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APLICAÇÃO EXPLORATÓRIA DE ANÁLISE MULTICRITÉRIO PARA REPRESENTAÇÃO MUNICIPAL DA SUSCEPTIBILIDADE A CHEIAS RÁPIDAS EM PORTUGAL CONTINENTAL

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XVI COLÓQUIO IBÉRICO GEOGRAFIA

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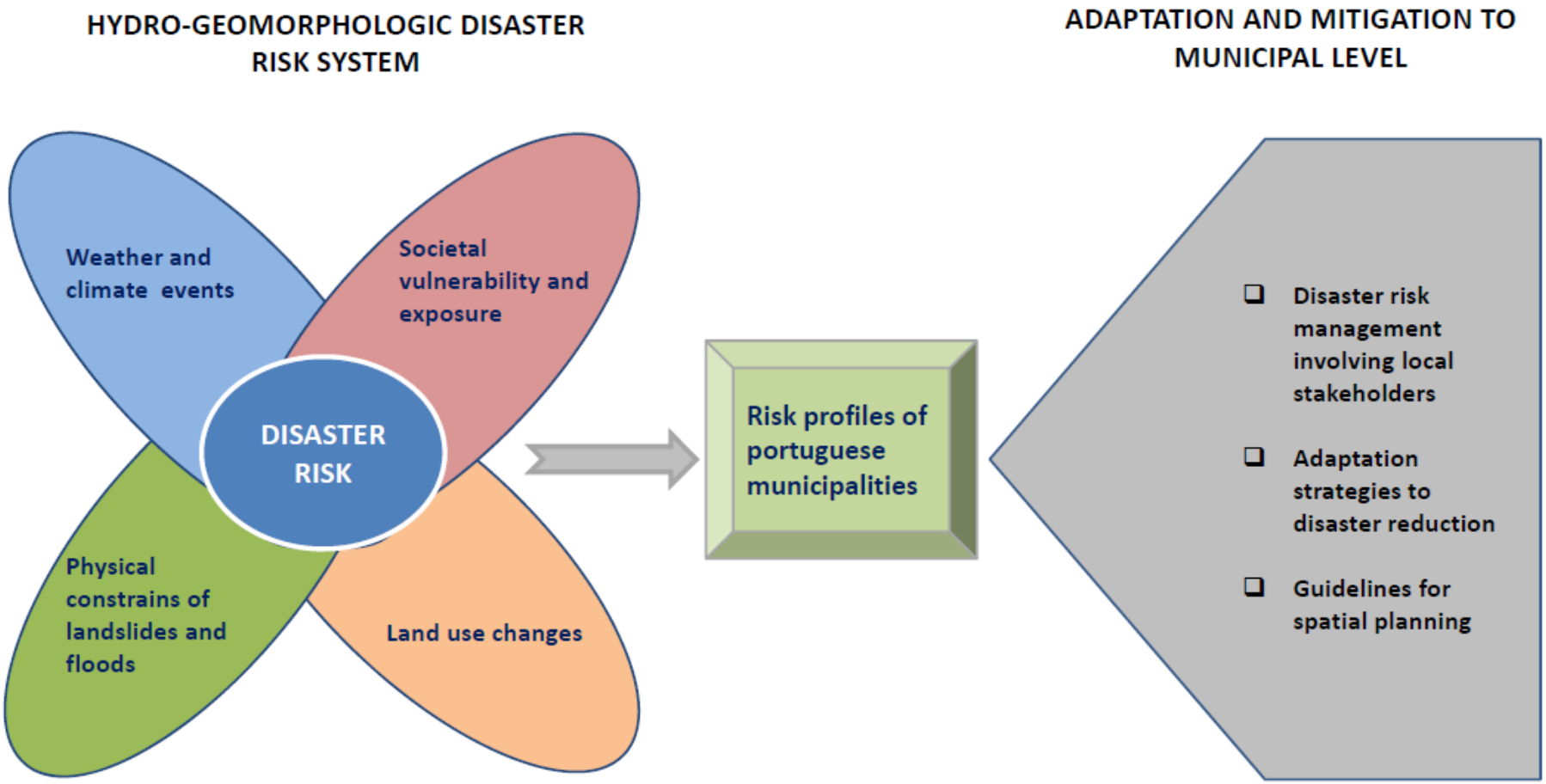
Estrutura da apresentação

