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Hydrological
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ECOHYDROLOGY

AS AN INTEGRATIVE SCIENCE FROM MOLECULAR TO BASIN SCALE

ECOHYDROLOGY GUIDELINES

“HOW TO BUILD A DEMOSITE CARD”

2017

INTERNATIONAL HYDROLOGICAL PROGRAMME

Division of Water Sciences

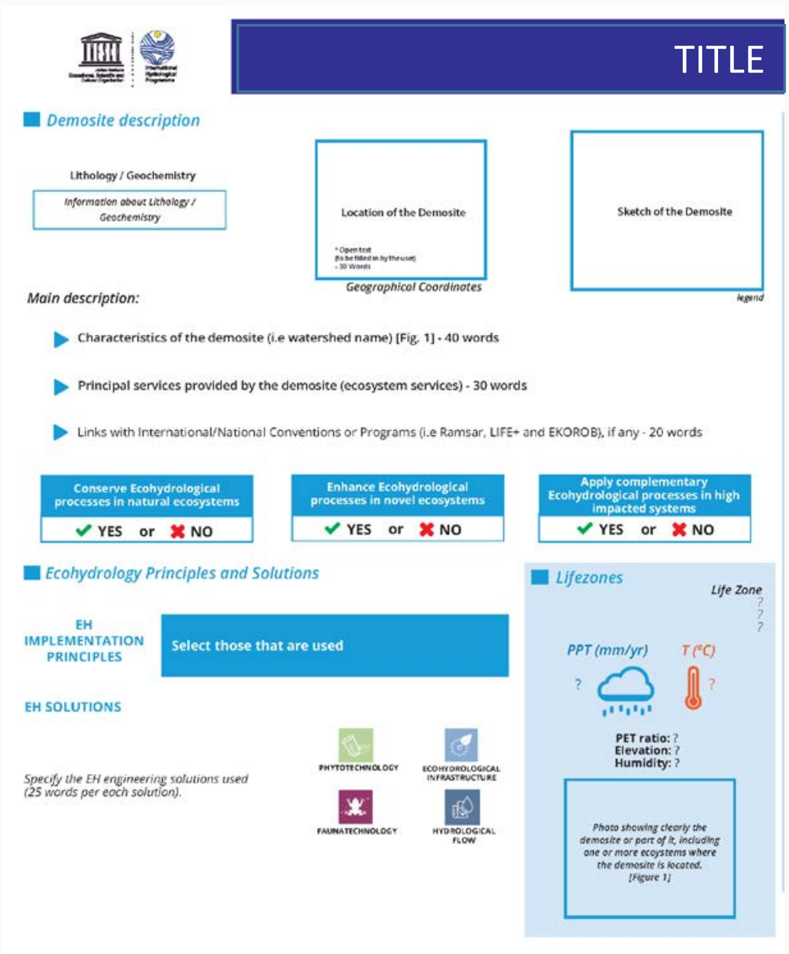
Introduction

In 2011, the Ecohydrology Programme of UNESCO IHP made a call for proposal for the establishment of a worldwide network of “demonstration sites” where ecohydrological approaches are implemented. There are key objectives of the network:

- Synthesize knowledge gaps for addressing ecohydrological issues related to critical water ecosystems, such as those in arid and semiarid zones, coastal areas and urbanized areas.
- Showcase how better knowledge of the interrelationships between the hydrological cycle, livelihoods and ecosystems can contribute to more cost-effective and environmental-friendly water management.
- Demonstrate system solutions and technology transfer opportunities through North-South and South-South linkages

Each demonstration site aims to show an application of ecohydrology to deal with issues such as nutrients concentrations, water purification, diverse aquatic habitats like wetlands, marshes, mangroves, cyanobacterial blooms, among others, in order to find long-term solutions integrating social components. The demonstration sites integrate the concept of enhanced ecosystem potential with ecohydrological strategies to achieve sustainability of ecosystems closely related with water to improve IWRM on specific areas. This is termed WBSRC (w-water, b-biodiversity, s-ecosystem services, r-resilience and c-cultural heritage) containing the five elements that should be taken into consideration while trying to improve the ecosystems potential. Through the dissemination of this initiative, it is expected to contribute to the development of research and knowledge-sharing of ecohydrology.

