Integrated Water Resources Management

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Framework of IWRM Course

- Concepts and Challenges
- Water and River System
- Human Interferences and Water Uses
- Planning Issue
- Operational and Demand Management
- Water Tariff and Pricing
- Water Allocation
- Decision Support System
- Institutional Issues

Concepts and Challenges

(what and why and how)

Concepts

- What dose WRM mean ?

  Different people have different ideas, since they may have different water problems.

Too much :	Flood
Too limited:	Drought
Too dirty:	Pollution

Understanding from different people

- To people in arid countries
- To people in wet countries
- To the water engineer
- To the environmentalist
- To the lawyer
- To the economist
- To the politicians

Baseline: from WRD to IWRM

- **W**ater **R**esources **D**evelopment (**WRD**)
- **W**ater **R**esources **P**lanning (**WRP**)
- **W**ater **R**esources **M**anagement (**WRM**)
- **I**ntegrated **W**ater **R**esources **M**anagement (**IWRM**)

WRD and WRP

- **WRD** means **actions**, mostly physical, that lead to the beneficial use of water resources for single or multiple purposes.
- **WRP** is planning of the development, conservation and allocation of a scarce resources, matching water availability and water demand, taking account the full set of **different level** objectives and constraints and the interests of stakeholders.

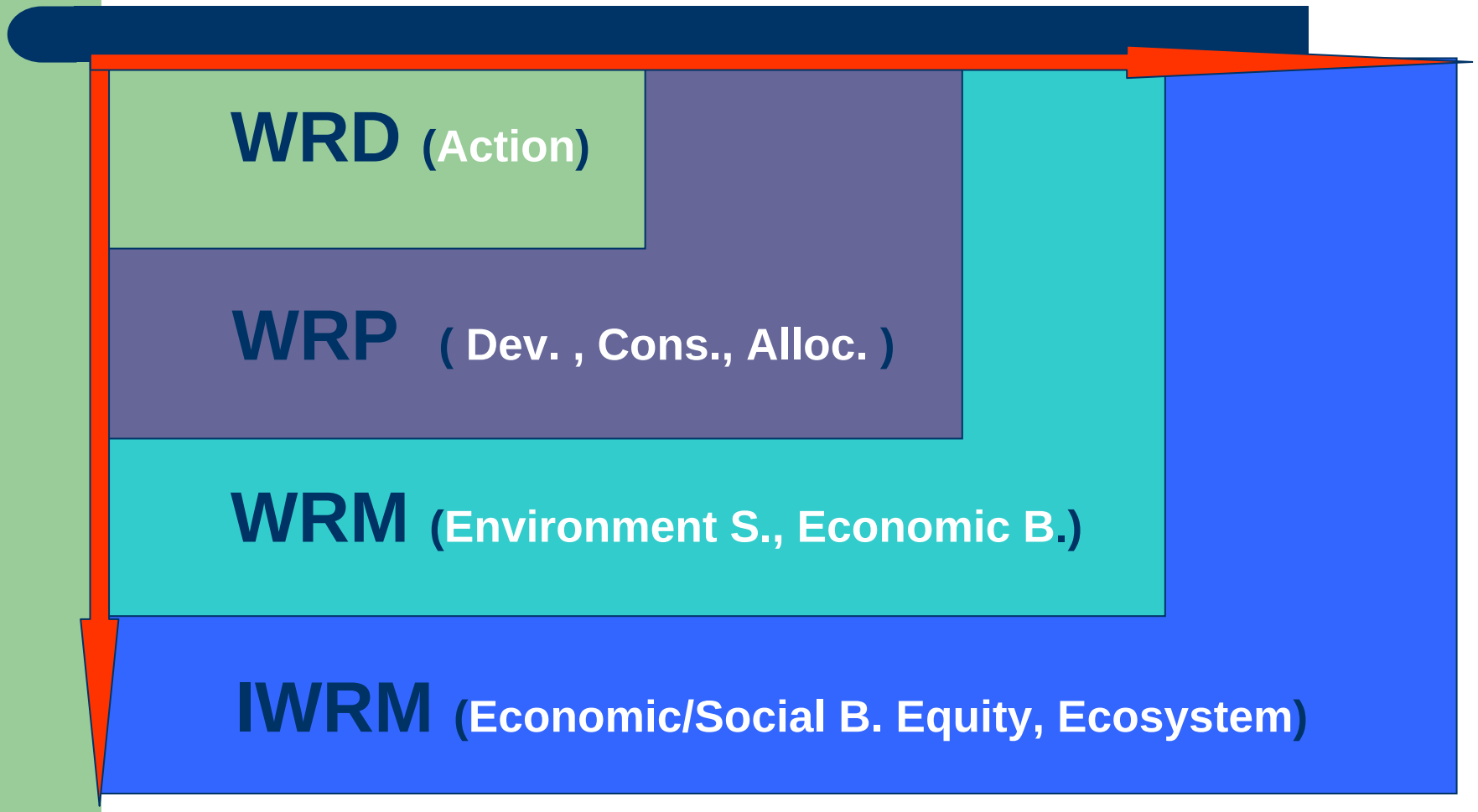
WRM and IWRM

- **WRM** is to ensure the sustainability of the water environment for multiple uses as an integral part of a country's **economic development** process.
- **IWRM** includes the whole set of technical, institutional, managerial, legal and operational activities required to plan, develop, operate and manage water resources for sustainable development

IWRM

Integrated Water Resources Management is the process of coordinating conservation, management and development of water, land and related resources across sectors, in order to maximize the **economic** and **social benefits** derived from water resources in an **equitable manner** while preserving and, where necessary, restoring freshwater **ecosystems.**

Relationship: expending



IWRM: Integration Levels

Integrated Approach Levels:

1. **Surface water - groundwater**
   water quantity - water quality

2. **Water in relation to land, soil, climate**

3. **Water in relation to environment and socio-economic development**

IWRM: Intergrated parameters

- All natural aspects of the water system: surface water, groundwater, water quality (physical, biological and chemical).
- All sectors depending on water: agriculture, households, industry, hydropower, navigation, fisheries, recreation, ecosystems.
- The relevant national objectives and constraints: social, economic, institutional, environmental.
- Institutions at all relevant levels: basin, national, provincial, local.
- The spatial variation of resources and demands: upstream-downstream interaction, basin-wide analysis, inter-basin transfer.
- The temporal variation: floods, droughts, peak demands, growth patterns.

IWRM: How Integrated ?

Although the term “integrated” most commonly refers to integration across use sectors, it can also encompass a number of other divisions, including the following:

Administrative jurisdictions;
Ground and surface water;
Upstream and downstream reaches;
Environmental and human uses;
Supply and demand management;
Water quantity and quality;
Land and water use; and
Transboundary uses etc.

IWRM: aim and criteria

- The aim of IWRM is to ensure the multi-functional use of water resources for the present and future generations.

The three major criteria:

- Economic efficient use of natural resources
- Equitable sharing of welfare
- Sustainability

IWRM: Among or Beyond

- **IWRM** is the management of freshwater systems as part of the broader natural environment and in relation to their socio-economic environment.

Links with:

- IRBM – Integrated river basin management
- ICZM – Integrated coastal zone management

Challenges: Why we need IWRM ?

- some 1.2 billion people are still without safe drinking water
- some 3 billion people are without sanitation, which threatens public health and water quality
- between 1950 and 1995 per capita water availability has dropped by 38% (in developed countries) to 70% (in developing countries with an arid climate)
- many ecosystems are being destroyed
- floods occur more often and cause more damage
- many conflicts occur between upstream and downstream uses and between different types of water use

A single discipline approach can no longer provide satisfactory solutions, because of

Strong linkage between different phenomena

- **land use → erosion → water quality**
- **land use → runoff → peak flows**
- **water use for irrigation → food supply**
- **public water supply & sanitation → human health**
- **water withdrawals → base flows**
- **wastewater & solid waste → water quality**
- **water quality → human health, productivity of ecosystems**
- **flood regulation → downstream land fertility**
- **large-scale infrastructure → environmental integrity**
- **global climate change → regional water availability**

IWRM and IRBM

IWRM is still a relatively new concept, focussed on the process through which people can develop a vision, agree on shared values and behaviours, make informed decisions and act together to manage the natural resources.

IRBM: River Basin

Sustainable Development and management of water can be achieved by applying Integrated Water Resources Management.

Elements of IWRM and IRBM

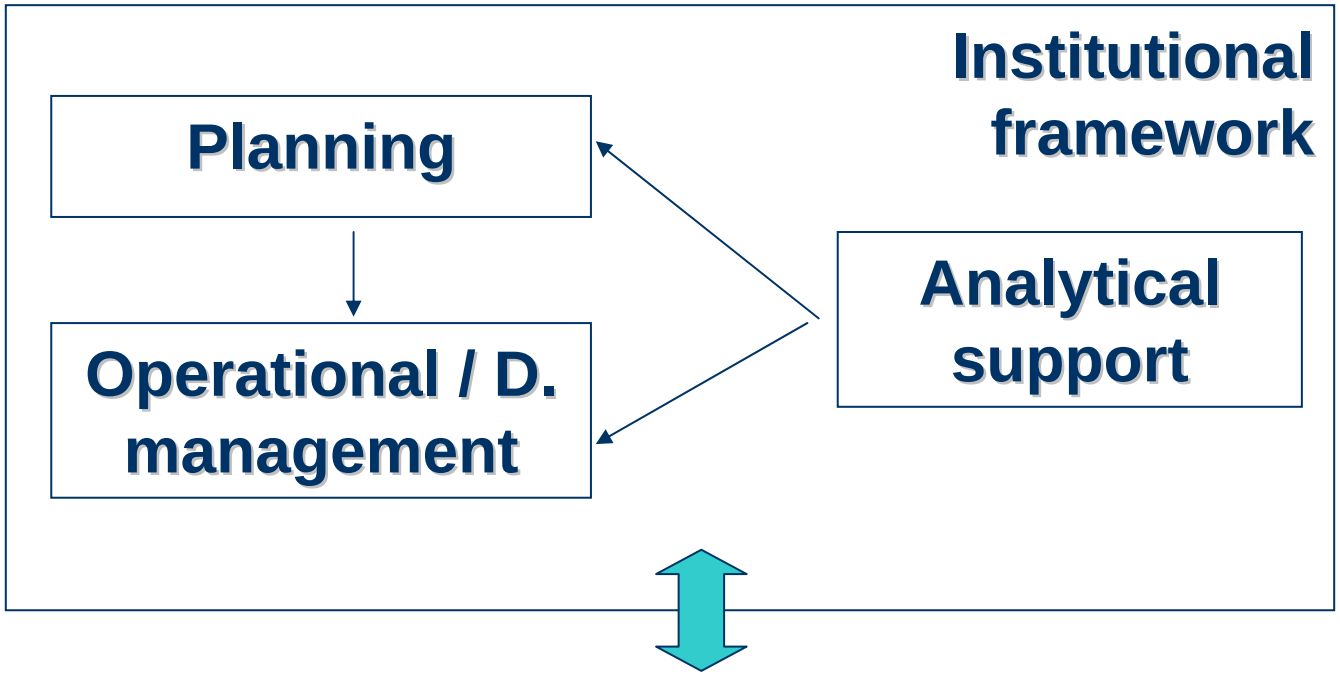
1. **Operational management**
   Activities that affect river basins directly.

