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Water resources management in river basins facing floods and droughts

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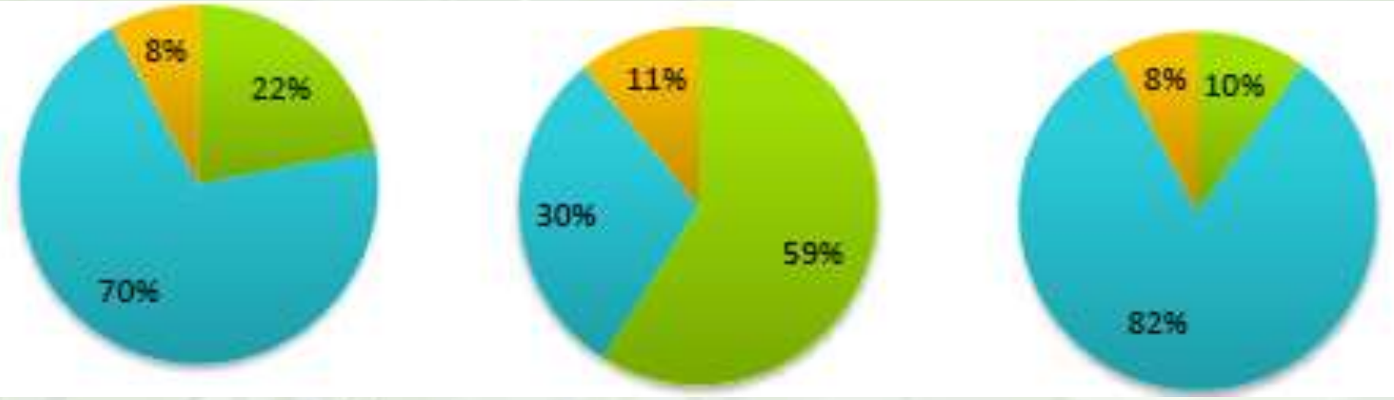
OVERVIEW

- Water availability and quality determine the productivity of all ecosystems.
- It is a resource of extreme importance for the environment, economy and society.

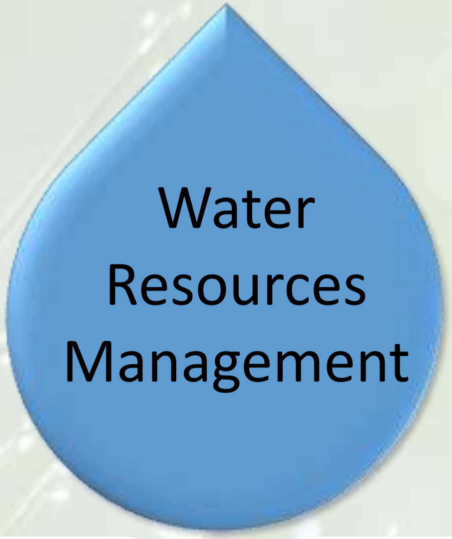


OVERVIEW

The **Access** to quality water and in the amount that man wants is not always easy, due to:

- Seasonal water availability;
- Increased **pressure on water resources**;

Climate changes that can lead to an increase in the **frequency** and **intensity** of extreme events.



Droughts

Floods

OVERVIEW

With the focus on the mitigation of these extreme phenomena, solutions such as:

Rainwater Harvesting, at the river basin scale for agroforestry applications

- Combat Forest Fires
- Water availability for agriculture
- Consumption

Allocation of sustainable detention basins for flow control

- Flood Attenuation

MOTIVATION

Develop an optimization model for the location of flood retention basins or rainwater harvesting systems.

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Rainwater Harvesting

(for agroforestry applications)

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Research papers

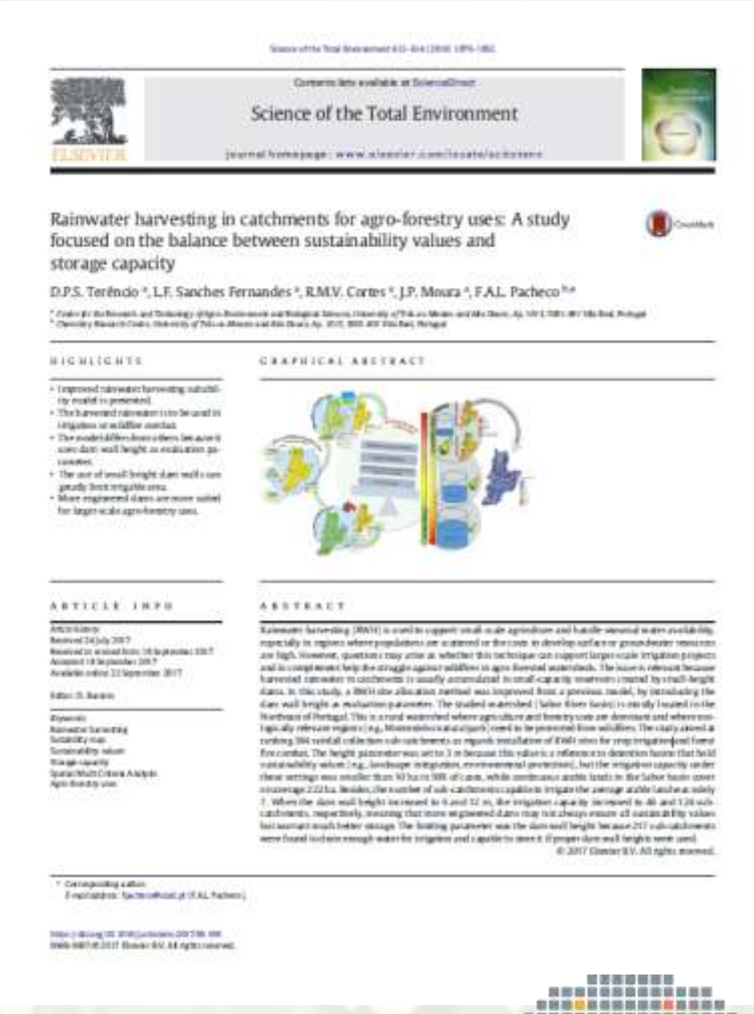
Improved framework model to allocate optimal rainwater harvesting sites in small watersheds for agro-forestry uses

