 www.time.com AOL Keyword: TIME

SPECIAL REPORT GLOBAL WARMING

TIME

BE WORRIED. BE VERY WORRIED.

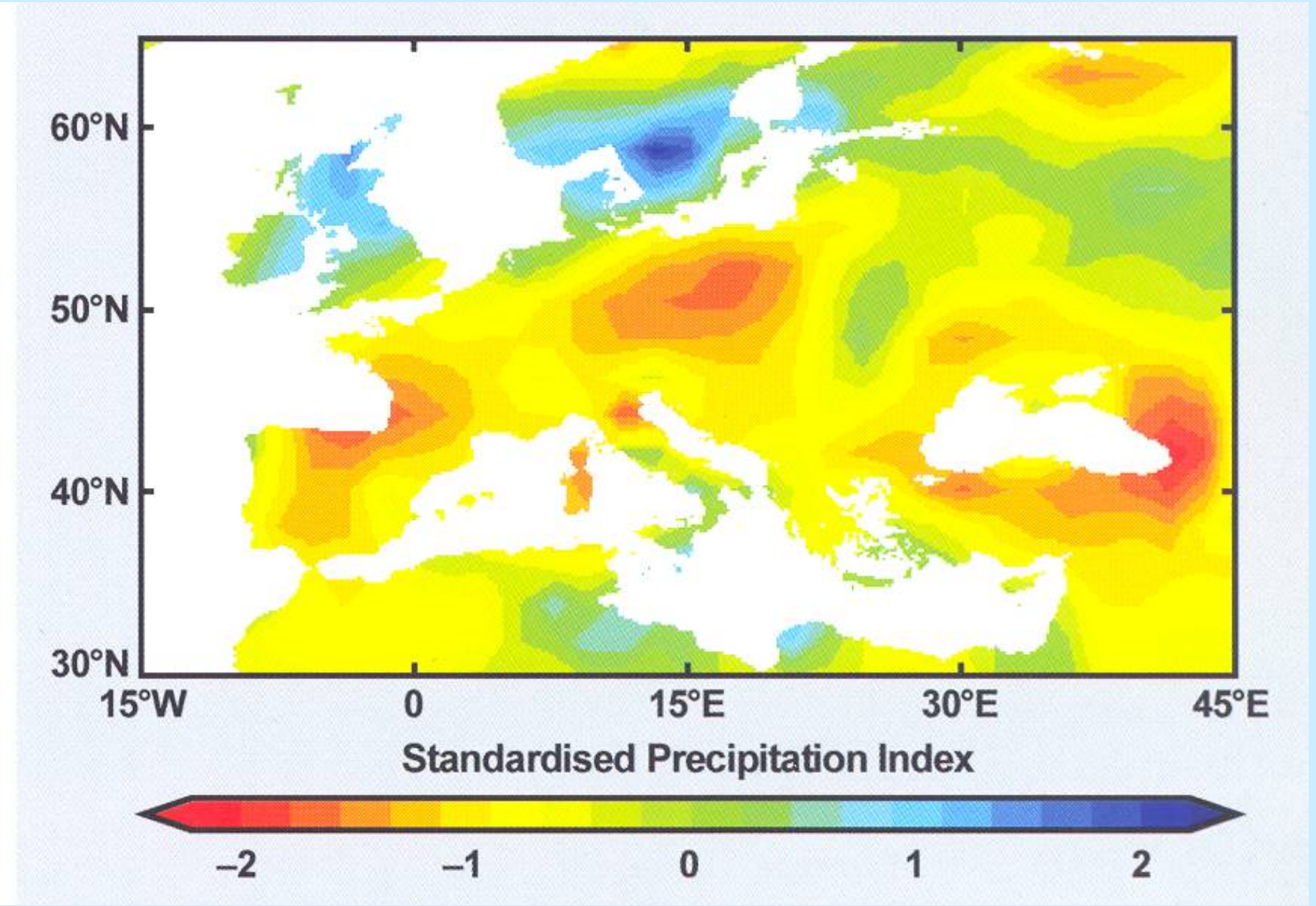
Climate change isn't some vague future problem—it's already damaging the planet at an alarming pace. Here's how it affects you, your kids and their kids as well

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

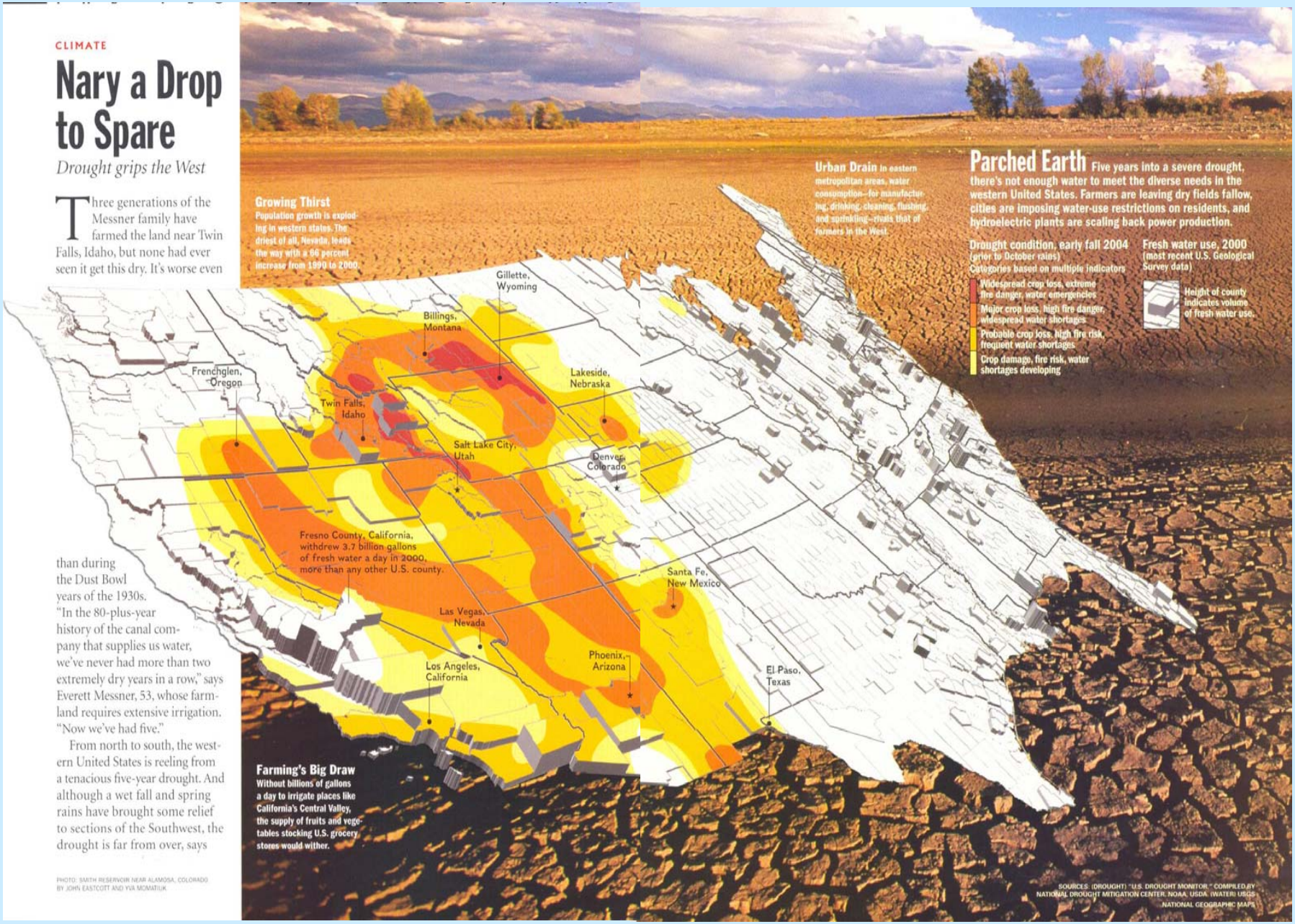
Nary a Drop to Spare

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 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."