- Contexto da investigação
- Contexto geográfico das cheias rápidas
  - ✓ perdas, imprevisibilidade, diversidade hidrográfica/morfológica
- Objetivos
- Metodologia utilizada
  - ✓ fatores condicionantes, AHP, registos históricos, índice municipal
- Resultados
- Notas finais

Contexto da investigação

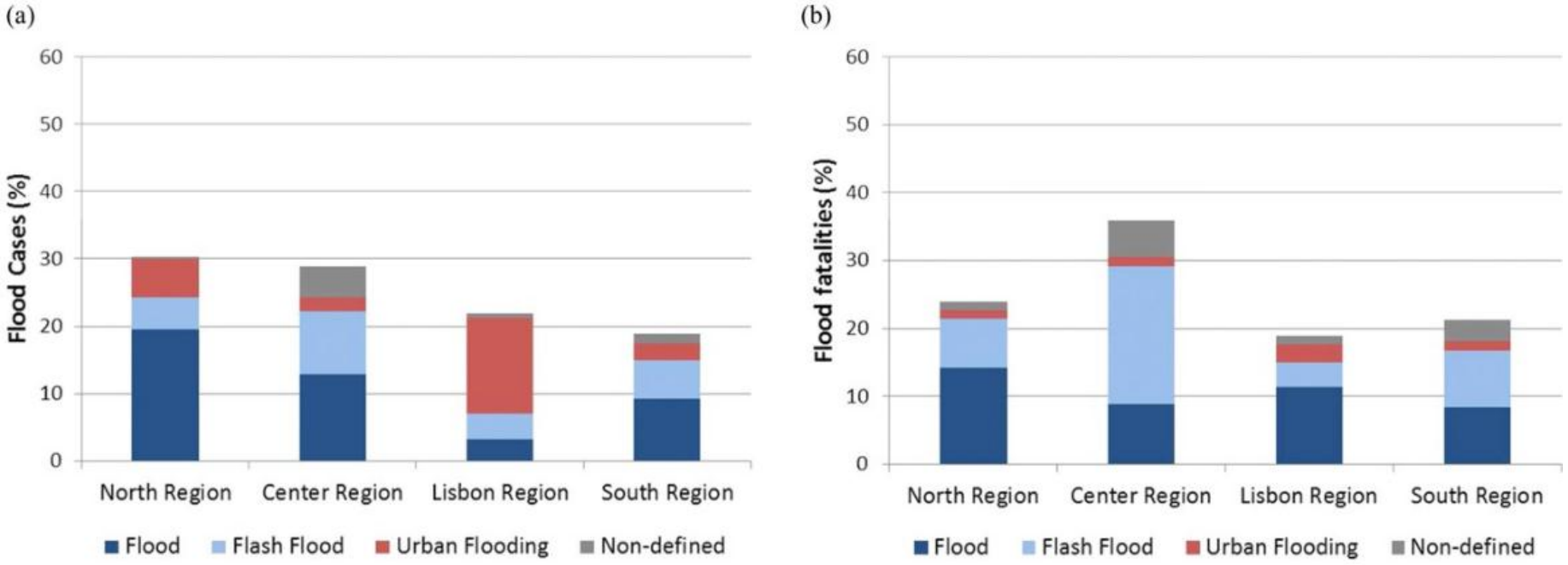
FORLAND - Hydro-geomorphologic risk in Portugal: driving forces and application for land use planning



Annex 1 - Conceptual model of the project

Contexto geográfico das cheias rápidas

- Principal causa de mortalidade por cheia em Portugal (Pereira et al., 2016)

