United Nations
ucational, Scientific and
Cultural Organization

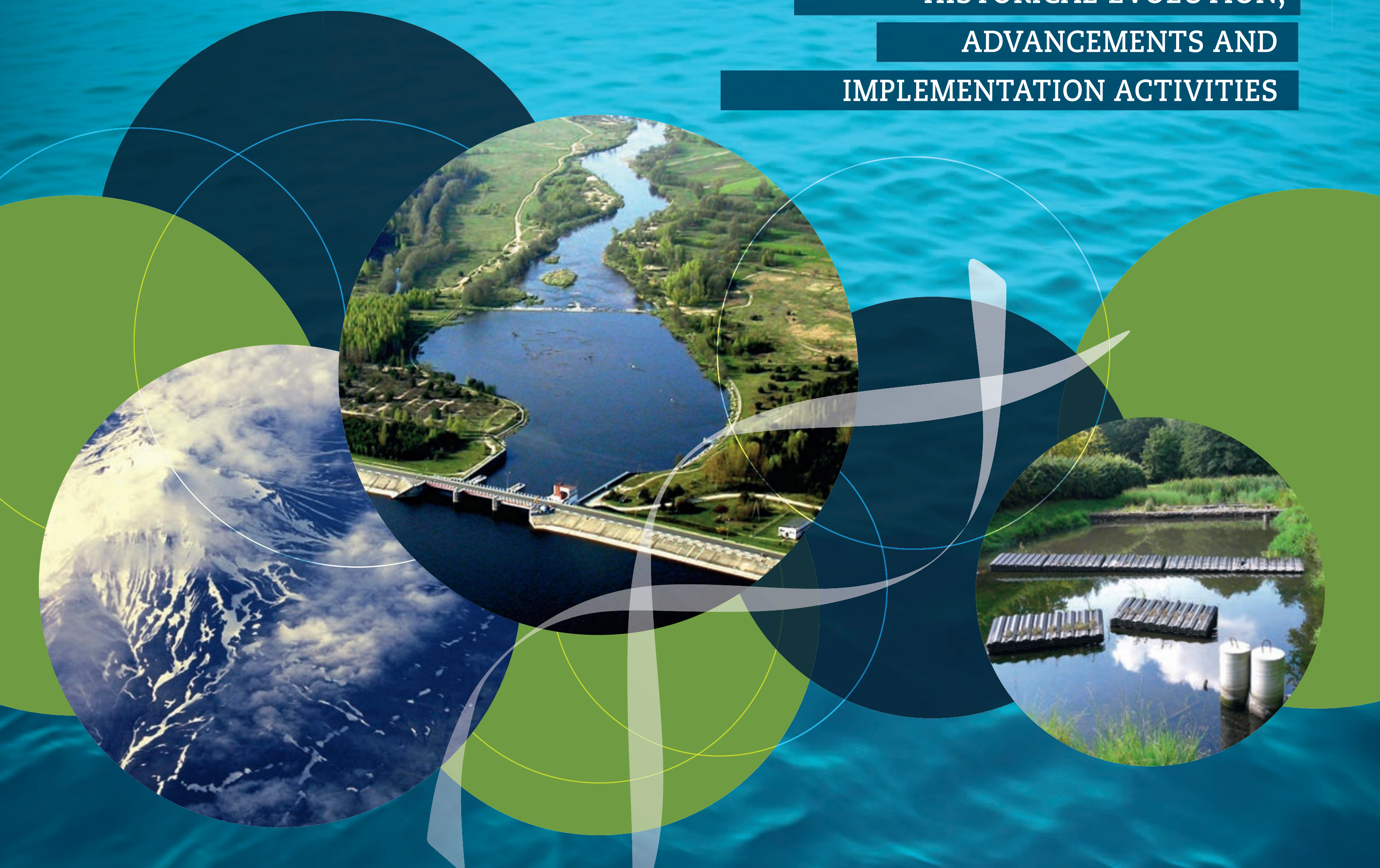
International
Hydrological
Programme

ecohydrology
programme

ECOHYDROLOGY

AS AN INTEGRATIVE SCIENCE FROM MOLECULAR TO BASIN SCALE

HISTORICAL EVOLUTION, ADVANCEMENTS AND IMPLEMENTATION ACTIVITIES



INTERNATIONAL HYDROLOGICAL PROGRAMME
Division of Water Sciences

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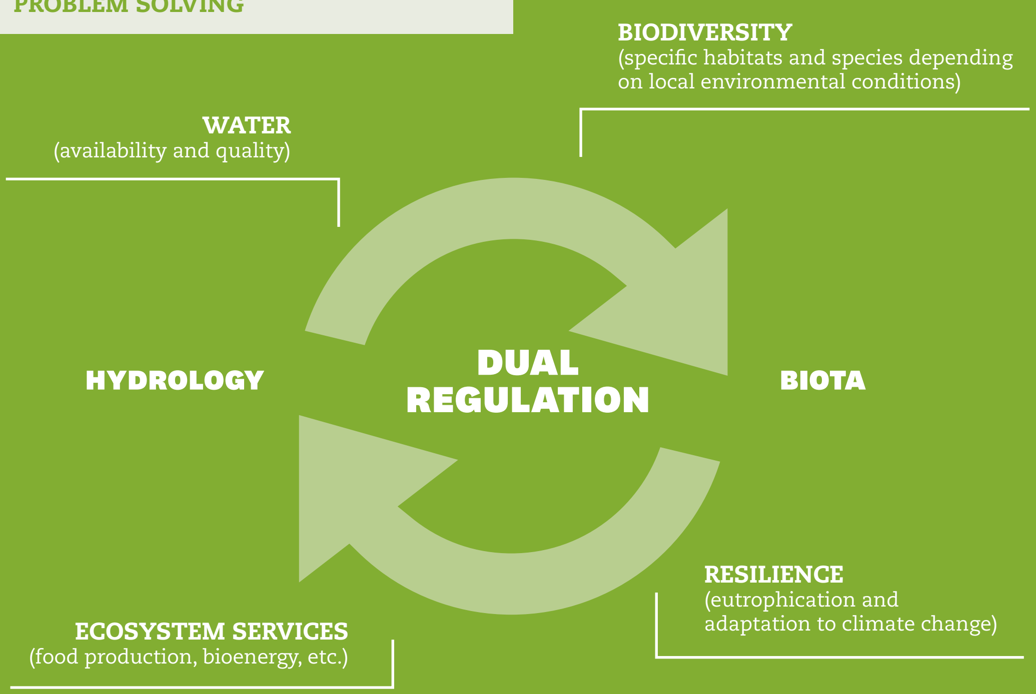
INTRODUCTION

Ecohydrology is an integrative science that focuses on the interaction between hydrology and biota. The concept emerged as a transdisciplinary approach to finding solution-oriented methods for reducing anthropogenic impacts on ecosystems. Indeed, the transformation of landscapes in recent decades, from pristine ecosystems to novel or highly-impacted systems has entailed negative effects on their natural processes. It is with the aim of reversing these that Ecohydrology seeks to reinforce ecosystem services in these modified landscapes.

Aiming to achieve sustainability in both ecosystems and human populations, as well as to improve Integrated Water Resources Management, Ecohydrology leads the way for the accomplishment of the Sustainable Development Goal on Water (Targets 6.5, 6.6). Through managing dual regulation of hydrology and biota, Ecohydrology seeks to take into consideration four multi-dimensional parameters within river basins: Water, Biodiversity, Ecosystem Services for Society and Resilience to climatic changes (WBSR).

This brochure provides an update of the network of demonstration sites, presenting the progress and selected results of the activities implemented in the context of Ecohydrology. Additionally, a summary of the development of the concept of Ecohydrology is presented through a review of the UNESCO Ecohydrology documents and of some major publications, establishing a data set that contains the year of publication, authors and abstracts.

APPLICATION OF ECOHYDROLOGY IN PROBLEM SOLVING



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2015-2016

UNESCO-IHP DEMONSTRATION PROJECTS

Ecohydrology concept today

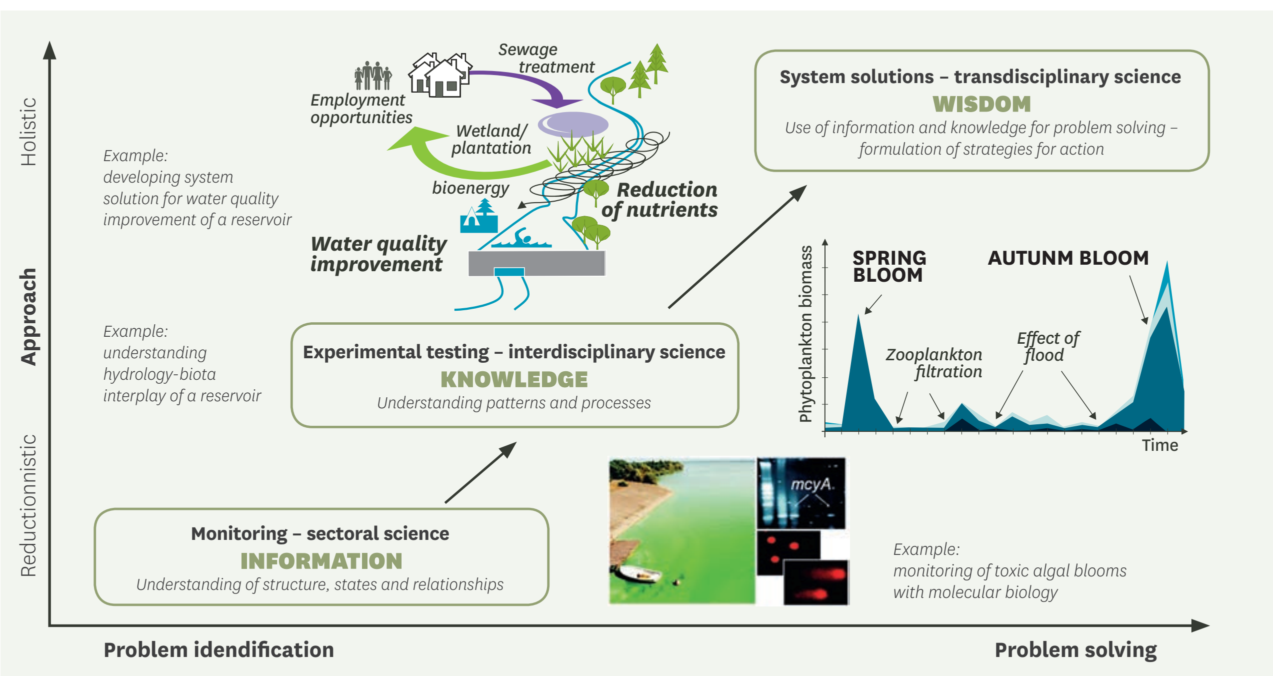
Ecohydrology is a sub-discipline of hydrology focused on ecological aspects of the hydrological cycle, which proposes three implementation principles:

- **QUANTIFICATION** of the hydrological processes at catchment scale and mapping the impacts.
- **IDENTIFICATION** of potential areas for enhancement of sustainability potential (carrying capacity).
- **MANAGING** biota to control hydrological processes and vice versa (ecological engineering).

“Ecohydrology (EH), which by identifying a plethora of water-biota interactions, provides a scientific background for the development and quantification of problem-solving methodology: principles of EH “dual regulation” and EH biotechnologies. The above framework serves not only to mitigate intermediate forms of impact but also to increase the ecological potential of a river basin expressed by a multi-dimensional goal – Water, Biodiversity, Ecosystem Services for Society and Resilience to climatic changes (WBSR), which helps to harmonise the enhanced ecosystem potential with society needs and, in turn, achieve sustainability of river basins.”

Maciej Zalewski,
extract from the abstract of “Dual regulation and ecosystem biotechnologies for the enhancement of ecohydrological potential of the catchments-Water, Biodiversity, Ecosystem services and Resilience” (Ecohydrology’2015, September, Lyon)

FIGURE 1.
Methodological background of ecohydrology as a problem solving science (Zalewski, 2015)



2015-2016
ECOHYDROLOGY DEMONSTRATION SITES

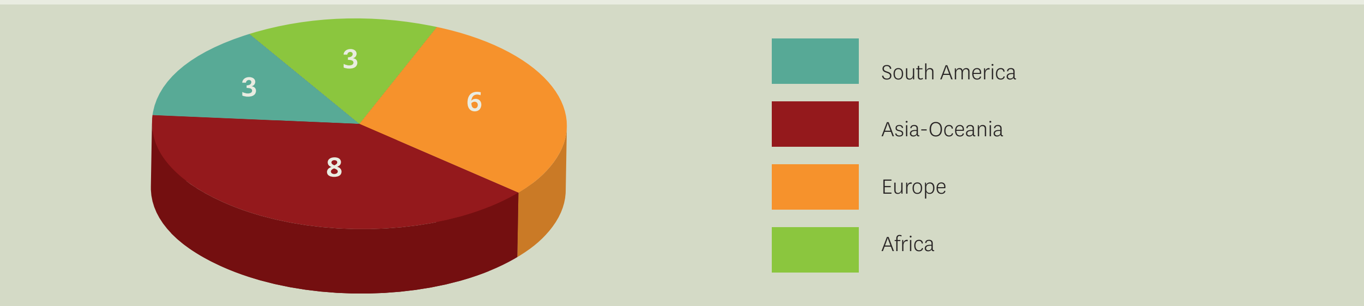
A demonstration site displays an application of ecohydrology in its objective of dealing with issues such as nutrient concentrations, water purification, etc. Hydrological and ecological processes are studied in diverse aquatic habitats like wetlands, marshes, mangroves, cyanobacterial blooms in order to find **long-term solutions, that integrate social components**. The demonstration sites include the concept of **enhanced ecosystem potential through the application of ecohydrological strategies** to achieve sustainability of ecosystems closely related to water so as to **improve IWRM in specific areas**. This is termed **WBSR** (W-water, B-biodiversity, S-ecosystem services, and R-resilience), containing the four elements that should be taken into consideration while trying to **reinforce the sustainability potential (carrying capacity)**. To be fully effective, **each region's respective water culture** should also be taken into account.

LEGEND

Demonstration sites

- Basins
- Inland wetlands
- Rivers/Lakes
- Estuaries/Coastal Water


Stockholm-Norrström Basin-SWEDEN
Kielstau Basin-GERMANY
Lodz-Sokolowka River-POLAND
Sulejow reservoir-Pilica River-POLAND
Lodz-Ner River-POLAND
Trasimeno Lake-ITALY
Split-Kastela Bay-CROATIA
Guadiana Estuary-PORTUGAL
Sanjiangplain-CHINA
Metropolitan Beijing-CHINA
Assela-Burkitu reservoir-ETHIOPIA
Gumera Basin-ETHIOPIA
Lake Naivasha-KENYA
Putrajaya Lake&Wetlands-MALAYSIA
Davao City-PHILIPPINES
Western Sydney-AUSTRALIA
Griffith-Murray-Darting Basin-AUSTRALIA


3
3
6
8
South America
Asia-Oceania
Europe
Africa

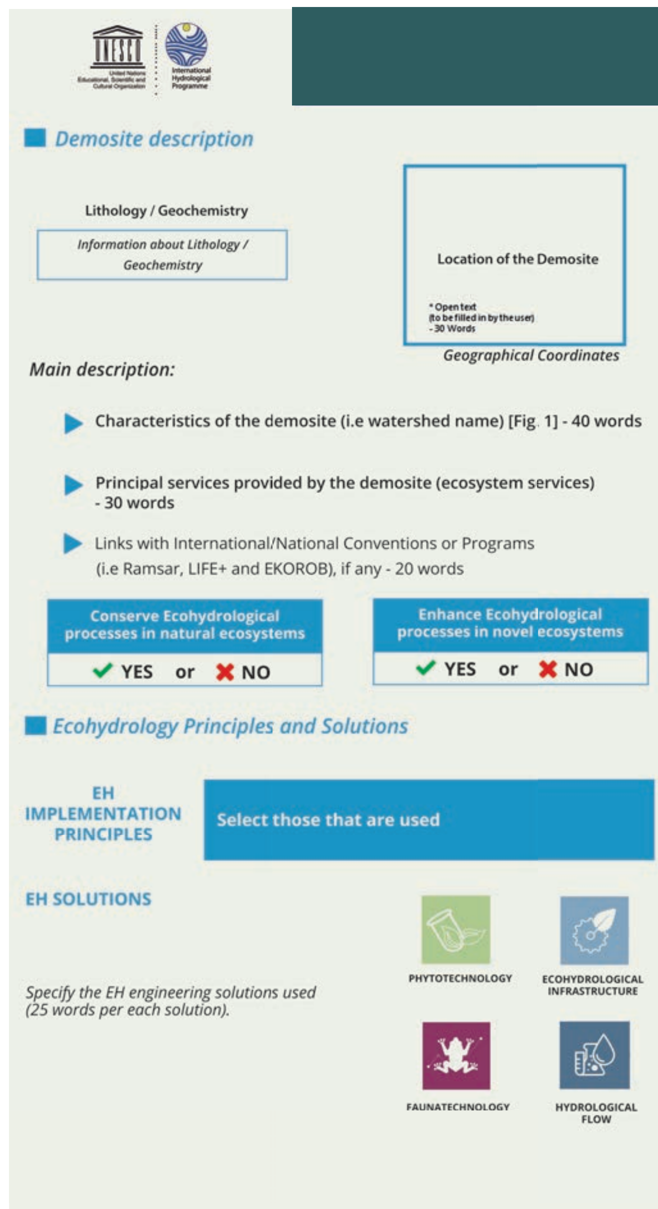
THERE ARE **THREE KEY OBJECTIVES** FOR THE ESTABLISHMENT OF NEW ECOHYDROLOGY DEMONSTRATION SITES

- Identify knowledge gaps to address ecohydrological issues related to critical water ecosystems, including those in arid and semiarid zones, coastal areas and estuaries, and urbanized areas.