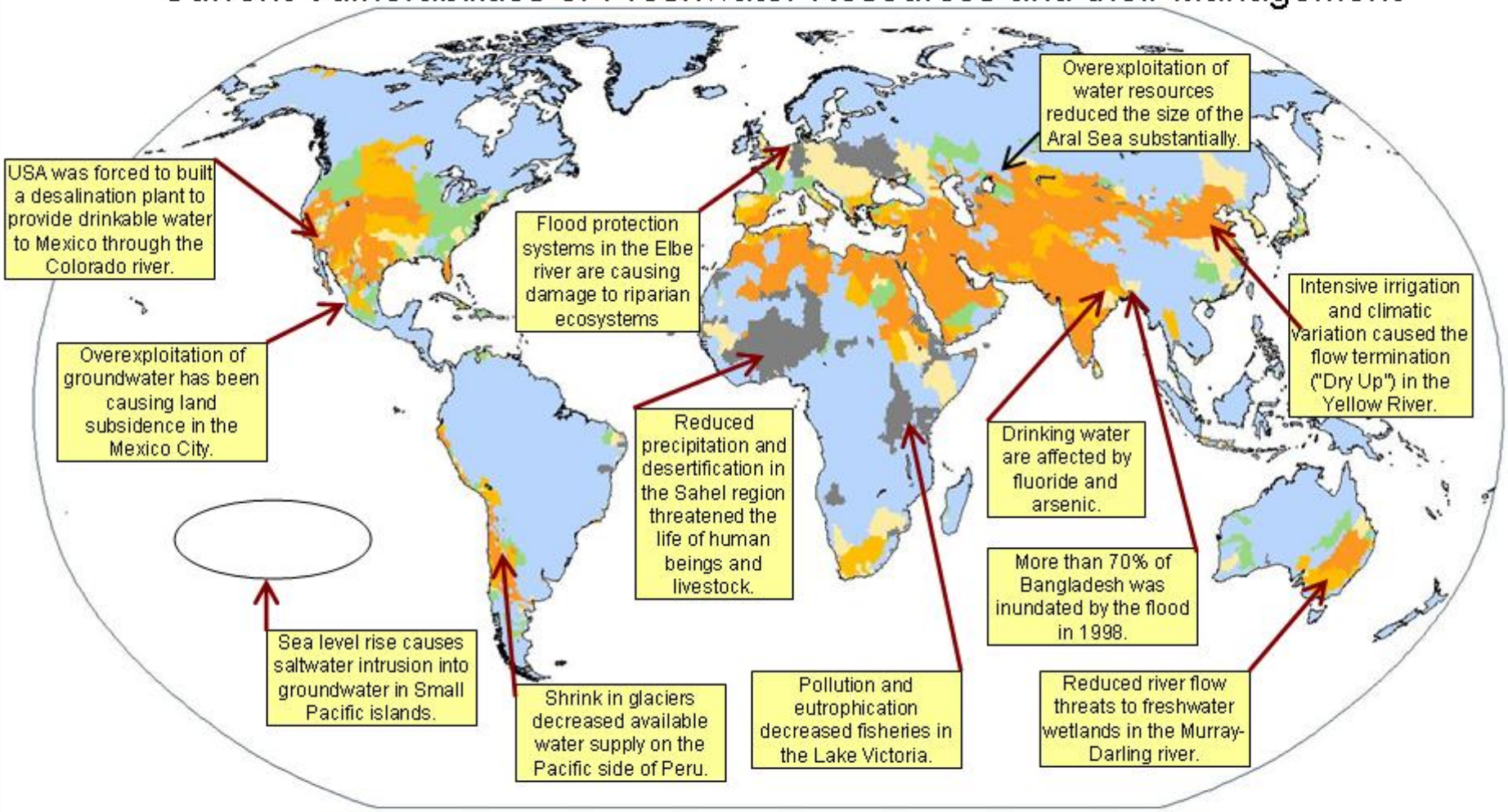
From north to south, the western United States is reeling from a tenacious five-year drought. And although a wet fall and spring rains have brought some relief to sections of the Southwest, the drought is far from over, says