D.P.S. Terêncio[a], L.F. Sanches Fernandes[a], R.M.V. Cortes[a], F.A.L. Pacheco[b,*]

ARTICLE INFO

ABSTRACT

1. Introduction



Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Rainwater harvesting in catchments for agro-forestry uses: A study focused on the balance between sustainability values and storage capacity

D.P.S. Terêncio[a], L.F. Sanches Fernandes[a], R.M.V. Cortes[a], J.P. Moura[a], F.A.L. Pacheco[b,*]

HIGHLIGHTS

GRAPHICAL ABSTRACT

ARTICLE INFO

ABSTRACT

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2. Study Area

1

Ave River Basin

↑ Higher population density;

↑ Urban and industrial waste water discharges;

↑ Livestock production;

↓ Freshwater quality is generally poor.

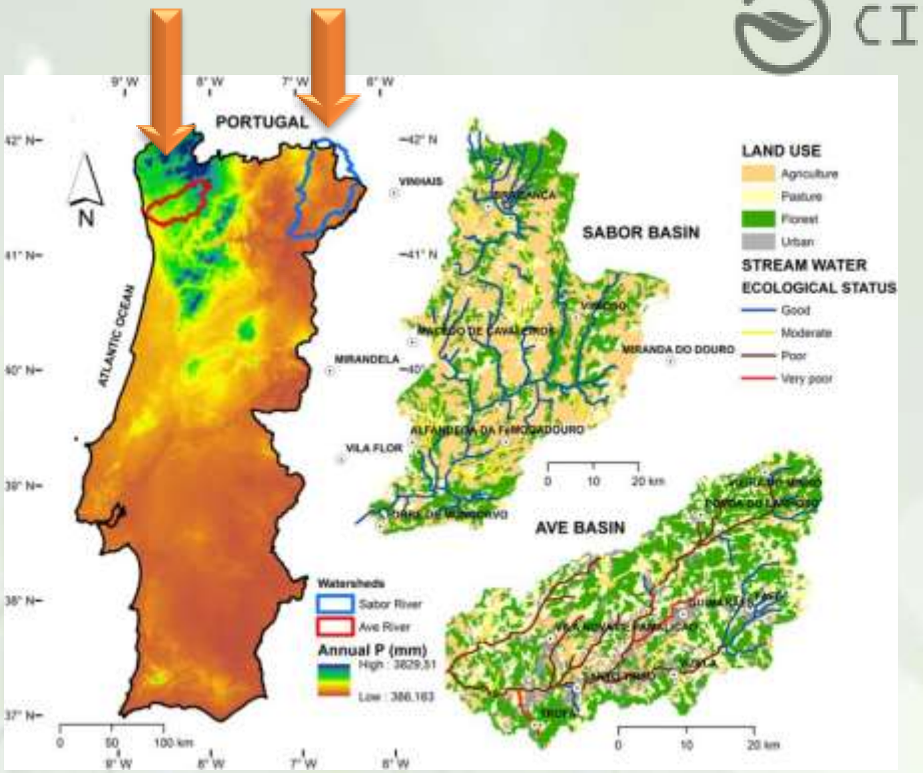
Sabor River Basin

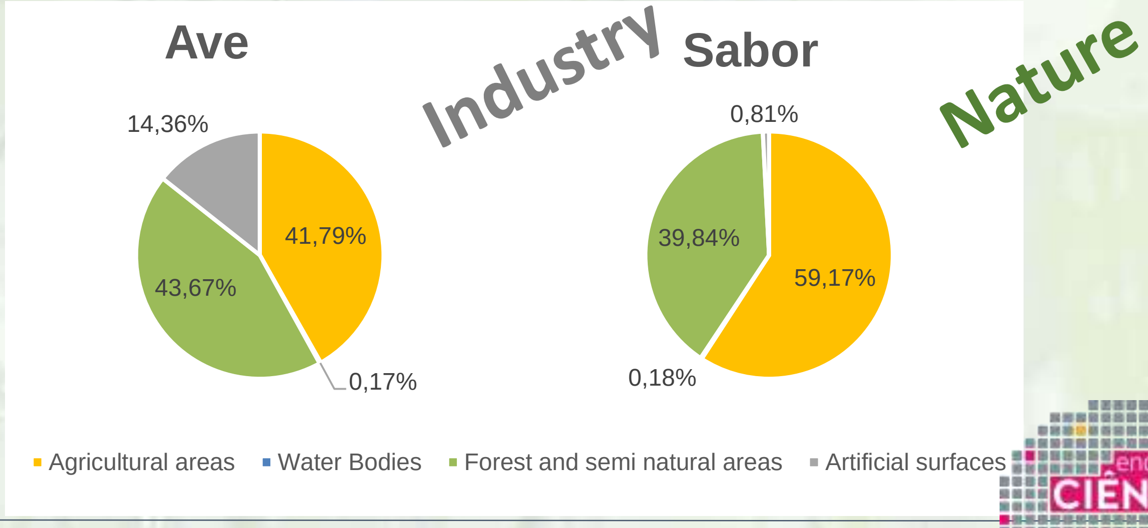
↓ Lower population density;

↑ Agriculture;

↓ Urban waste water discharges;

↑ Better freshwater quality.