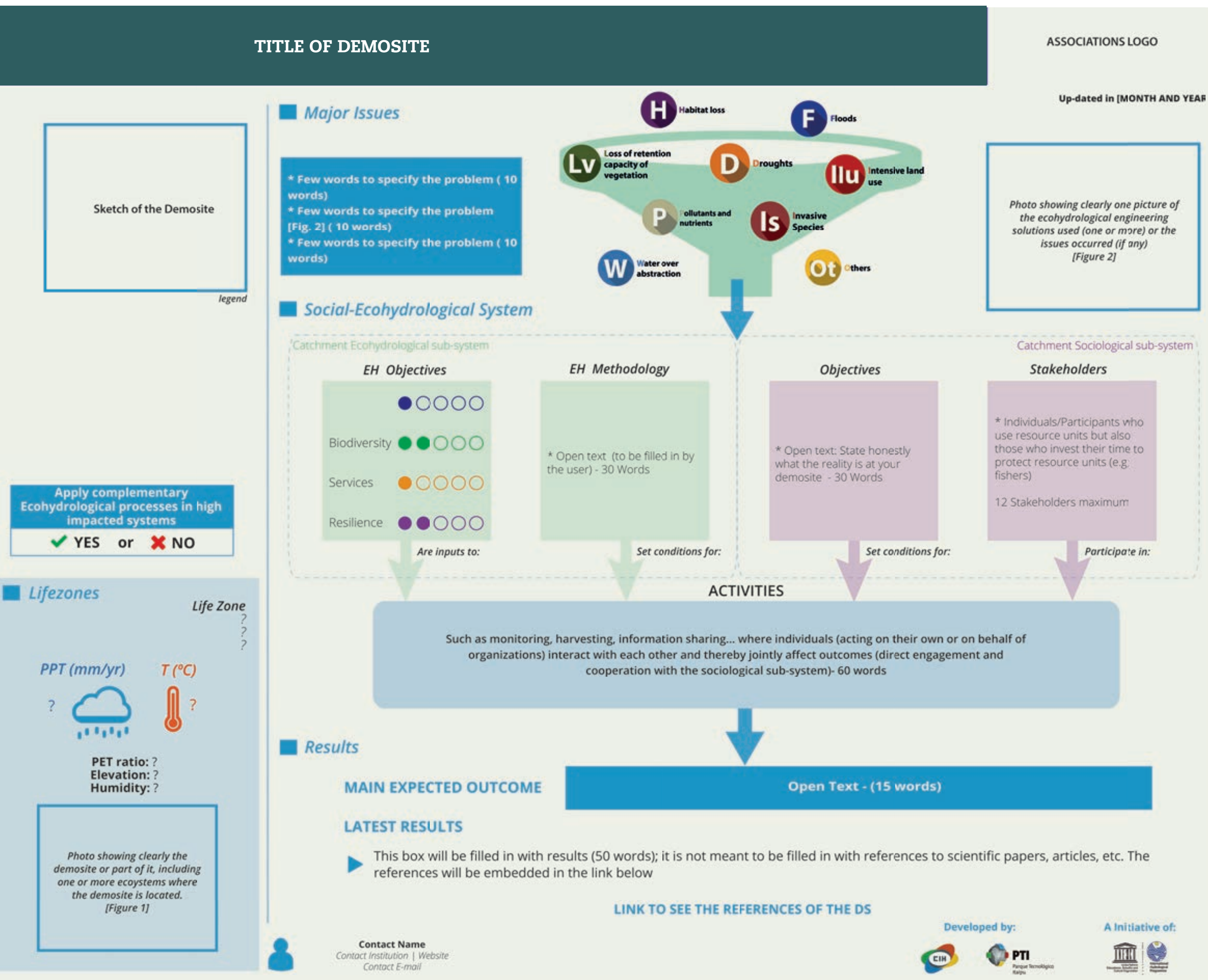
- Showcase how better knowledge of the interrelationships between the hydrological cycle, livelihoods and ecosystems can contribute to more cost-effective and environmentally-friendly water management.

- Demonstrate system solutions and technology transfer opportunities through North-South and South-South linkages in order to harmonize the ecosystem potential with societal needs.

FIGURE 2.
Template of a demonstration site card. Project managers will provide



relevant information online for each section of the demonstration site card.



WEB-ACCESS

Two types of web access are available to Member States, students and the general public

Firstly, an informative **WEBSITE** hosted in the UNESCO domain, explaining the programme and its focal areas.

www.unesco.org/new/en/natural-sciences/environment/water/ihp-viii-water-security/5-ecohydrology/

Secondly, the **WEB PLATFORM:**

ecohydrology-ihp.org

The web platform contains information about the demonstration sites and their main characteristics and activities (including related scientific papers, etc.). Other data are also available on this platform: major ecohydrology related events, symposia, advanced study courses, funding opportunities and a link to **apply to the Ecohydrology network.**

Application to become a UNESCO EH Demonstration site will be done through the web platform and "demo cards" will be designed via an automatic user-friendly process.

PUBLICATIONS OF THE ECOHYDROLOGY PROGRAMME

1997

UNESCO Ecohydrological Processes in small basins

UNESCO Ecohydrology: A new paradigm for the sustainable use of aquatic resources

1998

Ecohydrology: A List of Scientific Activities of IHP-V

2001

Ecohydrology: Science and the sustainable management of tropical waters

2004

Integrated Watershed Management—Ecohydrology & Phytotechnology Manual

2006

Demonstration Projects Ecohydrology (Brochure)

2007

Ecohydrology: An interdisciplinary approach for sustainable management of water resources (Brochure)

2009

Practical Experiments guide for Ecohydrology

2011

Ecohydrology for sustainability (Brochure)

2016

Ecohydrology & Hydrobiology Journal (2001-ongoing)

1997-2015
PUBLICATIONS IN HYDROLOGY

“Regionalisation and scale effects remain important unsolved problems which are frequently being discussed here, and probable effects of climate change on hydrological behaviour and mass budgets also. Accordingly, the selected Conference results published here largely fit many relevant discussions undertaken elsewhere, but they strictly concentrate on the process scale, with preference of both agricultural and forested basins.”

Andreas Herrmann,
ERB Coordinator (1994-1998)

1997 UNESCO-IHP TECHNICAL DOCUMENTS IN HYDROLOGY

TITLE:

ECOHYDROLOGICAL PROCESSES IN SMALL BASINS

AUTHORS:

Viville D. and Littlewood I.G. (Eds.)

ABSTRACT:

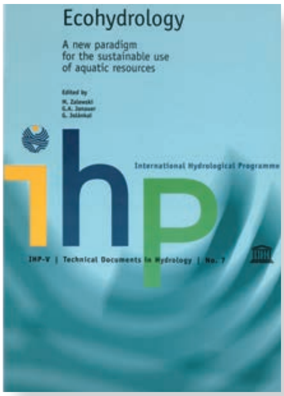
This publication gathers the proceedings of the Strasbourg Conference (24-26 September 1996), held in the same year as the tenth anniversary of the Experimental and Representative Basin (ERB) Network. These proceedings include 30 papers out of 29 oral and 15 poster presented at the conference.

The contributions cover research carried out on ecohydrological processes in small basins and related topics across Southwestern and Central Europe. They focus mainly on the monitoring and modelling of soil-atmosphere interactions, runoff generation processes and water pathways, and water quality and hydrobiogeochemical behaviour at small basin scale.

FACTS AND FIGURES:

The papers are grouped under four broad thematic headings corresponding to the four Sessions of the Conference:

- Evapotranspiration components and modelling (9 abstracts submitted);
- Surface water quality (5 abstracts submitted);
- Runoff formation, discharge generation and water pathways (11 abstracts submitted); and
- Runoff modelling (6 abstracts submitted).



TITLE:

ECOHYDROLOGY: A NEW PARADIGM FOR THE SUSTAINABLE USE OF AQUATIC RESOURCES

AUTHORS:

Zalewski M., Janauer G. A. and Jolánkai G. (Eds.)

ABSTRACT:

This publication shows that ecotone projects deal mostly with small-scale and short-term processes. One conclusion is that the sustainable development of freshwater resources needs to be based on a profound understanding of processes, mechanisms and the economy at a regional level.

One of the goals of the Ecohydrology Programme is established in the publication: it should create a background of transition towards operational procedures aimed at sustainable development and generate new ways of thinking among scientists, policy-makers and decision-takers.

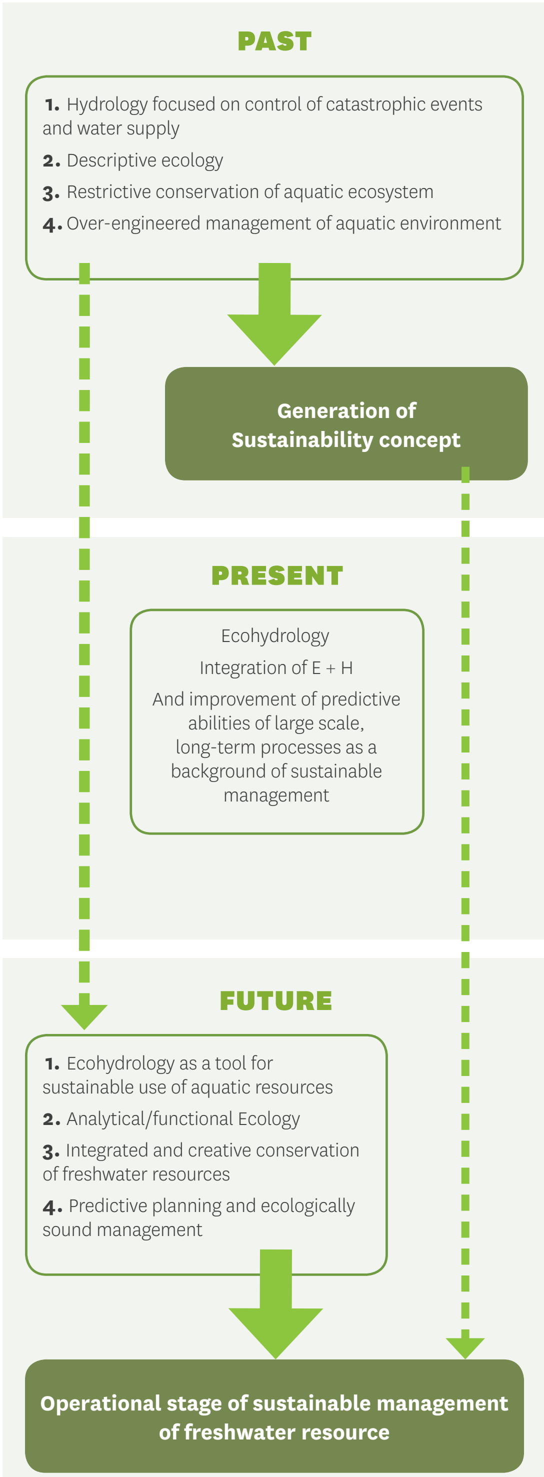
FACTS AND FIGURES:

- Firstly, an efficient and realistic strategy for the management of aquatic resources was developed by the UNESCO MAB Programme “Role of land/inland water ecotones in water management and restoration” (Naiman, Decamps, Fournier, 1989).
- In most situations it is impossible to stop catchment development which often degrades aquatic ecosystems. Thus, the solution should be the building, management and restoration of ecotone buffering zones between land and water.
- The conclusion is an urgent need to develop a conceptual background on the integration of large-scale and long-term hydrological processes with biota dynamics. That is how the Ecohydrology Programme started and integrated an understanding of hydrology, biotic mechanisms and the economics of the region (catchment), which in most regions of the world is usually discussed but never implemented. Besides, an important aspect of the new Ecohydrology Programme should be the provision of a new solution to socio-economic problems.

