Ecohydrology

Transdisciplinary Science/New Approach and Methodology for Integrated Water Resources and Sustainable Development

Ministry of Water and Energy

Yohannes Zerihun
E-mail:yhnns_zerihun@yahoo.com

May, 2013

Content:

- Introduction
  - **Earth at the "Anthropocene era"**
  - -Fresh water degradation
  - -Why are the present methods not providing satisfactory results?
- Ecohydrology and Its implementation in Ethiopia
- Conclusion

Earth at the beginning of 21st Century "Anthropocene era"

Almost 80% **has been changed by man into various forms of ecosystems such as:**

- agrocenosis
- urbanized center and
- transport pathways.

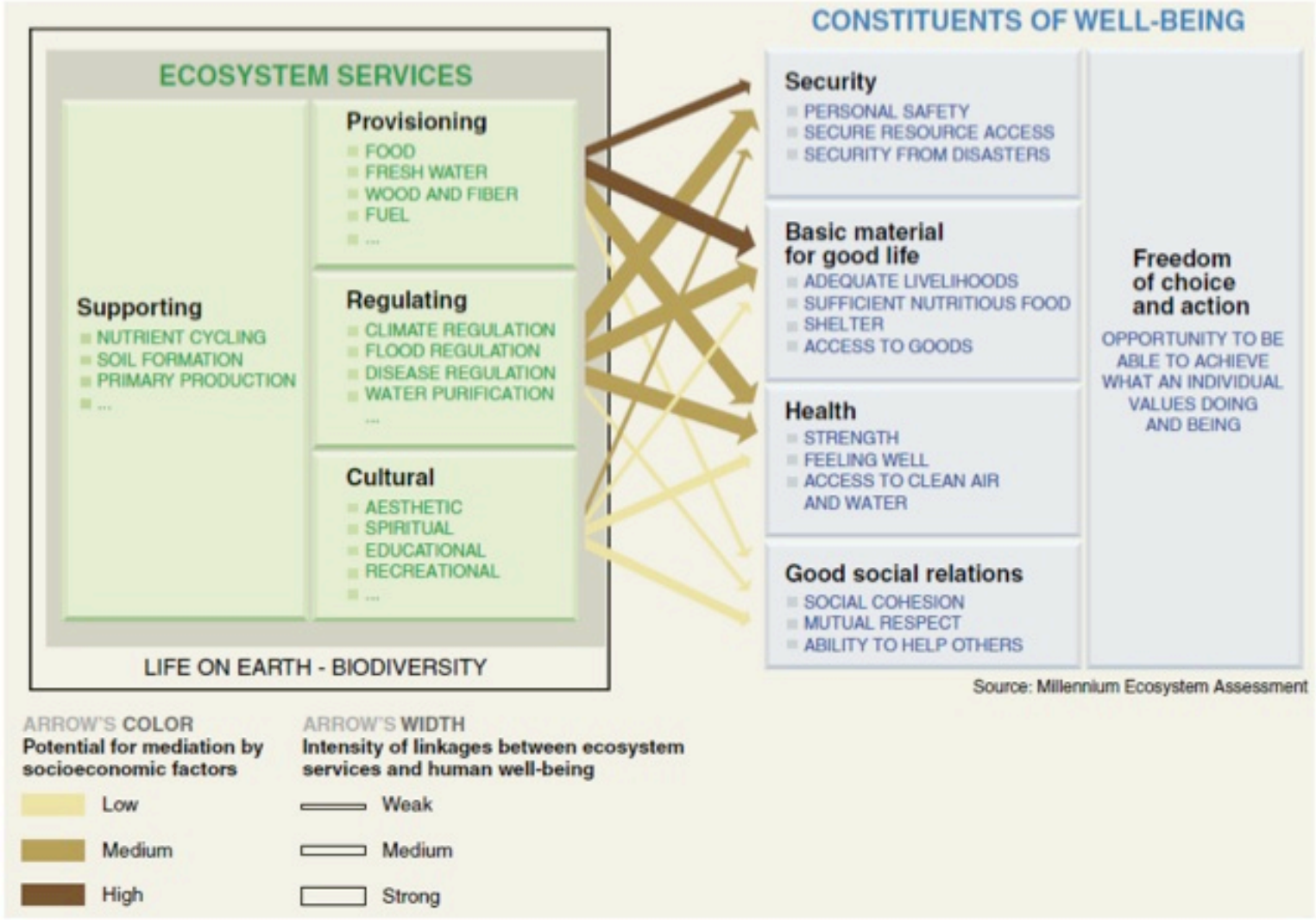
These are characterized by degradation of:

- hydrological cycle,
- emission of nutrients and
- pollutants,

which result in a drastic reduction of

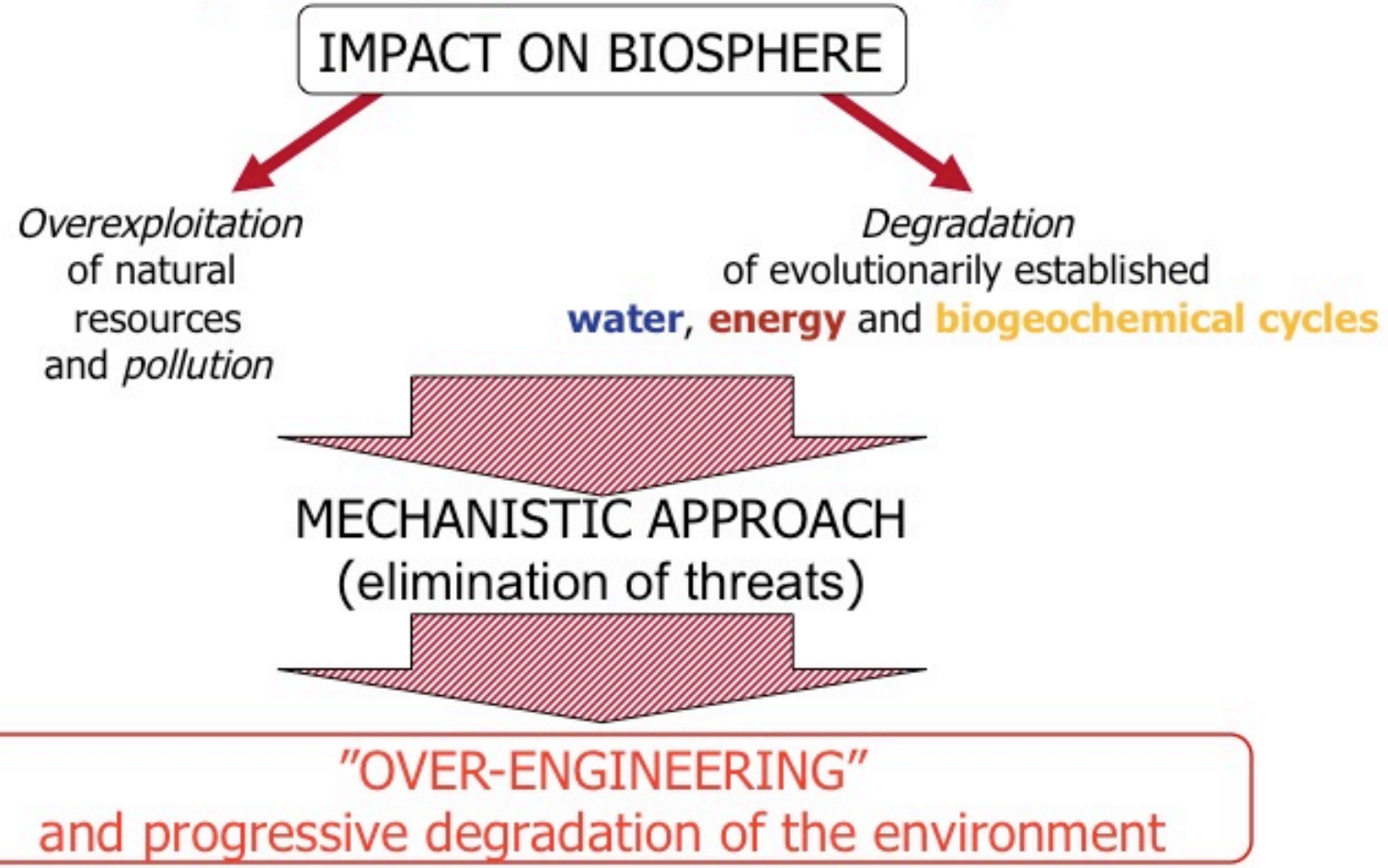
- biodiversity and hence ecosystem services for societies