2. **Planning**
   A means to improve and support operational management.

3. **Analytical support**
   Support to both planning and operational management.

4. **Institutional framework**
   The boundary conditions, the context.

IWRM Course Structure

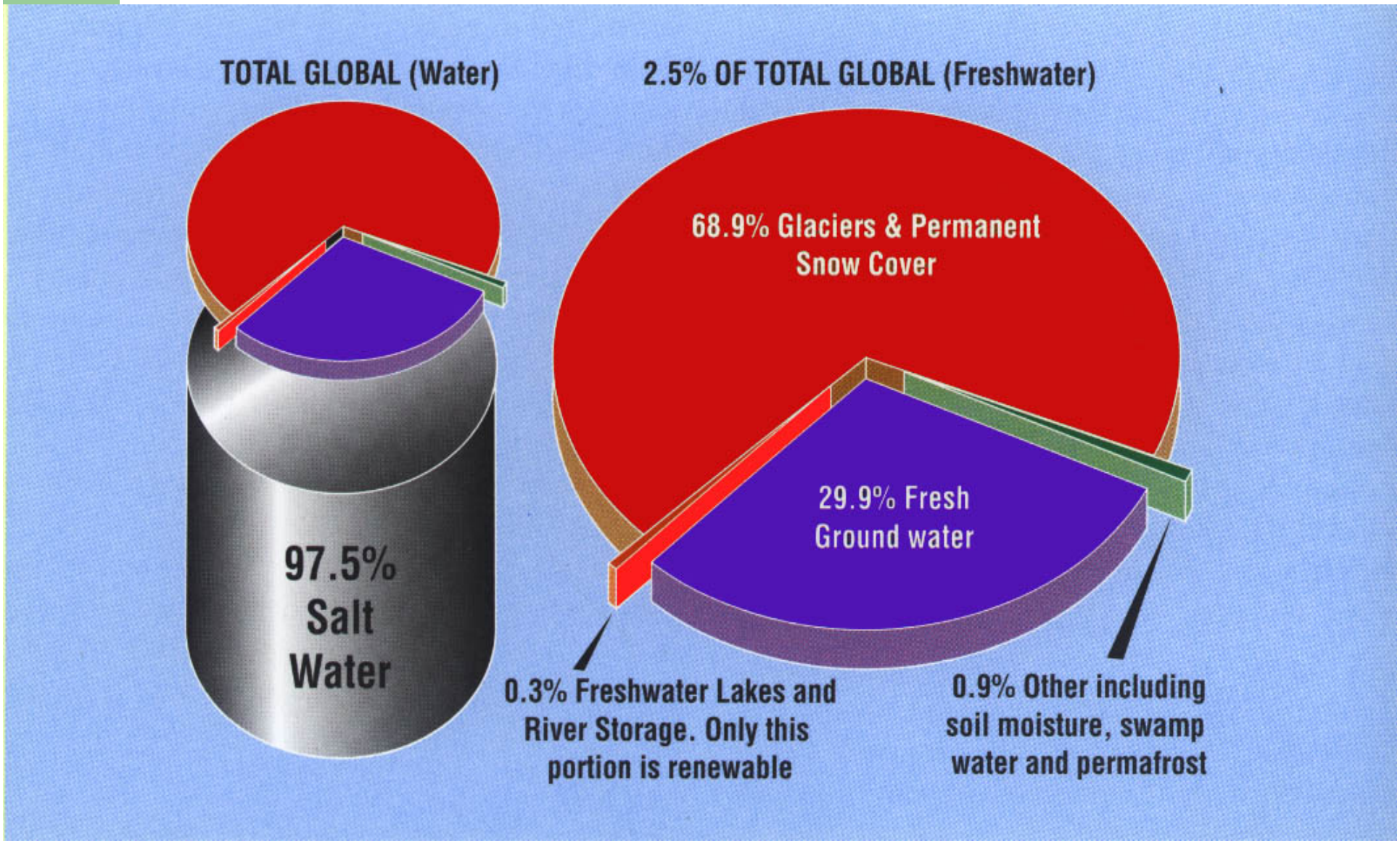


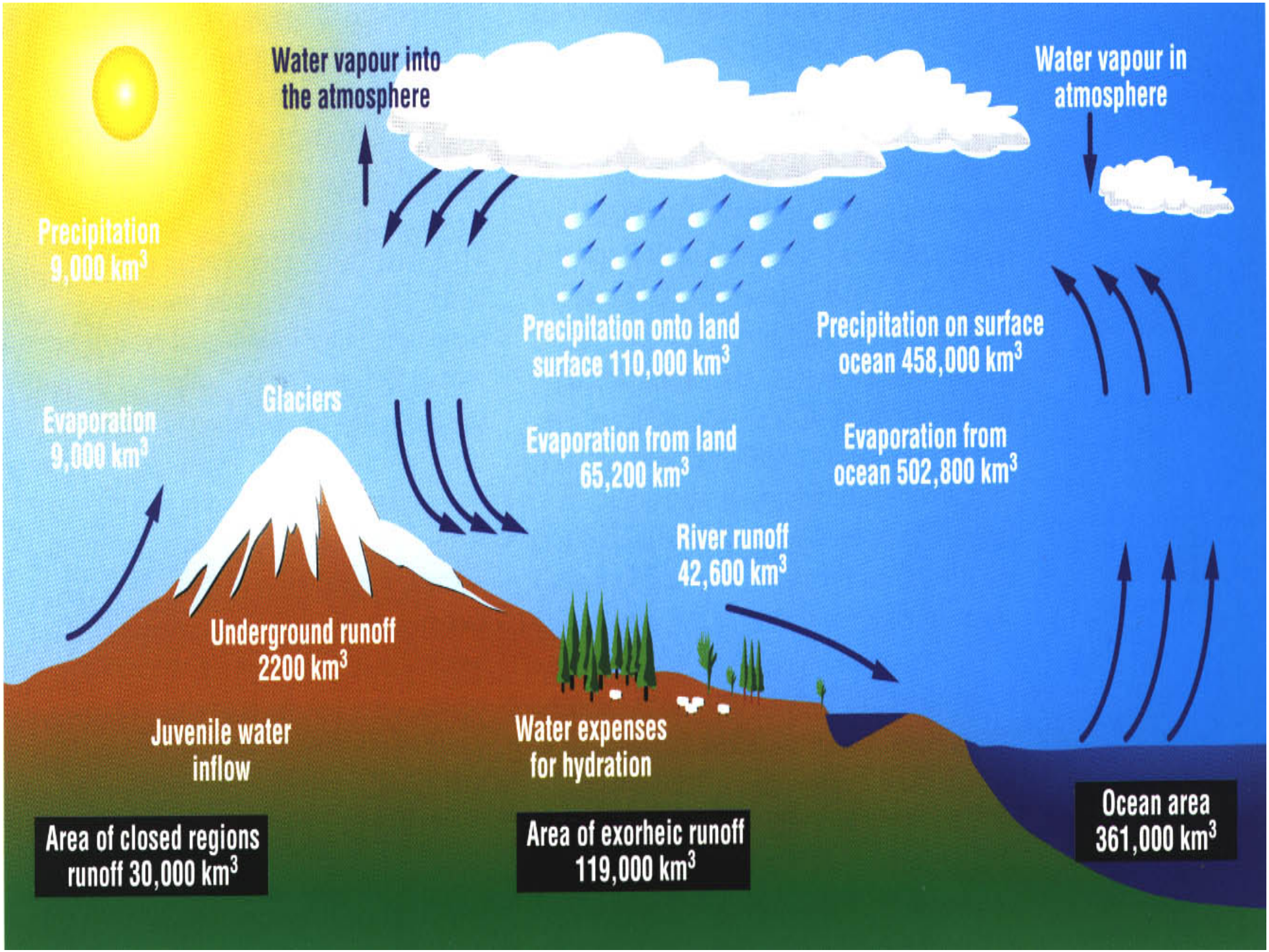
Water and River System

Hydrosphere

- Water: 1386 million km^3 on earth
  - in which: 97.5% saline water
  - 2.5% freshwater
- Freshwater
  - 68.9% : ice, snow in the Antarctic, the Arctic and the mountains
  - 0.3% : lakes, reservoirs and river systems
  - 29.9%+0.9%: groundwater + others