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

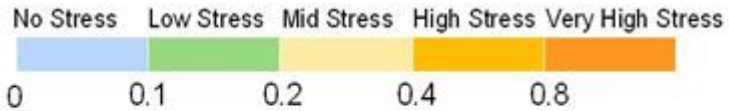


Borders and structure of GIWA subregion 22: Black Sea

Current Vulnerabilities of Freshwater Resources and their Management



Water Stress Indicator: Withdrawal-to-Availability Ratio

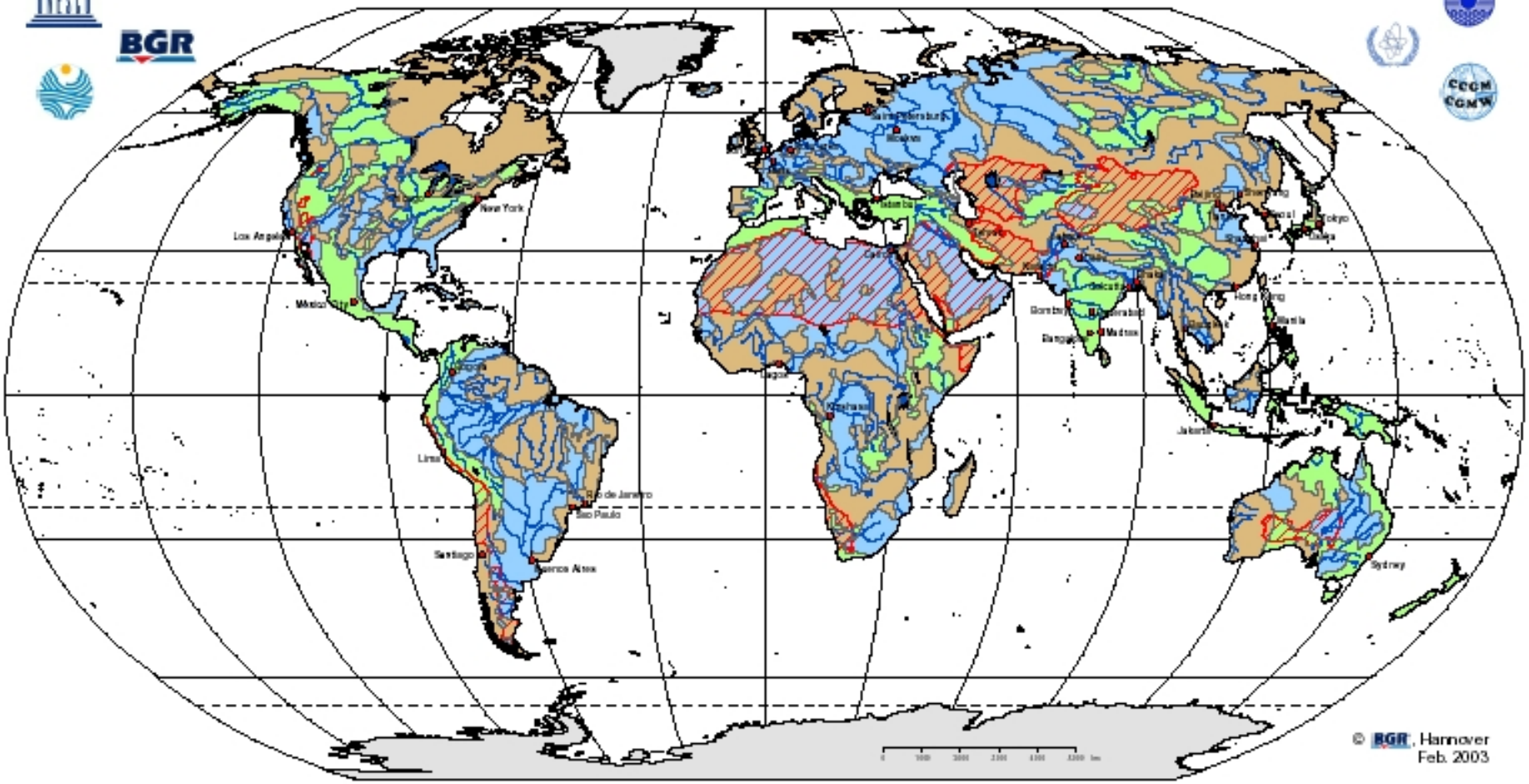


no/low stress and per capita water availability < 1700 m³/year

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



Hydrogeology

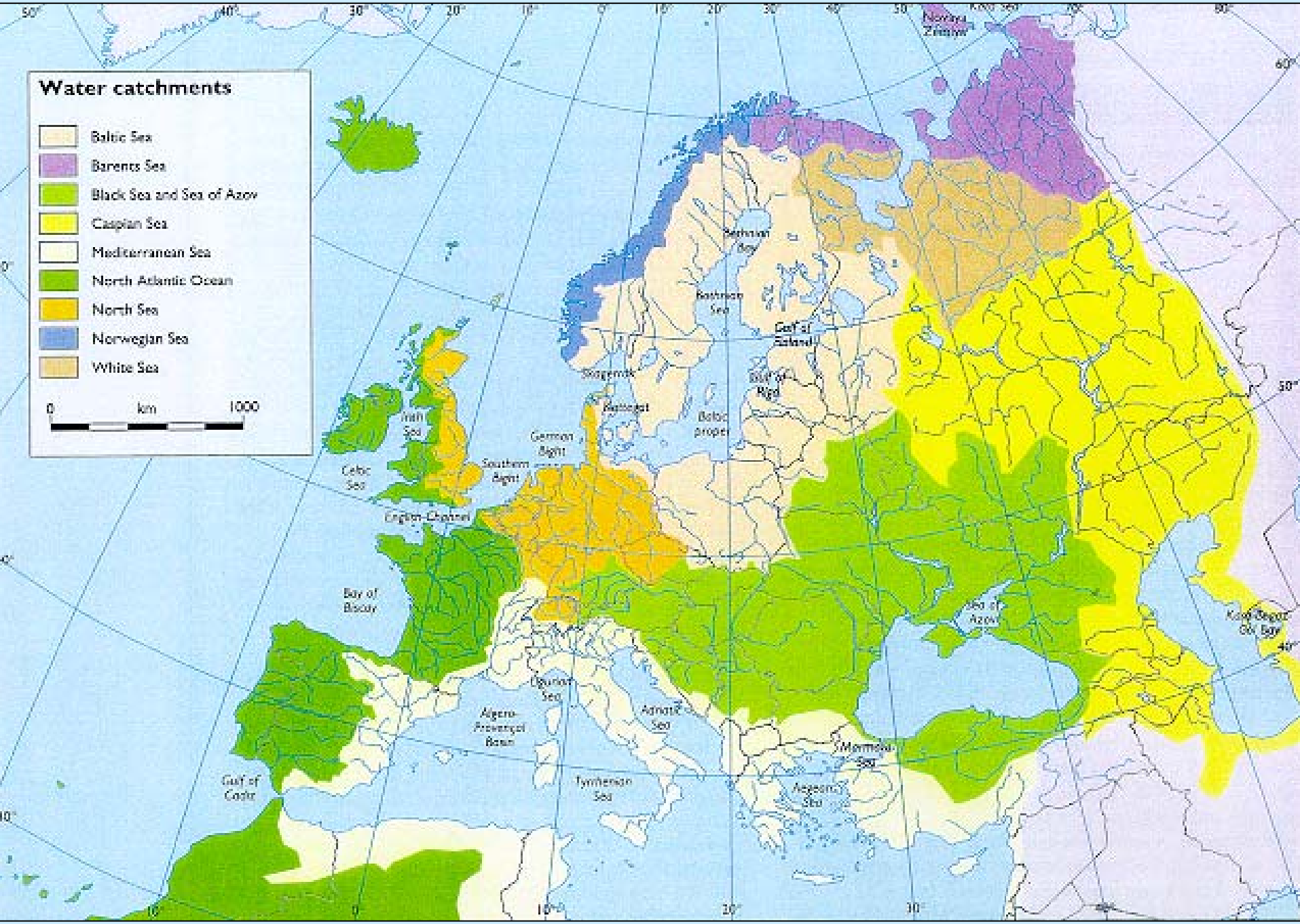
- major groundwater basin with highly-productive aquifers
- area with complex structure including some important aquifers
- area with generally poor aquifers, locally overlain by river-bed aquifers

Surface Water

- polar ice
- large freshwater lake
- major river

Other Geographic and Climate Features

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


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
0
km
1000
Bothnian Bay
Bothnian Sea
Gulf of Finland
Gulf of Riga
Skagerrak
Kattegat
Baltic proper
German Bight
Southern Bight
Irish Sea
Celtic Sea
English Channel
Bay of Biscay
Ligurian Sea
Algero-Provençal Basin
Tyrrhenian Sea
Adriatic Sea
Aegean Sea
Marmara Sea
Sea of Azov
Gulf of Cadiz

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

IntegratedWRM

- 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 2. Distribution of large dams across the mainland SADC region (image, courtesy of Peter Ashton).

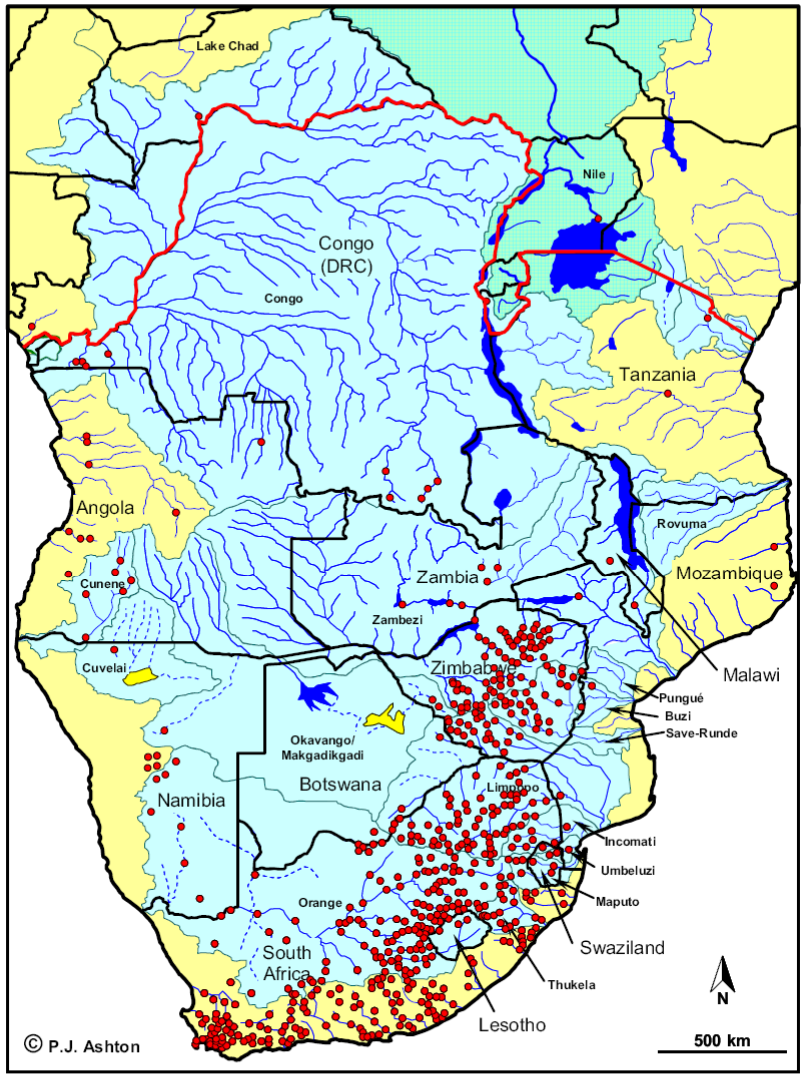
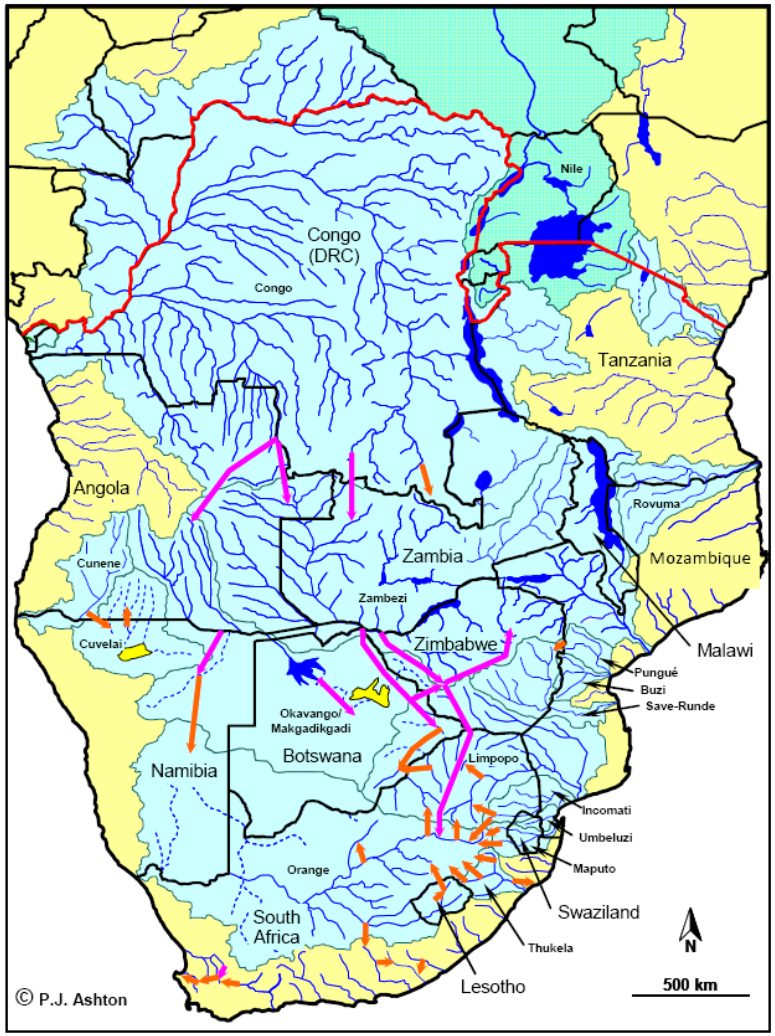


Figure 3. Inter-basin transfers (IBTs) and the SADC regional integration (image, courtesy of Peter Ashton).