Linkages between Ecosystem Services and Human Well-being



Source: Ecosystems and human well-being, *Synthesis, 2005*

The degradation of freshwater ecosystems can be characterized in terms of two dimensions/**ECOLOGICAL PROBLEMS**
(in global, regional and local scale)



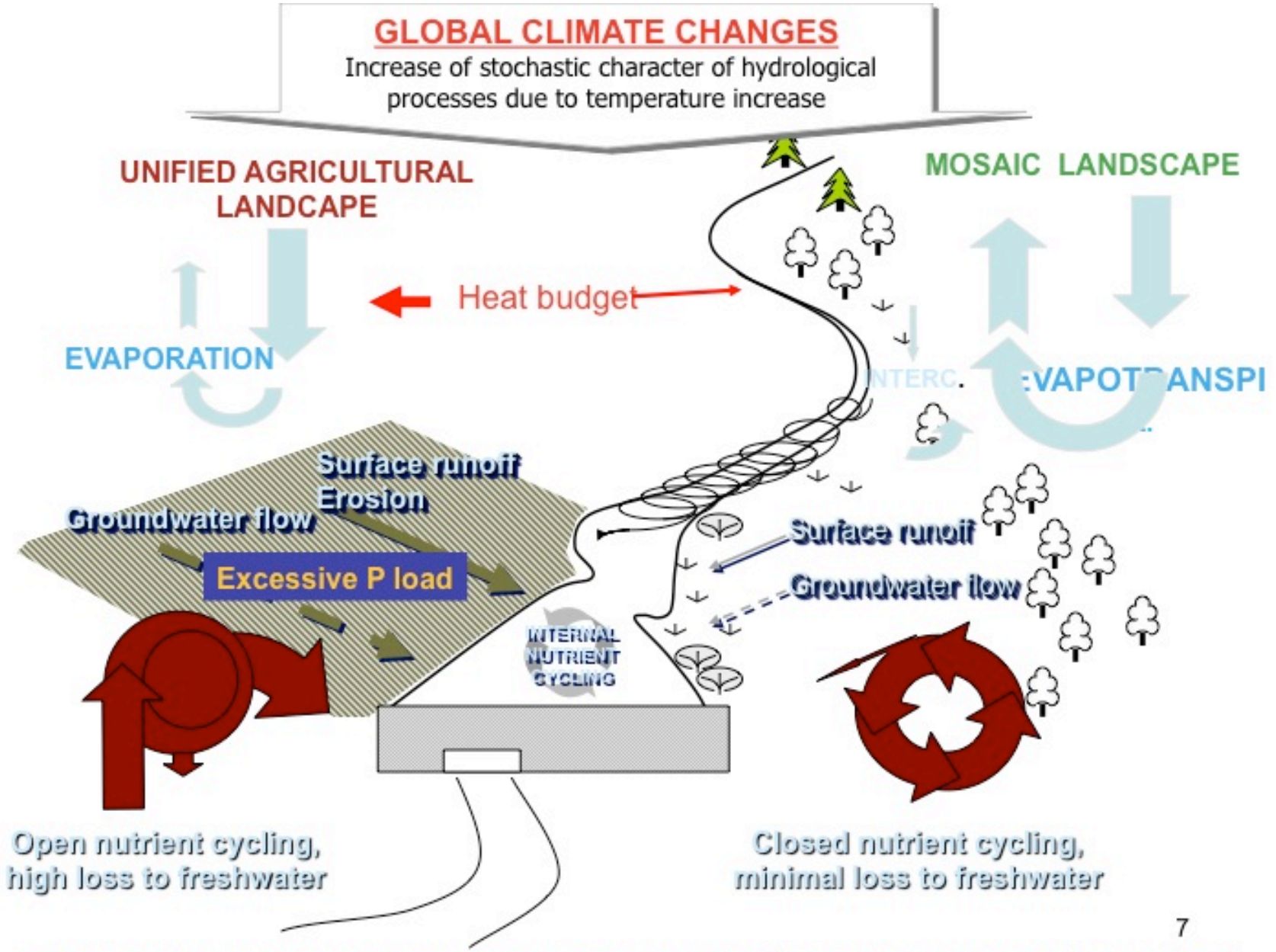
International Centre for Ecology Polish Academy of Sciences, Warsaw
Department of Applied Ecology University of Lodz

To date, water management has concentrated on the elimination of threats. The major threats and their elimination have been:

1. **Catastrophic floods and droughts**, by building dams and levees and canalization of rivers.

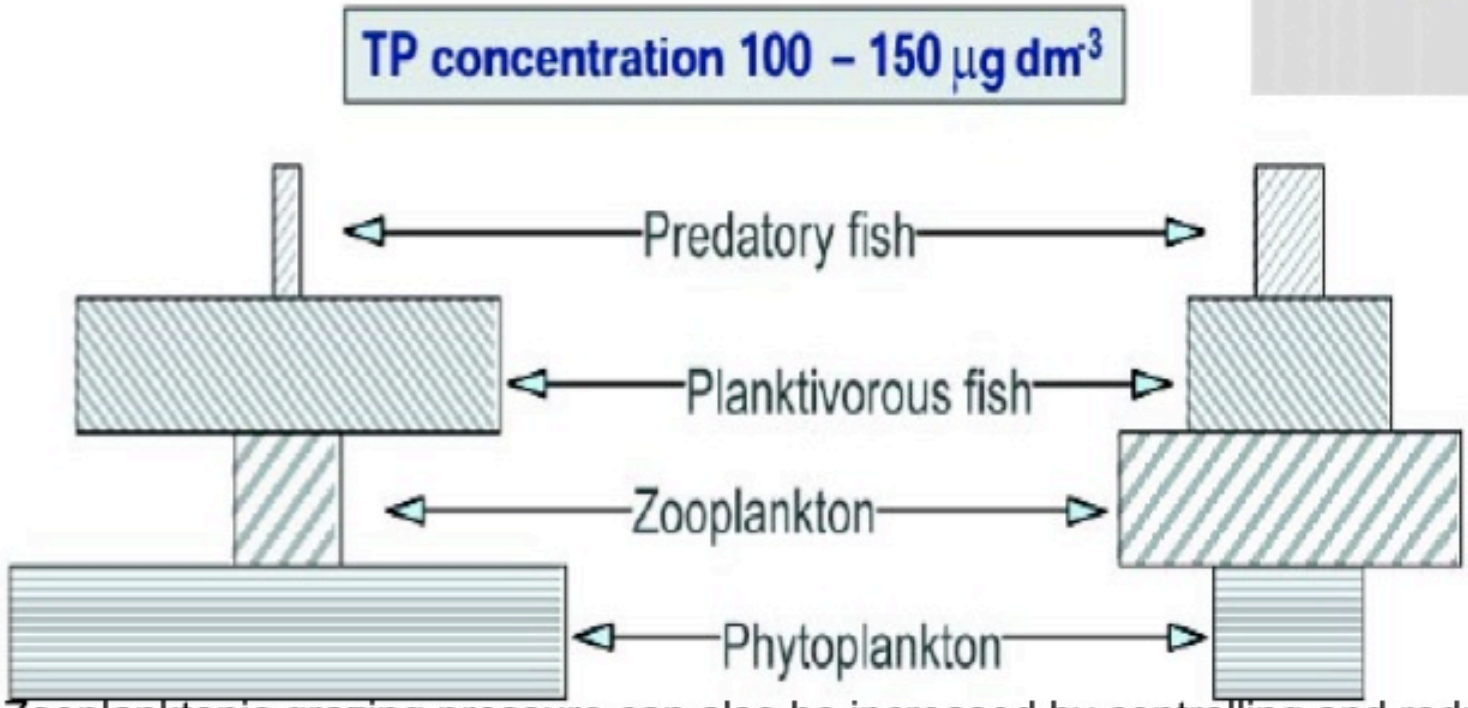
2. **Pollution**, by construction of sewage treatment plants.