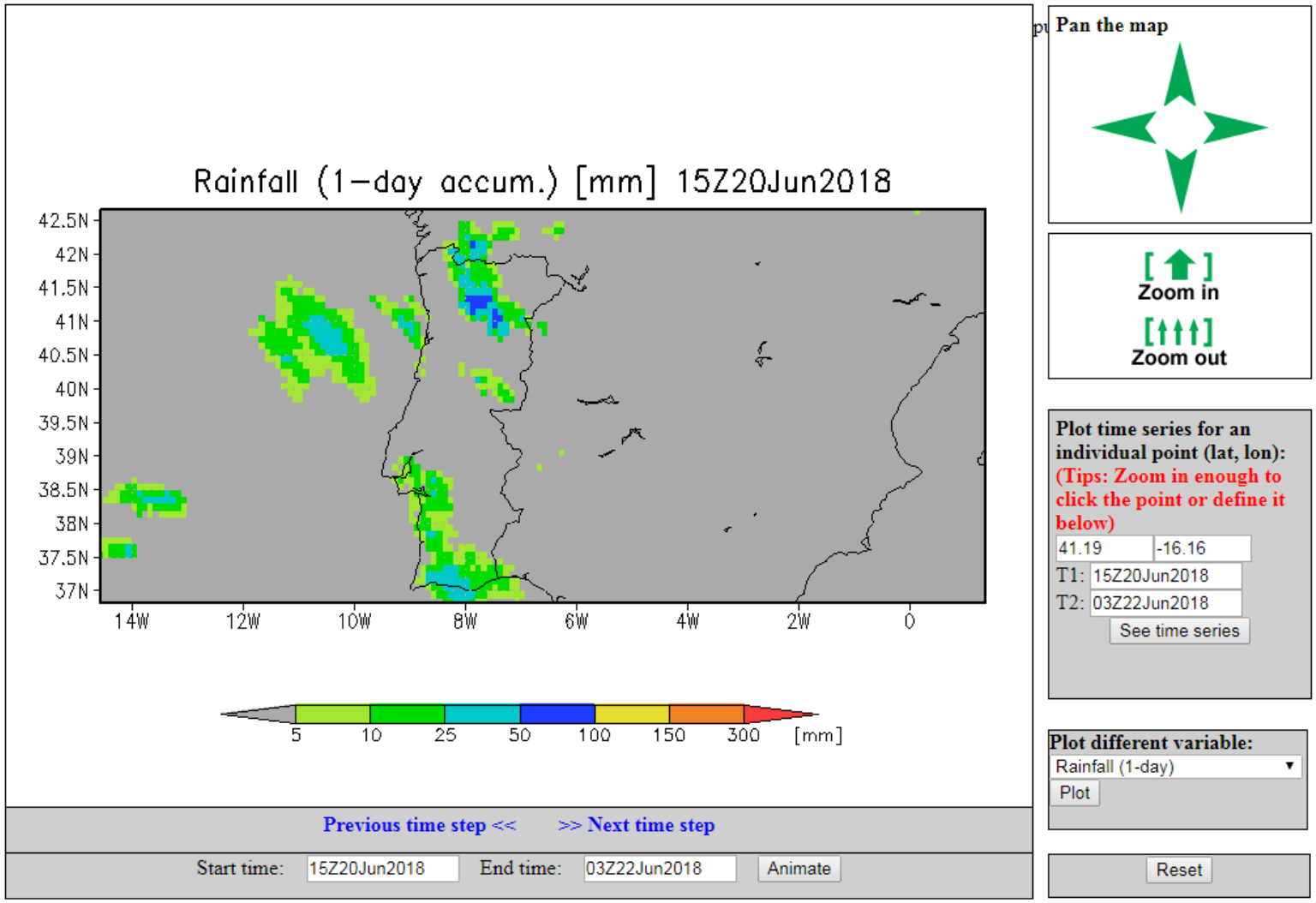


Frequency of flood DISASTER cases (a) and flood mortality (b) by flood type for each Portuguese region in the period of 1865–2010. The flash flood event of November 1967 was not considered.

Fonte: S. Pereira J. L. Zêzere I. Quaresma P. P. Santos M. Santos (2016) Mortality Patterns of Hydro-Geomorphologic Disasters, Risk Analysis, 36(6), 1188-1210 (https://doi.org/10.1111/risa.12516)

Contexto geográfico das cheias rápidas

- Difícil previsibilidade que informe sistemas de aviso e alerta



Fonte: Global Flood Monitoring System (GFMS) (http://flood.umd.edu/).

Contexto geográfico das cheias rápidas

- Difícil previsibilidade que informe sistemas de aviso e alerta

Queda de granizo provoca dezenas de inundaçoes em Lamego

Sandra Borges
20 Junho 2018 às 17:08

COMENTAR

TÓPICOS
Lamego
Local

A cidade de Lamego foi atingida pela queda intensa de granizo, esta quarta-feira, por volta das 15 horas, o que provocou dezenas de inundações em lojas, garagens e escritórios. Cerca de meia centena de operacionais estão no terreno a proceder a operações de limpeza e de desentupimento de sarjetas.