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.

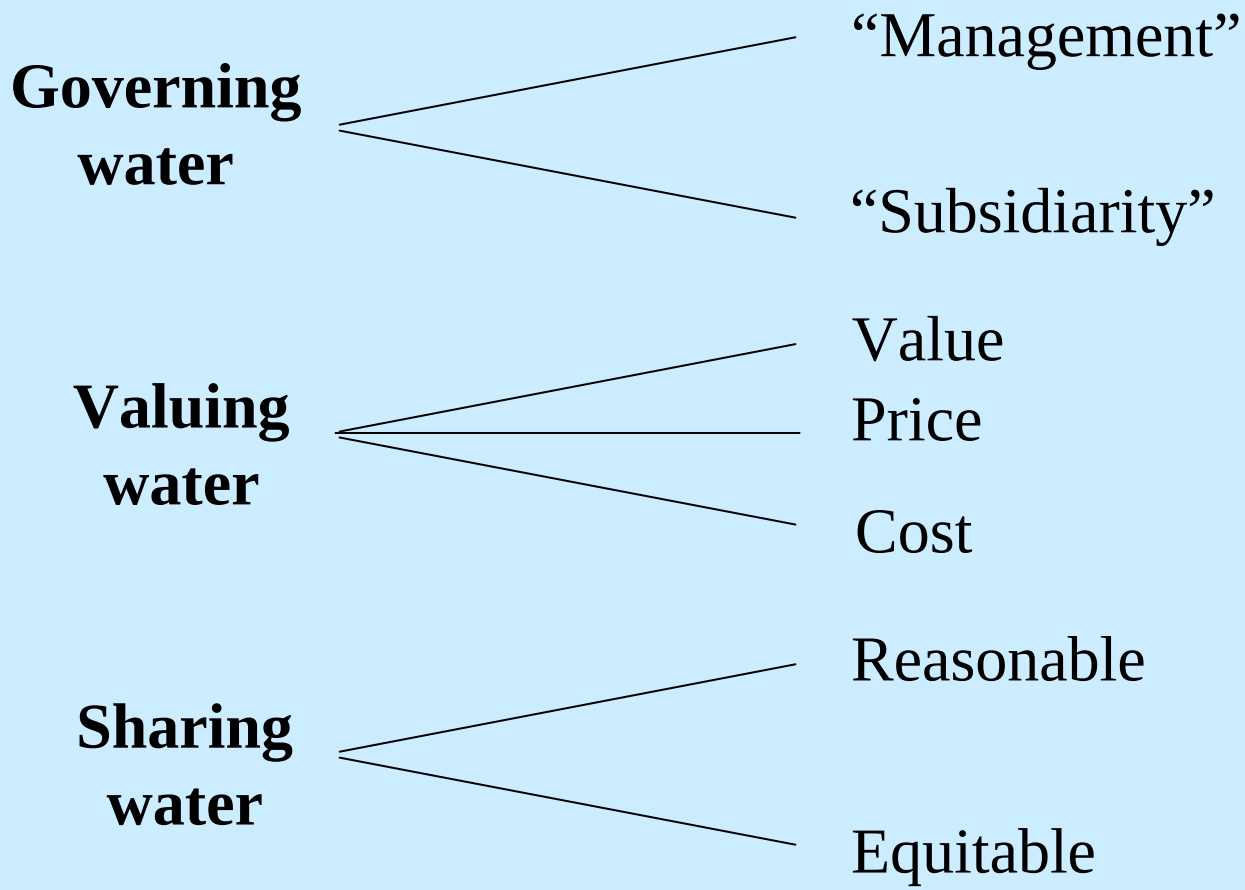
Table 1. Comparison of the traditional paradigm and the proposed benefit-sharing approach.

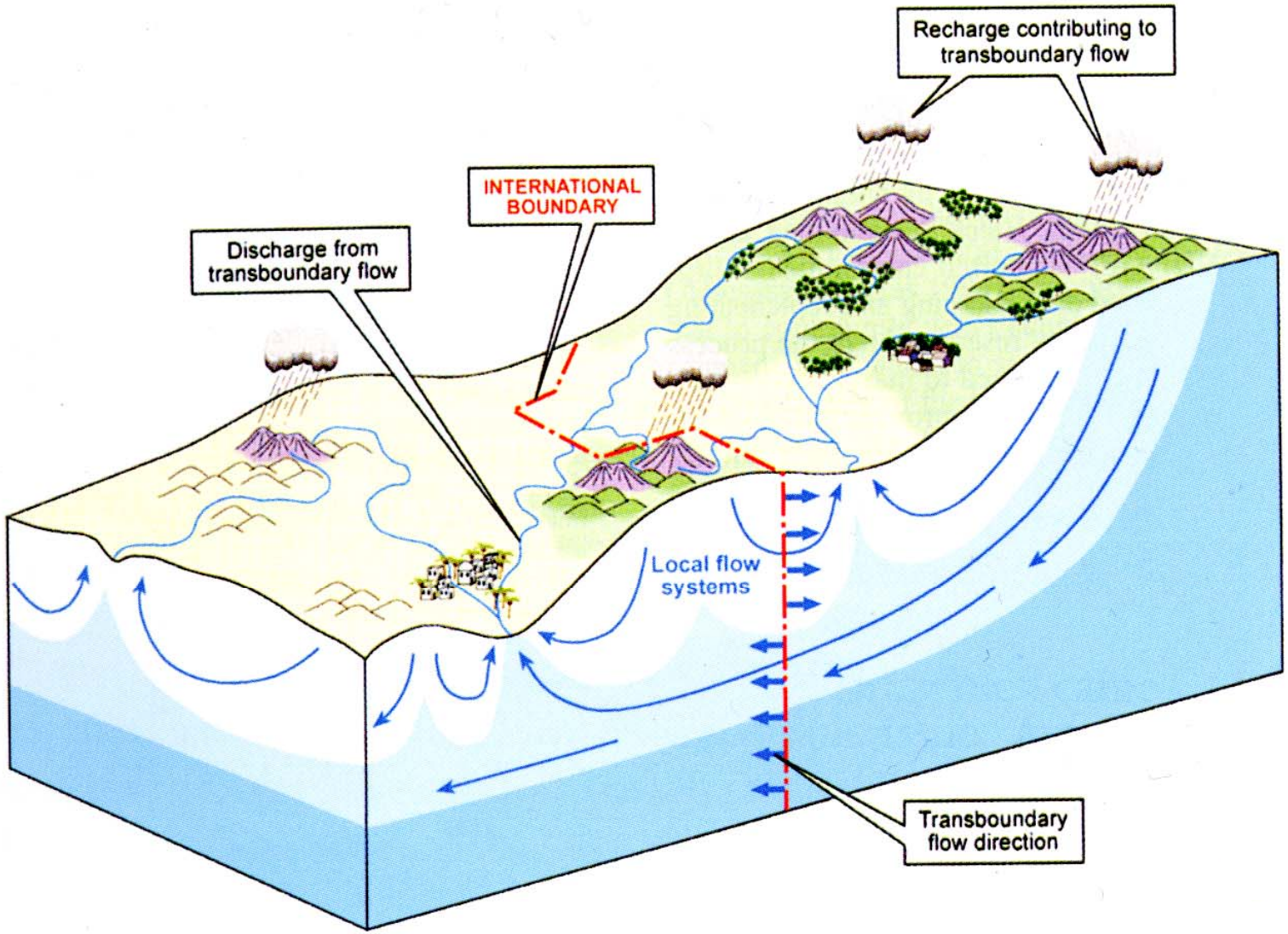
Element	Traditional paradigm	Benefit-sharing paradigm
Perspective on water	Water is treated as a finite stock.	Water is treated as a less finite flux with technological capacity becoming a key variable (Homer-Dixon, 2000).
National sovereignty	Fear of the erosion of sovereignty stunts institutional development (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

