A framework to assess wetlands' potential as Nature-based Solutions

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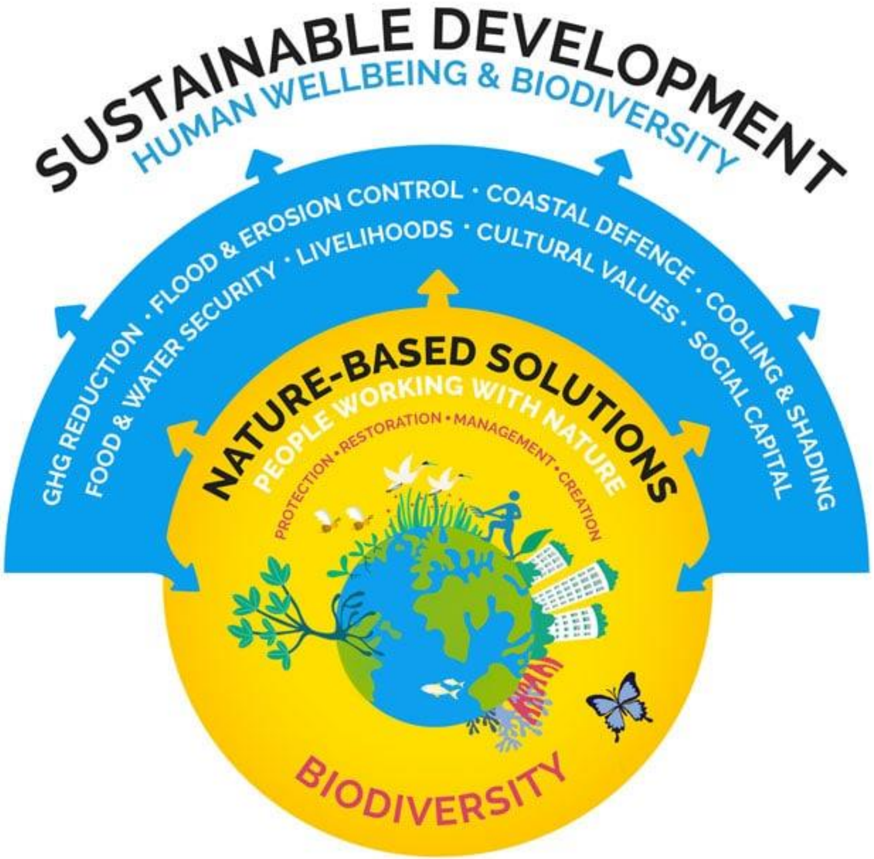
Synopsis

- What are Nature based Solutions (NbS)? - Focus on Ireland
- Wetlands as a promising NbS
- Ecosystem Services
- Current situation and practices
- How to evaluate the performance of wetlands for different services?
- Presentation of a tool to achieve this with an easy, user-friendly, and low-cost way
- Conclusions - generalisation

Nature-based solutions (NbS)

NbS are actions that involve the **protection, restoration or management of natural and semi-natural ecosystems**;

- working with nature to address societal challenges, providing benefits for both human well-being and biodiversity



- Plethora of Ecosystem Services (ES)

- From NbS we can derive a plethora of ES → direct and indirect benefits

https://www.naturebasedsolutionsinitiative.org/what-are-nature-based-solutions/

NbS in Ireland

gov.ie Departments Consultations Publicatio

Publication

Climate Action and Low Carbon Development (Amendment) Bill 2020

From Department of the Environment, Climate and Communications
Published on 7 October 2020
Last updated on 11 January 2021

The Climate Action and Low Carbon Development (Amendment) Bill is an ambitious piece of legislation. It commits us, in law, to move to a climate resilient and climate neutral economy by 2050.

The Programme for Government commits to a 7% average yearly reduction in overall greenhouse gas emissions over the next decade, and to achieving net zero emissions by 2050. This Bill will drive implementation of a suite of policies to help us achieve this goal.

NbS received extra support in the recent publication of the Climate Action and Low Carbon Development (Amendment) Bill in Ireland

It allows funding for climate action to be granted for projects that “*support projects that seek to increase the removal of greenhouse gas, particularly nature-based solutions that enhance biodiversity*”

What do we want from a NbS?

Another definition of NbS:

"Solutions that are inspired and supported by nature, which are **cost-effective**, simultaneously **provide** environmental, social and economic **benefits** and **help build resilience**.
Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through **locally adapted**, **resource-efficient** and **systemic interventions**."