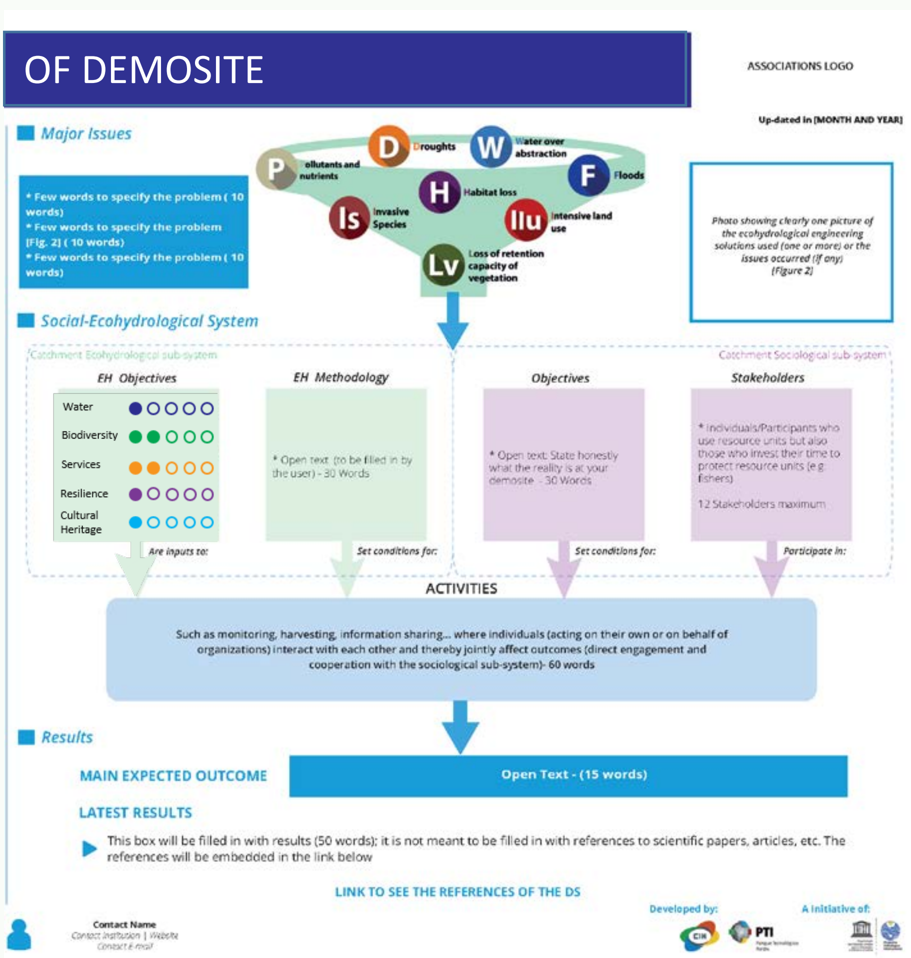
Template of a



The efforts to develop the initiative continued throughout further ecohydrology conferences (Jakarta 2011, and 2014,3 and Paris 2014, Lyon 2015, Addis Ababa 2016 and Rio de Janeiro 2017) establishing a network of ecohydrology demonstration projects. As a follow-up, the UNESCO-IHP Ecohydrology programme designed the so-called “demonstration site cards”, developed to provide concise and harmonized summary of the demonstration sites, in a standardized, simplified overview of information *-main characteristics*, *life zones, ecohydrology implementation principles, ecohydrology engineering solutions, major issues, social-ecohydrological system, results, additional references and pictures*- on the actual state of the demonstration sites.