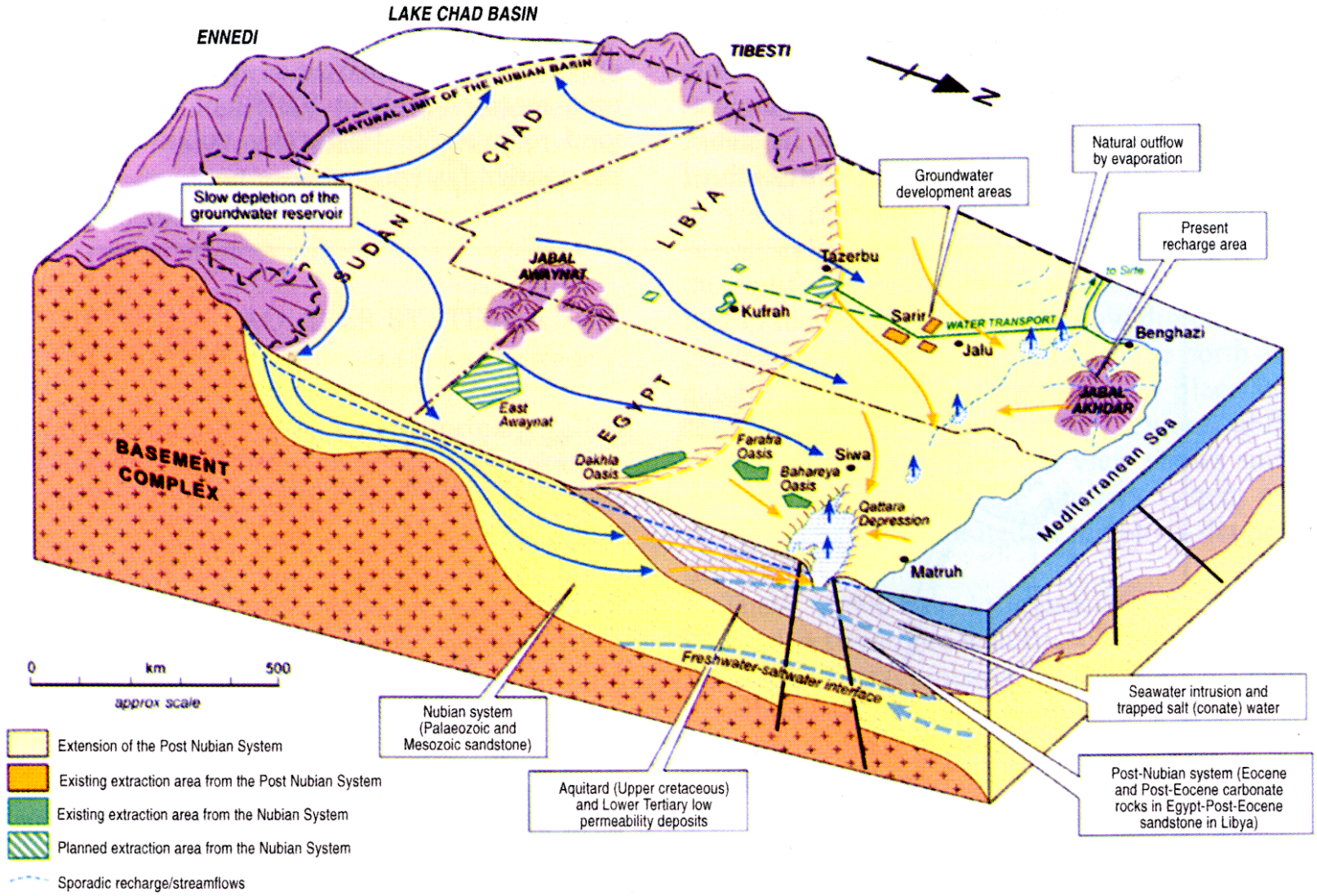
- Duty to Cooperate
- Conjunctive Management
- Integrated Management
- Equitable Utilization
- Sustainable Use
- Minimization of Environmental Harm

THREE KEY ISSUES IN COMPREHENSIVE WATER RESOURCES PLANNING & MANAGEMENT

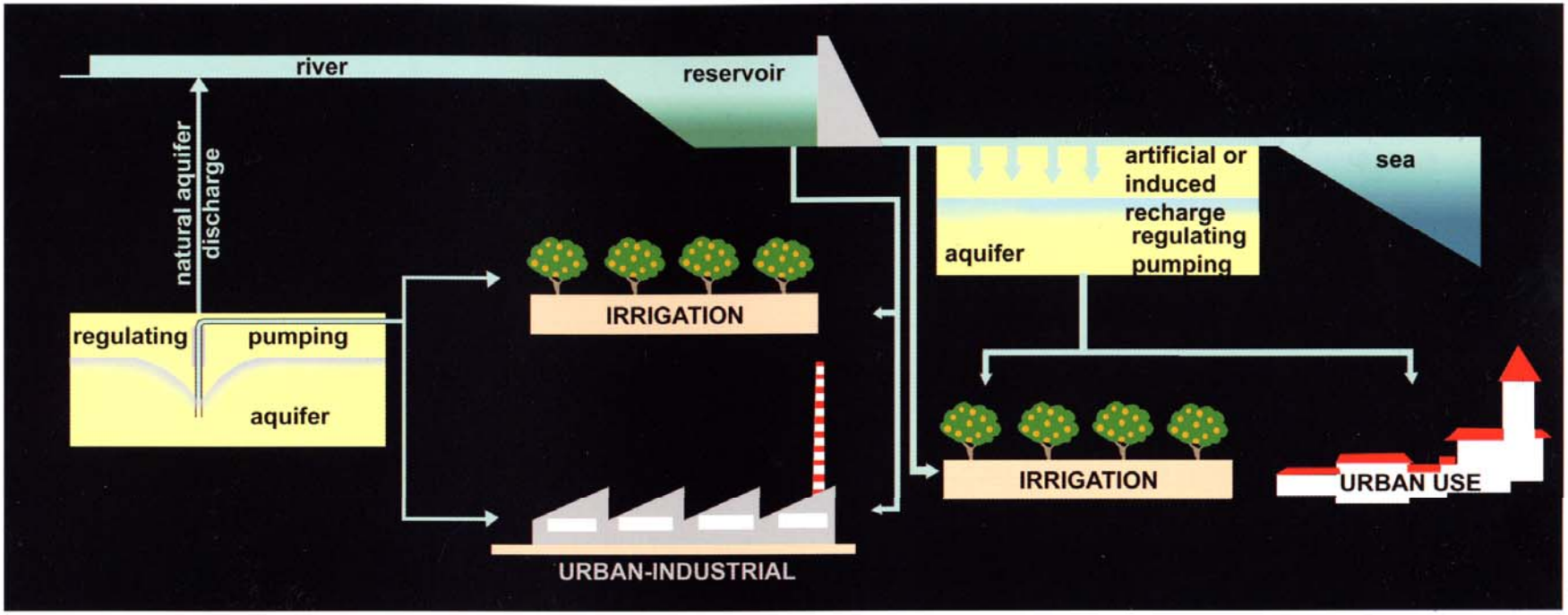




Puri, S. & El Naser, H. (2003). Schematic of a transboundary aquifer. In "Intensive use of groundwater. Challenges and opportunities"



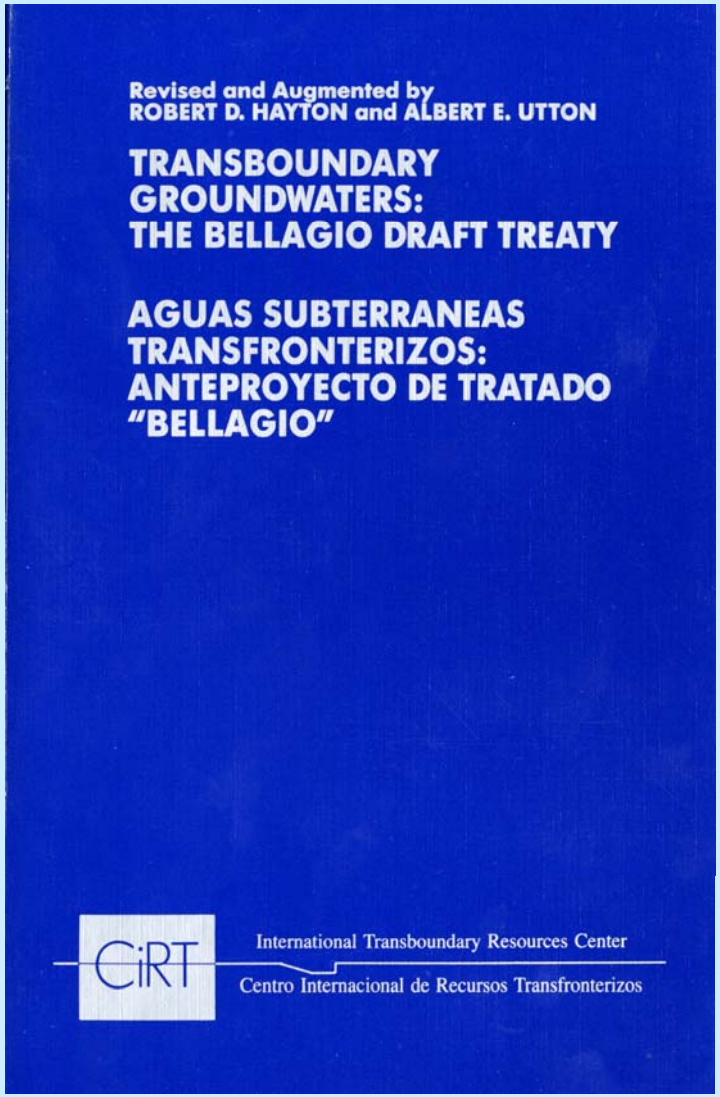
Puri, S. & El Naser, H. (2003). Block diagram of the Nubian aquifer system. In "Intensive use of groundwater. Challenges and opportunities"