3. **Erosion**, by planting trees or reduction of slope of rivers valleys by terraces



Water and nutrients cycles on the basin scale (from Zalewski 2002) modified)

What should be the biotic structure of an Ecosystem to maintain the water quality?



Zooplanktonic grazing pressure can also be increased by controlling and reducing the abundance of zooplanktivorous fishes

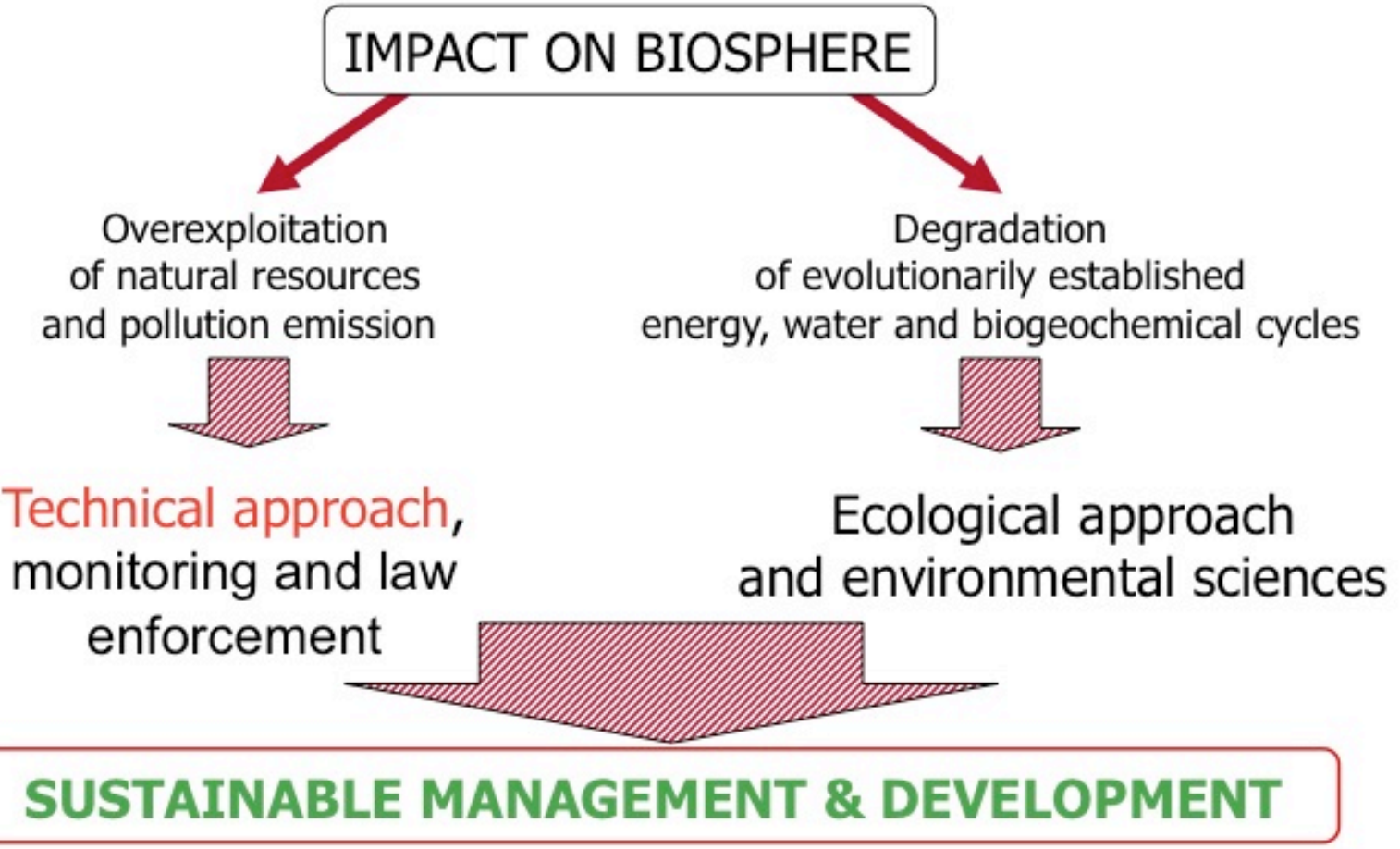
IMPROVEMENT OF WATER QUALITY

The "Factor Four concept" (FF)

The key assumption of FF is a twofold reduction of energy and matter consumption per unit of GDP while maintaining a potential for doubling economic growth.

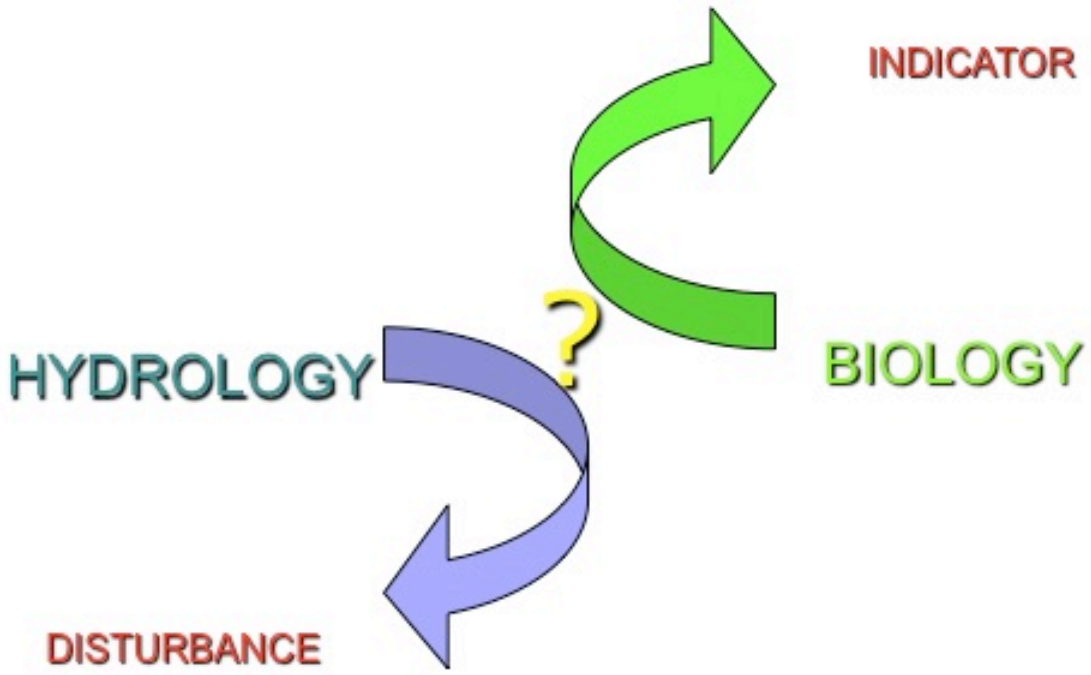
The FF concept on its own, although very important for a sustainable future of the planet, is not sufficient because it **focuses only on the elimination of threats** to societies