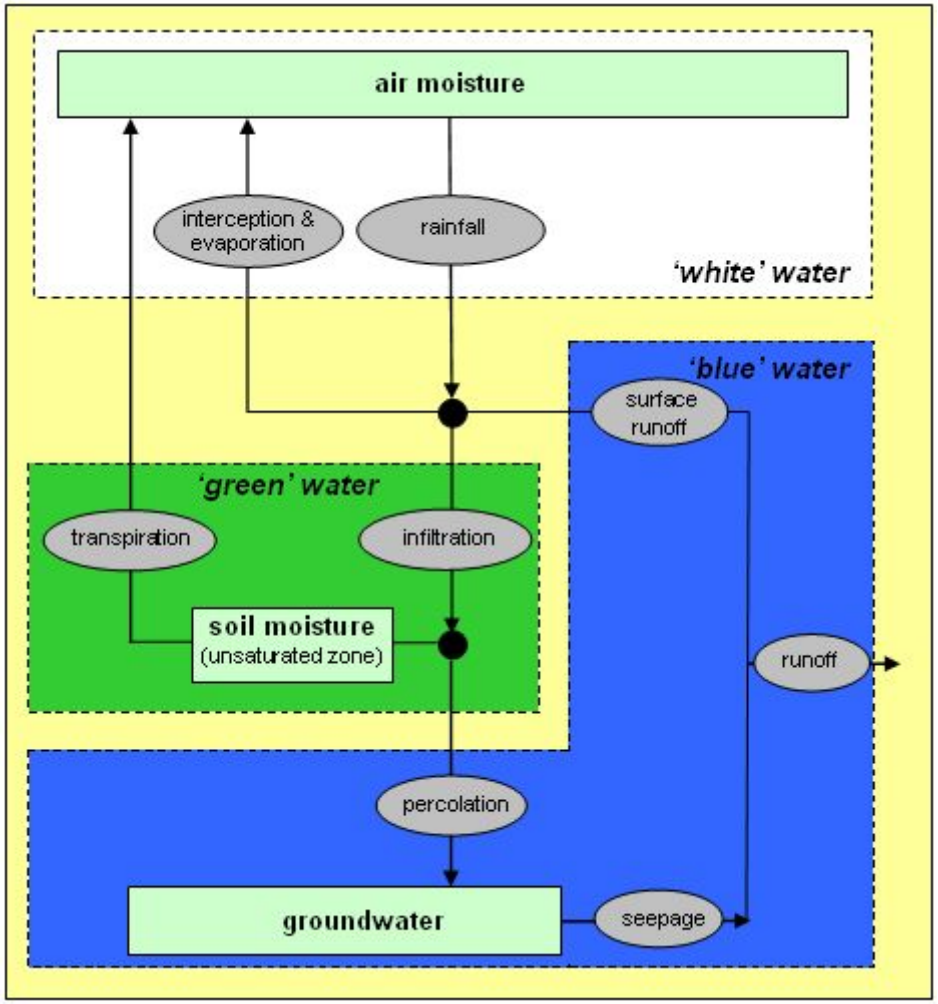
Water distribution on the earth




Water vapour into the atmosphere
Water vapour in atmosphere
Precipitation 9,000 km3
Precipitation onto land surface 110,000 km3
Precipitation on surface ocean 458,000 km3
Glaciers
Evaporation 9,000 km3
Evaporation from land 65,200 km3
Evaporation from ocean 502,800 km3
River runoff 42,600 km3
Underground runoff 2200 km3
Juvenile water inflow
Water expenses for hydration
Area of closed regions runoff 30,000 km3
Area of exorheic runoff 119,000 km3
Ocean area 361,000 km3

Three types of water

- In the hydrological cycle three types of water can be distinguished: white, blue and green

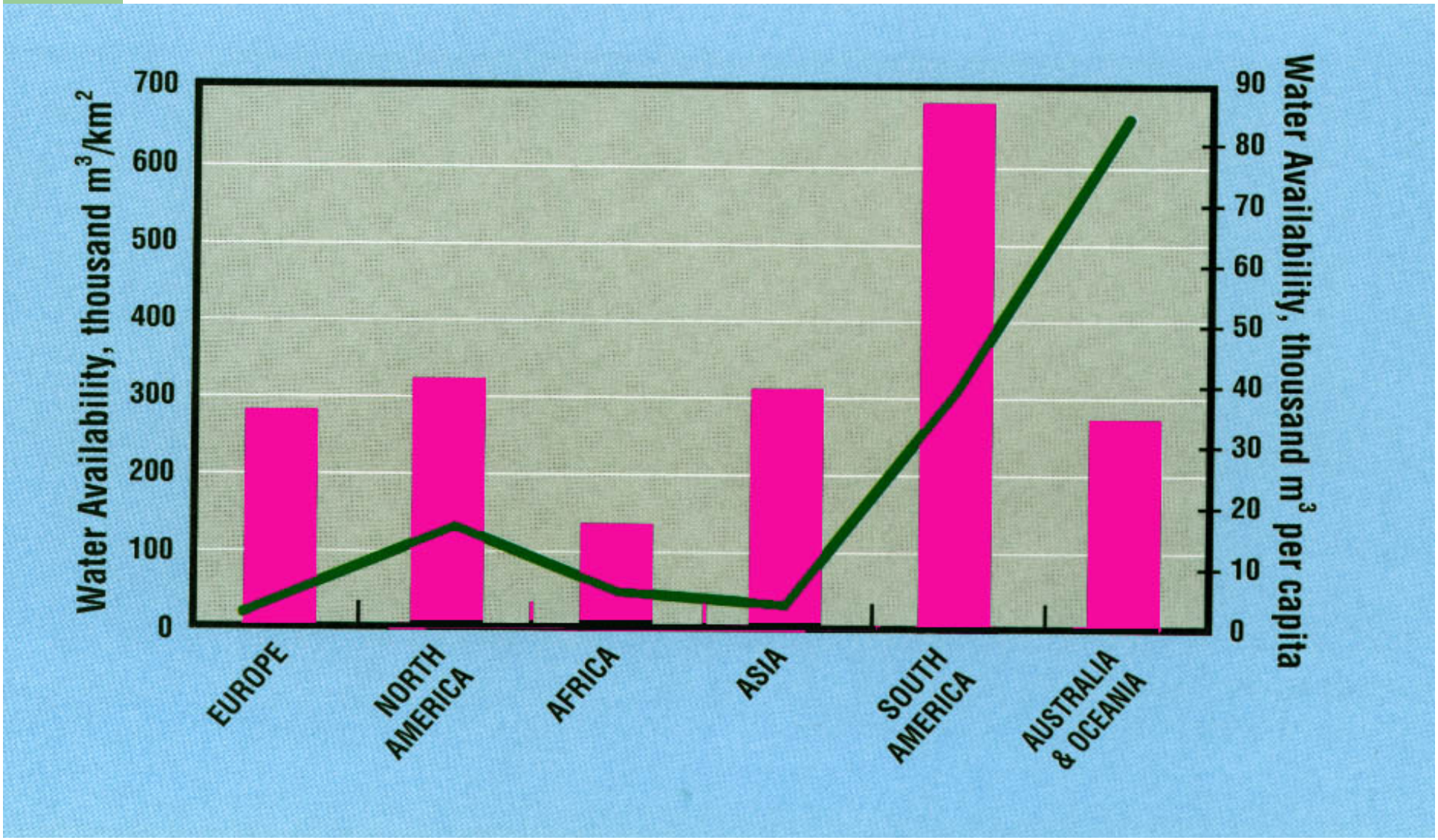


Distribution

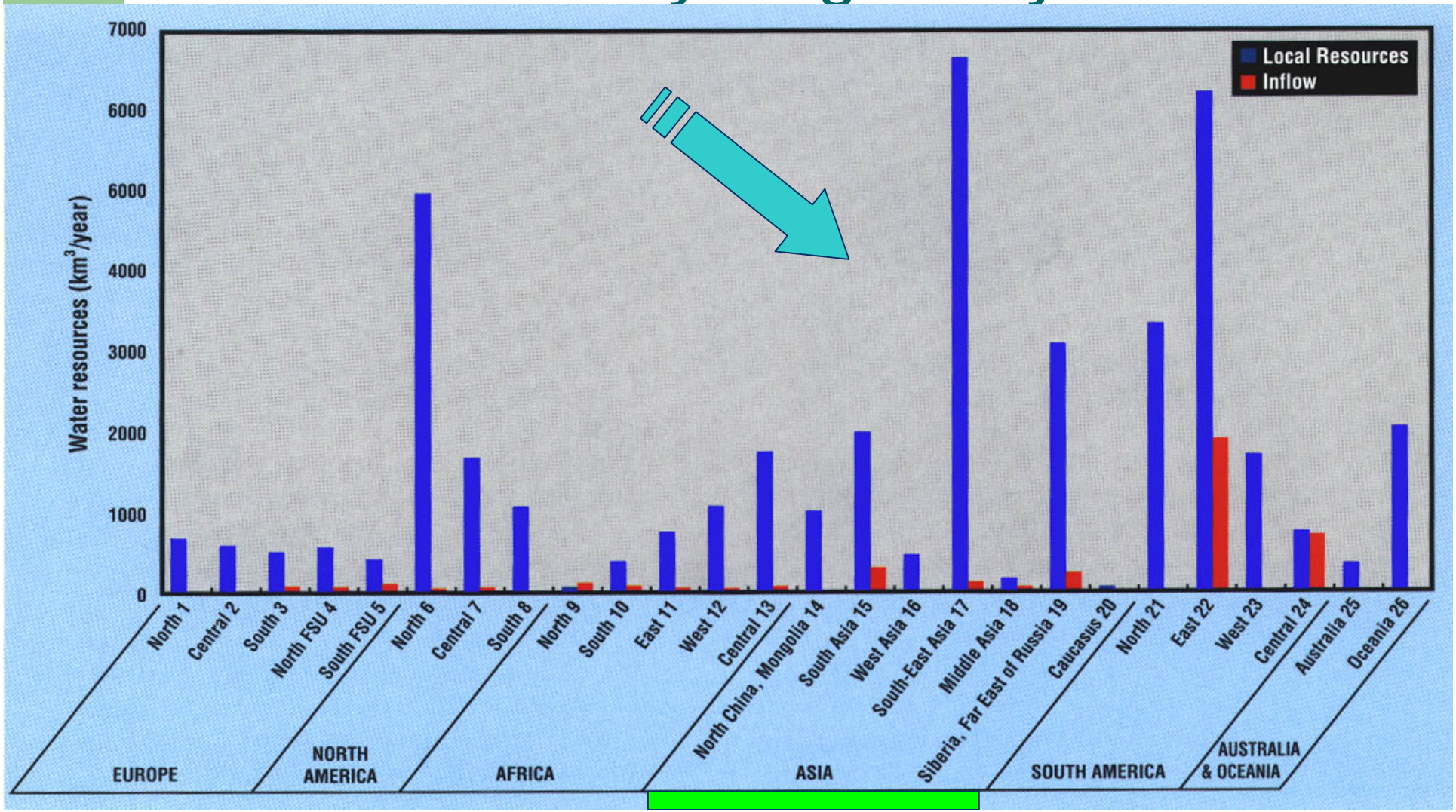
- Renewable global water resources 42,700 km^3 per year, however,