Questions:

- How to use them right to achieve the sustainable management and the resilient systems?
- What measures and works can we make to derive all these benefits?

https://ec.europa.eu/info/research-and-innovation/research-area/environment/nature-based-solutions_en

Wetlands/ Peatlands

- 1.46 million ha of peat soils (1/5 of land area)
- <15% is protected
- 25% state-owned:

  333,000 ha Coillte; 80,000 ha Bord na Móna; 42,000 ha NPWS

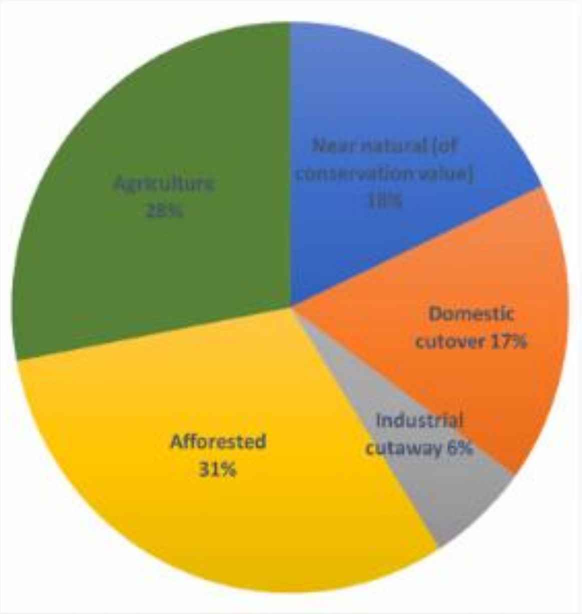


Figure 1: Estimates of area of peatland in Ireland under major land use classifications.

The state of Irish peatlands

- Most peatlands (82 %) are drained and utilised for other purposes
  - Few extraction sites have been rewetted
  - It is unknown how much peatland used for forestry and agriculture has been rewetted
- Only 18% of peatlands are considered to be of conservation value
  - Only a small proportion of these have been rewetted and restored
- Rewetting combined with other restoration techniques (e.g. reseeding or transplanting of essential peatland species) can speed up revegetation and improvements in water quality.

Peatlands = a type of wetlands (peat soils)

ES = highest Carbon storage capacity, climate change mitigation, stormwater retention, nutrient filtering, climate stability, flora and fauna, soil improvement, timber, raw materials, habitats, culture, etc.

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https://www.iucn.org/resources/issues-briefs/peatlands-and-climate-change

Problems

Significant wetland loss in Ireland the last decades

- limited or no solid broader management and planning, because of the lack of the specific knowledge required to estimate their Ecosystem Services (ES) potential
- Conservationists support the rewetting of peatlands/wetlands, but still we cannot quantify the benefits

To consider wetlands as Nature-based solutions (NbS), policymakers need to know their effectiveness on the ES of interest.

- Technical solutions' performances can be easily known from their design studies (e.g. water treatment ability, retention ponds capacity, etc.).
- With wetlands this cannot be the case because their performance depends on various factors (physical, geomorphological, hydrological, climatological, vegetation, soil, surrounding land uses, inflows, initial concentrations, connectivity with other water bodies, infiltration, etc.).

Subsequently, it is tough to compare them with other technical solutions on the same basis and with equal certainty.

Research question

<u>Provide a tool for the estimation of wetlands' effectiveness:</u>

- fast,
- cost-free,
- easy and user-friendly, built on simple and well-known tools,
- considering most of the factors that determine it (depending each ES studied),
- in order to provide policymakers with more info on such NbS, and make the comparison of alternative options fairer.

<u>A novel approach, based on classic techniques:</u>

- Geographic Information Systems (GIS) are used to map the factors that affect wetlands' effectiveness (criteria),
- combined with Multi-Criteria Analysis (MCA) (to assign weights to those criteria), and produce a map with classified wetland potential performances on the ES of interest
- Catchment scale <u>(compatibility)</u>