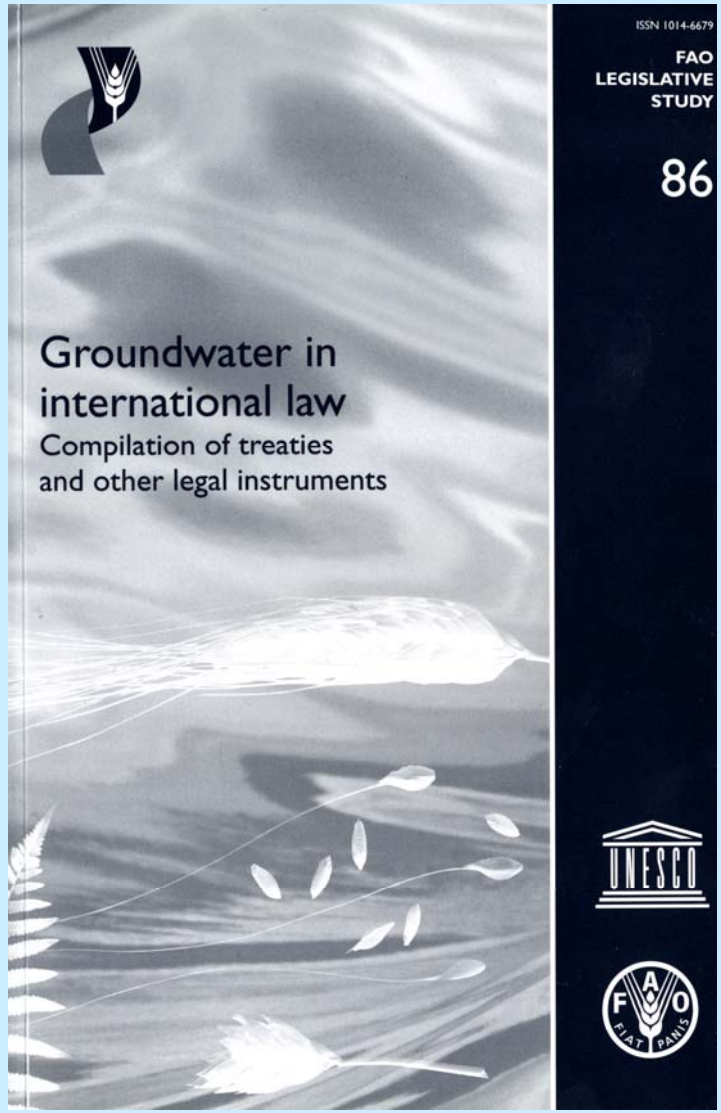


A system of conjunctive use of surface water and groundwater, comprising a surface reservoir and two aquifers, one of which is located upstream from the surface reservoir. The diagram also shows the different areas of water demand (urban, industrial and irrigation). Depending on the availability of water 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


ISSN 1014-6679
FAO LEGISLATIVE STUDY
86
Groundwater in international law
Compilation of treaties and other legal instruments
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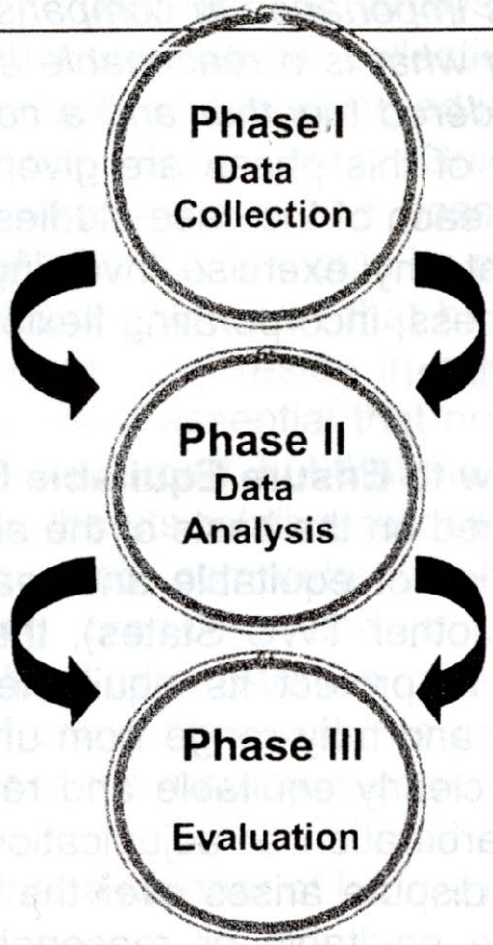
The Legal Assessment Model



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

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

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

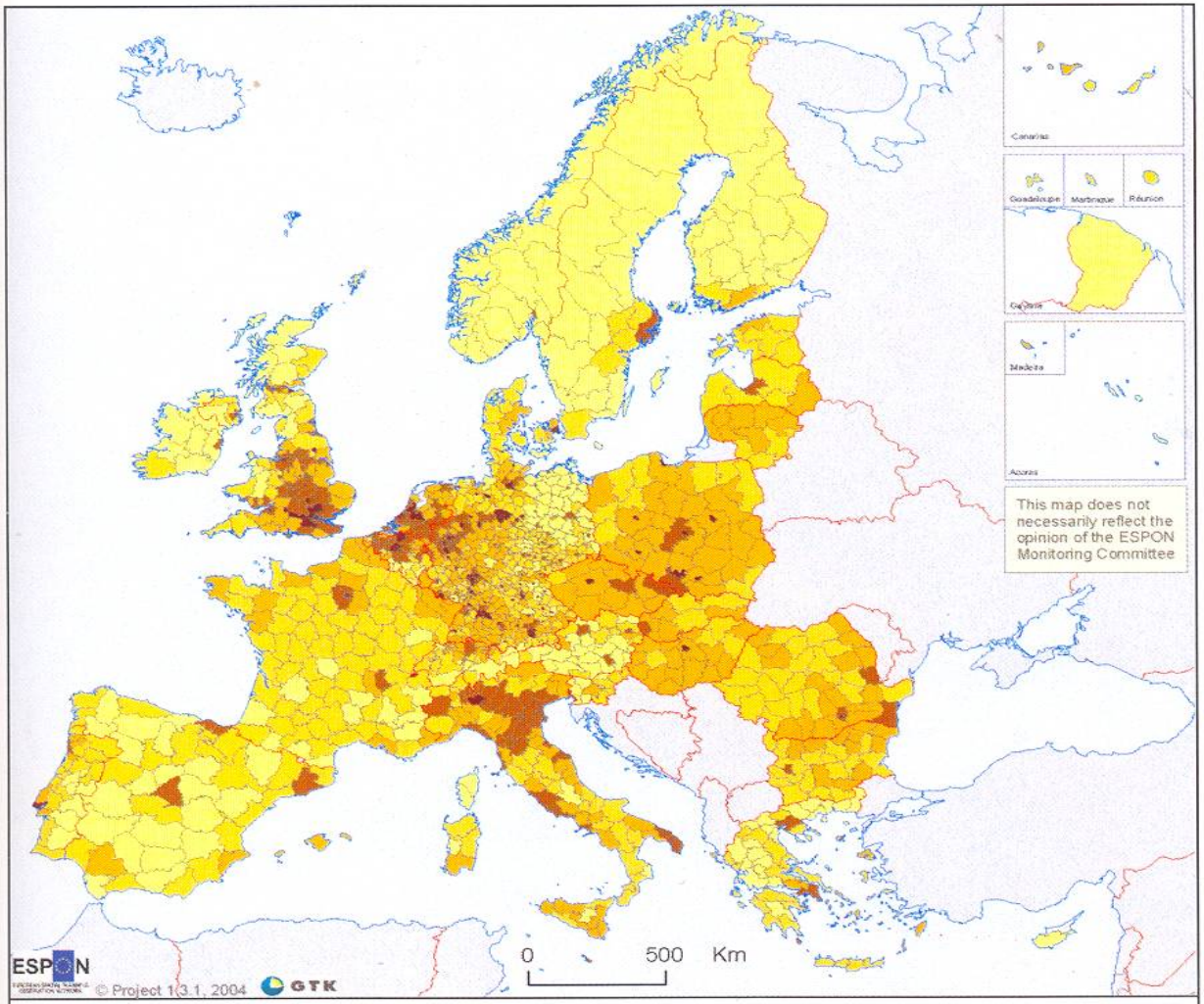
Apply most appropriate method of evaluation to determine whether current utilisation of a TWS is consistent with "equitable and reasonable utilisation"