Fonte: Jornal de Notícias online (https://www.jn.pt/local/noticias/viseu/lamego/interior/inundacoes-e-quedas-de-arvores-em-lamego-armamar-e-resende-9489832.html).

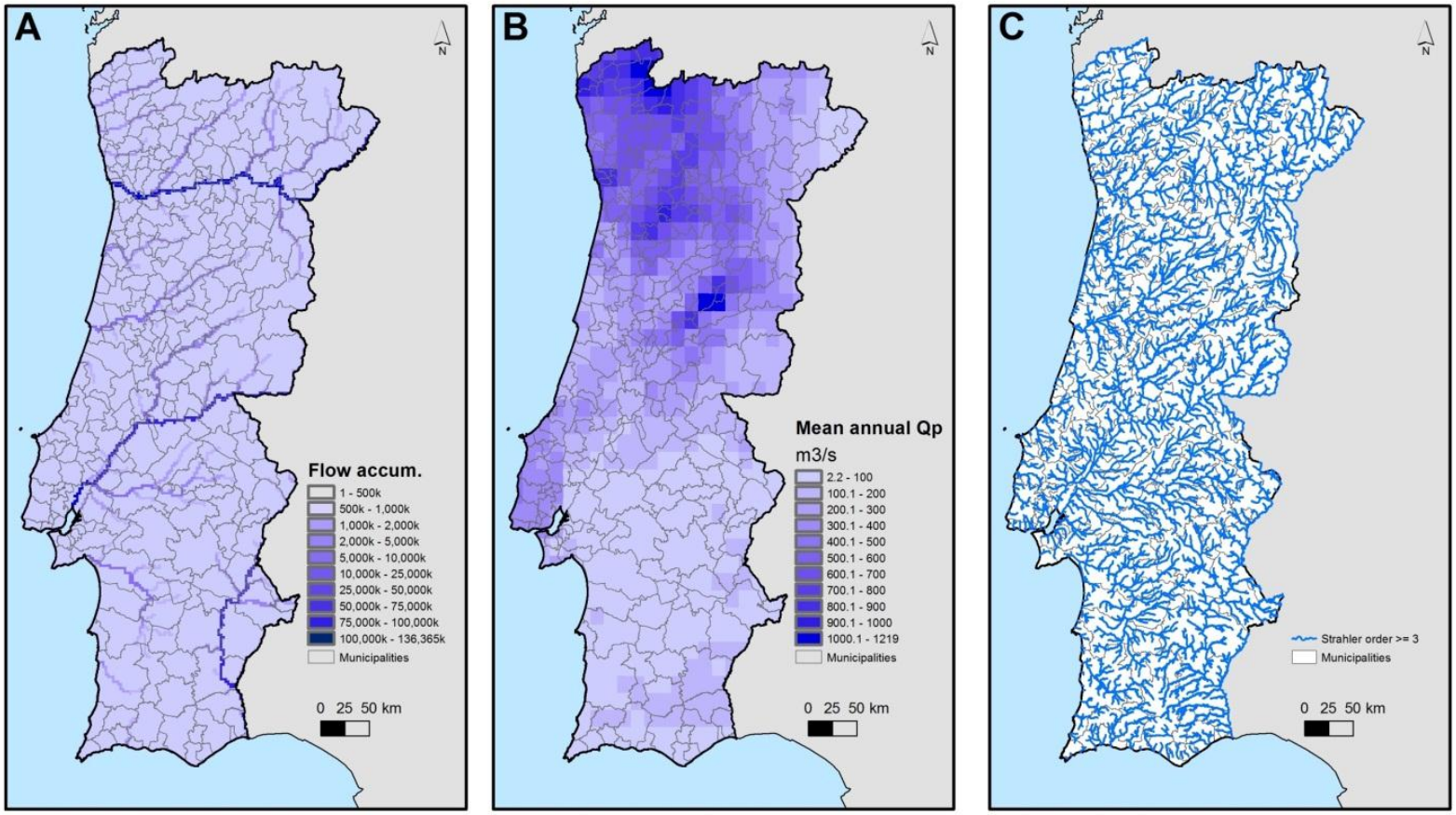
Objetivos

Definir uma metodologia de aplicação a pequena escala (escala nacional e regional) que identifique os municípios mais susceptíveis a cheias rápidas