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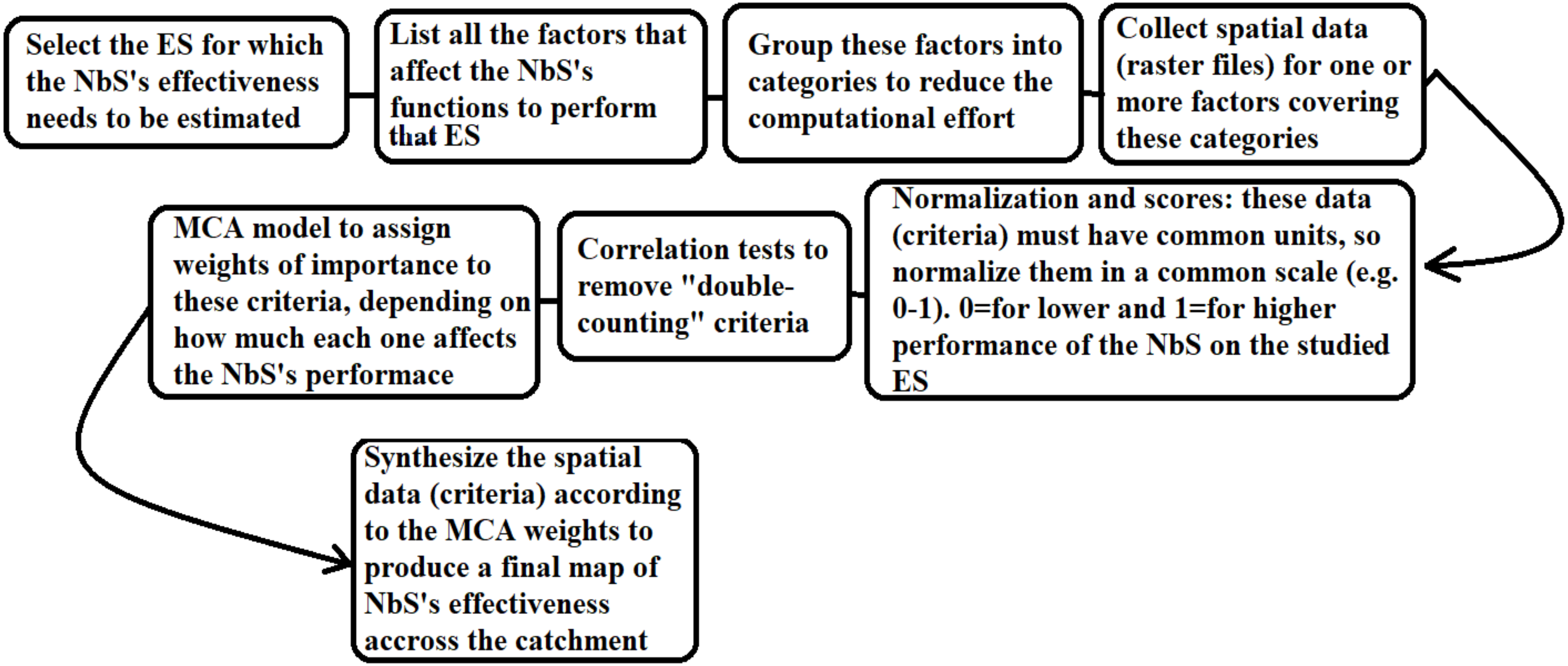
Conceptual flowchart



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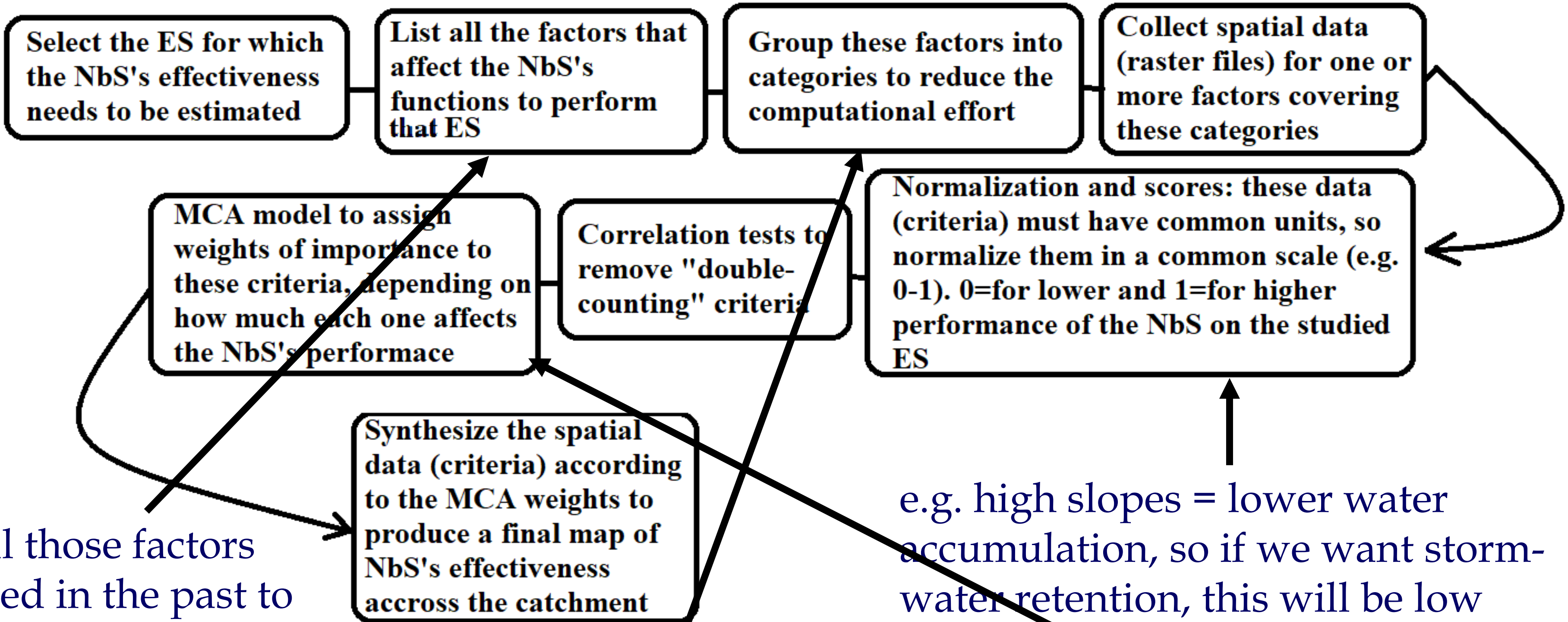
Conceptual flowchart