Final Phase

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

Sources of Uncertainty in the Water Management Process

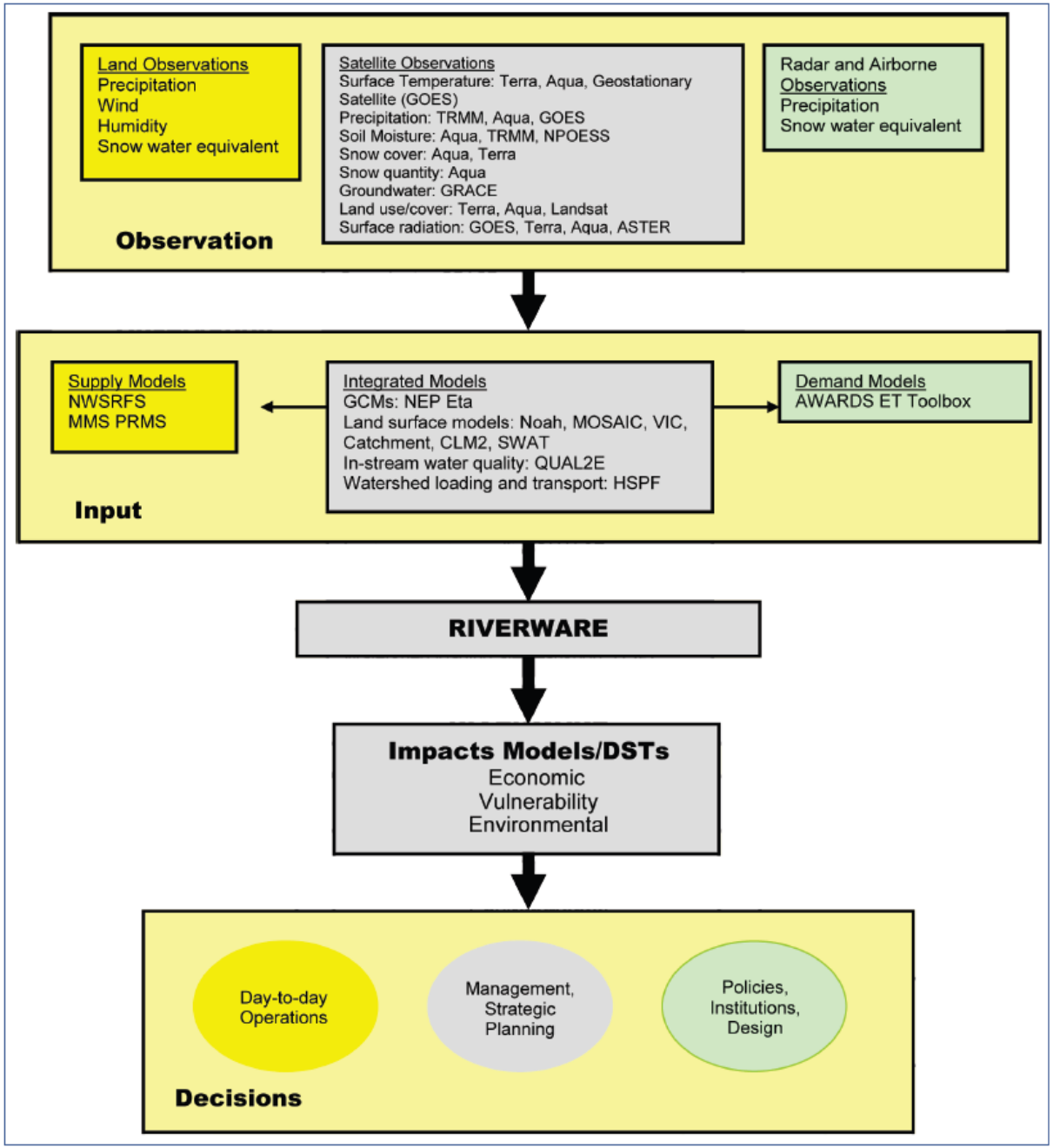
1. Data
   - physical, chemical, biological, etc.
   - scale problems (temporal and spatial)
2. Model
   - parameter values
   - numerical solution (approximations)
   - bugs in the model code
   - model structure (process equations, hydrogeological conceptual model)
3. Context – framing of problem
   - ambiguity (multiple framing) among decision makers and stakeholders
   - external factors not accounted for study
   - legislation, regulatory conditions, etc.



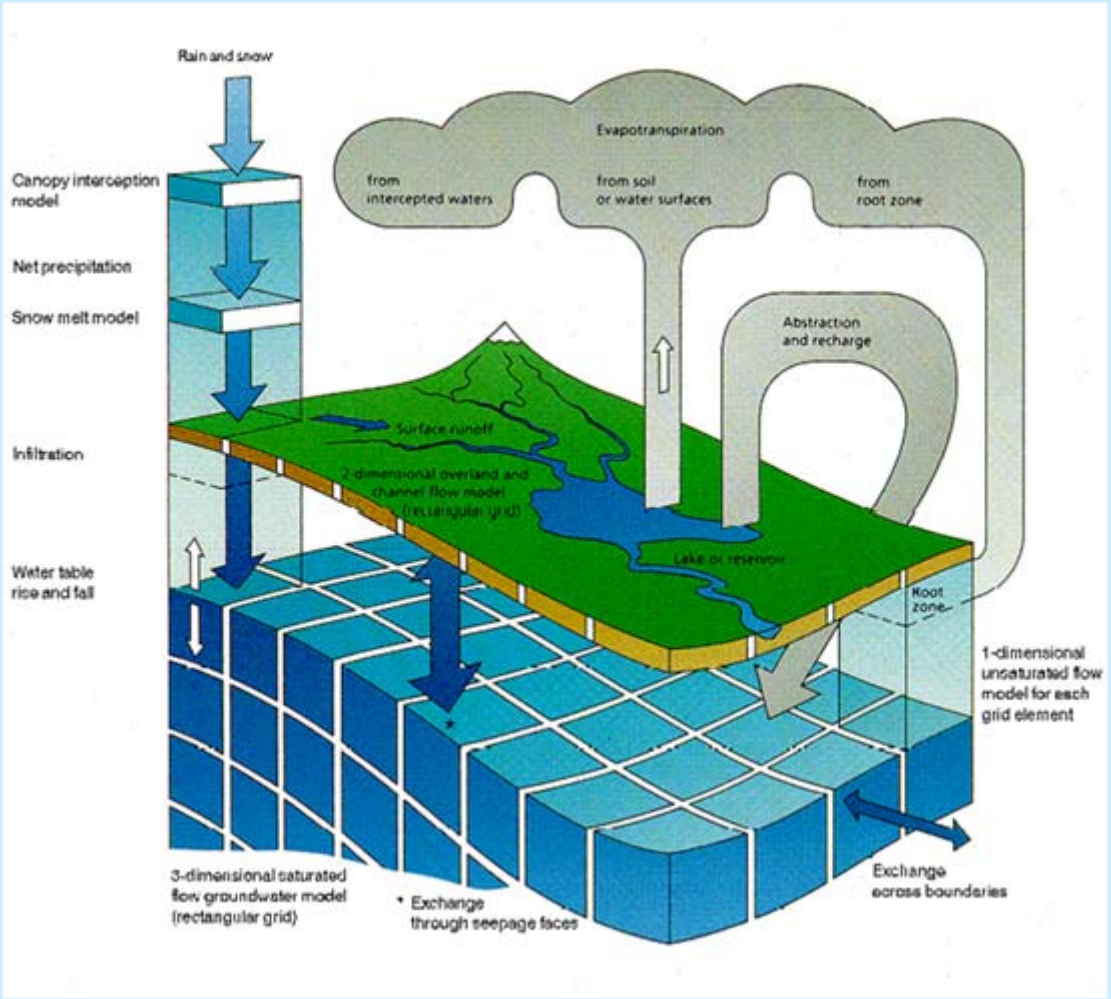
Integrated vulnerability

- I (Low vulnerability)
- II
- III
- IV
- V (High vulnerability)
- Non ESPON space