1. Study Aim

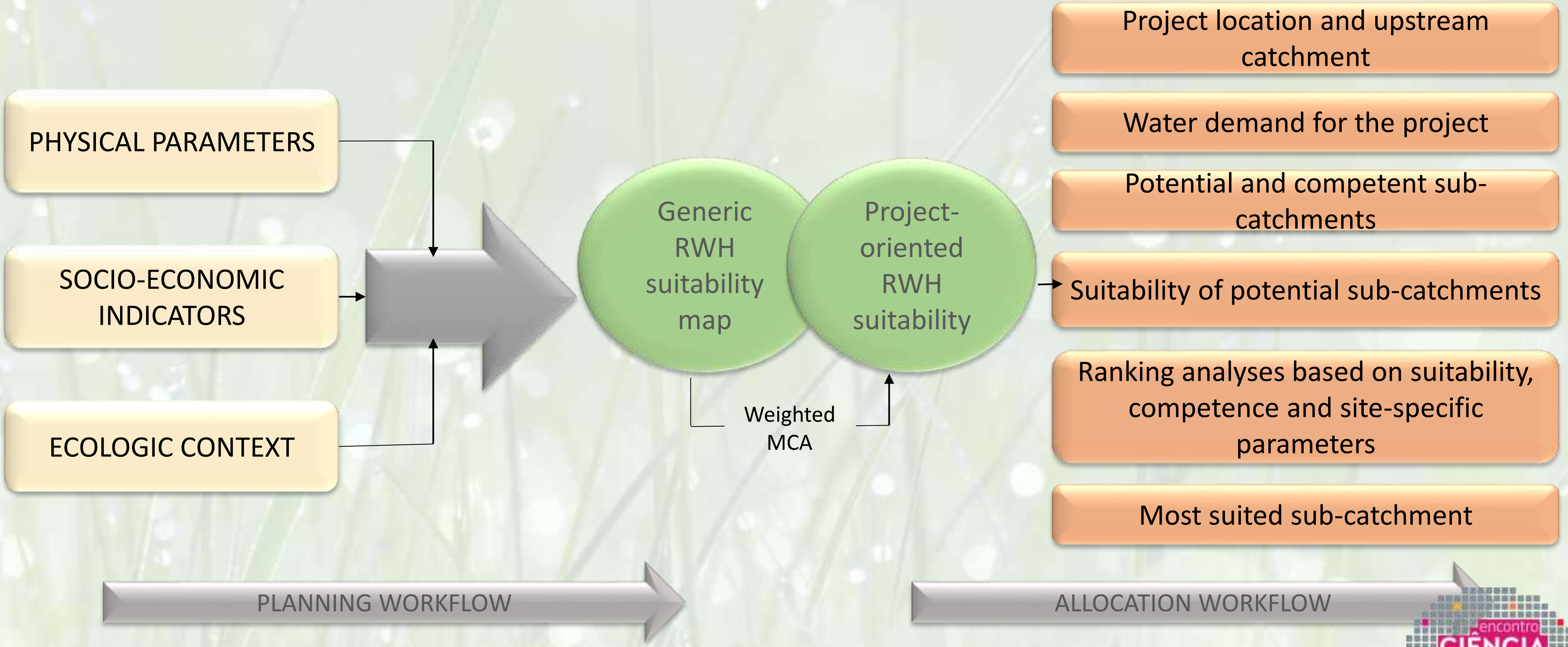
1

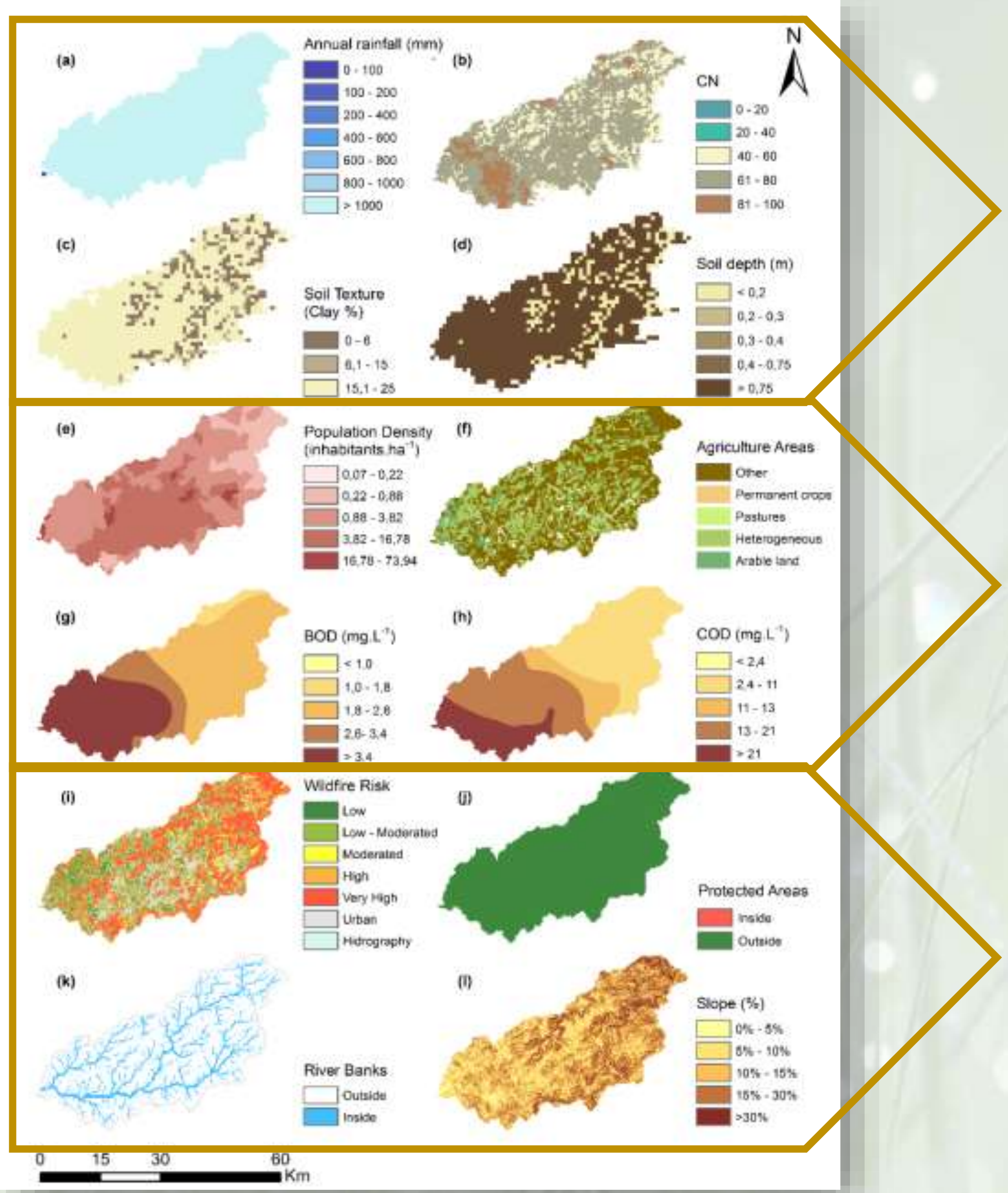
The main objective of this study is to propose a new model for the implantation of **RWH Systems** in small watersheds, that incorporates **site and project specific features** as well as **flexible weights**:

- To develop a model that distinguishes a **planning stage** from the **allocation stage**;
- To develop a **planning stage**, that replace fixed by flexible weights in the **MCA design**;
- To develop an **allocation stage** that constrains suitable RWH sites as function of site and project specific parameters.

3. Workflow

1


PHYSICAL PARAMETERS
SOCIO-ECONOMIC INDICATORS
ECOLOGIC CONTEXT
Generic RWH suitability map
Project-oriented RWH suitability
Weighted MCA
Project location and upstream catchment
Water demand for the project
Potential and competent sub-catchments
Suitability of potential sub-catchments
Ranking analyses based on suitability, competence and site-specific parameters
Most suited sub-catchment
PLANNING WORKFLOW
ALLOCATION WORKFLOW