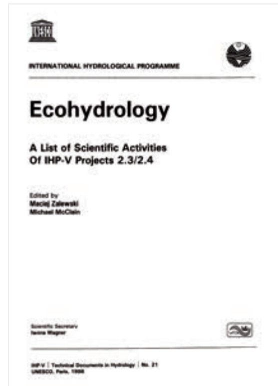
WORKING HYPOTHESIS ON ECOHYDROLOGY WERE EXPLAINED

1. To achieve profound understanding for the present hydrological regime and distribution of biota in fluvial corridors, historical changes should be analysed, and interpreted for application.
2. The ecohydrological approach can be a tool towards the sustainable use of aquatic resources **by enhancement of the resistance, resilience, and buffering capacity of fluvial corridors**.
3. Vulnerability of rivers, reservoirs, and estuaries is dependent on the seasonal pattern of hydrological and biotic processes and can be changed by human impact.
4. Nutrient loads reaching aquatic systems depend highly on the man-induced disturbances of the natural hydrological and ecological characteristics of the catchment.
5. **The intensity and duration of floods are modified by the biological characteristics of fluvial corridors, which in turn are modified by the hydrological regime** (prototype of the DUAL REGULATION).
6. The nutrient status of rivers is influenced by ground water inflow and the biotic structure of the river valley.
7. The transport and transformation of pollutants are highly influenced by the hydraulic–hydrological regime and by the ecological characteristics of fluvial corridors.
8. The application of GIS-based ecohydrological approaches to subsystems of catchments consisting of ecotones and elementary patches, makes hydrological and ecological information gained in these microscale systems aggregable into higher levels of abstraction. The integration of this information into hydrological concepts will lead towards a more profound interpretation of the hydrological regime of catchments.
9. Comprehensive understanding of ecohydrological processes and improving predictive ability forms a basis **for a cost efficient management of water resources and landscapes**.
10. Optimisation of the structure of ecotonal zones like riparian buffer zones, wetlands, or floodplains is the main tool for the reduction of nutrient transfer from the catchment to the river and other downstream recipients.
11. Indices for predictive planning and sustainable management of aquatic resources should be based on two points: point/local data and studies on large-scale hydrological processes.

FIGURE 3.
Ecohydrology as a factor accelerating the transition from descriptive ecology, restrictive conservation and over-engineered management of aquatic ecosystems to analytical/functional ecology, and creative management and conservation of freshwaters.



1998 UNESCO-IHP TECHNICAL DOCUMENTS IN HYDROLOGY



TITLE:

ECOHYDROLOGY: A LIST OF SCIENTIFIC ACTIVITIES OF IHP-V

AUTHORS:

Zalewski M. And McClain M. (Eds.)

ABSTRACT:

This publication compiles several activities related with the UNESCO-IHP Ecohydrology Programme and it also explains through case studies how the concept of Ecohydrology is being implemented.

Other aims of the publication are:

1- Present progress made toward identifying gaps.

2- Popularise the concept of Ecohydrology wherein the river systems are recognised as “superorganisms” controlled by hydrological processes which might be modified by biotic responses and interactions to a great extent.

FACTS AND FIGURES:

- Integrating our understanding of biotic controls on hydrological processes and investigating their potential to influence water dynamics and quality at the catchment scale are the implicit goals of UNESCO IHP-V 2.3/2.4 Ecohydrology Activities.
- Two core pilot activities, 14 core activities and eight associated activities were described.
- Five Conceptual Considerations were made:

  1 - Optimisation models for correlation between ecological and hydrological parameters (Romania).

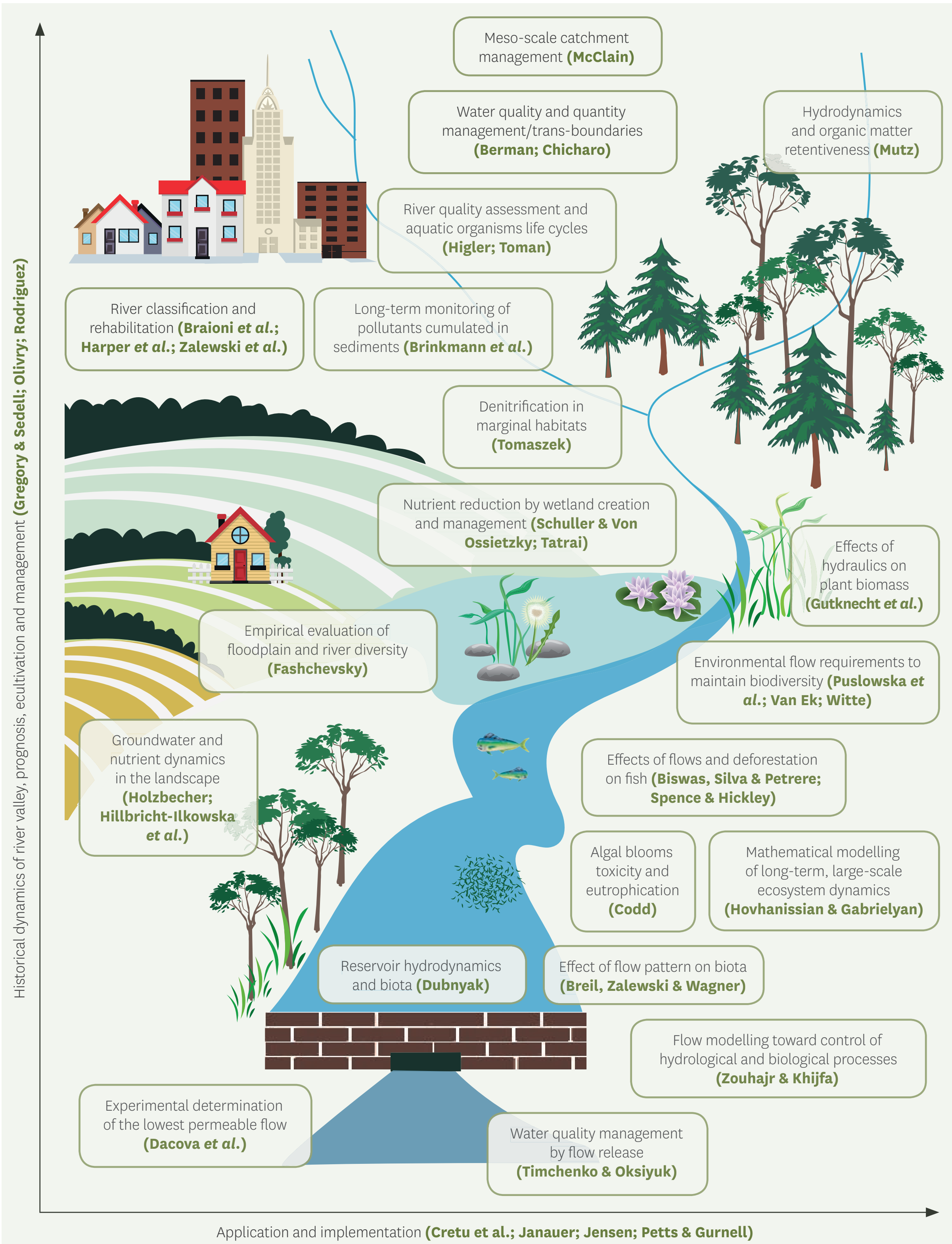
  2 - Sustainable management of shallow tropical lakes and lagoons (Tropical Zone).

  3 - Ecohydrology: fusing concepts and scales (Europe).

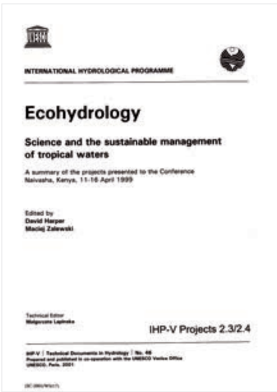
  4 - The point of view of some hydrologists on the new paradigm of “Ecohydrology”.

  5 - Contingent plan to evaluate ecohydrological surface processes caused by “El Niño” phenomenon equatorial littoral region (Equatorial Littoral Region).

FIGURE 4.
It's stated that a more efficient approach must be based on understanding of the temporal and spatial patterns of catchment-scale water dynamics. These patterns are determined by four fundamental components: climate, geomorphology, plant cover/biota dynamics and anthropogenic modifications.



2001 UNESCO-IHP TECHNICAL DOCUMENTS IN HYDROLOGY



TITLE:

ECOHYDROLOGY: SCIENCE AND THE SUSTAINABLE MANAGEMENT OF TROPICAL WATERS

AUTHORS:

Harper D. and Zalewski M. (Eds.)