• Asia	13,500	km^3
• South America	12,000	km^3
• Europe	2,900	km^3
• Australia, Oceania:	2,400	km^3

Water Availability Continently

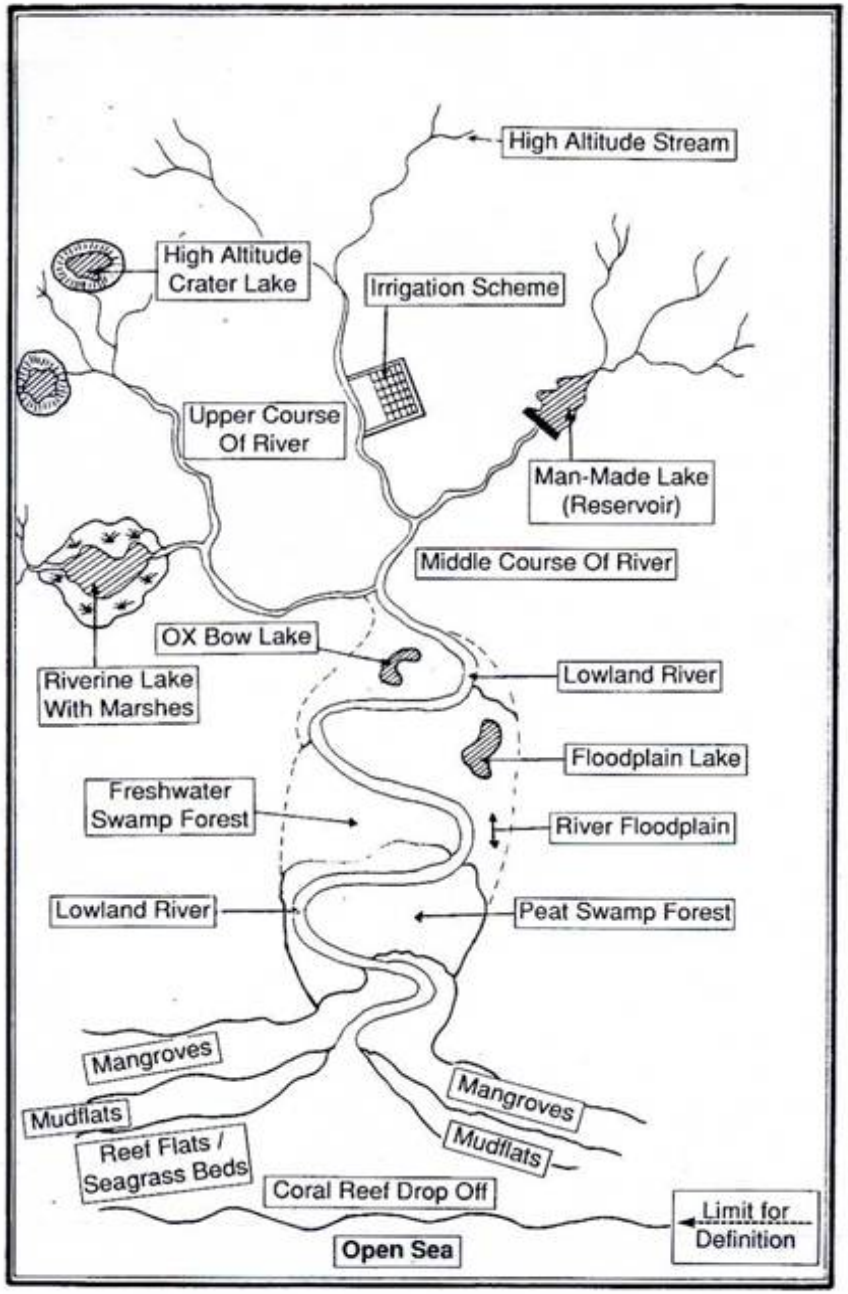


Water Availability Regionally



River and Wetland ecosystems

- The different types of wetlands.



Wetland ecosystems and biodiversity

- Many environmental problems can be understood better if addressed from an ecological perspective.
- *Ecology* is the scientific discipline that studies how organisms (plants, animals, bacteria) interact in and with the natural world.

River basin functions and interactions

- A river basin serves as the most appropriate unit for maintaining the health of its functioning and the conservation of freshwater systems
- River basins are defined by catchments

River basin functions and interactions

- Catchments can be defined at different spatial scales ➔ stream orders: scale up from sub-basin level

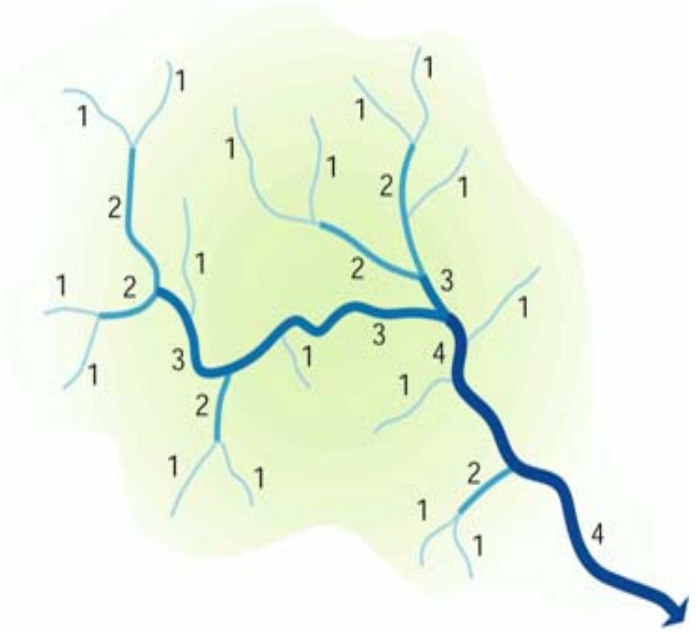
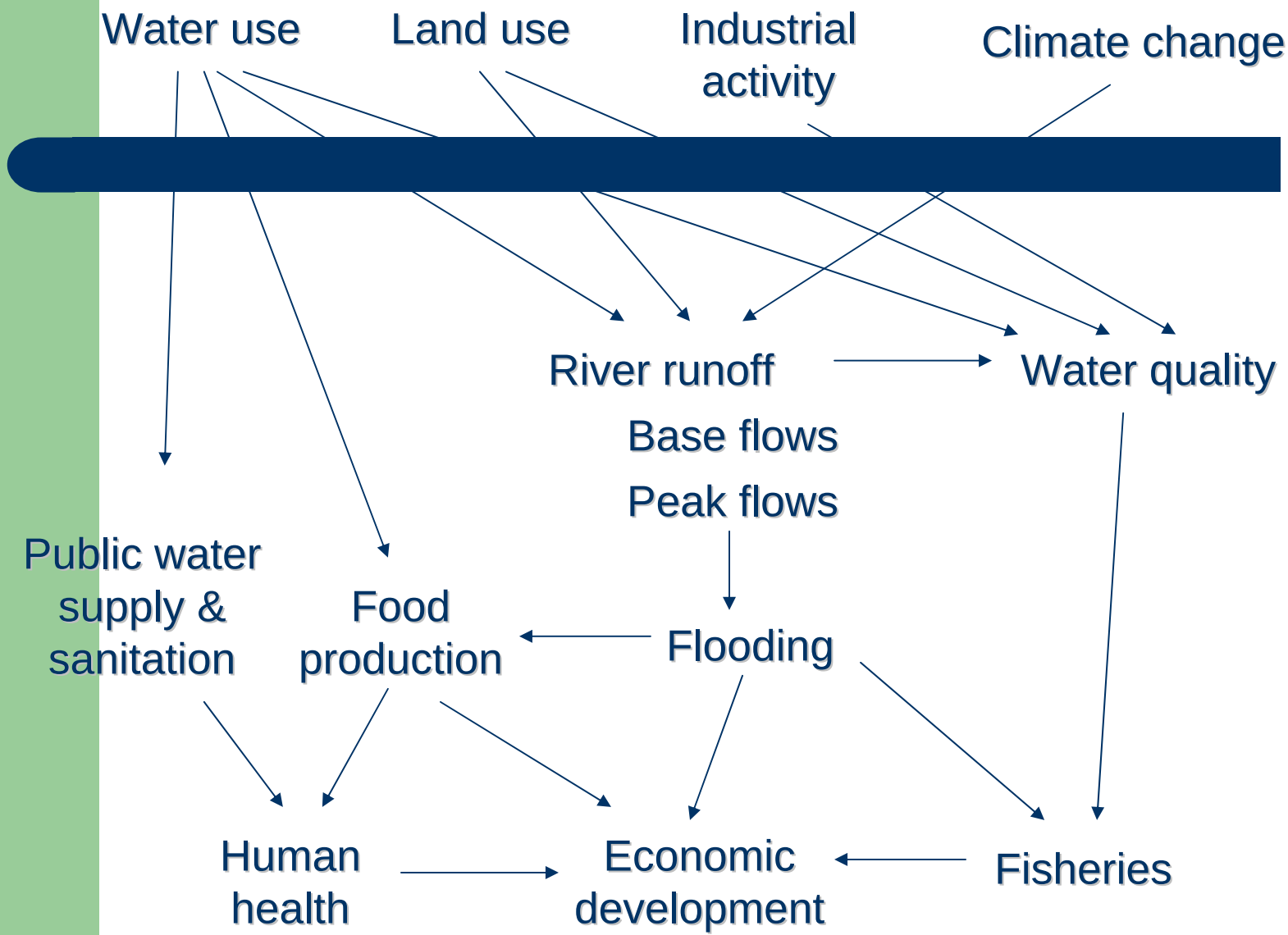


Fig. 1.30 – Stream ordering in a drainage network. "1" = first order stream; "2" = second order stream, etc.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).

Interactions in river basin systems



River basin functions and interactions

- Functions of river systems:
  - water supply
  - sewage discharge
  - nutrient retention
  - etc.