Analisar a cartografia do índice municipal de susceptibilidade a cheias rápidas com o registo histórico de perdas

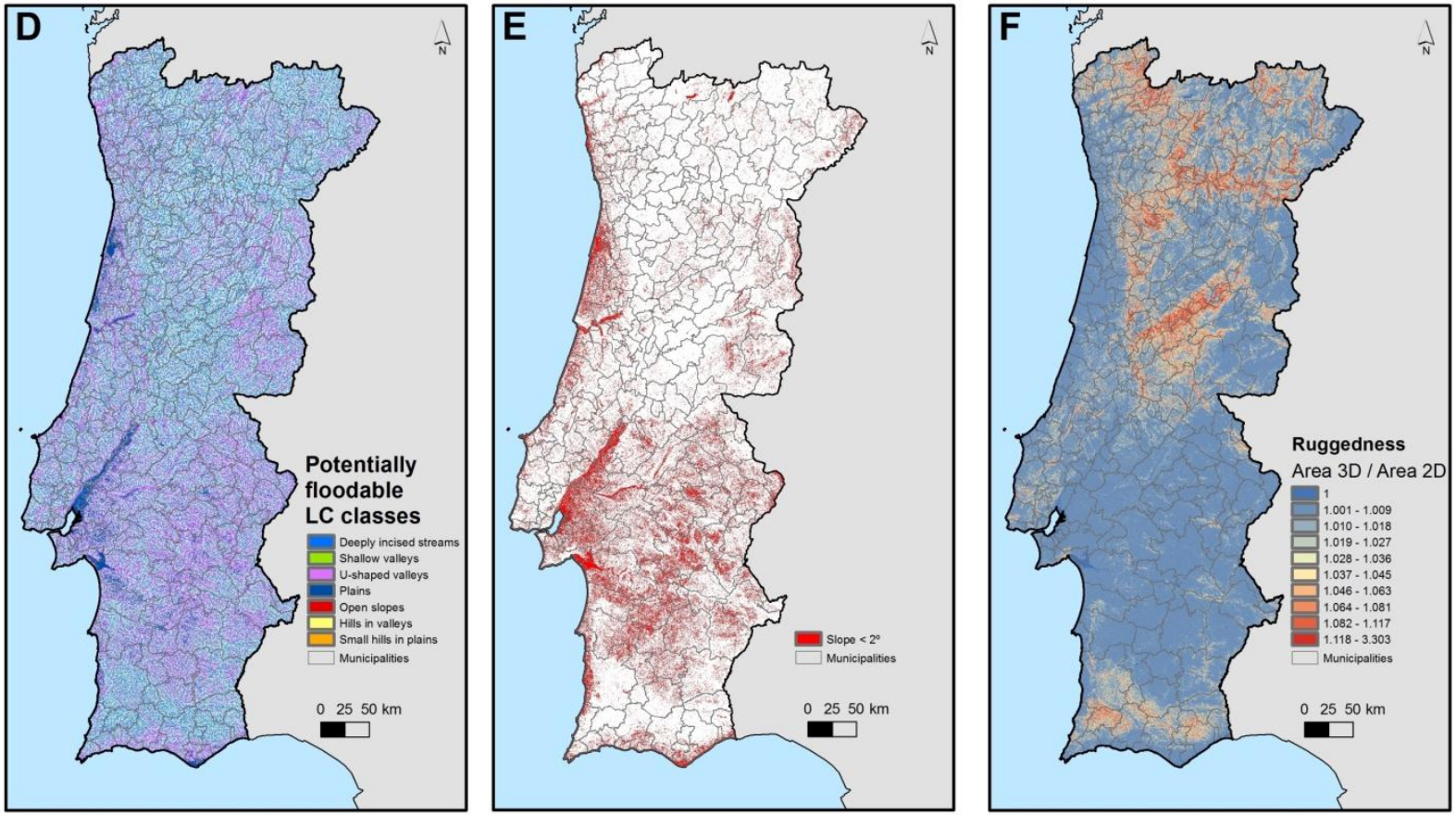
Métodos • Factores condicionantes

Raw input data for the flash flood susceptibility assessment:
A) flow accumulation, B) mean annual stream flow, C) fluvial hierarchy of Strahler of order equal or higher than 3