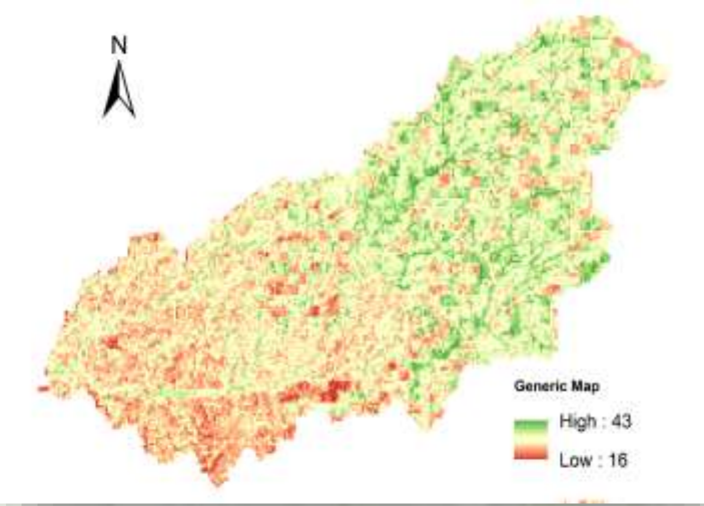
Physical parameters

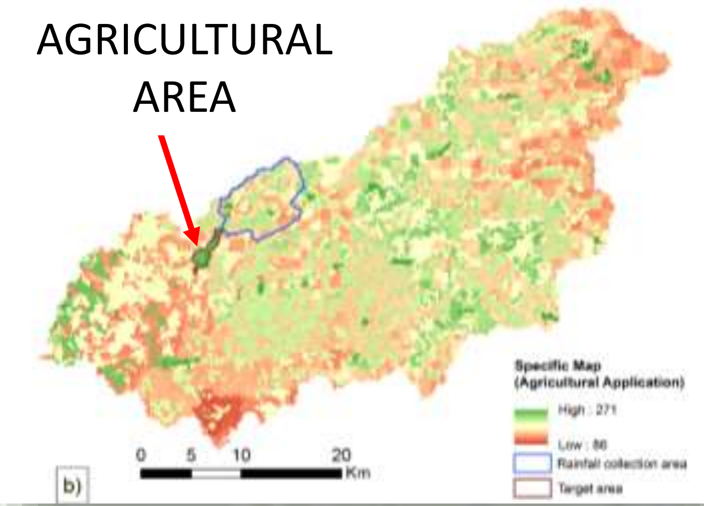
Socio-economic indicators

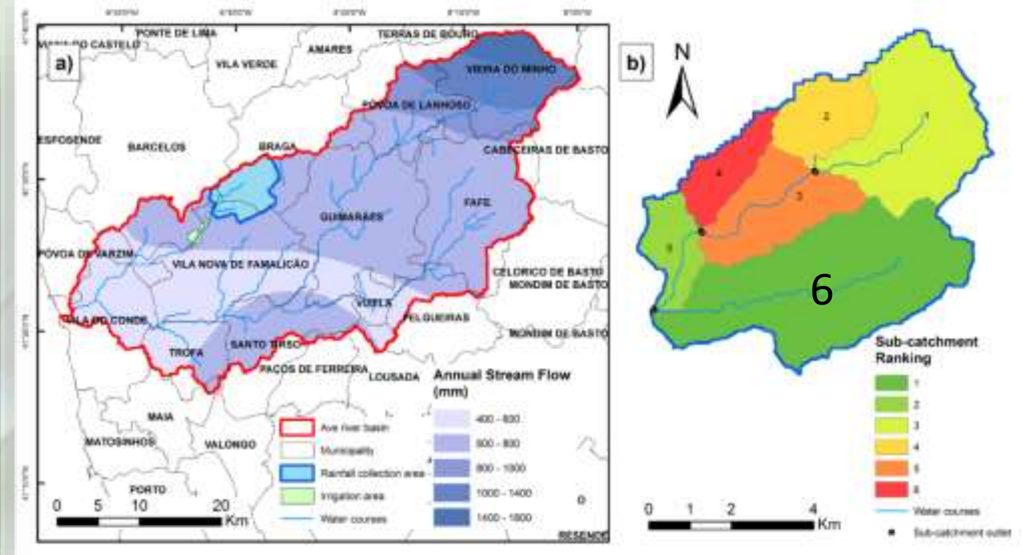
Ecological contexts

4. Results

1







Sub-catchment	Project-oriented suitability	Score	Long-term stream flow ($m^3.yr^{-1}$)	Score	Distance from the basin outlet to the target area centroids (m)	Score	Dam wall height (m)	Score	Sum of scores	Ranking
1	162	4	7631319	5	8148	1	12	4	14	3
2	163	5	2687025	3	8146	2	18	2	12	4
3	153	1	4186645	4	5296	3	14	3	11	5
4	157	3	2069005	2	5287	4	24	1	10	6
5	177	6	1973356	1	3089	5	6	6	18	2
6	157	2	12071781	6	3048	6	8	5	19	1

5. DISCUSSION

1

- ✓Planning allowed the production of a generic **RWH suitability map at catchment scale**.
- ✓Allocation incorporated **site** and **project specific parameters** as well as **flexible weights**.
- ✓Combining planning with allocation, it´s possible to **adapt the model to any agro-forestry application**.
- ✓The results obtained evidenced the importance of the site parameters when the application areas are pre-defined, eg. the basin with the **best Project-oriented suitability was not the most appropriate o**ne.
- ✓**Reduced contaminated water in crop irrigation**.

2

Sustainable Detention Basins

(Flood control)

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Manuscript Draft

Manuscript Number: HYDROL31762R1

Title: Flood risk attenuation in critical zones of continental Portugal using sustainable detention basins

Article Type: Research paper

Keywords: Flood risk attenuation; Detention basin; Hydraulic model; Watershed management; Mitigation strategies; GIS

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Order of Authors: Daniela Terêncio; Luís Sanches Fernandes, PhD; Rui Cortes, PhD; João Moura, PhD; Fernando A.L. Pacheco, PhD

Abstract: According to the Floods Directive (Directive 60/2007/EC), the management of floods represents an obligation of each EU member state to defend human lives as well as the economic well-being of societies, especially in areas defined as critical. The purpose of this study was to develop a flood attenuation model based on detention basins in the 23 critical flood risk zones of continental Portugal, capable to eliminate the high and very high flood risk areas instead of attempting to ensure full control of the flood in all potentially threatened areas. The model workflow comprised the sequential use of engineering formulae based on historical peak flows and a zoning algorithm embedded in a Geographic Information System. The formulas allowed to set up the volume of river water to retain in a detention basin during a flood, as well as the smallest catchment area (A) producing this volume. The results were divided into sustainable (h ≤ 8m) or non-sustainable (h > 8m) detention basins. Thus, these results indicated the possibility to install 27 sustainable and 71 non-sustainable detention basins in specific catchments within the critical zones contributing watersheds. The number of sustainable detention basins is reduced by about 30% when the full flood control model is used. Because the construction of non-sustainable (engineered) dams is extremely costly, the only possible way to mitigate flood risk in these critical zones would be to couple flood attenuation with hydroelectric use, or through the implementation of an extensive reforestation program in the catchment with the purpose to increase evapotranspiration and reduce runoff.