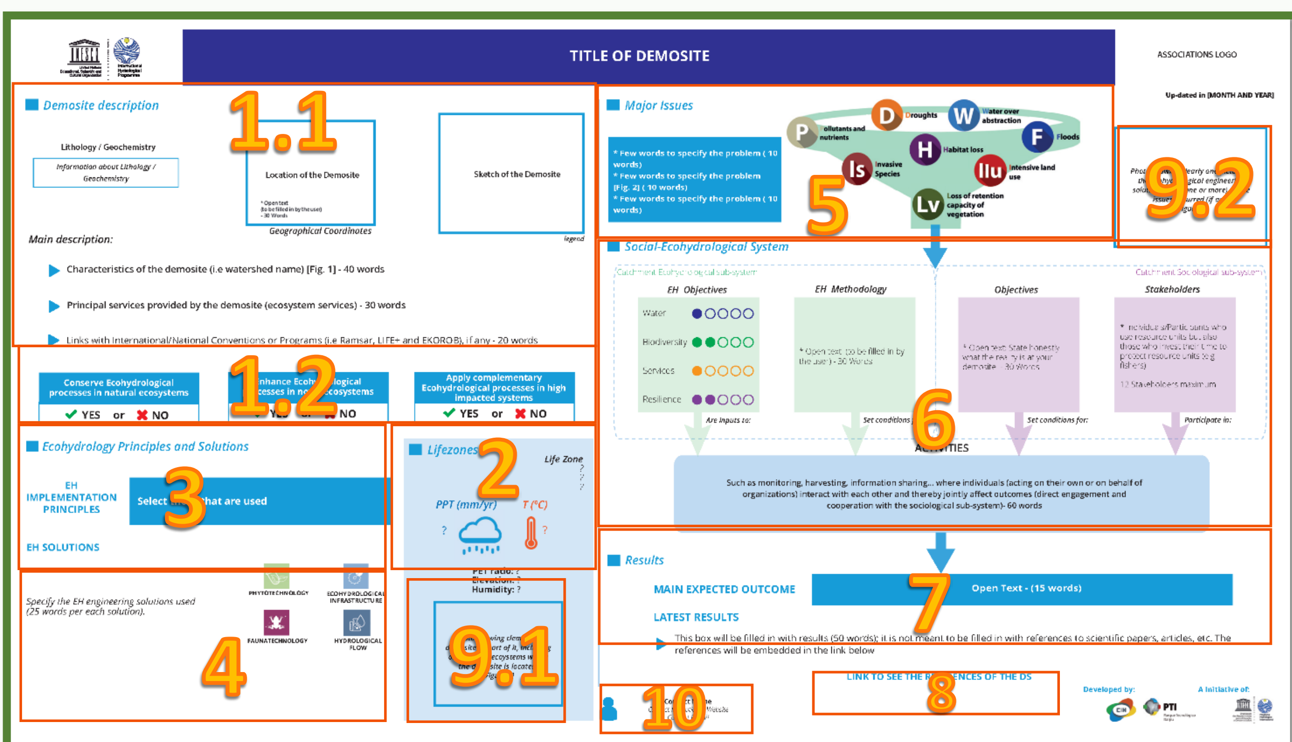
In addition to the current projects, new potential demonstration sites around the world are welcomed to join the ecohydrology network by applying through a web-platform developed for that purpose (http://ecohydrology-ihp.org). To facilitate this process, the present guidelines were designed to provide a detailed explanation on completing a demonstration site card. The user may follow each step of the 10 sections in the guideline and complete the necessary information also with the help of basis criteria.

Demonstration Site Card

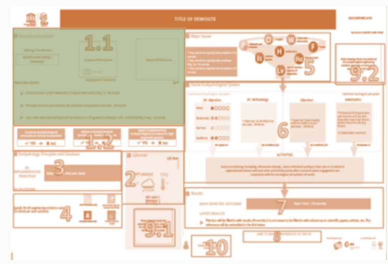


Template of a Demonstration Site

1.1. Description of the demosite.
1.2. Where Ecohydrology is being applied
2. Life zones
3. Ecohydrology Principles.
4. Ecohydrology Solutions.
5. Major issues.
6. Social Ecohydrological System.
7. Results.
8. References.
9.1. Picture.
9.2. Picture.
10. Contact.



1.1. Description of the demosite



Information about lithology/geochemistry (25 words)

Location of the demosite inside the country

Geographical coordinates

Map/Sketch of the demosite with relevant information

<u>Main description:</u>

- **Characteristics of the demosite:** (i.e. watershed name, precise location of the demosite, number of inhabitants in the basin...) - (40 words)

- **Principal Ecosystem services** (defined in TEEB as "the direct and indirect contributions of ecosystems to human wellbeing".) **provided by the demosite**: Brief text explaining which ones are enhanced or maintained, if any. (30 words)

Provisioning Services

Services that describe the material outputs from ecosystems

- Food
- Raw materials
- Fresh water
- Medicinal resources

Regulating Services

Services that ecosystems provide by acting as regulators

- Local climate and air quality regulation
- Carbon sequestration and storage
- Moderation of extreme events
- Waste-water treatment
- Erosion prevention and maintenance of soil fertility
- Pollination
- Biological control

Cultural Services

Include the non-material benefits people obtain from contact with ecosystems

- Recreation and mental and physical health
- Tourism
- Aesthetic appreciation and inspiration for culture, art and design
- Spiritual experience and sense of place