Interactions in river basin systems

- A river basin is a complex system.
  - Many sub-systems
  - Non-linear cause-effect chains
  - Feedback mechanisms
  - Uncertainties
- Complex systems can only be understood through holistic analysis.
- Complex systems can only be properly managed if one considers the consequences of activities and measures throughout the system.

Human interferences and Water Uses

Human interferences

- Different cultures have different attitudes towards nature
- Market economy and economic growth may lead to overexploitation of resources
- Search Balance of Quantity and Quality

Water Quantity

- flood protection
- irrigation
- drainage
- groundwater withdrawal
- water supply
- sanitation
- flow regulation
- power generation
- navigation

Water Quality

- organic matter and nutrients
- sediments
- chemical pollution
- thermal pollution

Water-Using Activities

- Consumption
  - Water Supply (domestic and industrial use)
  - Irrigation (Agriculture use)
- Non-consumption
  - hydropower
  - navigation
  - recreation and fishery

Unit municipal water use

China

Year	Urban L/d capita	Rural L/d capita
1980	117	71
1993	178	73
2000	215	97
2010	251	127

Unit municipal water use

Year	Urban L/d capita	Note
Japan 1970 Japan 1975	138 169	measured
UK 1977	168	measured
SW England	117-161	

Unit municipal water use

- Large cities in the world: 300-600 l/d
- Europe and N. America: 500-1000 l/d
- Asia, Africa, Latin America 50-100 l/d
- Some regions with insufficient water: 10-40 l/d

Municipal water use (Identify)

- Domestic (with and without public: Garden, Hotel, Hospital…)
- Use and consumption (10-60%, depends on water withdrawal)
- Projection: Real demand and consumption
- Alternatives: High, middle, low growth rate
- Proportional to total water use

Irrigation water demand

- Water condition: **P**recipitation, soil moisture…,→ dry year, normal year, wet year, (75%, 50%, 25% in probabilities)
- Crop pattern: rice, maize,wheat,vegetable…
- Natural zones: humid, semi-arid, arid…

Irrigation scheme

- Prepare irrigation scheme based on cropping pattern and growing stages, e.g, paddy rice:
  - establishment stage
  - vegetative stage
  - flowering stage
  - yield formation stage
  - ripening stage

Irrigation water use

- In practice, net water use:
  - water demand for each crop
  - cropping pattern
  - planting area

Gross water use:

- Efficiency : 0.5 or low

Irrigation issues

- Low efficiency
- High water consumption
- A lot of return flow
- Costly irrigation system construction and maintain

- Main output of food production
- High beneficial cropping pattern

Industry water use

- Industry situation in developing countries and developed countries
- GDP is mainly from industrial contribution (>=50%)

- Cooling water
- Air-conditioner
- Production (process)
- Other (clean or other water use in factories)

Water use processes

- Water use (Gross)
- Water intake
- Water drainage
- Water consumption
- Water reuse

Environmental water use

- Basic water storage in lakes
- Low flow of rivers
- Ecosystem water requirement
- Biodiversity and water need

Priorities in WRM

- Domestic
- Industrial
- Irrigation
- Environment

or

- Domestic
- Environment
- Industrial
- Irrigation

Or...

Planning Issues

Planning: Triggers

- **Problems that need solution**
- **Prevent future problems**
- **Planning for further development**
  e.g. development of resources currently not used
- **Drawing of a regular (e.g. 5-year) policy plan**

Better prevent problems than solve them afterwards.
Keep on thinking and regularly update your plans.

The planning process

Policy analysis

- **Problem analysis**
- **Design of alternative measures and strategies**
- **Evaluation of strategies (ex-ante evaluation)**

Decision making

- **Weighing of pros and cons of different strategies**
- **Making trade-offs**

Post-ante evaluation

- **Evaluation of policies that were implemented earlier**

Policy analysis

The Aim

- generate and present useful information for decision makers.

The Art

- common sense, experience and ingenuity
- knowledge and understanding
- lots of listening, co-ordination, translation
- systematic, methodical
- look for ‘good’ solutions : *‘optimal’ solutions do not exist*
- account for uncertainties: *avoid high-risk strategies*

Analysis ≠ decision making

but in the process of analysis choices have to be made, preferably by the decision maker, not by the analyst

Policy analysis: Framework

1. Problem analysis/identification
2. Formulation of objectives, constraints and criteria
3. Determination of analysis conditions
4. Systems analysis
5. Design of alternative measures and strategies
6. Assessment of policy impacts
7. Evaluation: comparison of alternatives

Policy analysis: First round of analysis

- **analysis of triggers**
- **problem analysis**
- **identification of possible measures**
- **identification of questions to be answered**
- **identification of objectives**
- **definition of criteria for evaluation**
- **limitations, constraints**
- **formulation of analysis conditions**
- **identification and involvement of stakeholders**
- **characterisation of stakeholders (problems, interests, strengths, weaknesses, linkages)**
- **setting priorities whenever possible**
- **working plan**

Policy analysis : Next rounds of analysis

- data collection and analysis
- analysis of human and economic conditions
- analysis of the natural system
- formulation of strategies
- impact assessment
- implementation assessment
- evaluation of alternative strategies
- comparison of alternative strategies
- presentation of results

Policy analysis: Concepts

- **triggers**
- **problems**
- **objectives**
- **constraints**
- **criteria**
- **indicators**
- **system, system boundaries and assumptions**
- **scenarios**
- **measures (structural, non-structural)**
- **strategies**
- **policy**
- **evaluation or/and post evaluation**

Planning: Planning approaches

Linear planning

The traditional approach: step after step.

Cyclic planning : **The same steps are repeated several times, with increasing detail.**

Open ended planning : **Keeping options open for later decision.**

Rolling planning : **Continuous updating and adjustment of plans in order to adapt to changing circumstances.**

Planning

In the course three items relevant in planning will be elaborated in separate units.

- **Public participation : involving the public in the planning process**
- **Strategic planning and management : assisting decision-makers in context of rapid change**
- **Decision making framework for river basin developments: a structured process, incorporating the full range of social, environmental, technical, economic and financial criteria and standards**

Operational and Demand Management

Operational Management

- There is no universal best approach
- Enforcement is often a problem
- Use of markets may be efficient (e.g. tradable emissions)
- Charging and full-cost recovery
- Water rights

Instruments

Concrete activities	**Direct interference by the managers**
Regulation	**Influencing other managers or users by forbidding activities or explicitly allowing**
Economic instruments	**Influencing other managers or users by financial (dis) incentives**
Communication & awareness raising	**Influencing other managers or users by providing information**
Financing	**Supporting the previous instruments by providing the necessary funds**
Capacity building	**Supporting the previous instruments by providing the other necessary resources (personnel, legal competencies, policy directives)**

Activities

Concrete activities	**Structural flood protection, river regulation, water supply and sanitation infrastructure, reforestation**
Regulation	**Standard setting, permitting, compliance monitoring, sanctioning**
Economic instruments	**Charges (taxes, levies), subsidies, tradable water use and pollution rights**
Communication & awareness raising	**Public information, non-binding plans, voluntary agreements**
Financing	**Charges, general taxes**
Capacity building	**Staff training, legislation, planning**

Balance and Coordination

- **Structural vs. non-structural measures**
- - water supply vs. water demand policy
- - dikes vs. land-use planning and insurance
- - the social and environmental side-effects of infrastructure

- **Regulatory approaches to pollution control**
- - product policy, process standards, emission standards or water quality standards?
- - using up the space up to standard

- **Regulation vs. communication**
- - the problem of regulatory instruments: enforcement
- - also (more?) important: understanding & commitment
- - voluntary agreements and other communicative instruments

Balance and Coordination (cont.)

- **Potentials and limitations of market mechanisms**
- - market mechanisms are efficient
- - e.g. tradable emission rights, tradable water use rights
- - risks: safeguarding the interest of the poor, speculation, monopoly
- - monitoring & control remain as necessary as with regulatory approach

- **Charging and full cost recovery**
- - marginal cost pricing is economically efficient
- - prices should include full economic and environmental cost
- - drawbacks: water delivery to the poor at risk, irrigated agriculture less profitable, reduction in production

Demand Management (DM)

- The development and implementation of strategies to influence demand for the efficient and sustainable use of scarce resource.

- 1992 Dublin Conference declared

Demand Management

- Difference between SUPPLY & DEMAND
- SUPPLY oriented
  - As much as possible water supply capacity
  - Users will use water properly
  - Water is a free or almost free good

However, water waste considerably

Demand Management

- DEMAND orientation
  - looks at the real demand
  - water is a economic good (users pay)
  - water is precious (equal distribution)

The manage focuses on the demand

Demand Management Aims

- To safeguard the rights of access to water for future generations
- To limit water demands
- To ensure equitable distribution
- To protect environment
- To maximize the socio-economic output
- To increase the efficiency of water use

From Supply Strategies

- Supply oriented measures
  - Surface water capture and storage
  - Inter-basin water transfer
  - Groundwater exploitation
  - Watershed management
  - Conjunctive use of surface and ground water
  - Desalination
  - Pollution control
  - Water sharing agreement

Strategies of WRM

- Demand oriented measures
  - Institutional and legal framework
  - Macro economic policy
  - Awareness raising, education
  - **Economic incentives**
  - **Legal incentives**
  - Canal lining
  - Leak detection
  - User appliance
  - Water reuse, efficiency, recycling

Environment

Incentives

Technologies

Demand Management Tools

- Technical (water conservation, water saving technology, leakage control, cropping)
- Economic (subsidies, tax and price policy,water tariff)
- Administration (licenses, regulations, policing,capacity building)
- Legal (water law, water rights, fines)

Demand Management Tools

- Educational (awareness raising, communication, education)
- Operational (operating rules, water allocations)
- Political (priorities, objectives, constraints)

Benefit Trade-off

- Water rights
  - Sector transfer
  - Distribution variation
- Water price
  - Exchange rate
- Water market
  - Agreement
  - Tradable water or emission rights

Demand Management
technical methods

- Reduce waste
  - Leakage
  - Illegal user identification
- Improve maintenance
  - Encourage investment
  - Reliable system
- Double systems for supply
  - Distinguish water qualities and supply purposes

Demand Management
technical methods

- Water saving technologies
  - Instrument: bibcock, muzzle…
- Good water use habit
  - Household education
- Prohibition, quota, limitation
  - In urgent case (extreme drought situation)
- System management
  - Records and meters