ABSTRACT:

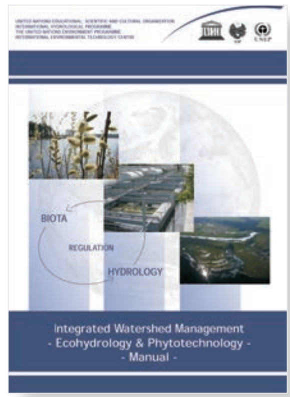
This publication compiles the summary of the projects presented at the Conference in Naivasha, Kenya, 11-16 April 1999. It is divided in three main sections named: (i) Lake Naivasha and its Basin, Eastern Rift Valley, Kenya (ii) Ecohydrology in Africa (iii) Ecohydrology- Related Projects.

The first part explains that the management of waters in the tropics is affected by difficulties more severe than those in temperate zones. The second explains the terms shallowness and topicality in relation with lakes and their relation to Ecohydrology. The third explains the purpose of the conference in Kenya and its significance for the Ecohydrology concept.

FACTS AND FIGURES:

- This volume brings Ecohydrology to tropical ecosystems for the first time.
- This conference was the first step in taking the V^th UNESCO International Hydrological Programme's theme "Ecohydrology" to the region of Tropical Africa – and 201 delegates from 26 countries participated in four days of scientific presentations and discussion on topics which ranged from reservoirs in Northeast Brazil to inland and coastal waters in Africa to shallow floodplain lakes in Indonesia.
- Ecohydrology needs to integrate the socio-economic implications of water management. This management should also involve local communities and incorporate local concepts and traditions. Involvement of local communities will help establish these concepts of sustainability as an integral part of rural development.
- Fundamental to ecohydrology is the concept of low-cost, high-technology applications, and this study shows that using aquatic plants for subsistence farming can provide solutions, for example.

2004 ECOHYDROLOGY AND PHYTOTECHNOLOGY HANDBOOKS



TITLE:

INTEGRATED WATERSHED MANAGEMENT– ECOHYDROLOGY & PHYTOTECHNOLOGY MANUAL

AUTHORS:

Zalewski M. and Wagner-Lotkowska I. (Eds.)

ABSTRACT:

This guideline explores diverse applications of Ecohydrology and phytotechnology. The integration of the two components – hydrology and ecology – by means of regulating hydrological, biotic and landscape interactions and processes, has contributed to improving ecosystems' resistance to stress. The concept of phytotechnology, developed by UNEP, encompasses a variety of environmental approaches and technologies based on the ecosystem services that plants provide, even reversing the degradation of water resources.

FACTS AND FIGURES:

- So far **Ecohydrology as a concept has three general principles:**

1

REGULATION of hydrology by shaping biota and, vice versa, regulation of biota by regulating hydrology.

2

HARMONISATION of ecohydrological measures with necessary hydrotechnical solutions (e.g., dams, sewage treatment plants, levees at urbanised areas, etc.).

3

INTEGRATION – at the basin scale various types of regulations (E↔H) act in a synergistic way to improve and stabilise the quality of water resources.

- The use of phytotechnologies, together with the development of ecohydrology, can help prevent and control.

2006 UNESCO-IHP DEMONSTRATION PROJECTS IN ECOHYDROLOGY

TITLE:

DEMONSTRATION PROJECTS ECOHYDROLOGY
(Brochure)

AUTHORS:

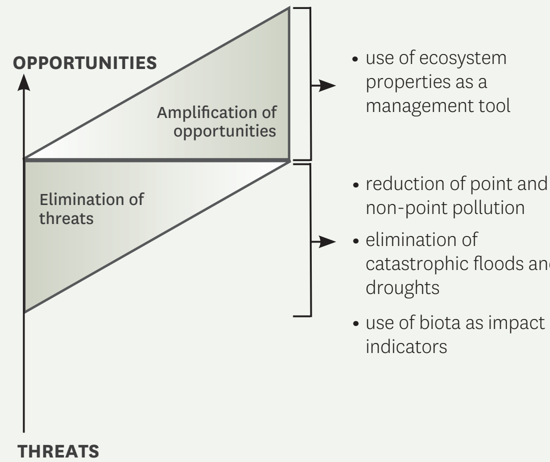
UNESCO-IHP

ABSTRACT:

This publication introduced 10 Ecohydrology demonstration sites which address a wide range of issues.

The ecohydrology approach is based on the assumption that ecosystem properties and water dynamics can be managed to maximise their synergistic interactions and to optimise ecosystems' resilience to human-induced stresses, while also reducing such stresses. The history for the establishment of the demonstration sites network is also summarised.

FIGURE 5.
Application of ecohydrology as a factor maximizing opportunities of sustainable freshwater management



Modified from Zalewsky, 2002

FACTS AND FIGURES:

- The ecohydrology approach is based upon the assumption that sustainable water resources management can be achieved by:
  - regulating and maintaining water circulation patterns, nutrient cycles and energy flows at catchment scale ;
  - enhancing the carrying capacity of ecosystems against human impacts by managing them according to ecosystem properties;
  - using these ecosystem properties as a water management tool.
- Demonstration Projects in 2006 :

Cities

1 - Saguling Reservoir & Citarum River, Indonesia: Study of urban and industrial pollution and reduction of sedimentation by controlling hydrological dynamics.

Landscapes

2 - Lacar Lake, Huahum River Basin, Patagonia, Argentina: Reduction of erosion in a catchment using ecohydrology and phytotechnology.*

3 - Amazon River Floodplain, Brazil: Sustainable timber production and management of Central Amazonian white-water floodplains.

Wetlands

4 - Mara River & Serengeti Plain, Kenya & Tanzania: Water deficit and inter-basin transfer of water resources for large mammals migrating to Serengeti (UNESCO World Heritage Site and MAB Biosphere Reserve).

5 - Polesie Region, Belarus, Poland and Ukraine: Conservation and sustainable use of a transboundary wetland in the Polesie region (planned West Polesie Transboundary Biosphere Reserve).

Floodplains

6 - Danube River, Lobau floodplain, Austria: Hydrological regime optimisation to maintain biodiversity in the Lobau Biosphere Reserve and flood protection for Vienna.

7 - Paraná Floodplain, Brazil: Creation of a biosphere reserve to prevent decline in the unique subtropical river floodplain biodiversity

Lakes and Reservoirs

8 - Lake Naivasha, Kenya: Re-creation of artificial *Cyperus papyrus* wetlands surrounding the lake and in inflowing rivers using phytotechnological methods for restoration.*

9 - Pilica River, Poland: Application of ecohydrology and phytotechnology for water resources management and sustainable development.*

Estuaries & Coastal Areas

10 - Guadiana Estuary, Portugal: Sustainable estuarine zone management for control of eutrophication, toxic blooms, invasive species and conservation of biodiversity.*

* These projects are still part of the Ecohydrology Programme.

2007 UNESCO-IHP DEMONSTRATION PROJECTS IN ECOHYDROLOGY

TITLE:

ECOHYDROLOGY: AN INTERDISCIPLINARY APPROACH FOR SUSTAINABLE MANAGEMENT OF WATER RESOURCES (Brochure)

AUTHORS:

UNESCO-IHP

ABSTRACT:

In February 2006, the IHP Secretariat began the process of reconstituting the Scientific Advisory Committee and officially launching Task Forces (TFs) on ecohydrology. At the same time, the programmatic framework and the organisational structure of IHP's ecohydrology activities were reviewed and redefined. This brochure summarises those changes and shows the mission statement.

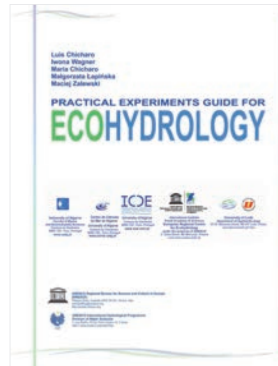
FACTS AND FIGURES:

- UNESCO's Ecohydrology Programme is a scientific programme whose aim is to understand and elucidate the dynamic relationships between hydrological, social and ecological systems; to consider how these act upon each other, and to find new ways to balance human and environmental needs for water resources.
- It aims to:

  1 - advance the integration of social, ecological and hydrological research;

  2 - generate outcomes that enable the development of effective policies and practices.
- Five Task Forces were launched: (i) Coastal Zones; (ii) Assessing Impacts of Global Change on Aquatic Systems; (iii) Social Sciences; (iv) Education and Capacity building; (v) Demonstration Projects (which incorporates the network of demonstration projects launched in 2005).
- In 2007, the newly reconstituted Scientific Advisory Committee (SAC) on Ecohydrology developed a new mission statement and strategy for the Ecohydrology Programme: to move ecohydrology forward as a transdisciplinary approach to solve some issues surrounding water, environment and people.

2009 ECOHYDROLOGY AND PHYTOTECHNOLOGY HANDBOOKS



TITLE:

PRACTICAL EXPERIMENTS GUIDE FOR ECOHYDROLOGY

AUTHORS:

Chicharo L., Wagner I., Chicharo M., Łapińska M., and Zalewski M. (Eds.)

ABSTRACT:

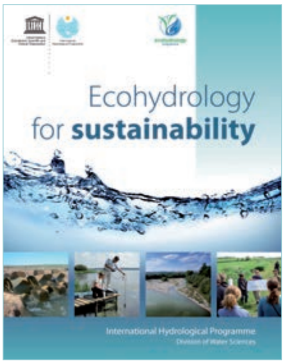
Aiming to contribute to the dissemination of the Ecohydrology concept in different types of aquatic ecosystems, this book proposes a series of practical experiments, mostly requiring non-sophisticated laboratory equipment and conditions.

The experiments proposed will provide water science students with practical knowledge of the methods to identify and design solutions to water and biodiversity degradation. The student will be guided to analyse and discuss the results of the experiment and draw their own conclusions.