All those factors used in the past to support effectiveness estimates, those that make estimations difficult, make each study case-specific, and prevent more general assessment,

Categories such as:
-Land-use criteria,
-Soil and vegetation criteria,
-Climatic criteria,
-Landscape/topography criteria
-etc

e.g. high slopes = lower water accumulation, so if we want storm-water retention, this will be low (towards 0)

AHP works well with 5-10 criteria and can use qualitative comparisons among them

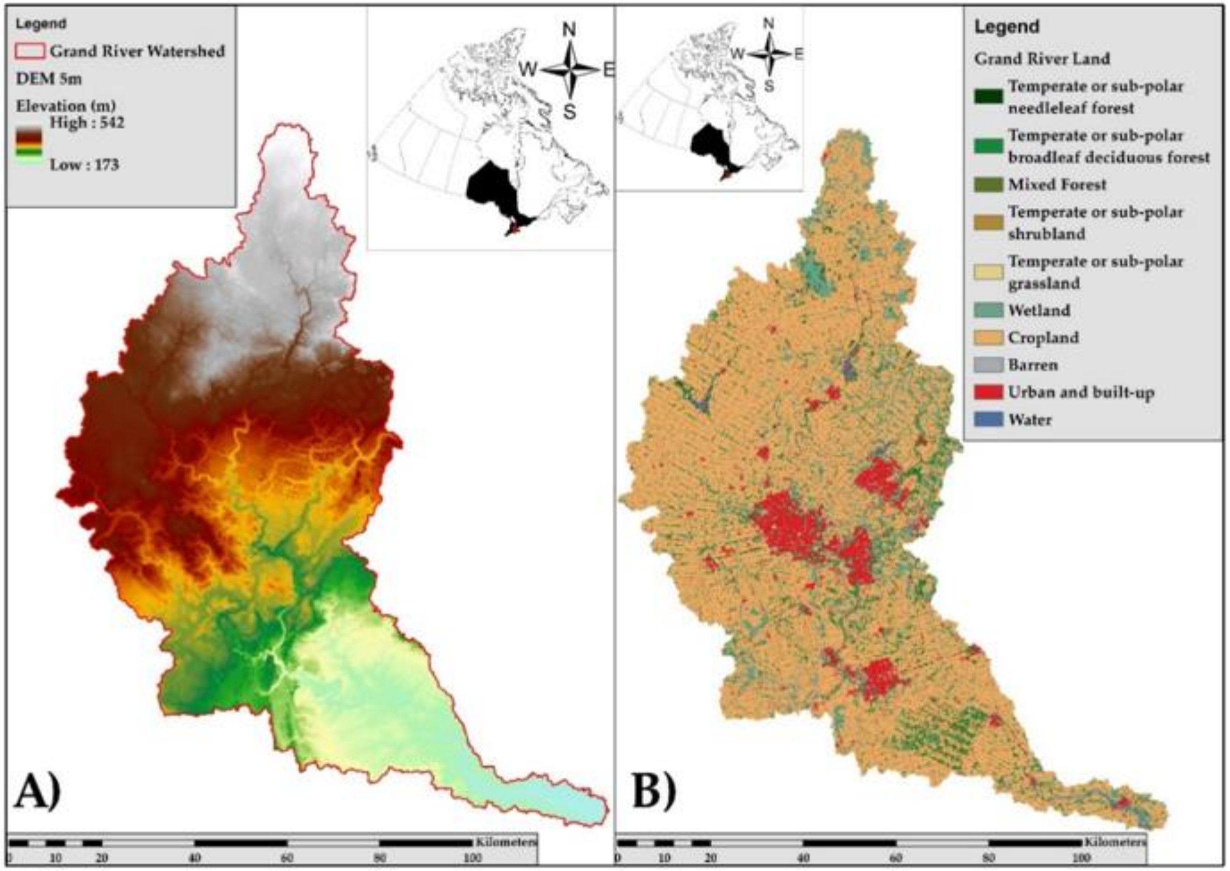
All the above must be according to the literature and the expert's judgement

Case Study Application

Grand River Watershed, Ontario, Canada

- Faces intense wetland loss (conversion to more profitable farmland)
- Legislations for reducing phosphorus (P) concentration from surface waters (Grand River flows into Lake Erie – eutrophication, reduce P by 40%)
- Wetlands as a NbS to reduce P

How efficient they are? Where must we protect them and where we can replace them with farmland?