Habitat or Supporting Services

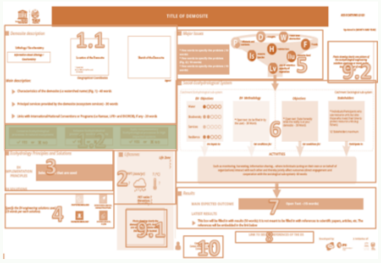
Underpin almost all other services. Ecosystems provide living spaces for plants or animals; they also maintain a diversity of different breeds of plants and animals

- Habitats for species
- Maintenance of genetic diversity

- **Links with International/National Conventions or Programs** (i.e. Ramsar, LIFE+ and EKOROB), if any (20 words)

TEEB (2010) The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.

1.2. Where EH is being applied

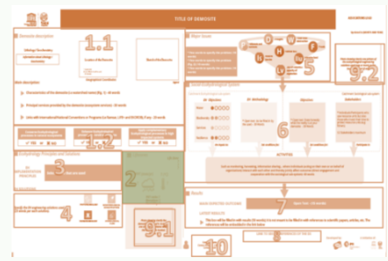


Conserve Ecohydrological processes in **natural ecosystems**	Enhance ecohydrological processes in **novel ecosystems**	Apply complementary Ecohydrological processes in **high impacted systems**
YES/NO	YES/NO	YES/NO

- **Natural ecosystems** are maintained by natural ecosystem processes (e.g.: self-denitrification in wetlands, natural regulation between flow and biota, etc.). However, it is hard, if not impossible, to completely remove the human footprint from many ecosystems. The difference between Natural and Novel ecosystems is made by the degree of human impact.
- **Novel ecosystems** refer to the anthropogenically highly modified portions of catchments.
- **High impacted systems** (e.g.: dams; intensive farmlands) are those ecosystems that are being manipulated in such way that pollution is higher than the law and regulation recommend, but demosites can implement complementary ecohydrological processes (e.g.: remediation etc.).

Hobbs, R. J., S. et al., 2006. **Novel ecosystems: theoretical and management aspects of the new ecological world order**. *Global Ecology and Biogeography* 15:1-7. http://dx.doi.org/10.1111/j.1466-822X.2006.00212.x
Hobbs, R. J., S. et al., 2009. **Novel ecosystems: implications for conservation and restoration**. *Trends in Ecology and Evolution*, Vol. 24, No. 11: 599:604. doi:10.1016/j.tree.2009.05.012
Hobbs et al., 2006 in Zalewski M., 2015. **Ecohydrology and Hydrologic Engineering: Regulation of Hydrology-Biota Interactions for Sustainability**. *J. Hydrol. Eng.* 20, SPECIAL ISSUE: Grand Challenges in Hydrology, A4014012 : 14p.