Integrated WRM

- Demand Management is one of the most important components of IWRM strategies
  - Awareness and promotion
  - Education and training
  - Implementation incentives

Demand Management
5P methodology

- Preachments (Awareness, education…)
- **Prices (Economic tools)**
- Politics (Equity, social stability)
- Practices (Technical tools & mechanism)
- Policing (Incentives, licenses…)

Strategy options

Demand Management or Supply Management

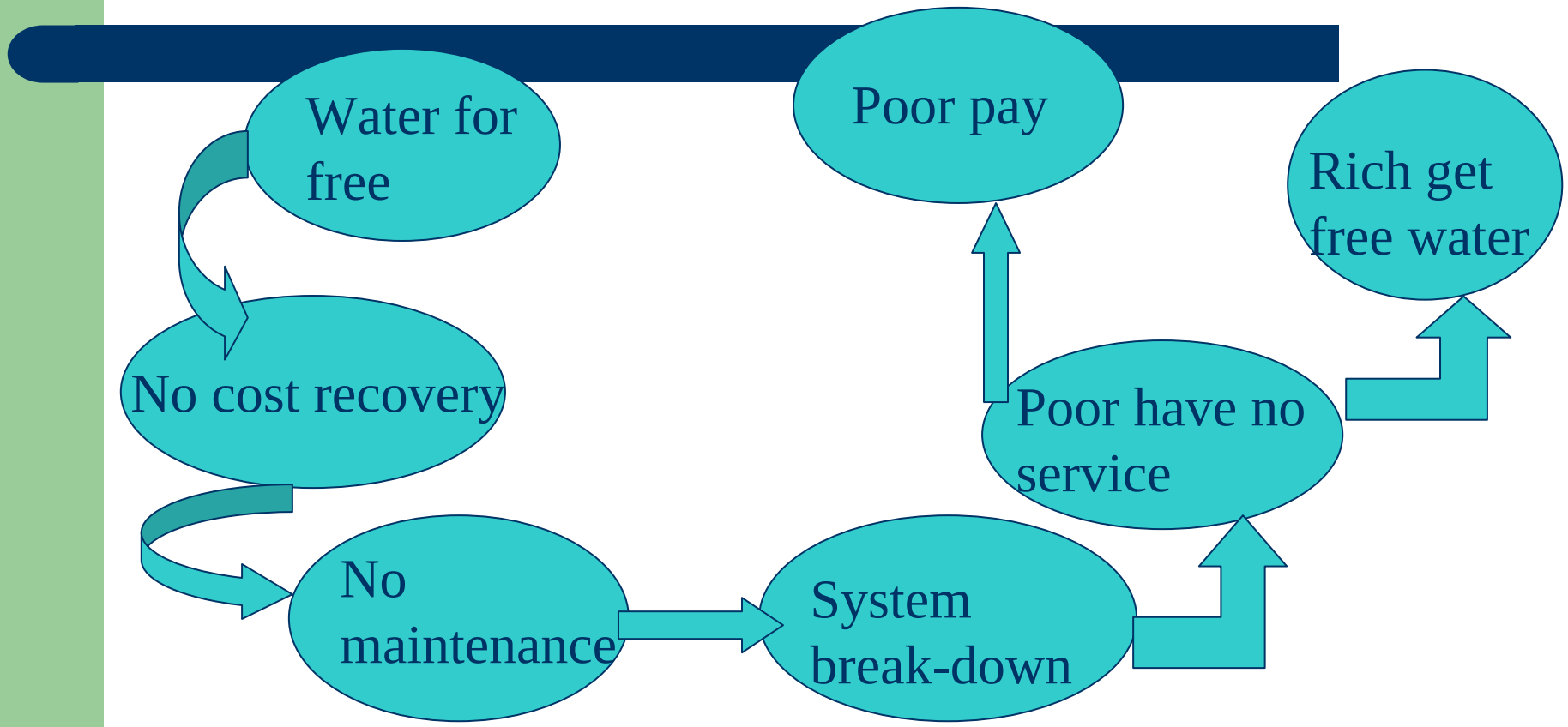
	High Supply	Low Supply
High Demand	Demand Management Water Quality Manage.	Supply Management
Low Demand	Demand Management Supply Management Pollution Control	Free Strategies: Demand Management Supply Management

Water tariff and pricing

Functions of Water Tariff

- a source of tax
- impact water use behavior (elastic)
- economic benefit
- income transfer
- equity and acceptability
- income stability and water tariff feasibility
- Water conservation

Water Pricing



FREE WATER DILEMMA

Water free of charge

- Mis-allocations of water resources
- Inefficient use
- Overexploitation

  - At Dublin Conference
  - Rio Conference (Agenda 21)

    →→→ Economic good

Most important economic tool

- Water pricing makes a key instrument for DM
  - Increased price reduces demand
  - Increased price increases supply
  - Increased price facilitate reallocation among sectors
  - Increased prices improve managerial efficiency

Composition of water pricing

- operational costs
- capital costs
- external costs
- opportunity costs
- tax or surcharge

Internal financial Cost

Economic costs

Users pay

Willing to pay (two cases)

- The willingness to pay is larger than the economic cost
  - Surcharge or tax
- The willingness to pay is less than the economic cost
  - Subsidies

Willingness to pay

Many parameters:

- Affordability
- Scarcity of the resources
- Appreciation for the resources
- Time and Spatial parameters

Elastic curve (Price and Demand)

$$E = \frac{dQ/Q}{dP/P} = \frac{PdQ}{QdP}$$

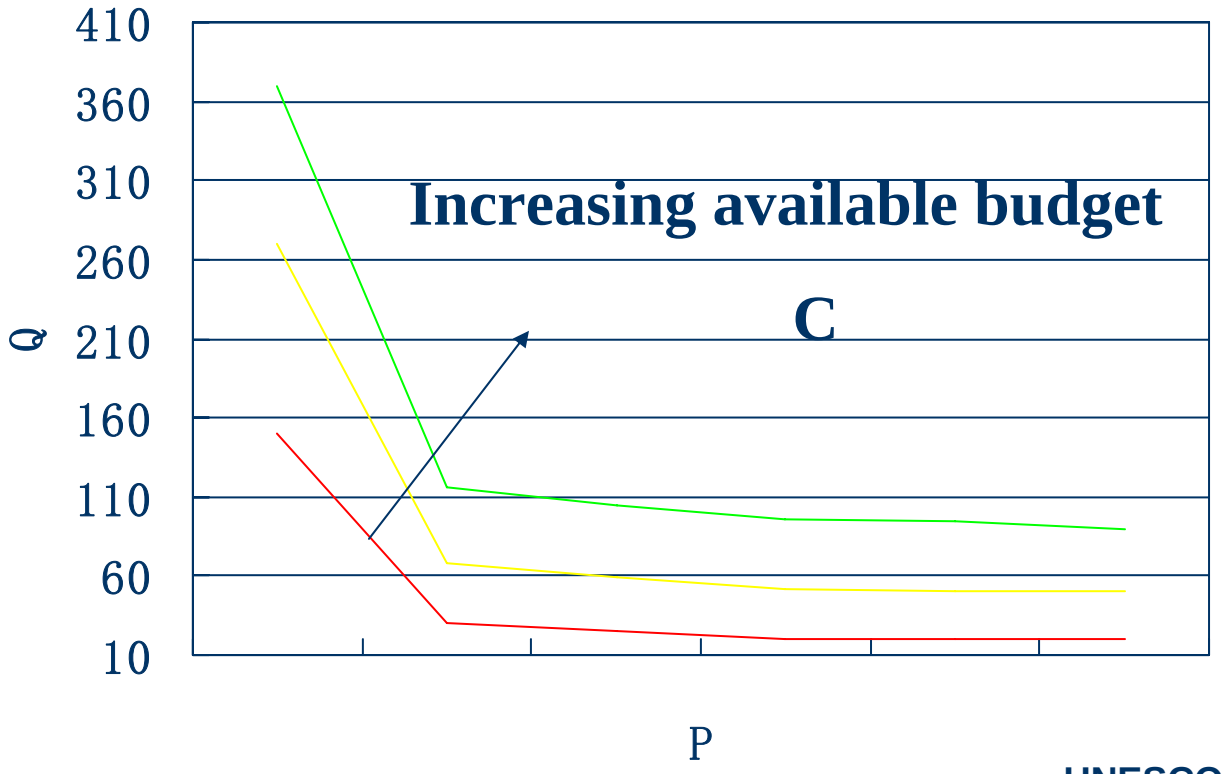
If E <-1, price increase is elastic (reactive)

If E –1<E<0, price response is rigid (inelastic)

Price-demand relations for drinking water are always inelastic

Price-demand relations

$$Q = C/P$$



Experiences (case study)

Unpaid Water Supply Stage (1949~1965)

Welfare Water Supply Stage (1965~1978)

Water Charges Reform Stage (1978~1984)

Commodity Water Stage (1985~up to now)

Water price for agriculture

No.	region	Document No.	Water price		remarks
			grain crops	economic crops	
1	Hebei	[1997]183	1.3~2.6yuan/mu + 7.5fen/m^3	The same as grain crops	
2	Shanxi	[1996]357	0.14 yuan/m^3 for GID, 0.18 yuan/m^3 for PID	0.18 yuan/m^3 for GID, 0.23 yuan/m^3 for PID	
3	Liaoning	[1996]9	3fen/m^3	3fen/m^3	
4	Jilin	[1996]95	2.34fen/m^3 for RID, 3.45fen/m^3 for REID, 2.21fen/m^3 for PID	the same as grain crops	
5	Heilongjiang	[1997]8	20 yuan/mu for IF, 10yuan/mu for NF	15yuan/mu	
6	Jiangsu	[1995]66	4~8 yuan/mu for IF, 0.5~2 yuan/mu for NF	4~8yuan/mu	

Proportion of water price to water supply cost

Unit: yuan/m^3

year / index	1996	1997	increment	increment rate（%）
water price	0.02	0.02	0	0
water supply cost	0.053	0.055	0.002	3.8
proportion of water price to WS cost (%)	37.7	36.4	-1.3	-3.4

Proportions of water charges to agricultural production cost Unit: %

crops year	wheat	corn	beet	Sunflower
1989	9.59	6.92	5.11	9.63
1993	6.90	5.95	4.80	8.74