Case Study Application
ES = Efficiency for P filtering

Catchment scale: wetlands are parts of a wider ecosystem that functions in a coupled and interactive way with nature's and human's activities

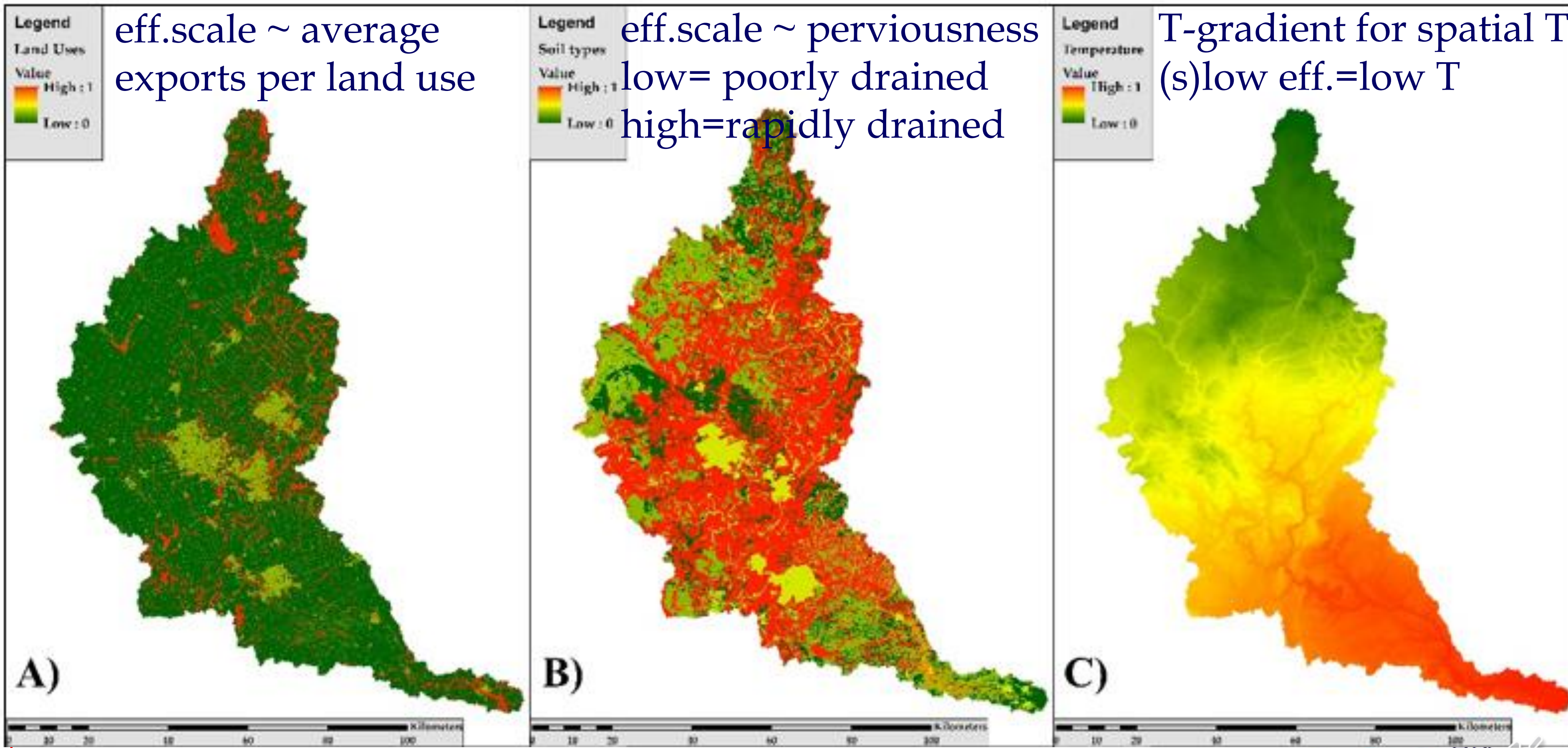
Listing the factors/ Grouping them into categories:

- Land-use criteria: surrounding land uses majorly affect its performance, inflows' quantity and quality.
- Soil and vegetation criteria: soil type, vegetation type and density result in different nutrient-absorbing capacities.
- Climatic criteria: temperature, precipitation, sunny hours, ice coverage, etc. Meteorological factors affect the speed of the processes and the response of other factors (such as soil and vegetation).
- Landscape/topography criteria: DEM-related parameters which allow the calculation of slope, aspect, Topographic Position Index (TPI), Topographic Wetness Index (TWI), overland flow distance, etc. These factors show the water concentration inside the watershed, topographic features, and are important elements to consider for wetlands acting as sources or sinks of nutrients. Also, flow rates and accumulation (or the time that phosphorus stay in the wetland) can be indirectly addressed.

Final set of criteria – Normalization & scoring (0-1, low-high scale)

Final set of criteria with spatial data (data availability & correlation tests):

Land Cover, Soil Type for Soil, Temperature, Slope, TPI and TWI.