2. Life zones



Holdridge Life Zone System: at the minimum, 3 variables

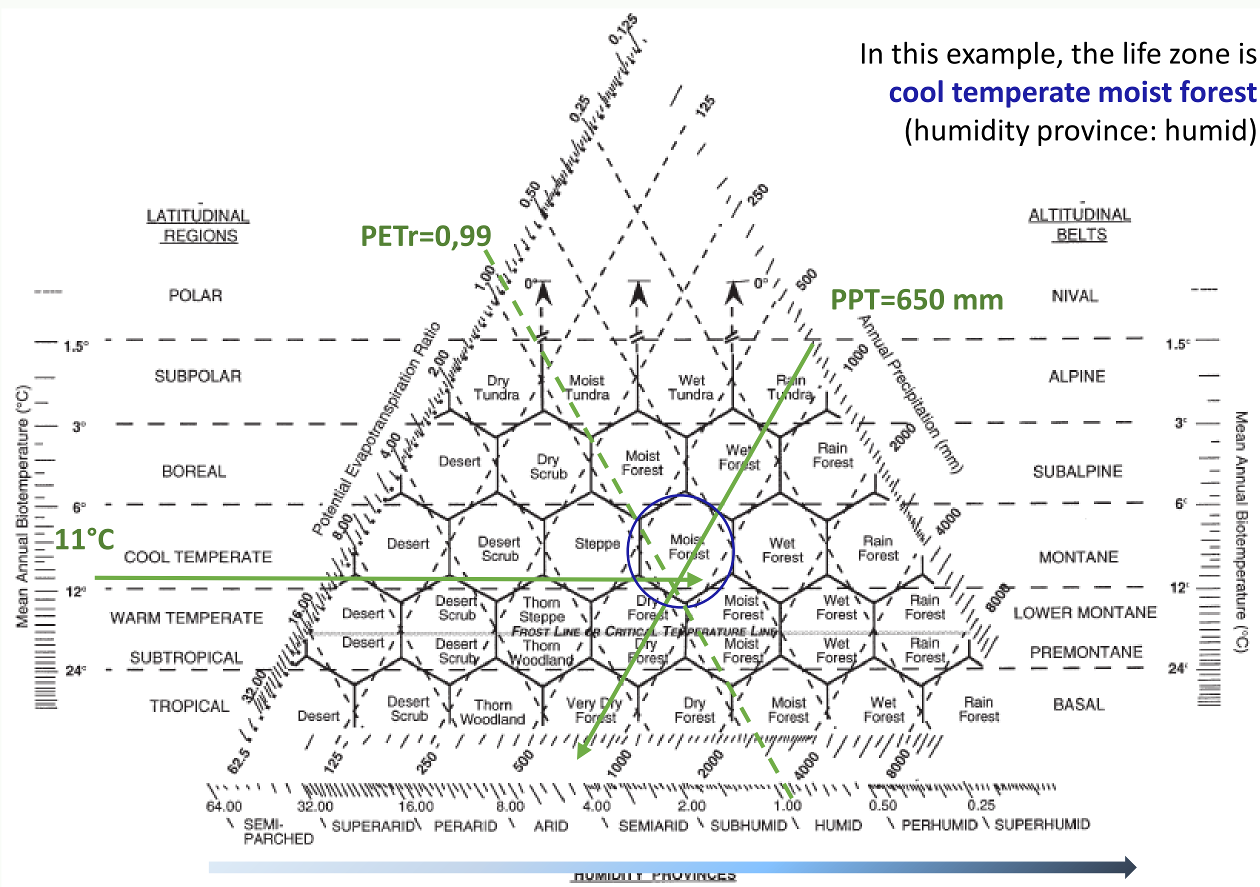
A - Mean annual biotemperature –Tbio- (in °C)

B - Mean annual precipitation –PPT- (in mm/yr.)

C - Elevation (in m)

From these two data (A and B), the potential evapotranspiration ratio value (PET) can be calculated using the following formula: **PET ratio= (Tbio *58.93)/PPT.** This value could be plotted on the figure below through a line drawn along its value on the corresponding scales on the left.

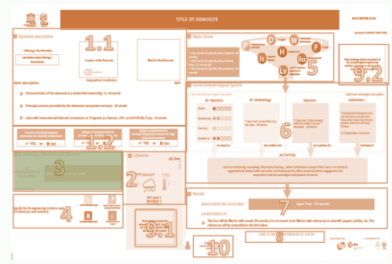
Additionally, Three life zone groupings according to: (i) Latitudinal regions, (ii) Altitudinal belt & (iii) Humidity province



Holdridge, L.R. (1967**). Life zone ecology**. *Tropical Science Center*. Jose, Costa Rica. 206 pp.

Lugo A.E. et al., 1999. **The Holdridge life zones of the conterminous United States in relation to ecosystem mapping.** *Journal of Biogeography*, 26, pp.1025-1038

3. Ecohydrology Implementation principles



I. Hydrological (Framework): Quantification of the hydrological processes at catchment scale and mapping the impacts.

II. Ecological (Target): Identification of potential areas for enhancement of ecosystem sustainability potential (carrying capacity).

III. Ecological Engineering (Methodology): Managing biota to control hydrological processes and vice versa.

Ecohydrology general principles

1

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

Dual regulation-water biota interplay

2

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

Harmonization of ecohydrological solutions with hydro technical infrastructure

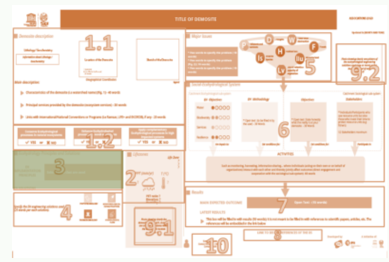
3

INTEGRATION - at the basin scale various types of regulations (E <-> H) act in a synergistic way to improve and stabilize the quality of water resources

Integration of various regulation acting in a synergistic way for enhancement of the ecological potential (carrying capacity)

Chicharo and Zalewski *et al*., 2009 . **Practical experiments guide for Ecohydrology.** UNESCO. 121p.
Zalewski M., 2000. **Ecohydrology-the scientific background to use ecosystem properties as management tools towards sustainability of water resources**. *Ecological Engineering* 16: 1-8
Zalewski M., 2002**. Ecohydrology, the use of ecological and hydrological processes for sustainable management of water resources.** *Hydrological Sciences-Journal des Sciences hydrologiques 47(5*): 823-832

3. Ecohydrology Implementation principles



I. Hydrological (Framework): Quantification of the hydrological processes at catchment scale and mapping the impacts

Hydrological(2): The quantification of the hydrological cycle of a basin, should be a template for functional integration of hydrological and biological processes.