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water

MDPI

Article

Can Land Cover Changes Mitigate Large Floods? A Reflection Based on Partial Least Squares-Path Modeling

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Abstract: Common approaches to large flood management are Natural Water Retention Measures and detention basins. In this study, a Partial Least Squares-Path Model (PLS-PM) was defined to set up a relationship between dam wall heights and biophysical parameters, in critical flood risk zones of continental Portugal. The purpose was to verify if the heights responded to changes in the biophysical variables, and in those cases to forecast landscape changes capable to reduce the heights towards sustainable values (e.g., <8 m). The biophysical parameters comprised a diversity of watershed characteristics, such as land use and geology, surface runoff, climate indicators and the dam heights. The results have shown that terrain slope (w > 0.5), rainfall (w > 0.4) and sedimentary rocks (w > 0.5) are among the most important variables in the model. Changes in these parameters would trigger visible changes in the dam wall height, but they are not easily or rapidly modified by human activity. On the other hand, the parameters forest occupation and runoff coefficient seem to play a less prominent role in the model (w < 0.1), even though they can be significantly modified by human intervention. Consequently, in a scenario of land cover change where forest occupation is increased by 30% and impermeable surfaces are decreased by 30%, interferences in the dam heights were small. These results open a discussion about the feasibility to mitigate large floods using non-structural measures such as reforestation.

Keywords: flood risk attenuation; PLS-SEM; detention basin; mitigation strategies; landscape change

1. Introduction

One of the consequences of climate change is the increase of spatial and temporal water variability as well as extreme events, in frequency and intensity [1,2]. Floods are among the most destructive water-related hazards and are the greatest economic natural disaster that occur in Europe via damage property and infrastructure, as well as physical injury and loss of human lives [3]. Nowadays, technical means for controlling extreme floods remain limited, fosters a need for an ongoing paradigm shift in how to deal with floods [4]. These difficulties powered the necessity for effective action programmes driven by policy in Europe. According to these limitations, European Commission and the Council of the European Union prompted to put forward the Directive 60/2007/EC, referred to as the Floods Directive [5]. Its purpose is to reduce the adverse effect of floods to preserve human health, the environment, cultural heritage, economic activity and infrastructure. According to the directive, each

1. Study Aim

2

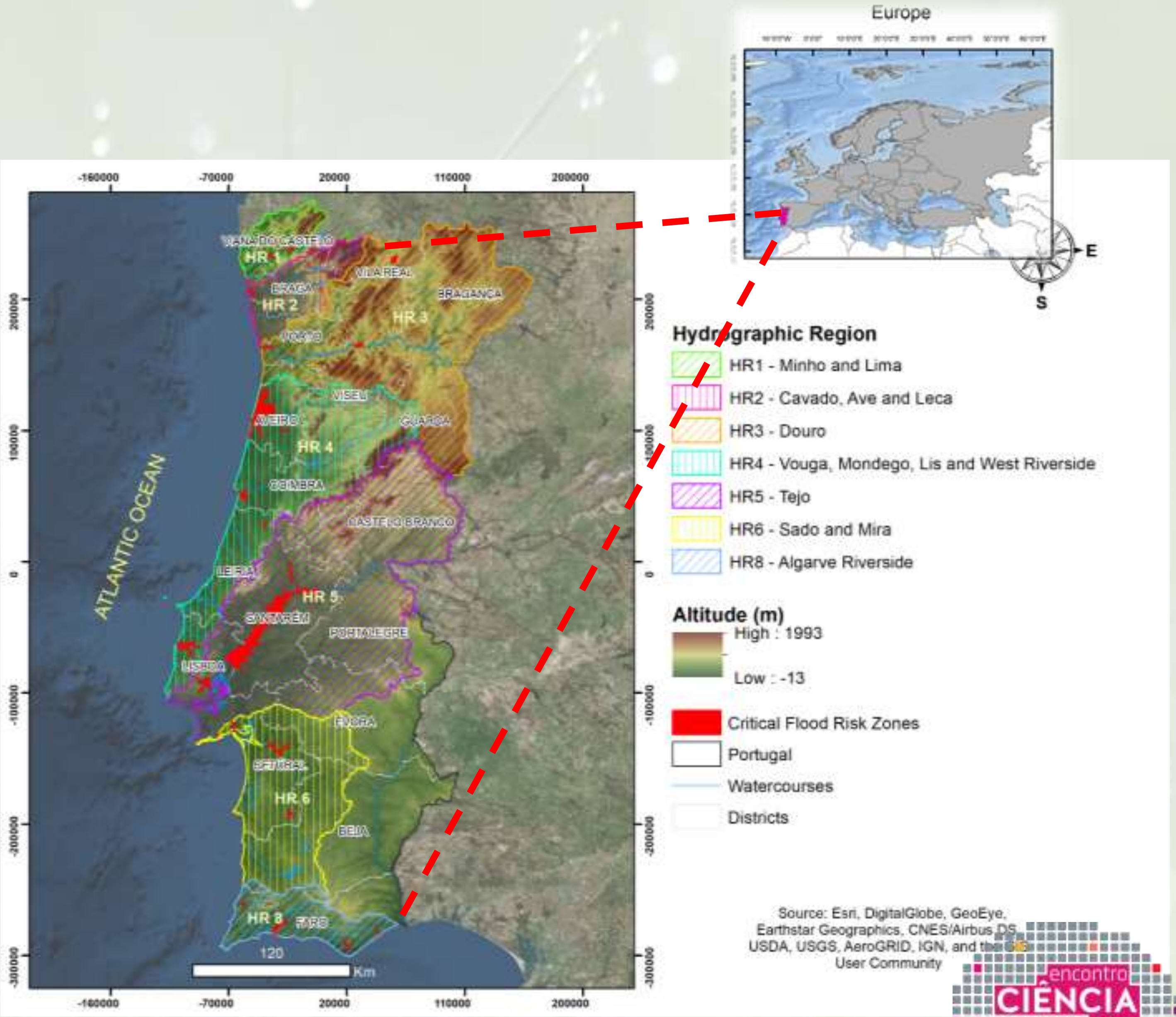
The purpose of this study was to develop a flood **attenuation model** based on detention basins **critical flood risk zones** of continental Portugal, capable to eliminate the high and very high flood risk areas instead of attempting to ensure full control of the flood in all potentially threatened areas.