Trend analysis of water price change in Tianjin

Unit: yuan/m^3

item / year	average cost	industry water		domestic water	
		water price	water price/water cost (%)	water price	water price/water cost (%)
1986	0.203	0.32	158	0.08	39
1987	0.219	0.32	146	0.08	36
1988	0.234	0.32	137	0.08	34
1991	0.266	0.34	128	0.09	34
1993	0.388	0.58	149	0.40	103
1995	0.516	0.70	136	0.40	78
1997	0.717	1.17	163	0.70	98

Water pricing design

- unit price decreasing

Water volume (m^3)	Water price ($/$m^3$)
0- 5	1.05
5-10	0.90
10-50	0.75
> 50	0.50

Water pricing design

- unit price increasing

Water volume (m^3)	Water price ($/m^3$)
0- 5	0.50
5-10	0.70
10-50	0.95
> 50	1.20

- Integrated price

Water volume (m^3)	Water price ($/m^3$)
0- 5	0.70
5-10	1.10
10-50	0.95
> 50	0.65

Other functions of water pricing

- Willingness to pay for water
- Encourage effective water use
- Reducing water demand
  - Reducing water tariff
  - Drought management
  - Protect water quality
- Increase water use
- Sustainable development

Water Allocation

Water allocation

- The purpose of the allocation of water to different users is to match or balance the demand for water with its availability
- Water allocation is not an issue when water availability far surpasses the demand
- Water allocation is not only concerned with the physical allocation of water. More broadly it is about satisfying conflicting interests depending on water

Water allocation – cont.

- Demand and supply varies through time (e.g. higher demand in dry season when supply is lower)
- Water exists in different “forms”
- Different qualities
- Consumptive (e.g. drinking water) and non-consumptive (e.g. hydropower) uses

Water allocation – legal framework

- Public vs. private goods
- Legal aspects of water allocation include:
  - types of water use that are regulated
  - water permits/rights
  - hierarchy of different types of water use
- No “recipe”; water manager need to make decisions

Value of water

- Agriculture uses a lot but low economic value (however, high multiplier effect)
- In some cases value difficult to estimate
- Allocation process strongly influenced by trans-boundary effects, in particular effect on downstream users

Issues in water allocation

- Defining key concepts → precisely and clearly defined
- Uncertainty → more efficient use through predictability; physical uncertainty and institutional uncertainty
- Efficiency and equity
- Water losses → depend on scale
- Water allocation between sectors
- Do higher value uses of water need to have priority over lower value uses?

Water for food

- Agriculture is the main user of freshwater
- Population increase will lead to a rising demand in water for food
- Responses could be more efficient use of water or improvement of irrigation systems, among others

Water for nature

- The environment also has a water demand that should not be forgotten
- Environmental water demand can affect the water available for human functions positively as degrading environment can affect the hydrological cycle

Water related infrastructures

- Infrastructure improves the water supply for human use
- However, in many cases infrastructure has a negative impact on nature
- In addition, other negative effects such as salt infiltration, increasing use of fertilizers, loss of historic sites and relocation of people may be caused by infrastructures.

Water quality management

- Proper river catchment management needs at least:
  - the development of integral management plans for whole drainage areas;
  - well-developed functional understanding of river and wetland systems;
  - the development of water pollution standards and monitoring programmes

Decision Support

Analytical support

Analytical support for operational management

- **Monitoring**
- **Databases**
- **Early warning systems**
- **Real time control**

Analytical support for planning

- **Simulation and optimization models**
- **Decision support tools**
- **Role plays**
- **Evaluation techniques**

Topics

- IWRM analysis and tools: an overview
- River basin analysis and modeling
- Information systems for IWRM
- Monitoring system

IWRM analysis and tools: overview

- Two types of river basin management support:
  - support of operational management
  - support of strategic policy making and planning
- This distinction is not absolute. Operational management and strategic policy-making interact, and data collection and ex ante analysis support each other
- many developments, but truly “integrated” support still rare

Operational support

- Monitoring
- Monitoring + models + internet (e.g. Flood Early Warning Systems)
- Automation (decision making) system (e.g. operation of storm surge barriers)

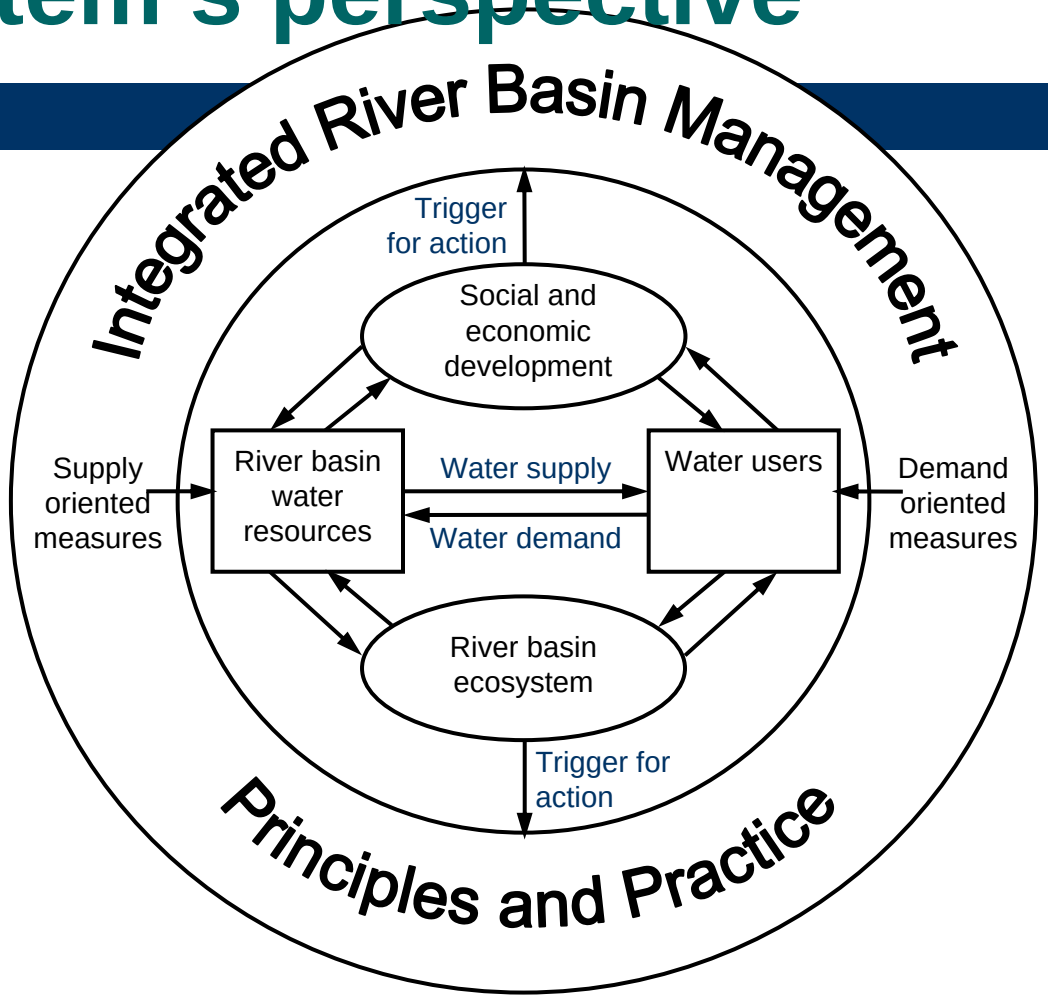
Analytical support

- Still often limited to specific river or topic, but Directions of development:
  - Analyzing interactions between socio-economic system and ecologic system
  - Linkages between levels (local, regional, basin)
  - Address mixed character of learning and negotiation developing

Analytical support – cont.

- Tune to dynamic and participatory processes of decision making
- Dealing with objective facts and subjective viewpoints
- Use of developments in computer technology

A system's perspective

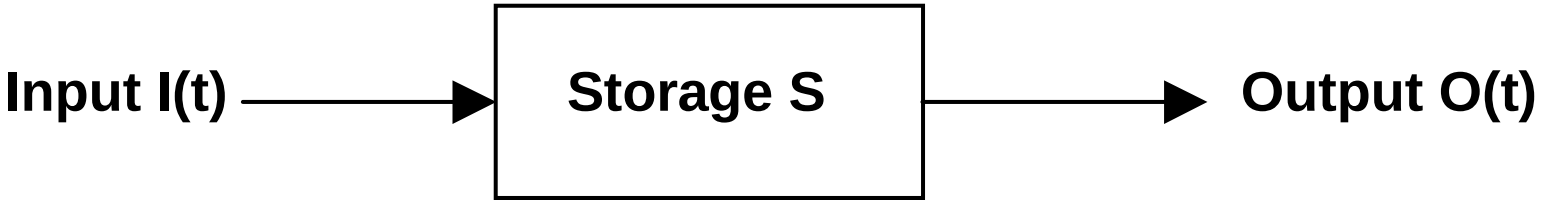


River Basin Analysis and Modeling

- Water balances: simulation models
- Other models and tools: Commercial and international software

Water balances (1)