The degradation of freshwater ecosystems can be characterized in terms of two dimensions/**ECOLOGICAL PROBLEMS**
(in global, regional and local scale)



Isource: nternational Centre for Ecology Polish Academy of Sciences, Warsaw Department of Applied Ecology University of Lodz

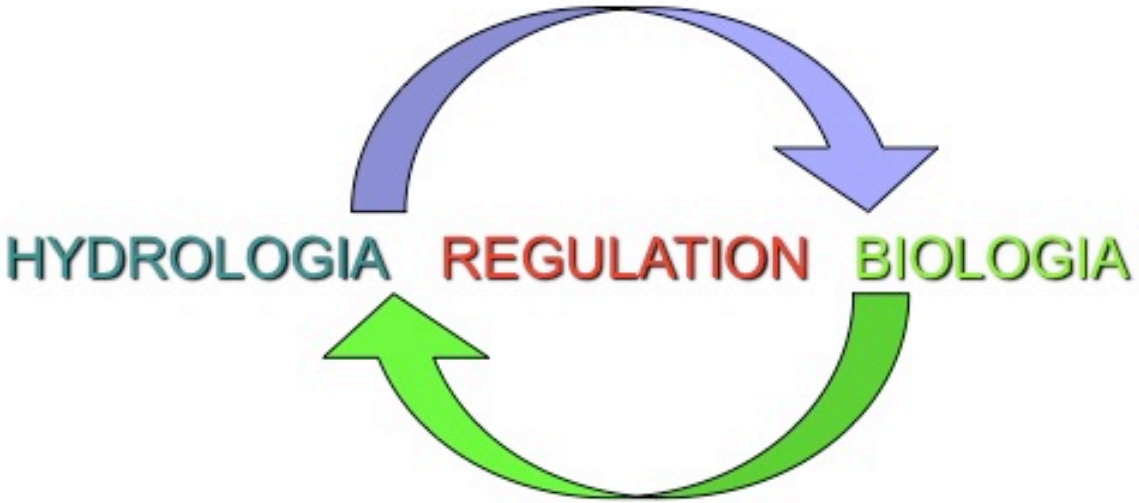
TRADITIONAL PERCEPTION OF BIOLOGY AND HYDROLOGY IN ENVIRONMENTAL SCIENCE



Source: European Regional Centre for Ecohydrology UNESCO / Lodz, Poland

ECOHYDROLOGY:
QUANTIFICATION AND DUAL REGULATION OF E & H
key element of ecological biotechnologies

Management of hydrological parameters
of an ecosystem/ecosystems to control biological processes



Shaping of biological structure
of an ecosystem/ecosystems in a catchment,
to regulate hydrological processes

Ecohydrology:

Is the new approach and methodology for achieving Integrated Water Basin Management, within what is now called *The **Ecosystem Approach** (IUCN, 2008).*

Integrates three components – **catchment, water and biota** –into an holistic model of river systems at basin scale, analogous to the '**Platonian superorganism**', thus implicitly identifying the management objectives as the maintenance of **sustainability, biodiversity, water quality and quantity.**

Is a transdisciplinary science applied to solve environmental problems of terrestrial (rural & urban) and aquatic ecosystem.

It can serve reduction of threats and amplification of chances and can contribute to alleviation of all three types of water problems—having **too much**, **too little**, and too **polluted water**.

Two major goals of Ecohydrology as a problem-solving science:

to enhance the retention of fresh water in terrestrial and freshwater systems and to reduce freshwater losses to the sea, and .

to reduce the input and **to regulate** the allocation of excess nutrients and pollutants to aquatic ecosystems, towards reversing ecosystem degradation and improving human well-being

The formulation of the Ecohydrology concept during UNESCO IHP V started by three hypotheses

H1: Hydrology can be used to regulate biota

H2: Shaping biota can be a tool to regulate hydrological processes

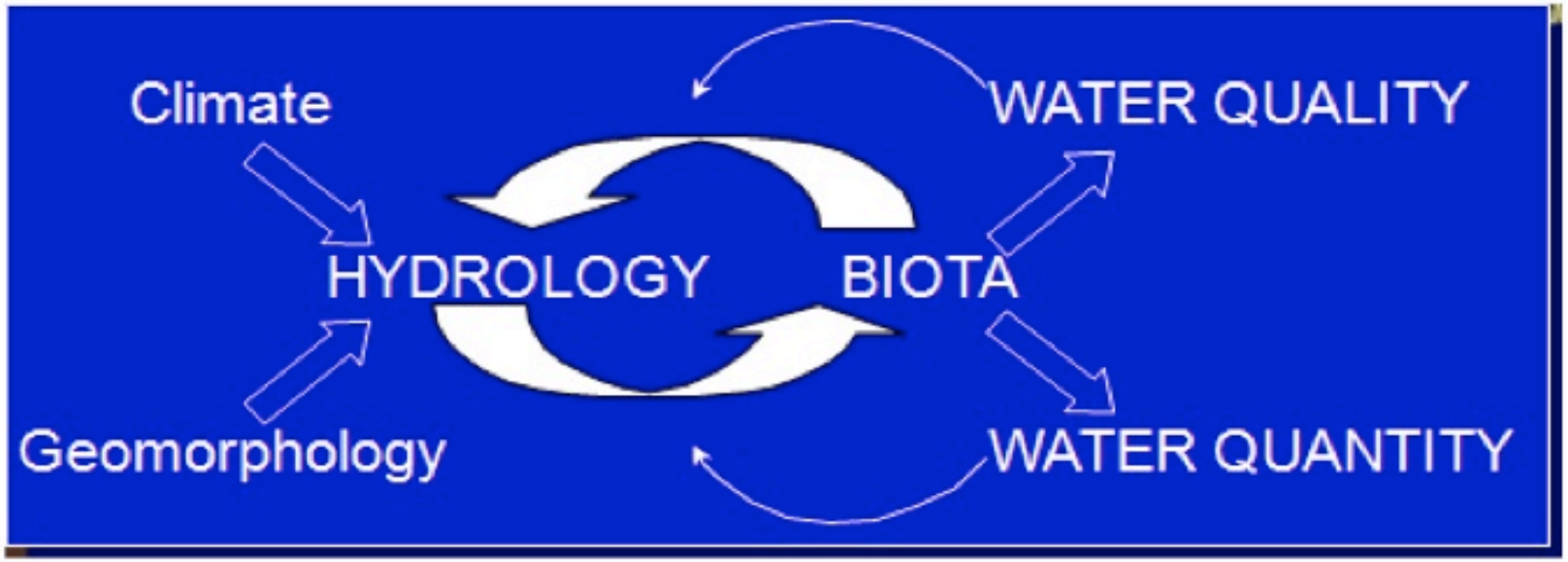
H3: : "Both types of regulation integrated at a catchment scale and in a synergistic way can be used to achieve the sustainable development of freshwater resources