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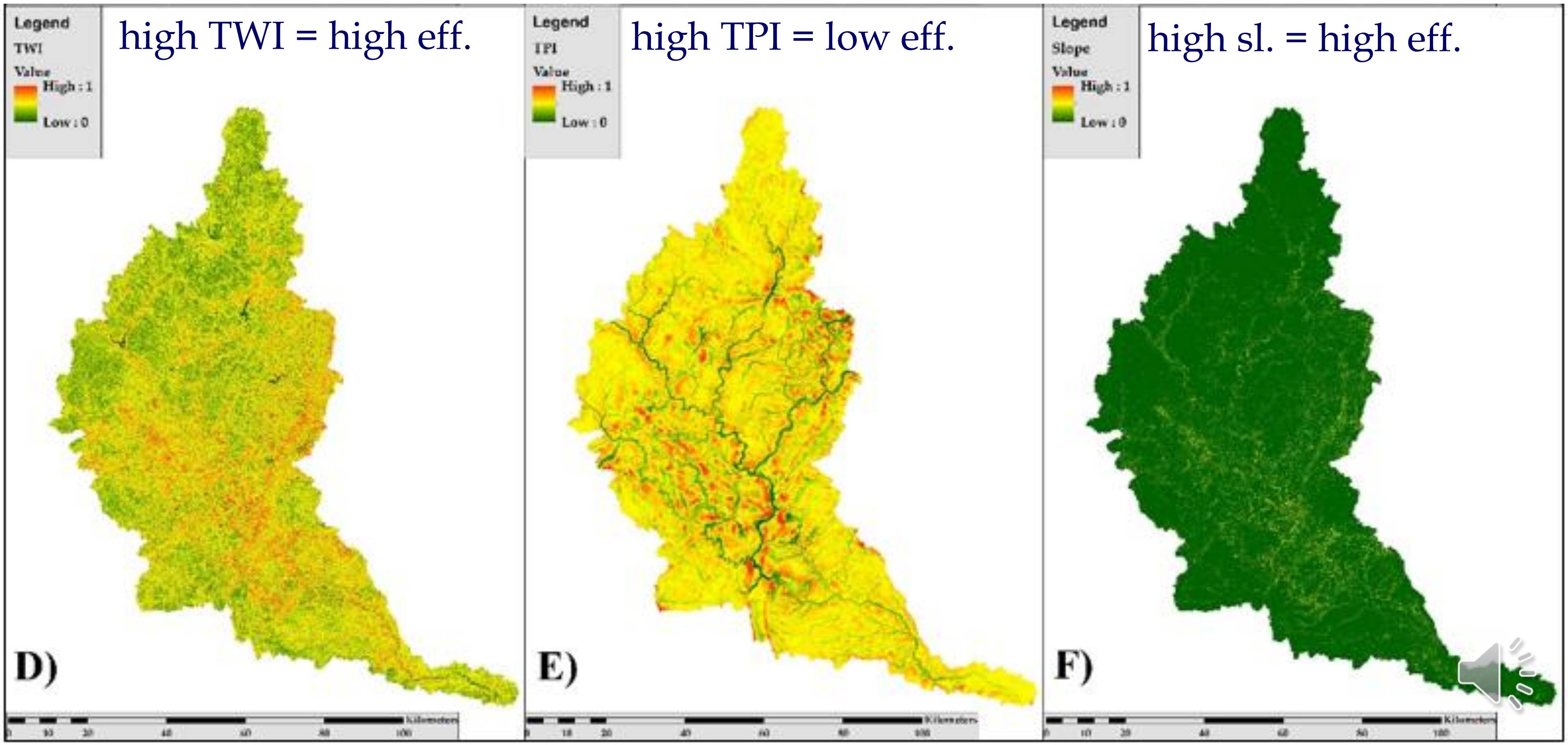
Final set of criteria – Normalization & scoring (0-1, low-high scale)

- small number of criteria makes the computational process simpler
- avoids double-effects on the evaluation process since they stand for different drivers
- all of them are in agreement with other studies



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Case Study Application

MCA model – How important is each layer (criterion)?

AHP – pairwise comparisons 6x6 matrix (Table 1) →

$$A^{i}_{AHP} = \sum_{j=1}^{6} a_{ij} \cdot w_j$$

- The right principal eigenvector was calculated for the matrix
- Synthesis of preferences determines which criterion has the higher priority and effect on the estimated result (consistency)
- Through the comparison relations the criteria were weighted (aij), for each map (wj) (Table 2)
- A spatial value occurred for each grid's cell, i.e. the potential effectiveness (i)