FRAMEWORK (1.a; 1.b): It conceptualizes the catchment as a "superorganism" in a similar fashion as the Gaia concept of the planet as a "superorganism" (Lovelock, 1995). **A hierarchy of factors influences this "superorganism"**:

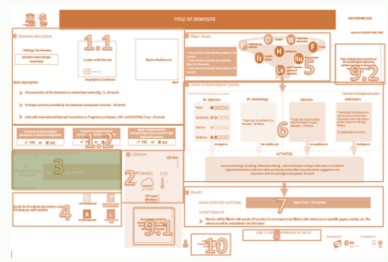
Scale - the mesoscale cycle of **water circulation within a basin** is a template for the quantification of ecological processes;

Dynamics - **water and temperature** are the driving forces for both terrestrial and freshwater ecosystems;

Hierarchy of factors - **abiotic (e.g., hydrological) processes** are dominant in regulating ecosystem functioning. **Biotic interactions** may manifest themselves when abiotic factors are stable and predictable

1a. Zalewski M., 2000. **Ecohydrology-the scientific background to use ecosystem properties as management tools towards sustainability of water resources**. *Ecological Engineering* 16: 1-8
1b. Zalewski M., 2002**. Ecohydrology, the use of ecological and hydrological processes for sustainable management of water resources.** *Hydrological Sciences-Journal des Sciences hydrologiques 47(5*): 823-832
2. Chicharo and Zalewski *et al*., 2009 . **Practical experiments guide for Ecohydrology.** UNESCO. 121p.

3. Ecohydrology Implementation principles



II. Ecological (Target): Identification of potential areas for enhancement of ecosystem sustainability potential (carrying capacity).

Ecological [2]: The integrated processes at river basin scale can be steered in such a way as to enhance the basin's carrying capacity and its ecosystem services.

TARGET [1a; 1b]: The conceptual "superorganism" can be viewed in a natural state as possessing resistance and resilience to stress. In the face of increasing global changes (such as increasing population, energy consumption, global climate change), **it is necessary to increase the carrying capacity of ecosystems, and their resistance and resilience, to absorb human-induced impacts**

III. Ecological Enginering (Methodology): Managing biota to control hydrological processes and vice versa.

Ecological engineering [2]: **The regulation of hydrological and ecological processes**, based on an **integrative system approach**, is a new tool for Integrated Water Basin Management and Integrated Costal Management.

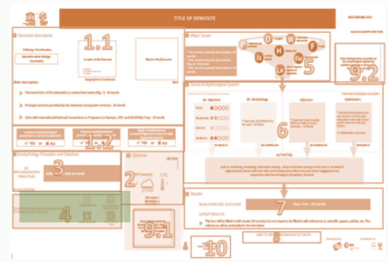
METHODOLOGY [1.a; 1.b]: Ecohydrology **uses ecosystem properties** as a management tool. It is applied by using **biota to control hydrological processes and, vice versa**, by using hydrology to regulate biota. Scientific basis for the methodological aspect of using biota for **water quality improvement** has been seriously advanced by **ecological engineering** (e.g.,Mitsch & Jorgensen, 2004).

1a. Zalewski M., 2000. **Ecohydrology-the scientific background to use ecosystem properties as management tools towards sustainability of water resources**. *Ecological Engineering* 16: 1-8

1b. Zalewski M., 2002**. Ecohydrology, the use of ecological and hydrological processes for sustainable management of water resources.** *Hydrological Sciences-Journal des Sciences hydrologiques 47(5*): 823-832

2. Chicharo and Zalewski *et al*., 2009 . **Practical experiments guide for Ecohydrology.** UNESCO. 121p.

4. Ecohydrology engineering solutions



Ecohydrological Infrastructure

Ecohydrology and Ecological engineering[1, 2]
Including 4 measures:

- Dual regulation
- Biotechnologies
- Self-design
- Ecosystem conservation

Based on integration of hydro-geomorphodynamics, ecological succession and dual regulation
E.g Denitrification process, river dynamics

Hydrological Flow

Use of hydrological flow to regulate and/or stimulate ecological status (inundation of floodplains to maintain specified valued features of the ecosystem as productivity)[3, 4]

E.g. modelling

Phytotechnology

Using plants:

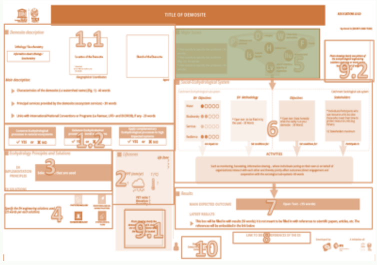
- to increase water retentiveness.
- to enhance aquatic resilience.
- to regulate nutrient dynamics in catchment.

Fauna-tecnología

E.g.: Use of macroinvertebrates to regulate water quality (reduce eutrophication and algal blooms).

1. Capobianco M. and Stive M. J. F., 2000. **Soft intervention technology as a tool for integrated coastal zone management**, *Journal of Coastal Conservation* 6, pp. 33-40
2. Zalewski M., 2015. **Ecohydrology and Hydrologic Engineering: Regulation of Hydrology-Biota Interactions for Sustainability**. *J. Hydrol. Eng. 20*, SPECIAL ISSUE: Grand Challenges in Hydrology, A4014012 : 14p.
3. Bunn S. E. and A. H. Arthington, 2002. **Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity**. *Environmental Management Vol. 30, No. 4* : 492–507
4. Tharme R. E., 2003. **A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers**. *River Res. Applic. 19*, pp. 397-441

5. Major issues



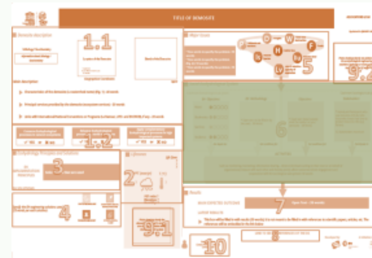
What are the major issues occurring in the demosite ?

P	☐ Pollutants and Nutrients	
Ilu	☐ Intensive land use	
W	☐ Water over abstraction	
F	☐ Floods	
Is	☐ Invasive Species	
D	☐ Droughts	
H	☐ Habitat loss	
Lv	☐ Loss of Retention capacity of vegetation	
Ot	☐ Other	Which?

If the major issue on the demosite is not one of the listed, please add in "other" issues (in this box, please only type one term or word that explains the issue). If there are more than one "other" issue, please separate each with a semi-colon (;). The explanation of each issue can be described more in detail in the next text box.

Then, for the major issues selected above, please write a short explanation on how it is affecting the area, their causes and consequences (10 words each).

6. Social Ecohydrological System



Major Issues

Social-Ecohydrological System

Catchment Ecohydrology sub-system

EH Objectives

Water	●○○○○
Biodiversity	●●○○○
Services	●●○○○
Resilience	●○○○○
Cultural Heritage	●○○○○

Are inputs to:

EH Methodology

* Open text (to be filled by the user) – 30 words

Set conditions for:

Catchment Sociological sub-system

Objectives

* Open text: State honestly what the reality is at your demosite – 30 Words

Set conditions for:

Stakeholders

* Individuals/participants who use resource units but also those who invest their time to protect resource units (e.g. fishers)

12 Stakeholders max.

Set conditions for:

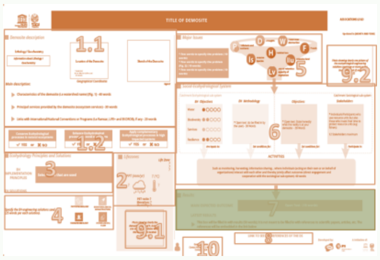
Activities

Such as monitoring, harvesting, information sharing… where individuals (acting on their own or on behalf of organizations) interact with each other and thereby jointly affected outcomes (direct engagement and cooperation with the sociological sub-system) – 60 words.