Zalewski 2000

Ecohydrology principles

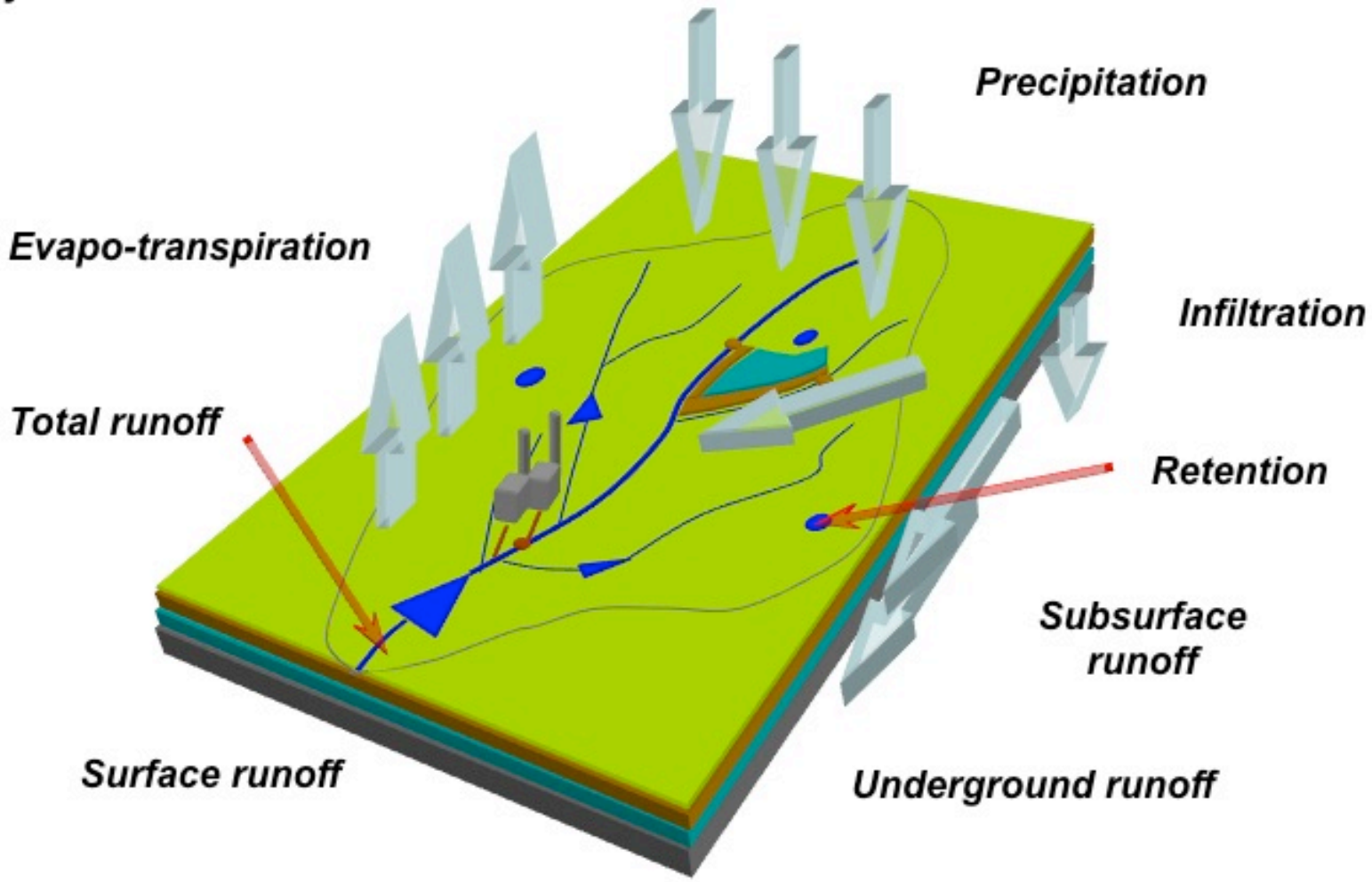
As a framework for scientific investigation and problem-solving

Ecohydrology (EH) is a new paradigm developed over the lifetime of UNESCO IHP-V.



First Principle - Hydrological

„Quantification of hydrological cycle as a template for biogeochemical cycle in a catchment scale"



THE ECOHYDROLOGY PRINCIPLES

First Principle, Hydrological...

Framework: **Integration and quantification of hydrological and biological processes in a basin scale *and it has three aspects:***

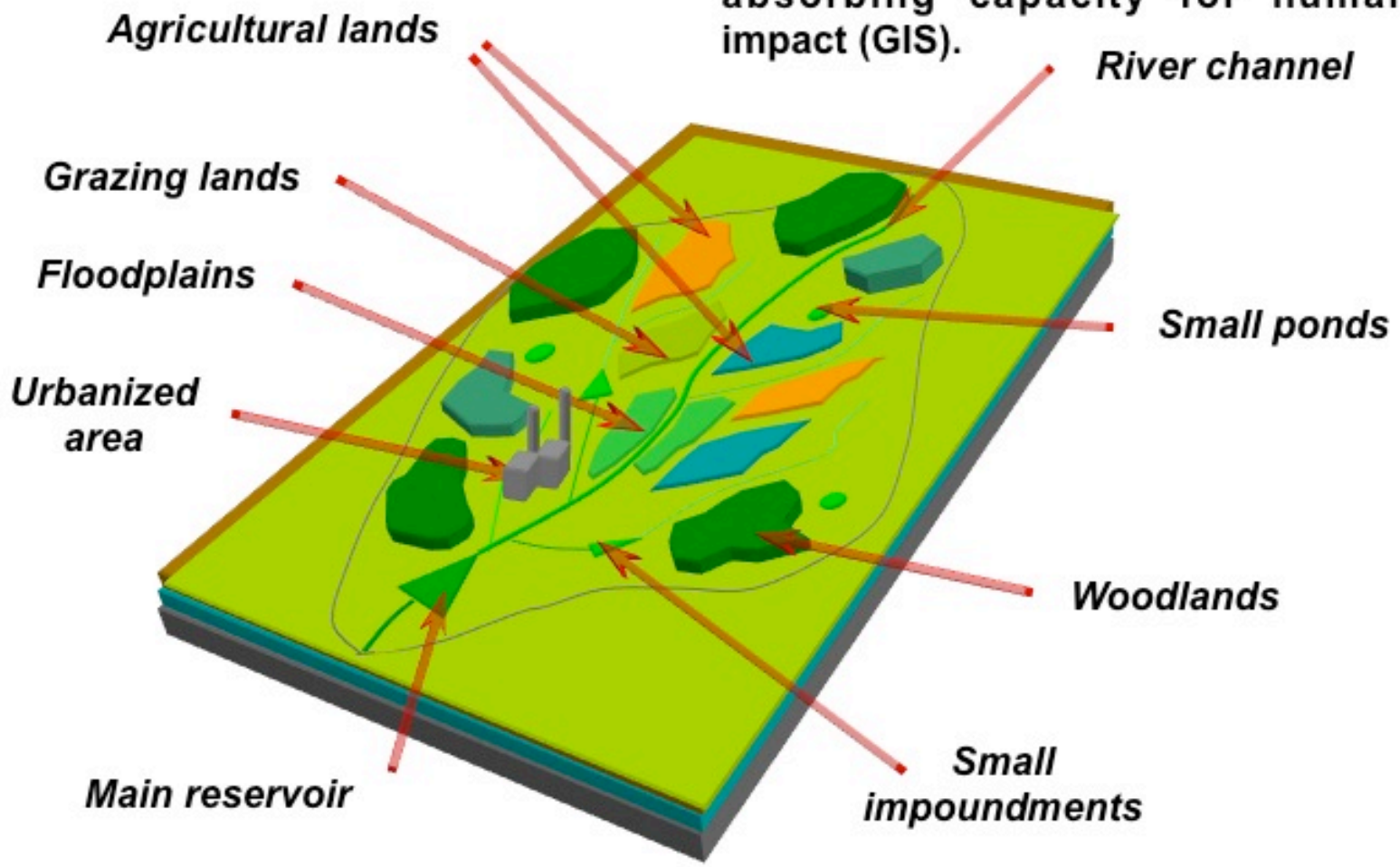
- **SCALE** - **the meso-scale cycle of water circulation within a basin (the terrestrial/ aquatic ecosystem coupling) provides a template for the quantification of processes;**