2. Study Area

2

- Portugal identified 22 critical flood risk zones in a study coordinated by the *APA*.
- Directive 60/2007/EC, Floods Directive.

- It requires EU Member States to draw up flood risk maps.



3. Workflow

2

FLOOD RISK ATTENUATION MODEL

Rationale

Eliminate the areas of high and very high risk (*A*)

Step 1 - Set up peak flow vs risk area relationships:

$Q = Q_0 + b \times A$

Step 2 - Estimate the **volume** of storm flow to store in detention basin (***V***)

Step 3 - Estimate the **catchment area** delivering volume *V* as runoff during a storm (***A***)

Step 4 - Look for **catchments with area equal to *A*** within the studied critical zone

$Q = Q_0$ implies $A = 0$

(i.e. no **high** or **very high** risk areas)

The **triangular hydrograph method** estimates V from Q_0

The **Dutch method** relates V with A

The ***ArcHydro*** software and ***ArcGIS*** computer programs are capable to identify all possible catchments and **dam wall heights**

4. Results

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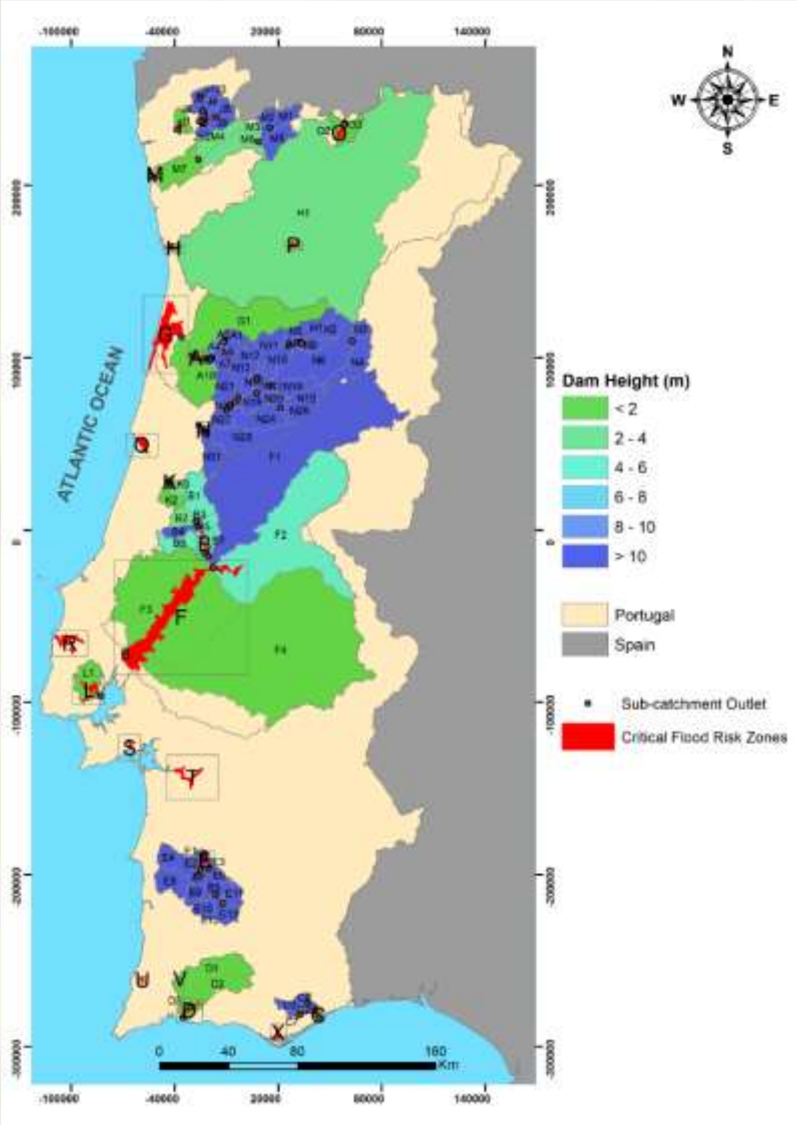

Critical zone	No.	Number of flood detention basins	No. of sustainable flood detention basins ($h \leq 8$ m)		No. of non-sustainable flood detention basins ($h > 8$m)	
			Flood risk attenuation	Full flood control	Flood risk attenuation	Full flood control
Ponte de Lima	1.1	1	1	1	0	0
Ponte da Barca	1.2	10	0	0	10	10
Esposende	2	7	3	2	4	5
✖ Régua	3	–	–	–	–	–
Porto	4	1	1	1	0	0
Chaves	5	3	3	3	0	0
Coimbra	6	30	0	0	30	30
✖ Estuário do Mondego	7	–	–	–	–	–
Águeda	8	11	2	1	9	10
Ria de Aveiro	9	1	1	1	0	0
Pombal	10	3	3	3	0	0
Santarém	11	4	3	2	1	2
Loures / Odivelas	12	1	1	1	0	0
✖ Torres Vedras	13	–	–	–	–	–
Tomar	14	7	5	1	2	6
✖ Setúbal	15	–	–	–	–	–
✖ Alcácer do Sal	16	–	–	–	–	–
Santiago do Cacém	17	13	0	0	13	13
✖ Aljezur	18	–	–	–	–	–
Tavira	19	7	1	1	6	6
✖ Monchique	20	–	–	–	–	–
✖ Faro	21	–	–	–	–	–
Silves	22	3	3	3	0	0
		Total: 102	27	20	75	82