Main expected outcome

With reference to WBSR we ask the user to decide, by selecting one or more squares, the relevance of the EH Objectives. Bearing in mind that Ecohydrology is becoming an important component for an integrative approach (IWRM) all the 4 options, W for water, B for biodiversity, S for ecosystem services and R for resilience should be envisaged. Please indicate approximately the degree of relationship that the Demonstration site has between each option and the Ecohydrology Objectives (Very low 1 circle ●○○○○, low 2 circles ●●○○○ , medium 3 circles ●●●○○ high 4 circles ●●●●○, very high 5 circles ●●●●●).
Within the IWRM concept, Ecohydrology aims at harmonizing society needs with enhanced ecosystem potential through increasing carrying capacity of ecosystems; it therefore expands the concept of balancing social economic needs by harmonization of the same with enhanced ecosystem potential. Ecohydrology also calls for maintaining notions of conservation for pristine ecosystems and expands efforts for regulation of ecohydrological processes at novel ecosystems (man modified) in order to increase their ecological potential in terms of water resources, biodiversity, ecosystem services and resilience to global change and anthropogenic stress (WBSR, for Water, Biodiversity, Services and Resilience). As such ecohydrology is compliant with the IWRM concept but also provides novel potent tools to achieve sustainability (Zalewski, 2015).

7. Results.



Main Expected Outcome

This box should be filled with an explanation on the outcome expected through the project on the site or the aim of the activities (15 words).

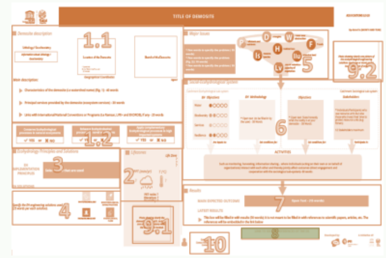
Latest Results

This box will be filled in with results (50 words); it is not meant to be filled in with references to scientific papers, articles, etc. The references will be embedded in the link below (*Link to the references)*

The aim of "Latest Results" is to:

Summarize the results or changes obtained on the demosite through the application of ecohydrological measures (e.g. decrease in the pollutant level from 50% to 30%, etc.).

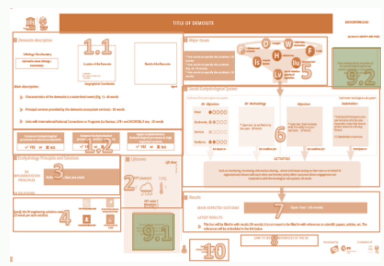
8. References



Link to the references, if any . Please indicate in a separate text out of the democard the relevant scientific papers/articles adding on the list provided by us.

This section deals with document references with information on specific results and solution-oriented approaches of ecohydrology on the demonstration site

9.1 & 9.2. Pictures



-One picture that clearly shows the demosite or part of it, including one or more ecosystems where the demosite is located.

Fig.1. The Sulejow Reservoir (W. Frątczak)

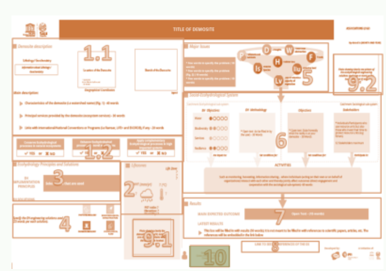
- One picture that clearly shows the ecohydrological engineering solutions used (one or more) or the issues occurred (if any).

Fig.2- Constructed wetlands (Courtesy of Wagner I. and Zalewski M.)

Two pictures will be included in the *demo card*, please be sure that they contain at least a resolution of 512px X 512px for a better visualization.

The name of the file will be the picture foot note

10. Contact



- Name, e-mail address and institute of the person(s) (max.3) mainly in charge of the project are necessary.
- In case there are any related websites of the demonstration sites, their web addresses should be provided as well.
- The logos of the main organizations participating in the demonstration site project are also necessary.

References used in the guidelines

Bunn S. E. and A. H. Arthington, 2002. **Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity**. *Environmental Management Vol. 30, No. 4* : 492–507

Capobianco M. and Stive M. J. F., 2000. **Soft intervention technology as a tool for integrated coastal zone management**, *Journal of Coastal Conservation* **6**, pp. 33-40

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Zalewski M., 2002**. Ecohydrology, the use of ecological and hydrological processes for sustainable management of water resources.** *Hydrological Sciences-Journal des Sciences hydrologiques* **47(5)**: 823-832

Zalewski M. *et al.* [eds.], 2004. *Integrated Watershed Management -Ecohydrology & Phytotechnology- Manual*. UNESCO IHP, UNEP, 246p.

Zalewski, M., 2015. **Ecohydrology and Hydrologic Engineering: Regulation of Hydrology-Biota Interactions for Sustainability**. *Journal of Hydrologic Engineering.* **20 (1)**, 14p.

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