- **DYNAMICS** - **water and temperature have been the driving forces for both terrestrial and freshwater ecosystems;**

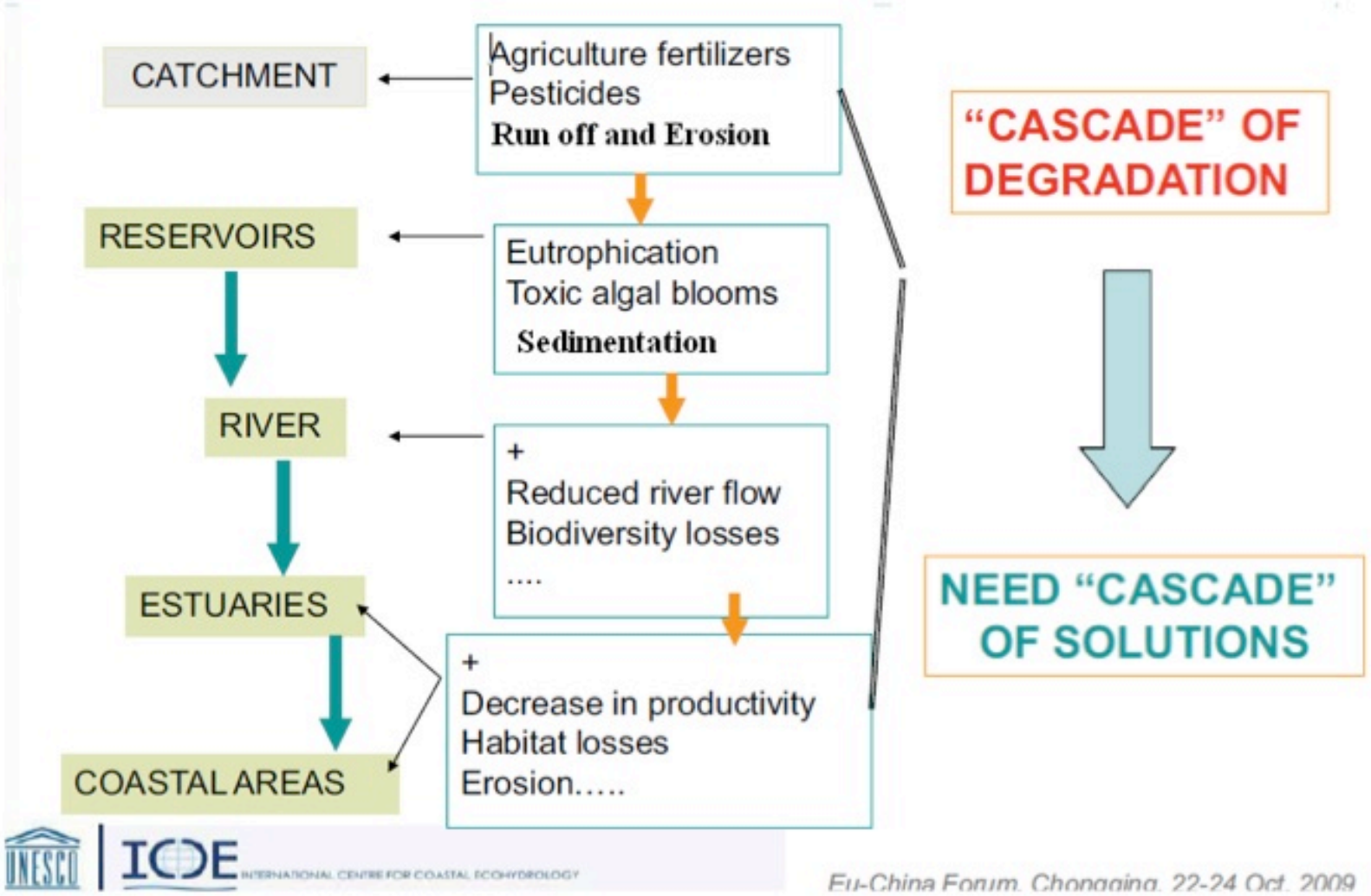
- **HIERARCHY OF FACTORS** - **while abiotic processes are dominant (e.g., hydrological processes), biotic interactions may manifest themselves when they are stable and predictable (Zalewski and Naiman 1985).**

Second Principle(Target) - Ecological

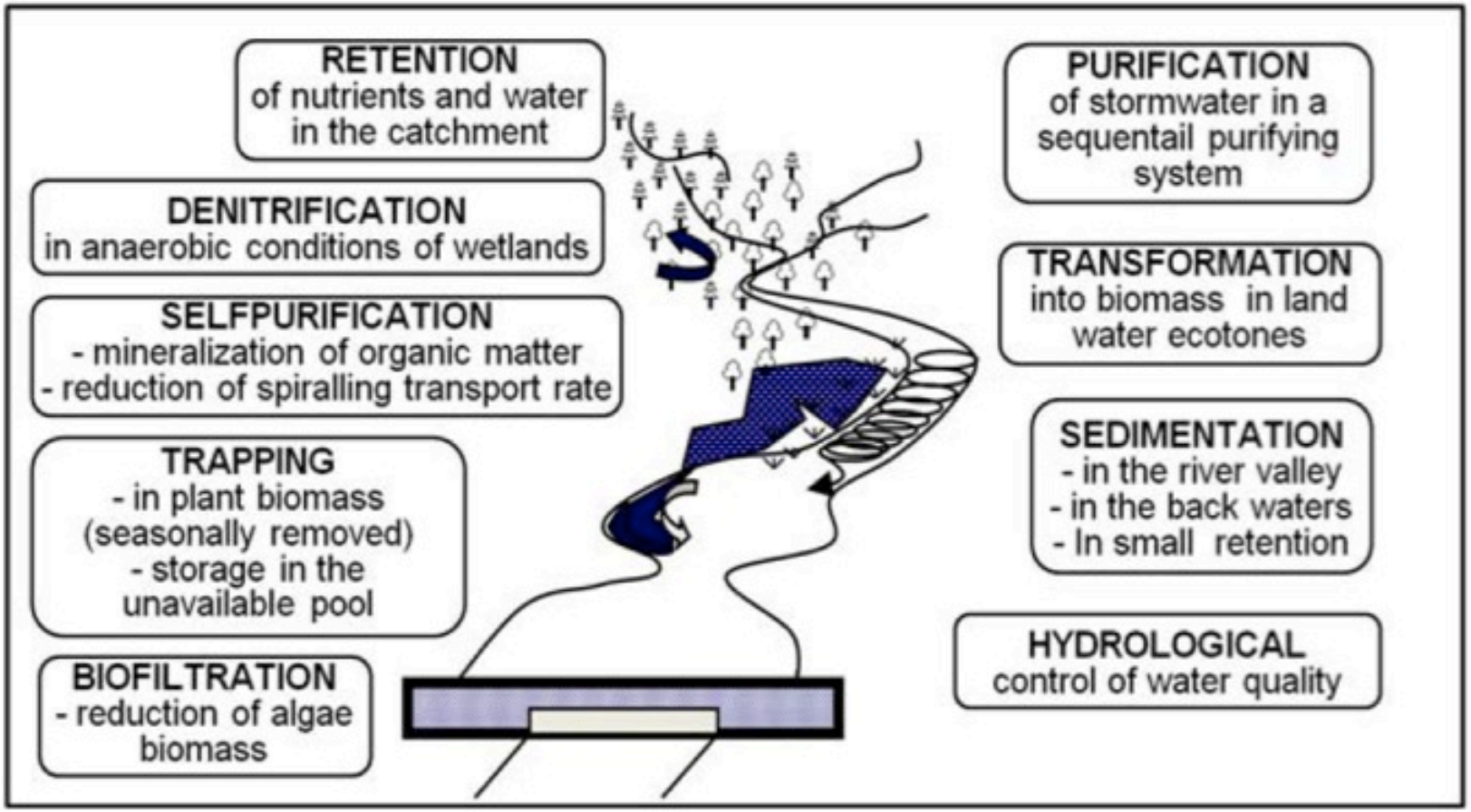
The analysis of distribution of various types of biocenosis/ ecological community/ and its potential to enhance resilience and absorbing capacity for human impact (GIS).