Simple input-storage-output model

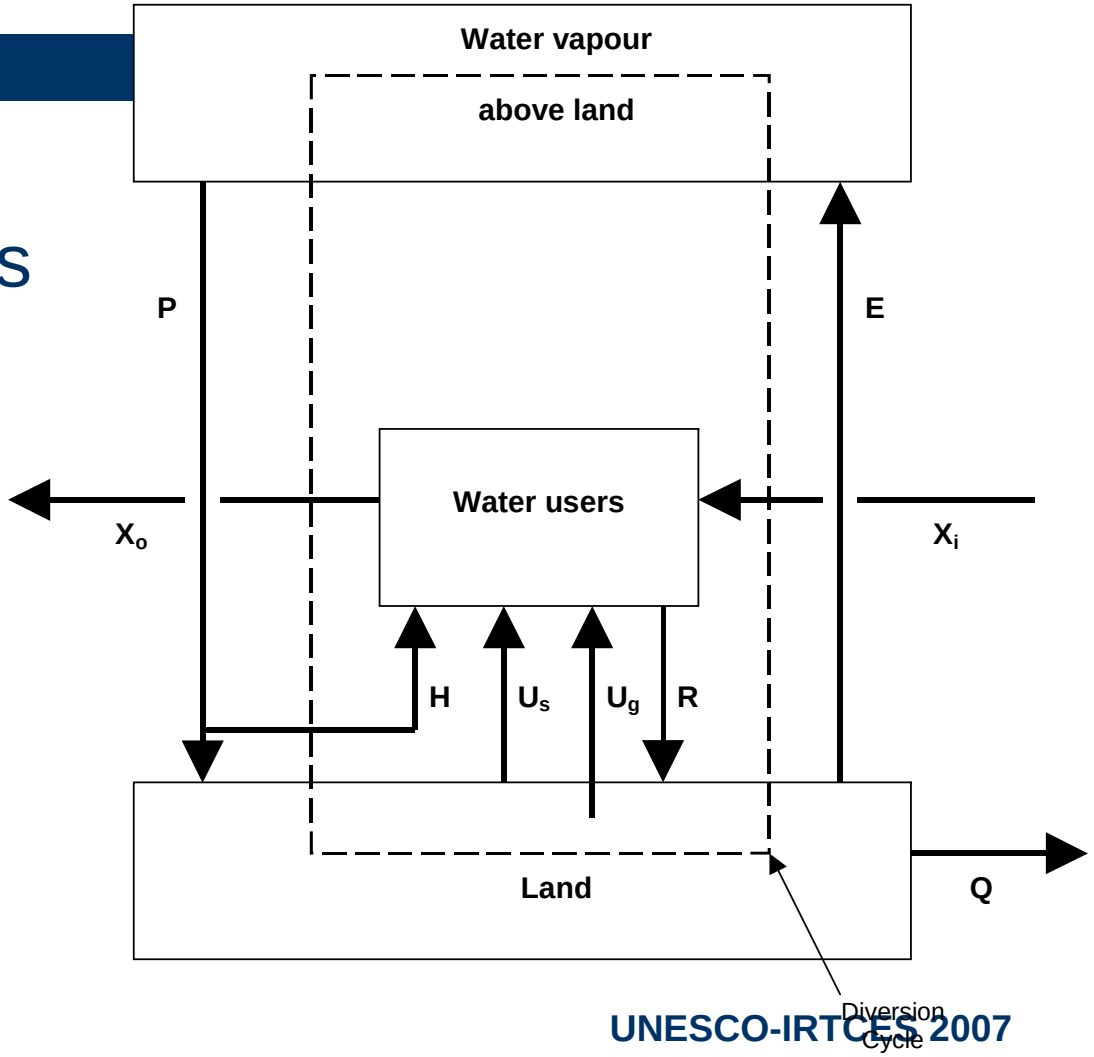


Water balances (2)

- In river basin much more complex:
  - precipitation
  - evapotranspiration
  - river discharge
  - use by human activities
- In particular human interference can strongly affect the water balance in a river basin

Water balances (3)

- Water diversion cycle included as result of human interference

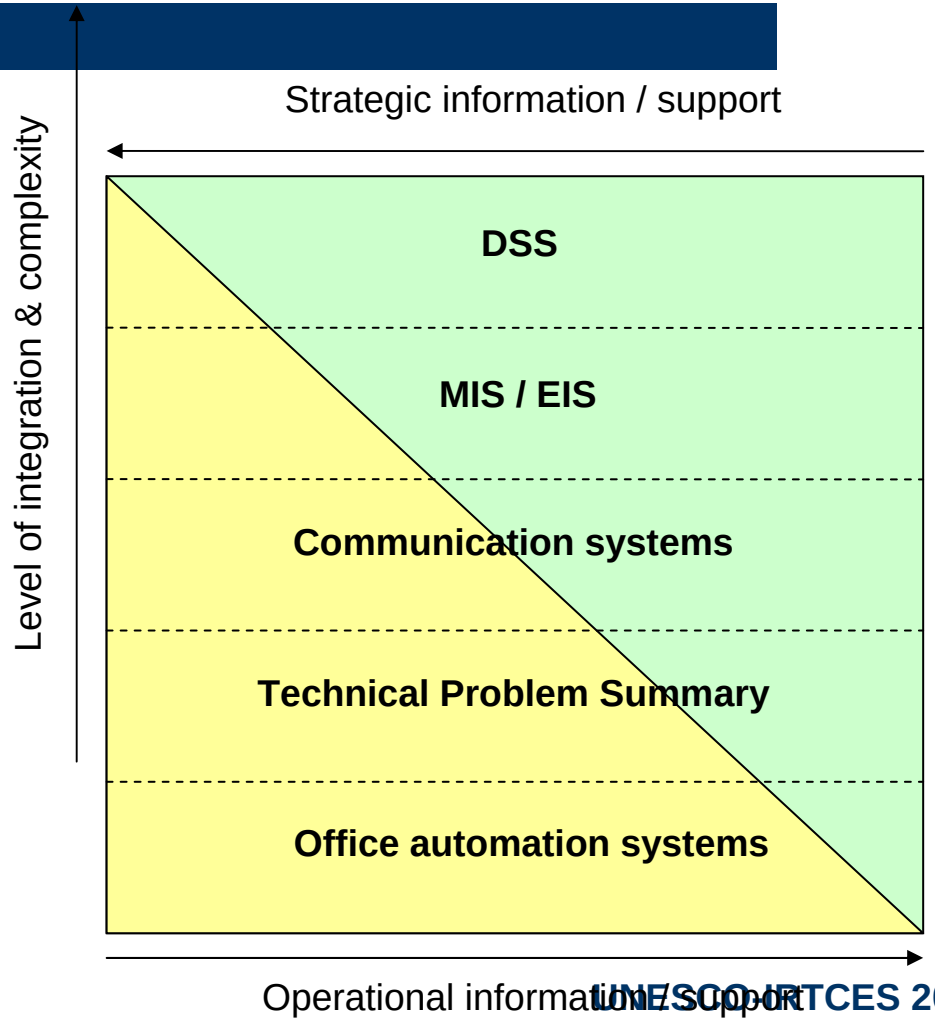


Other models and tools

- Examples:
  - SOBEK
  - TOPIC
  - Economic models
  - GWP Toolbox

Information systems for river basin management

- Developments in information systems



Information systems for river basin management

- Increasing trend of innovative use of information technology
- Geographical Information Systems (GIS)
- Decision Support Systems (DSS)
- Information management (MIS)

Geographical Information Systems

- GIS is a (computer) system for the storage, retrieval, analysis and display of spatial information.
- Fundamental concept: space
- Integration of information in GIS takes place through space: everything can be related to a location
- Different types of information in IRBM can be integrated using GIS

Decision Support Systems

- DSS are (computer) systems that particularly aim at the structuring and supporting of less-structured decision problems
- Integration of different (research) components of IRBM in a structured computer environment makes knowledge more accessible for non-experts

Decision Support Systems

- Many DSS are (being) developed. Two examples:
  - RIBASIM
  - ELBE-DSS

Information management

- IRBM analysis often requires large amounts of information
- Information management is essential
- The GIS house concept to implement information systems in an organization

Institutional issues

Concepts: Three models

- Hydrological model: organisational structure for water management is based on hydrological boundaries
- Coordinated model: river basin commissions with a co-ordinating task
- Administrative model: water management is the responsibility of provinces, municipalities and other bodies

Decision making rules : who did what

Operational rules	**Provide a framework for operational management** **e.g. emission standards, policy directives**
Collective choice rules	**Describe how operational rules should be developed** **e.g. permitting and planning procedures**
Constitutional rules	**Determine who is entitled to make collective choice rules** **e.g. legal arrangements on who has which mandate**

Technical ways: responsibilities

Hydrological model	**Extreme case: IRBM in hands of one single River Basin Authority.**
Administrative model	**Water management in the hands of national, provincial and local governments.**
Co-ordinated model	**Water management along administrative boundaries, but River Basin Commissions with a co-ordinating task.**

Planning :Public participation

Public participation (PP) plays an essential role in planning and policy-making.

- **a legal right of individuals and social groups, often resulting in procedural requirements for decision-making.**
- **a means for empowering individuals and groups and developing local communities.**
- **a means of improving the quality and effectiveness of decision-making**

Concepts: Decentralisation

- Is democratic
- Better response to local circumstances
- Less bureaucratic
- Not possible in all cases
- Often requires capacity building

Concepts: Privatisation

- Solution for the shortcomings of large bureaucracies
- Only possible for specific services such as the construction and operation of water supply and waste-water treatment infrastructure - not for regulatory functions and policy making
- Different forms exist

Concepts: Local institutions

- Beneficiaries organizing themselves
- Mix of private and public

Concepts: Institutional arrangements

In order to bring IWRM into effect, institutional arrangements are needed to enable:

- The functioning of a platform for stakeholders involved in decision making;
- Water resources management on hydrological boundaries;
- An organisational set-up in river basin and sub-basin authorities with their respective by-laws to incorporate decision making at the lowest appropriate level;
- A planning system oriented at the production of integrated river basin plans;
- The introduction of a system of water pricing and cost recovery.

Decision making framework

- Many technical guidelines for infrastructural projects have been developed by professional technical networks to ensure high engineering and quality standards.
- What is lacking is a comprehensive and integrated framework for decision-making on the provision of water and energy services.
- This unit presents a decision making framework that emphasis a structured process, incorporating the full range of social, environmental, technical, economic and financial criteria and standards.
- It is developed by the World Commission on Dams (WCD), but useful for any large-scale development project in river basins.

Priorities

- **The framework for decision-making is built on seven strategic priorities:**
-
- **1. Gaining public acceptance**
- **2. Comprehensive options assessment**
- **3. Addressing existing projects**
- **4. Sustaining rivers and livelihoods**
- **5. Recognising entitlements and sharing benefits**
- **6. Ensuring compliance**
- **7. Sharing Rivers for Peace, Development and Security**

Institutional framework

- Differs greatly from country to country
- Depends on tasks and competencies
- Aim should be integrated planning

China

- The main responsibility for water management lies at the Ministry of Water Resources
- At the national level a large number of institutions and ministries have some involvement in aspects of water management
- At the provincial, city-prefecture and county level similar organisations exist as at the national level

Note: More details refer to China's Water Issues

THANKS