(raster calculator- GIS) →

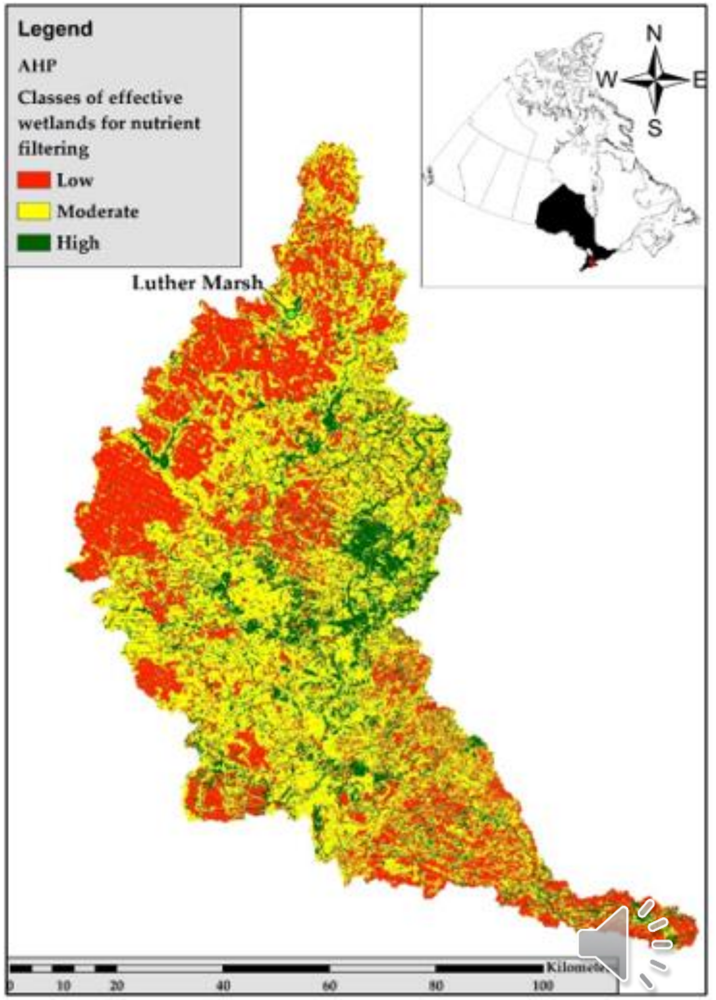
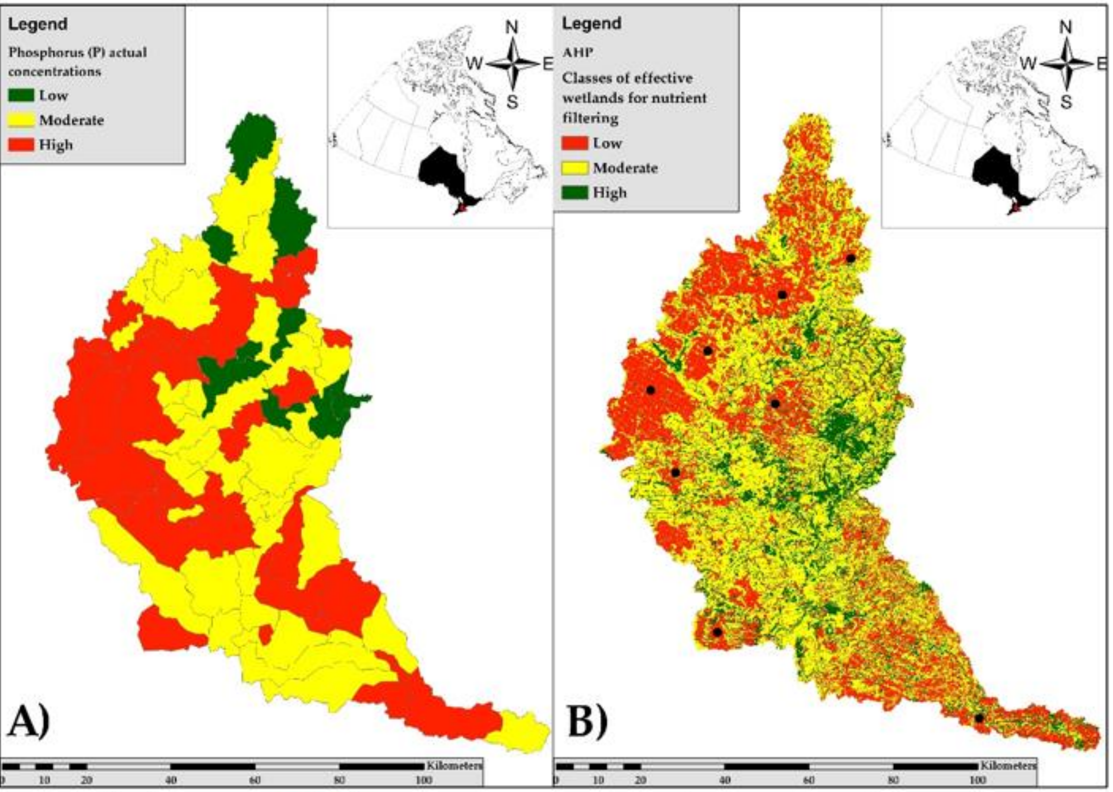


Table 1. Example of AHP pairwise comparison using the Saaty scale.