"Integrated Degradation" of aquatic ecosystems



INTEGRATED APPROACH TO FRESHWATER ECOSYSTEM MANAGEMENT AND RESTORATION



The second tenet of ecohydrology – synergistic "INTEGRATION" of various ecohydrological measures for system regulation in a catchment;

The ecological (second) principle expresses the proactive approach for sustainable management of freshwater resources it **stands for:**

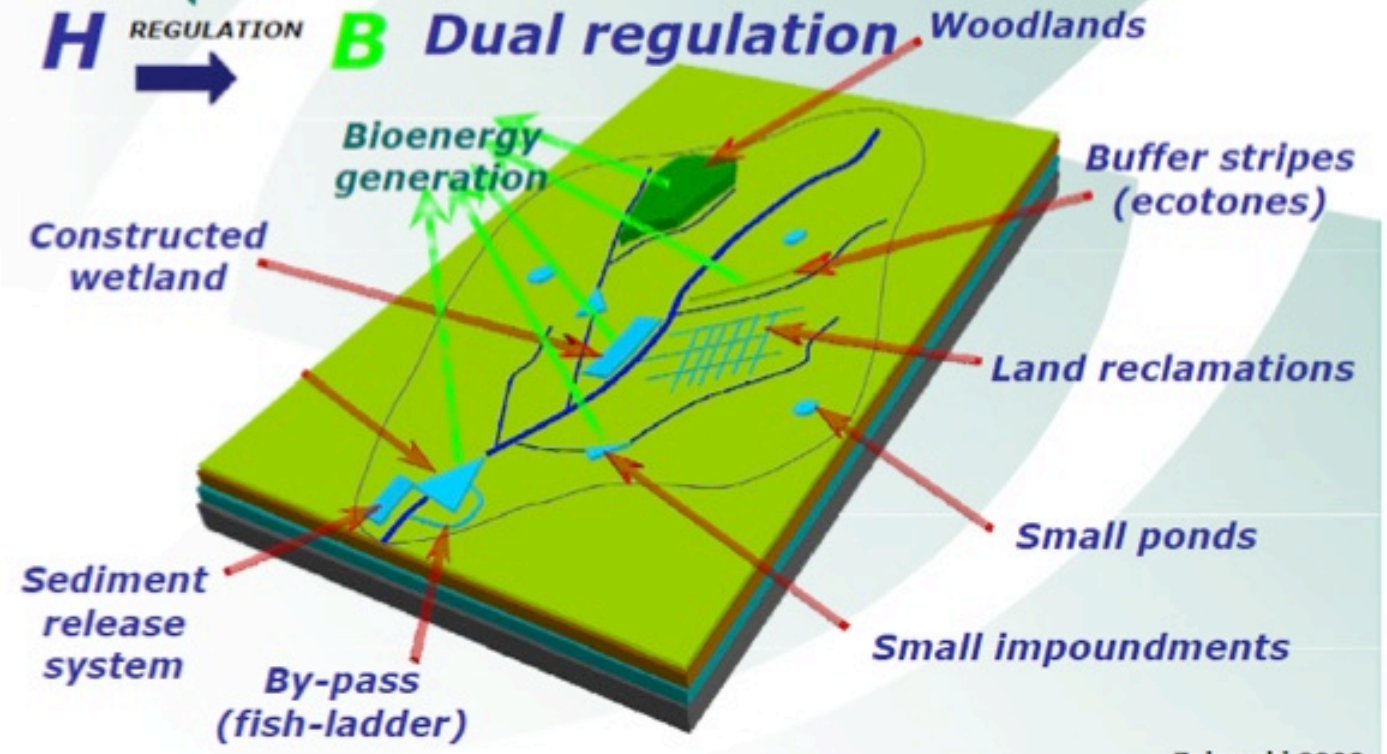
➢Target: enhancing **the carrying capacity of the ecosystem** (fresh water resources(water quantity and quality), restoration of biodiversity, enhancing resilience and ecosystem services for society in general).

➢This is based on the assumption that in the face of global change, i.e. an increasing population, energy consumption and growing needs at deteriorating ecosystems, it is **not sufficient to protect the environment, but it is necessary to regulate ecosystem structure and processes**

III – THIRD PRINCIPLE (ecotechnological)

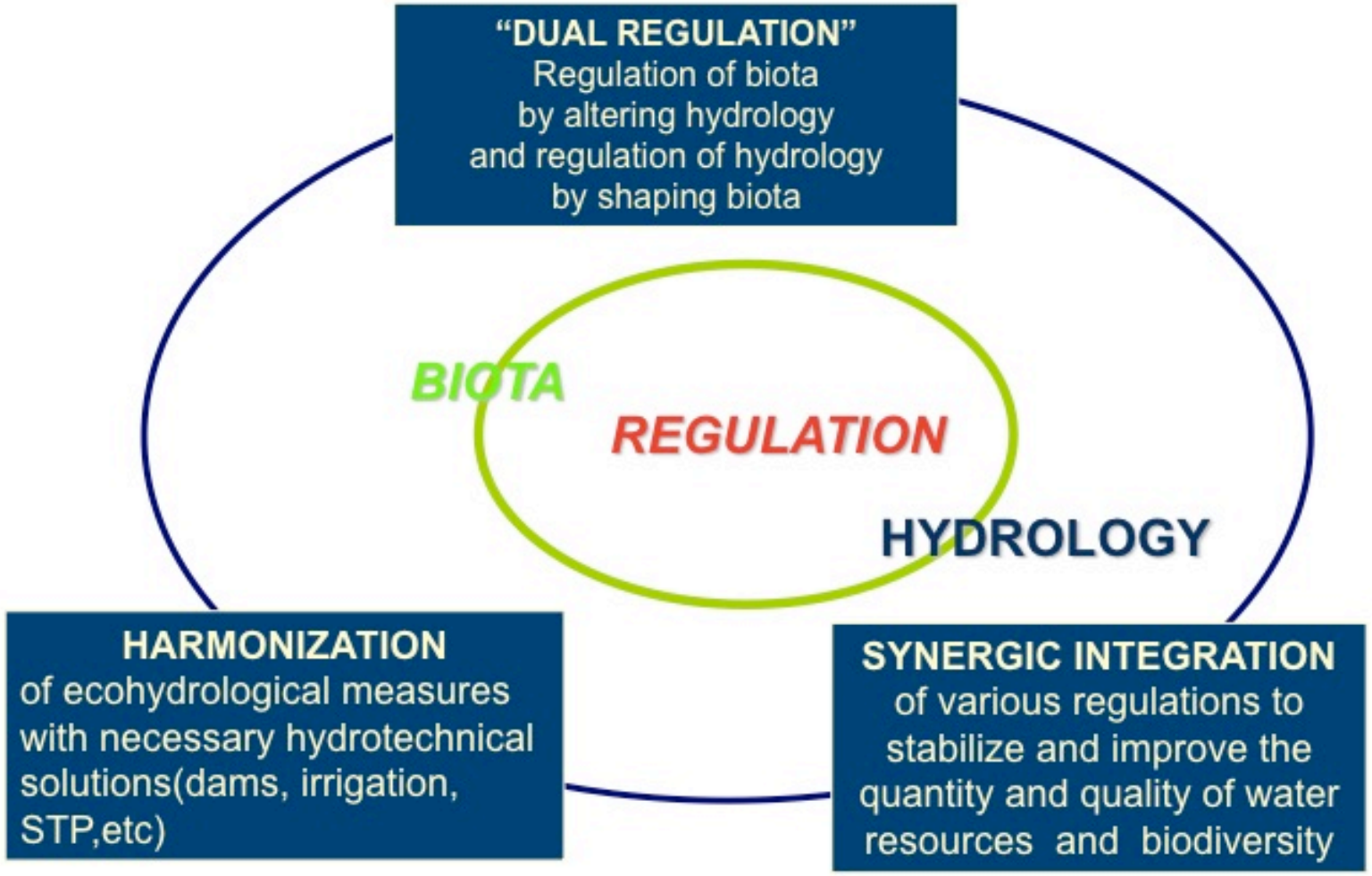
„The using of biota to control hydrological processes and vice versa, using hydrology to regulate biota"