5. Discussion

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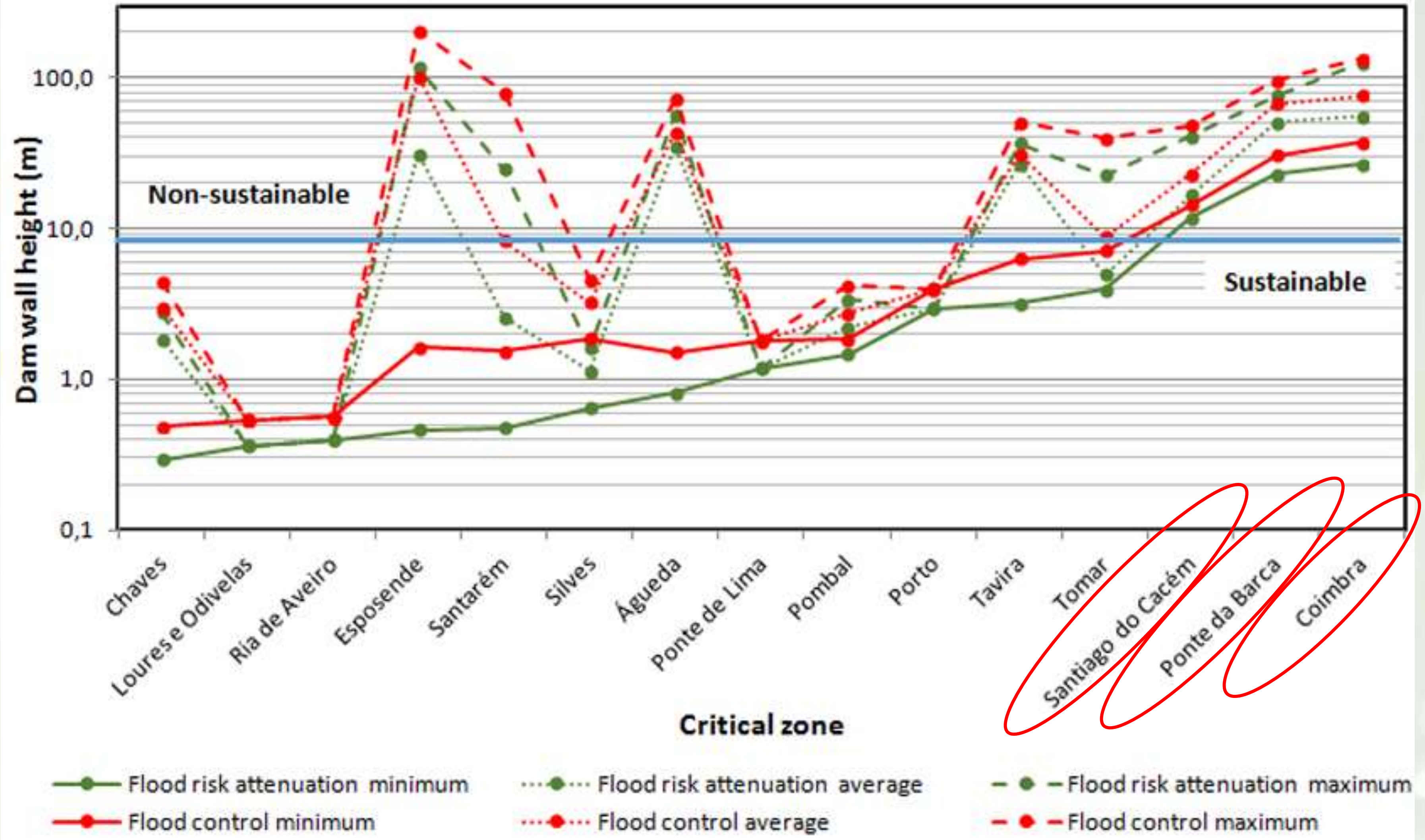

- The number of sustainable detention basins is reduced by ca. 30% when the full flood control model is used.
- In 3 critical zones (Ponte da Barca, Coimbra and Santiago do Cacém), the proposed detention basins are all non-sustainable.

DISCUSSION

2

- Of the 15 critical zones, **only 3** presented only non-sustainable retention basins.
- Because the construction of non-sustainable(engineered) dams is extremely costly, the possible way to mitigate flood risk in these critical zones would be to **couple flood attenuation** with **hydroelectric use**, or through the implementation of an **extensive reforestation program** in the catchment with the purpose to increase evapotranspiration and reduce runoff.

FINAL CONSIDERATIONS

1. The **Rainwater Harvesting study** outcomes are promising, because they **can assist politicians and water planners in their quest for good quality water to be used in agriculture**. In this context, it is worth recalling that the use of harvested rainwater in agriculture has been a prognostic in the latest watershed management report focused on the Ave River basin.

2. According to the second study, it is recommended that planners, **stakeholders and policy makers consider the use of sustainable flood detention basins for the attenuation of flood** risk in the critical zones of continental Portugal, as part of an integrated watershed management forecasting hydrologic climate change effects.

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Thank You!!!