FACTS AND FIGURES:

- Ecohydrology is based on a holistic approach to aquatic ecosystems that integrates hydrology and biology to find the most adequate solutions for the benefit of society and ecosystems.
- This book provides suggestions of practical experiments for addressing different water problems and demonstrates that long-lasting ecohydrology solutions – based on a deep understanding of the contribution of hydrological and ecological variables to the healthy functioning of ecosystems – can be implemented successfully with low-cost interventions, in different aquatic ecosystems.
- The notion that water quality and biodiversity can be controlled by managing hydrologic parameters (such as residence times or freshwater discharge volumes), or biological parameters (such as the presence of riparian vegetation or filter feeders) and that integration with existing infrastructures can be made in a synergetic way, **is a novel approach to water sciences**.

2011 UNESCO-IHP DEMONSTRATION PROJECTS IN ECOHYDROLOGY



TITLE:

ECOHYDROLOGY FOR SUSTAINABILITY (Brochure)

AUTHORS:

UNESCO-IHP

ABSTRACT:

This brochure recalls the key principles of ecohydrology and how UNESCO IHP and the ecohydrology network work together to implement them.

It also introduces the diversity of demonstration sites of the Ecohydrology Programme, with a total of 32 projects, grouped into four different categories: Global Reference Projects, Operational Projects, Evolving Projects and Emerging Projects.

FACTS AND FIGURES:

The Ecohydrology concept should operate in Demonstration Projects at four levels:

1

INFORMATION (monitoring, collecting of empirical data, defining interactions and hydrology-biota-society feedbacks),

2

KNOWLEDGE (defining patterns, describing and explaining processes),

3

WISDOM (ability to formulate policy, principles for action, problem solving by systemic solutions, stakeholders involvement, education, implementation),

3

COOPERATION FOR SOLVING PROBLEMS (willingness of different stake-holders to effectively contribute actively to the implementation of the Ecohy-drology approach in the demonstration site – it will ensure cooperation among all sectors and the achievement of the demonstration site goals).

ERASMUS MUNDUS MASTER OF ECOHYDROLOGY

The ERAMUS MUNDUS Master of Science in Ecohydrology (ECOHYD) is supported by a consortium built on highly experienced Higher Education Institutions in Ecohydrology, such as the UNESCO-IHE Institute for Water Education (Delft, Netherlands), the University of Lodz (Poland), the University of Algarve (Portugal), the Christian Albrecht University of Kiel (Germany) and the National University of La Plata (Argentina).

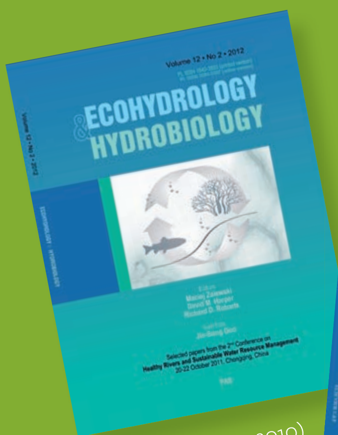
This Master course will provide students with a profound knowledge and understanding of the ecological processes that support the resilience of aquatic ecosystems, and of how these processes can be harmonised with engineering infrastructures in river basins, used to sustain aquatic ecosystems' quality and reverse degradation.

Several institutions, such as Research and UNESCO Centers, from Europe, Latin America, Asia and Australia are Associate Members of this course, contributing with their expertise in particular scientific areas, with the offer of advanced study courses and with student exchanges :

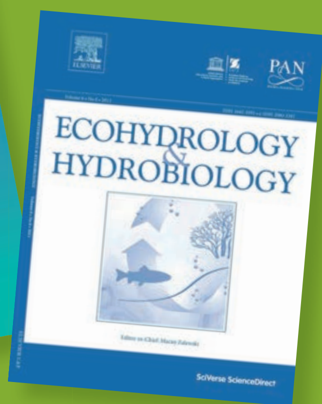
- Expertise on estuarine and coastal ecosystem ecohydrology will be provided by the University of Algarve (Portugal);
- Expertise in freshwater and urban ecohydrology will be provided by the University of Lodz (Poland); and
- Expertise on engineering and management components will be provided by UNESCO-IHE (Netherlands) and the University of Kiel (Germany).

See more details on **http://www.ecohyd.org/**

INTERNATIONAL JOURNAL – ECOHYDROLOGY & HYDROBIOLOGY



Vol 01-10 (2001-2010)



Vol 11-15 (2011-2015)

ECOHYDROLOGY & HYDROBIOLOGY is an international journal that aims to advance ecohydrology as the study of the interplay between ecological and hydrological processes from molecular to river basin scales, and to promote its implementation as an integrative management tool to harmonise societal needs with biosphere potential.

An essential component of ecohydrology is a rigorous understanding of hydrobiology, from ecosystem properties, dynamics and functions to modelling of abiotic and biotic interactions in relation to their hydrological determinants at the basin scale.

Research addressing one or several of the following issues will be of prime interest to the journal if it:

- Leads to new insights into the interactions of water, nutrient and pollutant cycles with biotic components of ecosystems;
- Employs this understanding for developing ecosystem biotechnologies and system solutions;
- Identifies possibilities to integrate engineering infrastructure with ecohydrological biotechnologies into system solutions at the catchment scale;
- Translates transdisciplinary knowledge into decision-support tools;
- Is policy-oriented and, within the scope of the journal, addresses the priorities and objectives of international initiatives such as the 2030 Agenda and UNESCO International Hydrological Programme.

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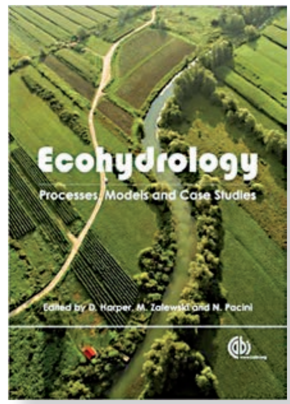
ECOHYDROLOGY BOOK



The book **"ECOHYDROLOGY: PROCESSES, MODELS AND CASE STUDIES"**, edited by Harper D., Zalewski M. and Pacini N. (2008) was the first book on the subject (remains one of the most important), in which Hydrobiologists and Hydrologists have combined to show how Ecohydrology, in the framework of UNESCO IHP, has been developed since the paradigm was first formulated twenty years earlier (e.g. Zalewski *et al.*, Chapter 1 *'Linking Biological & Physical Processes at River Basin Scale; the Origins, Scientific Background and Scope of Ecohydrology'*).

The importance and the innovative character of this book are evident in its introduction of the Hydrological perspective for understanding biological processes in the catchment (e.g. Gutknecht, Jolankai, Skinner, Chapter 2 *'Patterns and Processes in the Catchment'*) and the biological perspective for understanding the role of hydrology in shaping biota (e.g. Janauer & Jolankai, Chapter 4 *'Lotic Vegetation Processes'*; Gore *et al.*, Chapter 5 *'Factors Influencing Aquatic Fauna'*).

A very important way to enhance the integration of the understanding of the Hydrology-Biota interplay has been the use of mathematical modelling (e.g Gore & Mead, Chapter 7 *'The Benefits & Risks for Managing Scarce Water Resources in a Groundwater-Dominated Temperate System'*). It was clearly shown as a new perspective to deepen the understanding of the interplay between hydrological and biological processes, for the creation of a new tool of integrative water resources management in a river basin context (e.g. Hillbricht-Ilkowaska, Chapter 10 *'The Mid-European Agricultural Landscape: Catchment-scale Links Between Ecology & Hydrology'*).

All this was translated into management scenarios (e.g. McClain, Chapter 11 for South American rivers, Pacini & Harper, Chapter 12 for African and Fachevsky, Timchenko & Oksiyuk for former Soviet Union).

Finally, the importance of the Paleohydrological perspective (Starkel, Chapter 14) and potential effect of climate changes (Wagner, Chapter 15) were emphasised.

This publication is still considered one of the most important reference points for the development of new ideas and projects and the implementation of integrative environmental sciences as further steps towards "the sustainable future we want". The publishers have requested a second edition.

EXAMPLES OF MAJOR PUBLICATIONS IN ECOHYDROLOGY

Zalewski M., ***Ecohydrology - the scientific background to use ecosystem properties as management tools toward sustainability of water resources.***
Ecological Engineering, October 2000, Vol. 16, No. 1

This special issue on Ecohydrology of the Journal of Ecological Engineering presents selected papers from the International Hydrological Programme (IHP-V2.3:2.4) Symposium on Ecohydrology, held at the University of Lodz, Poland, in May 1998.