H REGULATION **B** **Dual regulation**



Zalewski 2008

The third principle features three steps of implementation which comprises the major body of Ecohydrology:



Therefore, implementation of EH in the basin scale is possible by setting the:

Framework- for quantification and integration of hydrological and ecological processes;

Targets-for enhancement of ecosystem absorbing capacity; and

It's management tool, using ecosystem properties for regulating biota by hydrology and hydrology by biota.

WHAT IS NEW?

For WATER SCIENCE

Use of ecosystem properties as a Management tool

For ECOLOGY

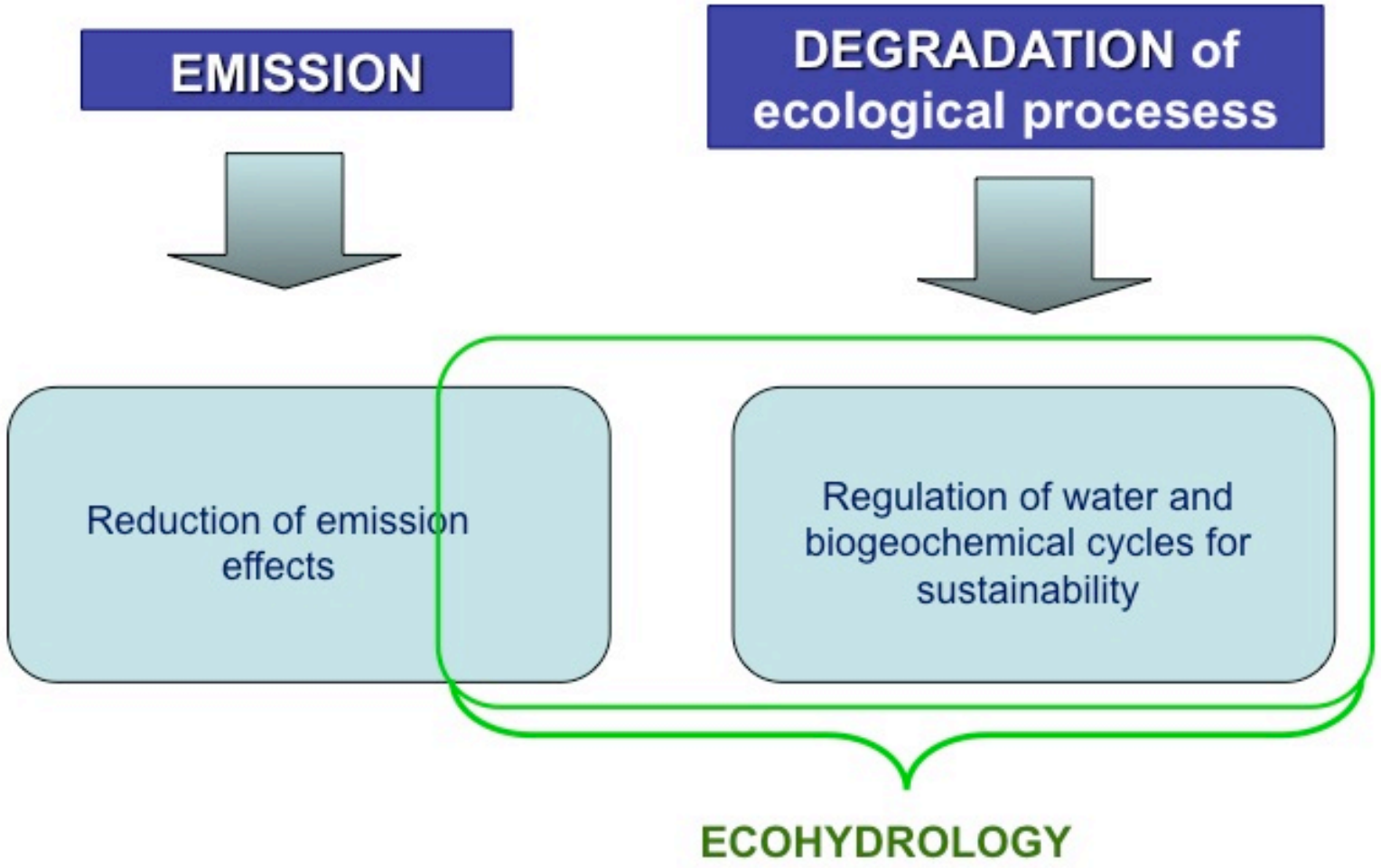
Enhancement Of Ecosystem Carrying Capacity to Absorb Human Impact

For SOCIETY

LOW-COST high technology

"Dual Regulation" and harmonization of integrated basin scale measures as a new methodology

Role of Ecohydrology in Reduction of emission effects and Regulation of water and biogeochemical cycles for sustainability:



ECOHYDROLOGY- process oriented thinking

Sustainable Water Resources Management can be achieved by :

- Reversing degradation and regulating the evolutionarily-established processes of water and nutrient circulation and energy flows at a catchments scale → environment integrated solutions
- enhancing the carrying capacity of ecosystems against human impact (resilience, robustness, biodiversity, ecosystem services for societies) → long-term sustainable solutions
- using water biota interplay as water management tools. → low cost solutions

Terrestrial and aquatic phases of EH :

In the terrestrial phase, diverse biota play a role in moderating water quantity and quality. Here, land-use and management, especially control of vegetation cover, play an important role in shaping the water cycle.

In the aquatic phase, much more complicated biotic interactions effects water quality to great extent e.g. interactions at the trophy pyramid “top down” and “microbial loop” may up to order of magnitude reduce or amplify the intensity of euthrophication symptoms such as toxic algal blooms.

Up to now both phases of ecohydrology has been independently developing however as far as both becoming new necessary component of IWRM

One of the key concepts which strengthen the application of ecohydrology is phytotechnology, described as application of science and engineering to examine problems and provide solutions involving plants (UNEP-DTIEIETC, 2003). Phytotechnology contributes not only to the **water cycle regulation**, but also to **water quality** improvement (Phytoremediation), bioenergy production and others.

Improvement of the water balance in an agricultural landscape can be obtained either by increasing **precipitation or reducing evapotranspiration**

The first is very difficult but it can be achieved at a regional scale. The second can be achieved by shaping the landscape to improve microclimatic conditions.