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


Land Observations
Precipitation
Wind
Humidity
Snow water equivalent
Satellite Observations
Surface Temperature: Terra, Aqua, Geostationary Satellite (GOES)
Precipitation: TRMM, Aqua, GOES
Soil Moisture: Aqua, TRMM, NPOESS
Snow cover: Aqua, Terra
Snow quantity: Aqua
Groundwater: GRACE
Land use/cover: Terra, Aqua, Landsat
Surface radiation: GOES, Terra, Aqua, ASTER
Radar and Airborne Observations
Precipitation
Snow water equivalent
Observation
Supply Models
NWSRFS
MMS PRMS
Integrated Models
GCMs: NEP Eta
Land surface models: Noah, MOSAIC, VIC, Catchment, CLM2, SWAT
In-stream water quality: QUAL2E
Watershed loading and transport: HSPF
Demand Models
AWARDS ET Toolbox
Input
RIVERWARE
Impacts Models/DSTs
Economic
Vulnerability
Environmental
Day-to-day Operations
Management, Strategic Planning
Policies, Institutions, Design
Decisions

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

A. **Interdependency** indicator as exemplified by the amount of water inflow from other river basins
B. **Cooperation** indicator measured by the number of significant joint projects, treaties or other formal agreements
C. **Vulnerability** indicator resulting from the ratio of water demand and supply
D. **Fragility** indicator “measured” in terms of environmental deterioration and social unrest (especially poverty and rivalries) within and between countries
E. **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**

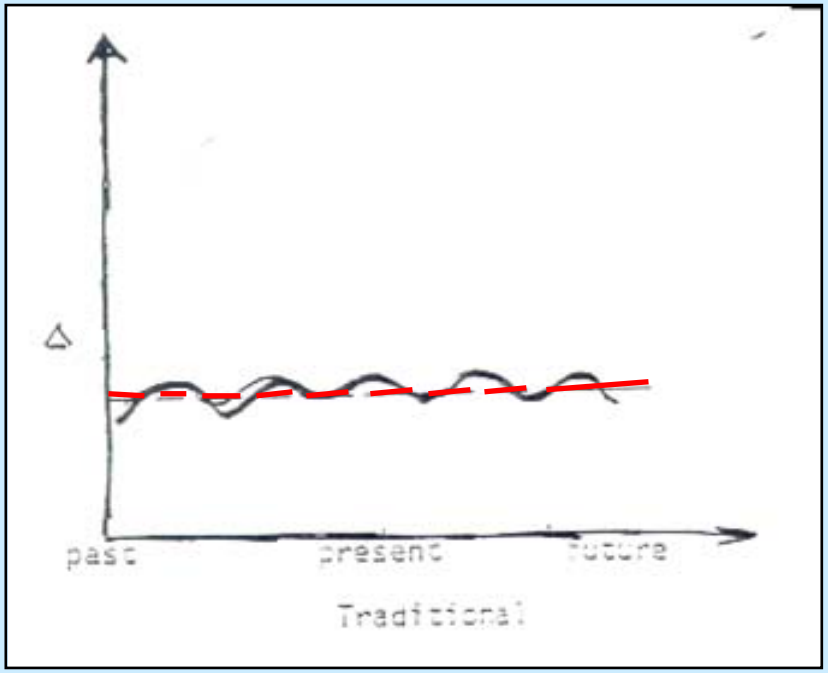
  Implementation, civic engagement

The 3 R's

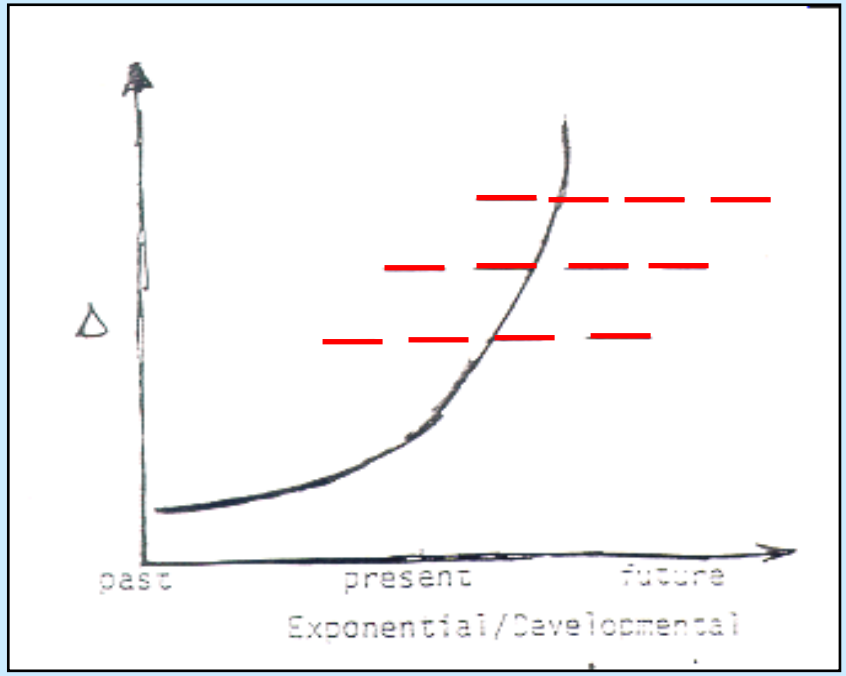
Rethinking → new paradigms

Reorganizing → organizational mobilization

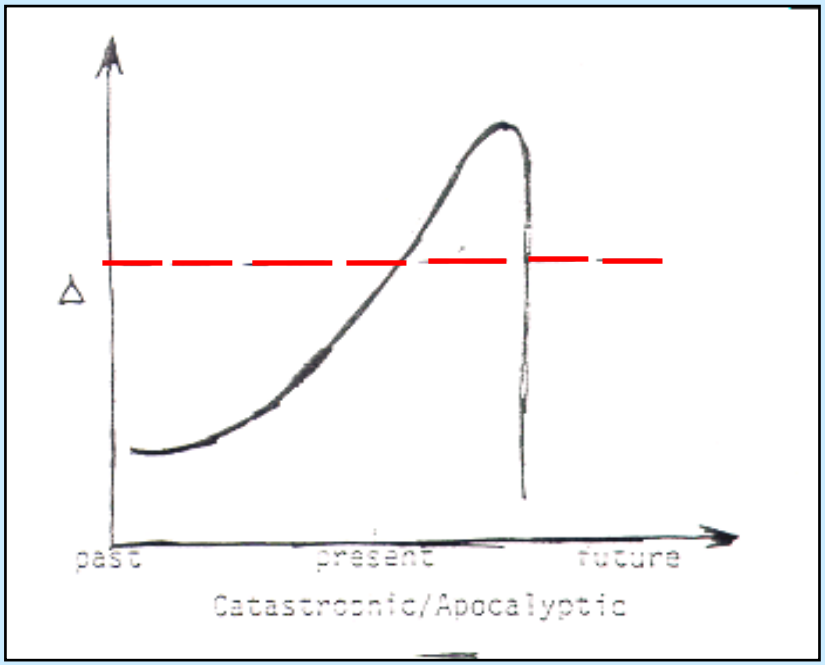
Retooling → new skills and resources



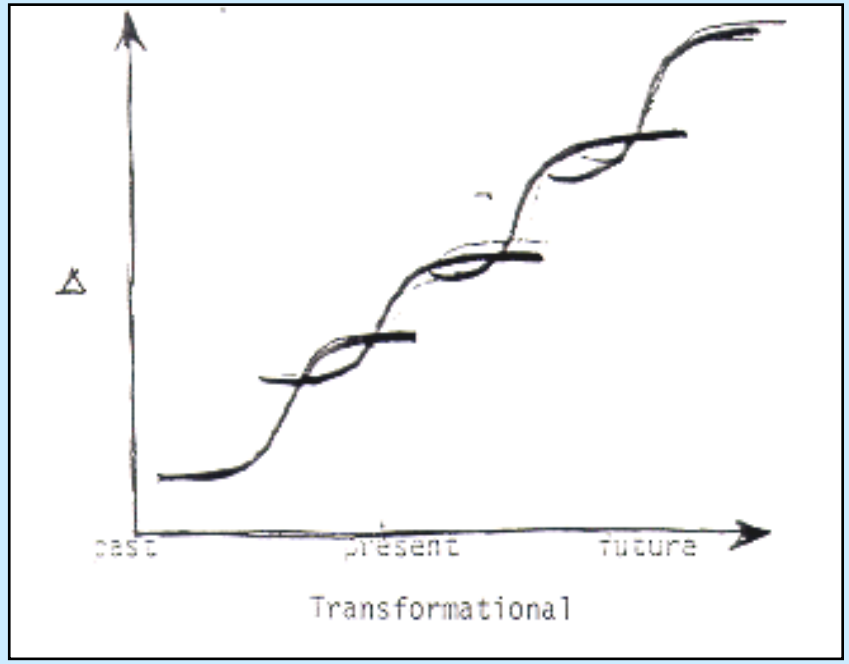
Traditional



Exponential/Developmental



Catastrophic/Apocalyptic



Transformational