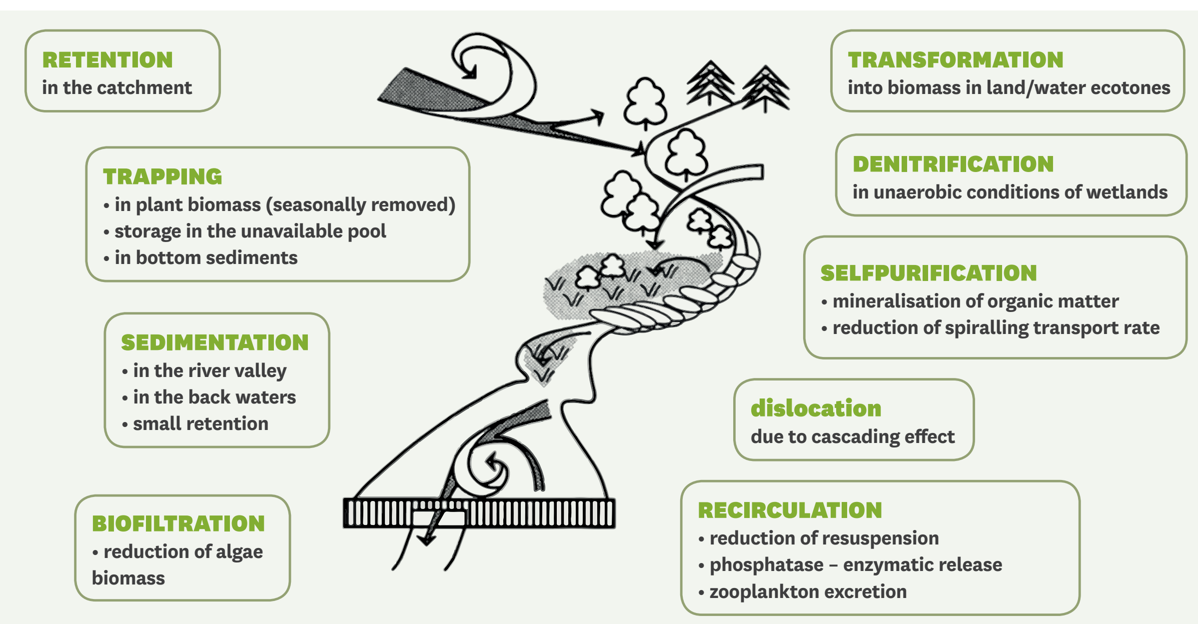
The papers of this special issue have been ordered along a gradient from small- to large-scale processes. Understanding and quantifying small-scale ecohydrological processes in different freshwater habitats provides the basis for constructing large-scale predictive models. Restoration of evolutionarily-established cycles in a freshwater ecosystem may be achieved by regulating nutrients and energy conversion using hydrology and the biota in the landscape (figure 6): this is the ecological engineering approach using ecosystem biotechnology.

Since properties of a large-scale system cannot be deduced from properties of its component elements, such a complex strategy for restoring nutrient cycling in a catchment landscape and freshwater ecosystem should be assessed continuously at every stage of implementation and adjusted to improve the efficiency of further steps. This ecohydrological approach to the restoration of river basin systems using ecological engineering and ecosystem biotechnology methods should be considered a challenge rather than a final solution. To meet the emerging global scale challenges, traditional discipline-oriented teams need to be replaced by problem-orientated interdisciplinary teams.

E. Wolanski, L.A. Boorman, L. Chicharo, E. Langlois-Saliou, R. Lara, A.J. Plater, R.J. Uncles and M. Zalewski, 2004. ***Ecohydrology as a new tool for sustainable management of estuaries and coastal waters.***
Wetlands Ecology and Management 12: 235–276

Estuaries are highly dynamic environments that exhibit strong temporal and spatial changes in their physical, chemical and biological variables (figure 7); thus, each estuary is unique and there is no general parameter to readily assess the 'health risk' of an estuary from natural and human influences.

FIGURE 6.
The ecohydrological concept of the restoration of a eutrophic shallow reservoir, by applying various ecosystem biotechnologies as an example of catchment-scale ecological engineering



Ecohydrology-based solutions call for the restoration and creation of wetlands, including mudflats, mangroves and saltmarshes, because of their ability to trap sediment and pollutants, to convert excess water-born nutrients into plant biomass and to provide habitats for demersal and pelagic species.

To develop science-based remediation measures at the river basin scale, ecohydrology therefore relies only on low-cost technology for mitigating the impact of human activity on coastal zones throughout river basins, using or enhancing the natural capacity of the water bodies to absorb, or process with no resulting estuary degradation, the nutrients and pollutants.

This necessitates changing present practices of official institutions based on municipalities or counties as administrative units, or the narrowly focused approaches of managers of specific activities. Without this change in thinking and management practices, estuaries and coastal waters will continue to degrade, no matter the integrated coastal management plans that are implemented.

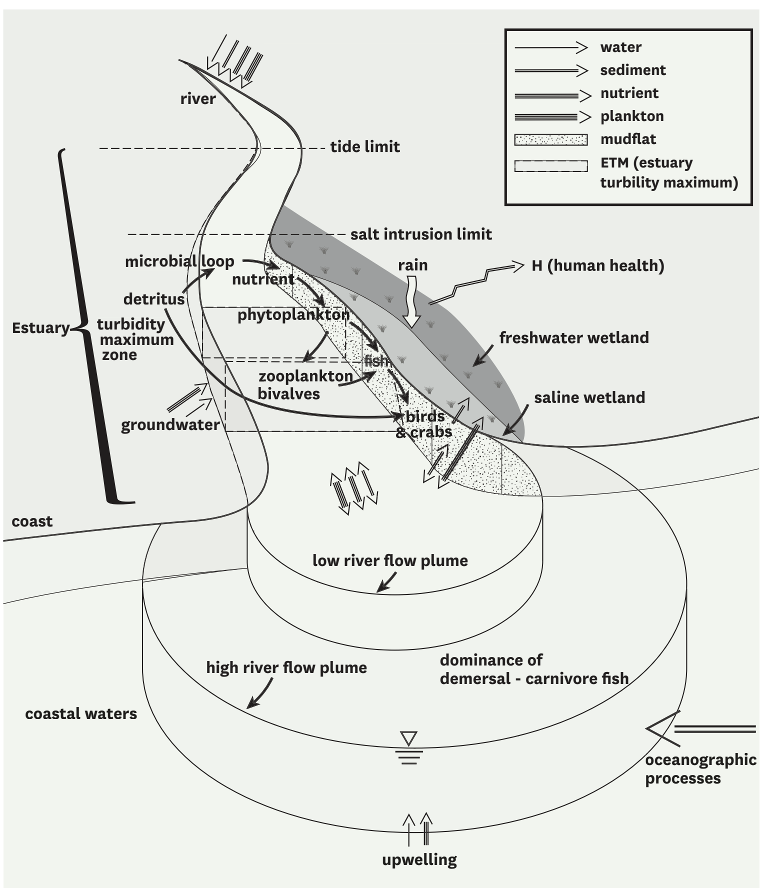
David Harper and Kenneth Mavuti, 2004. Lake Naivasha, Kenya: ***Ecohydrology to guide the management of a tropical protected area.***
Ecohydrology & Hydrobiology 4 (3): 287-305

The aim of this paper is to review existing scientific evidence, in order to evaluate the relative risk of each of the 21st century threats to the integrity of the Ramsar-status lake-wetland ecosystem, Lake Naivasha. It is one of the few examples in the world of a wetland which is of international importance for biodiversity conservation yet at the same time of high economic importance to the nation (horticulture, currently the second-highest foreign exchange earner, and power generation from Africa's sole geothermal station both depend on Lake Naivasha).

The net result is that *C. papyrus*, as a functioning swamp ecotone that protects both lake shallows from runoff in the hinterland and the whole lake from the negative inputs of its catchment, no longer exists. This loss has been caused by the combination of lake levels depleted by abstraction for horticulture/industry, combined with the increased pressure of uncontrolled human use of the lake and its shorelines on top of habitat destruction at the lake edge and its hinterland. It is the first step in initiating of ecohydrological buffering capacity in submerged and floating leaved plant beds. Now, eutrophication is continuously present in the lake, driven by land use changes in the catchment.

Sustainable management would enable the use of phytotechnologies to re-create the ecotone structure and mitigate the (now far greater) external impacts. The proposals have to use ecosystem properties to sustainably manage Lake Naivasha for both the ecology of the lake and the economy of the region and country.

FIGURE 7.
Sketch of the dominant pathways of water, fine sediment, nutrients, and plankton in an estuary



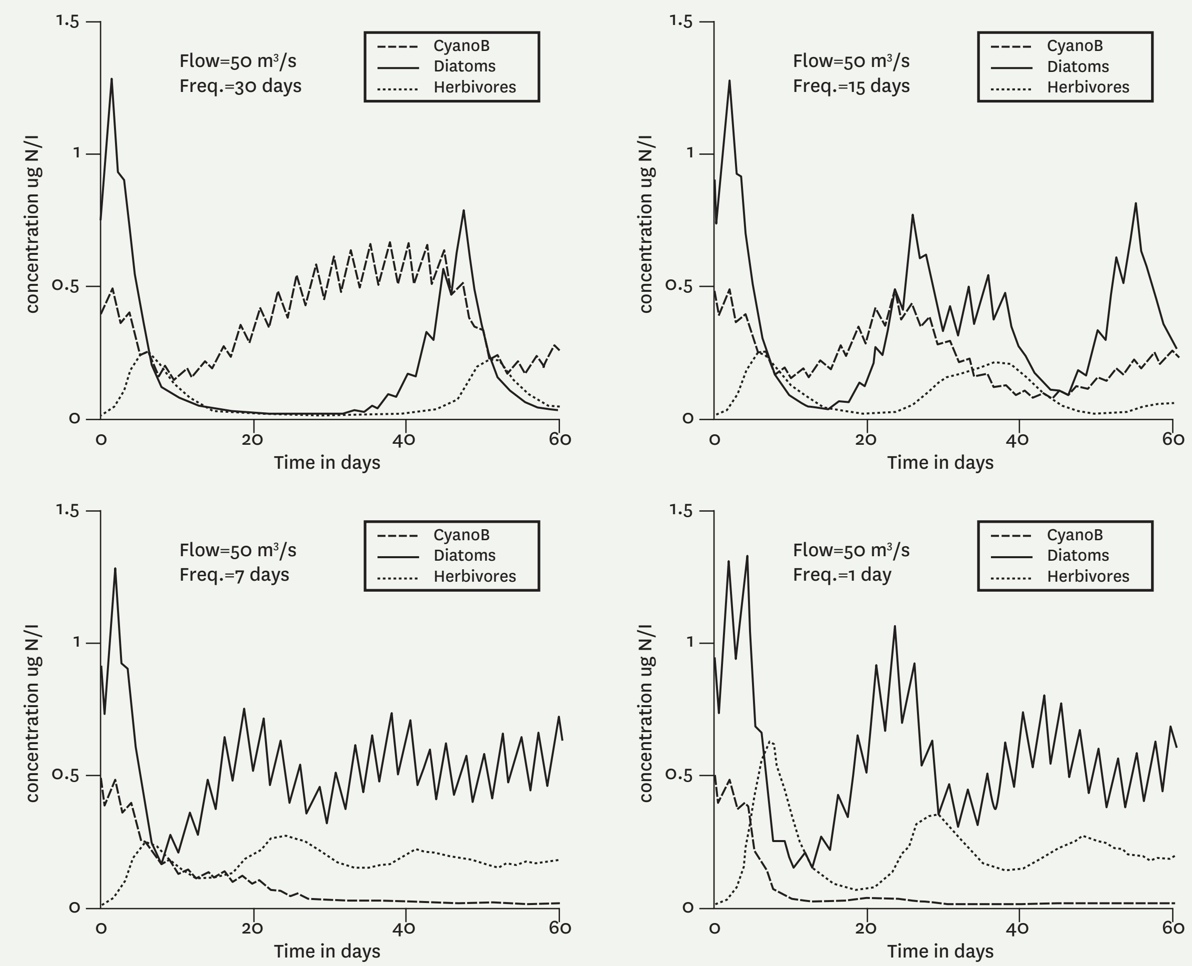
Luis Chicharo, M. Alexandra Chicharo, Radhouane Ben-Hamadou, 2006. ***Use of a hydrotechnical infrastructure (Alqueva Dam) to regulate planktonic assem-blages in the Guadiana estuary: Basis for sustainable water and ecosystem ser-vices management.***
Estuarine, Coastal and Shelf Science, Vol. 2, Iss.1-2: 3-18