	Temperature	TWI	TPI	Slope	Soil type	Land uses
Temperature	1	2	1/6	3	1/6	1/7
TWI	1/2	1	1/7	1	1/7	1/8
TPI	6	7	1	7	1/2	1/3
Slope	1/3	1	1/7	1	1/8	1/9
Soil type	6	7	2	8	1	1/3
Land uses	7	8	3	9	3	1

Table 2. Relative weights of the criteria, R.I, and C.R., as resulted from the AHP.

Priority Vector							Randomness Index (RI)	Consistency Ratio (C.R.)
Criteria	Temperature	TWI	TPI	Slope	Soil type	Land uses	Criteria n = 6	CR = 7.72%
Weights	0.06	0.03	0.20	0.03	0.25	0.42	RI = 1.24	

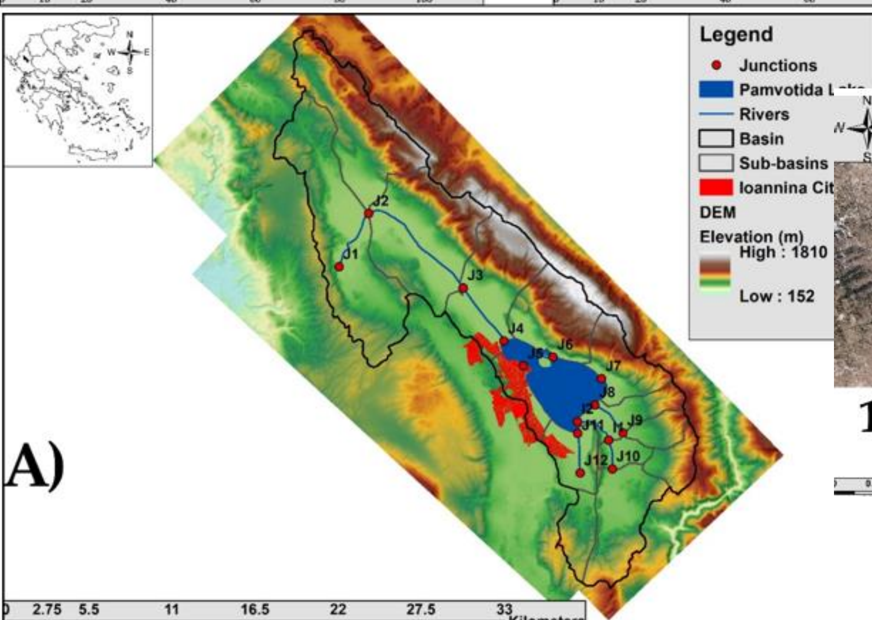


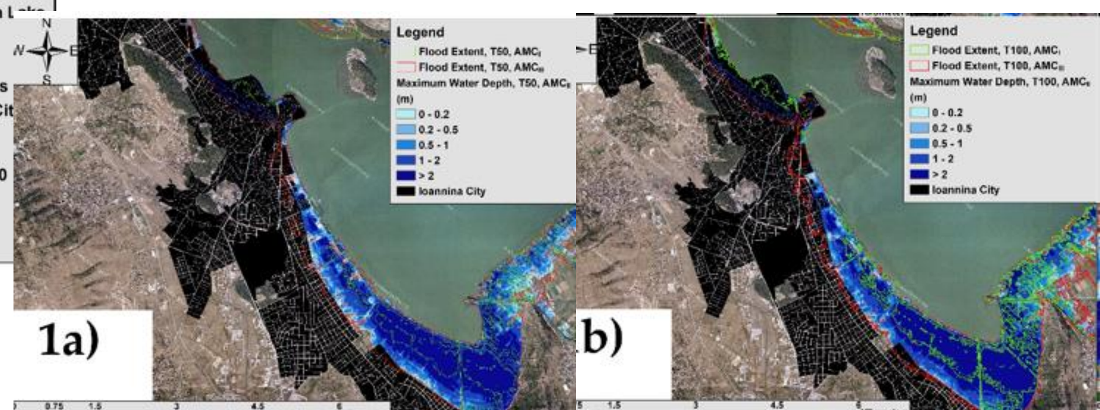
Validation

Indirect validation (e.g. nutrient filtering compared with nutrients modelled concentrations or estimated exports)

OR

Direct validation (e.g. storm-water retention compared with modelled floodplains)





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Conclusions

- Operational tool – it can be applied for any ES and similar problems on the identification of potential areas

preliminary estimator to detect locations of interest

- Objective & scientific logic to represent the "experts' judgement" process

- Easy and user-friendly tool: GIS/ or GIS + MS Excel/ or GIS + coding
- Cost-free + easy data manipulation
- Promotes the creation of spatial databases

Future research: quantify the ES through modelling

- e.g. flood or SWAT model → both are compatible with GIS → allows model-building expansion

- Quantification → validation → fairer comparisons of NbS with technical ones

Further reading:
https://www.mdpi.com/2073-4441/12/11/3134

Thank you for your attention