This study has shown how phytoplankton and zooplankton assemblages are affected by natural modifications in freshwater discharge. Such observations have been used to estimate the effect of the reduction of freshwater discharge in the example of the Guadiana River, and the repercussions on the estuarine and coastal planktonic assemblages, brought about by the construction of the Alqueva Dam across the river. Since freshwater "pulses" can be managed by controlling the freshwater release from hydrotechnical structures, understanding the relationships between the periodicity and magnitude of inflow pulse events and the estuarine ecosystem's structure and healthy functioning is crucial, especially considering the changes forecast in hydrologic regimes associated with climatic changes.

This article suggests that the development of simple models will contribute to a better management of the estuaries under the influence of dams, allowing sustainable and ecological uses of the estuarine ecosystem.

As shown in figure 8 below, the freshwater pulses (50 m^3/s every week) can disturb and enrich the estuary with nutrients, thereby excluding the cyanobacterial community from the system.

FIGURE 8.
Model sensitivity tests



William J. Mitsch, Li Zhang, Daniel F. Fink, Maria E. Hernandez, Anne E. Altor, Cassandra L. Tuttle, Amanda M. Nahlik, 2008. ***Ecological engineering of floodplains.*** Ecohydrology & Hydrobiology, Vol.8, No. 2-4: 139-147

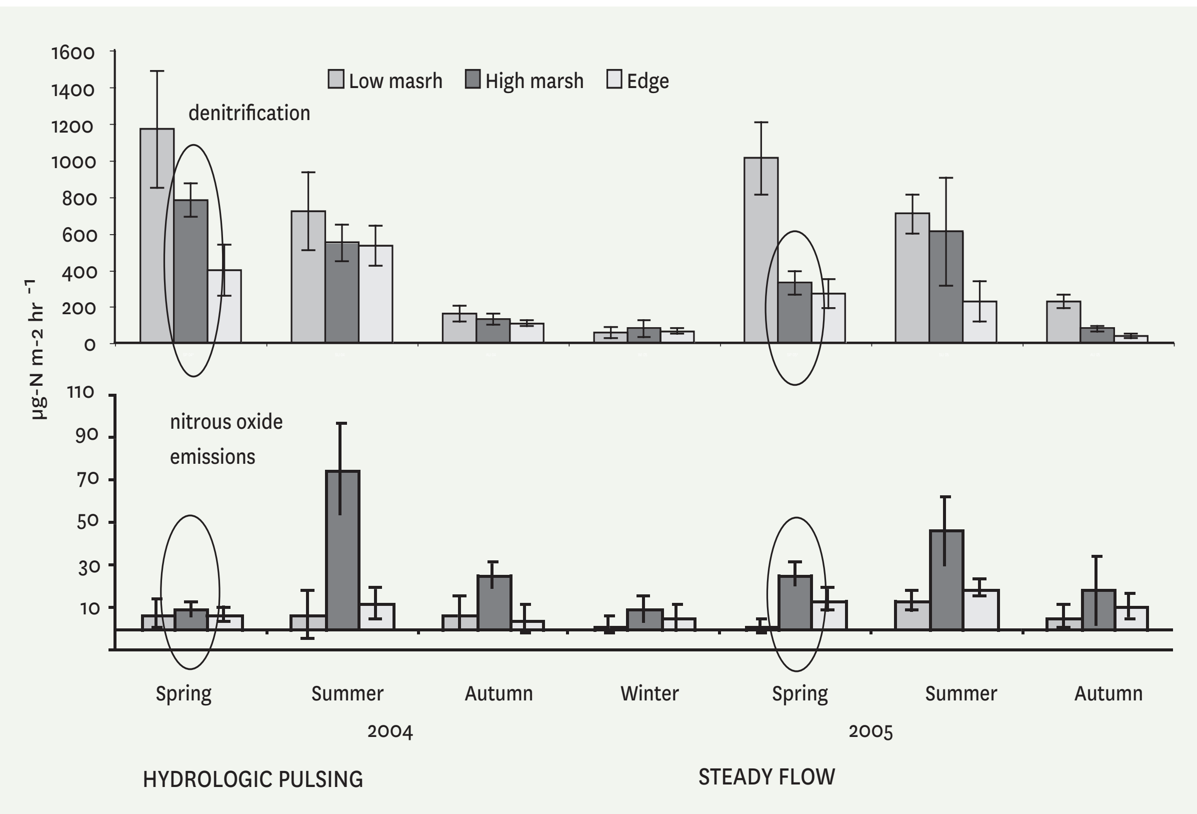
As a result of a multi-year, in-depth study of the effects and control of the Gulf of Mexico hypoxia in the late 1990s, ambitious plans for the use of floodplain wetlands and riparian ecosystems as buffer systems between farm fields and adjacent streams and rivers was proposed in the Mississippi-Ohio-Missouri River Basin. Specifically, two main multi-year experiments were conducted on full-scale wetlands at the Olentangy River Wetland Research Park in Ohio, USA (ORWRP); the river-pulsing study is presented in this article to investigate proper ecological design for the restoration and creation of 2.2 million hectares of wetlands and riparian ecosystems in this region, with a strategic emphasis on these ecosystems in the Midwest where nutrients are found in the highest concentrations.

The ORWRP was recognized as the 24th Ramsar wetland of international importance in the USA in April 2008. The recognition was for the biodiversity of the site and also for research and urban ecotourism, both important facets of this campus wetland site. At the research park, the two main goals are understanding:

1- how wetlands, rivers, and watersheds function in support of flood control, wildlife habitat, and water quality improvement, and

2- if and how we can create and restore these systems to protect the environment in Ohio and around the world.

FIGURE 9.
Denitrification and nitrous oxide emissions from two experimental wetlands at the ORWRP. Circles indicate important comparisons between times of hydrologic pulsing with steady-flow conditions where different denitrification and nitrous oxide emissions were determined for pulsing and steady-flow conditions.



Maciej Zalewski, 2015. ***Ecohydrology and Hydrologic Engineering: Regulation of Hydrology-Biota Interactions for Sustainability.***
Journal of Hydrologic Engineering, Vol. 20, Iss. 1. DOI: 10.1061/(ASCE)HE.1943-5584.0000999

The proposed approach in this article aims to initiate a discussion and joint efforts of hydrological engineers, hydrologists, and ecologists towards the formulation of a comprehensive strategy and a scientific background for the harmonisation of societal needs with the enhanced ecosystem potential. Indeed, the two often contradicting approaches to water resources management (i.e., hydrotechnical, and ecological) can be reconciled within the context of ecohydrology. The fundamental assumption of Ecohydrology is that water is the major driver of biogeochemical evolution and thus of biodiversity and bioproductivity. It seeks to understand the underlying water-biota interactions as well as providing a new tool for management of water resources.

Ecohydrology aims to harmonise societal needs with enhanced ecosystem potential by increasing carrying capacity of ecosystems. Therefore, instead of balancing social and economic needs, it opts for harmonising them with ecosystem potential, and instead of/and apart from protecting pristine ecosystems, it calls for regulating processes in the novel ecosystems in order to increase their ecological potential in terms of (1) water resources, (2) biodiversity, (3) ecosystem services, and (4) resilience to global change and anthropogenic stress

The two key interconnected issues that need to be addressed are (1) the water cycle, and (2) its linkages with biocenoses. Firstly, the hydrological cycle has to be considered a primary regulator of ecological potential. Secondly, understanding the role of biocenoses in shaping the water and nutrient cycles is fundamental to reversing the declining potential of the biogeosphere. As such ecohydrology is compliant with the concept of IWRM but gives novel potent tools to achieve sustainability.

The next fundamental step toward meeting these challenges should be an integration of hydrological engineering into the ecohydrological framework for implementing and fine-tuning existing practices through adaptive assessment and management approaches. As far as river basin management planning is concerned, a long-term high-cost enterprise and integration of engineering and ecology should be implemented with cross verification through the application of socioeconomic and technological foresight methodologies.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