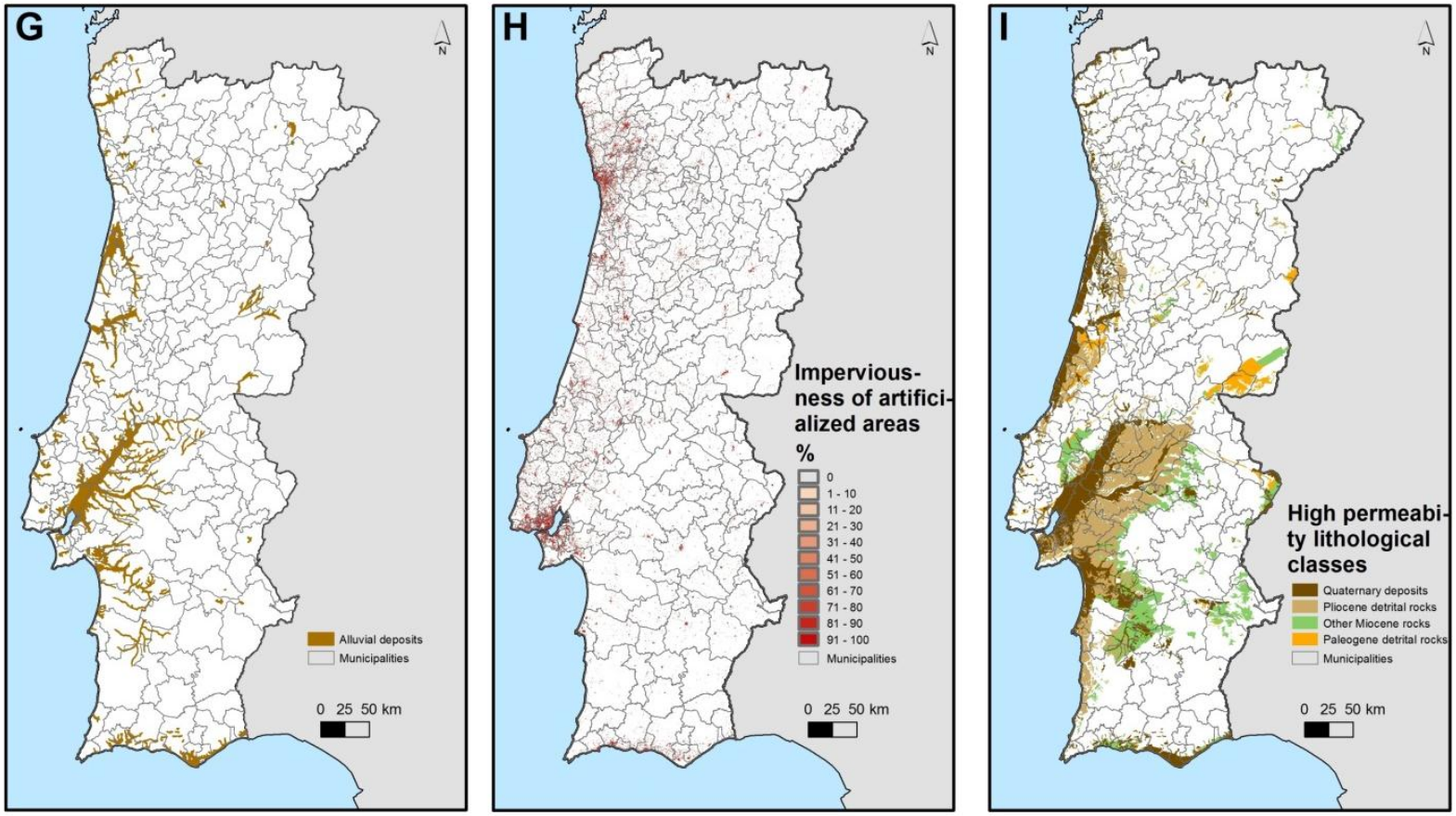
Métodos • Factores condicionantes

Raw input data for the flash flood susceptibility assessment:
D) potentially floodable Landform Classification classes, E) areas of slope lower than 2º, F) morphological ruggedness



Métodos • Factores condicionantes

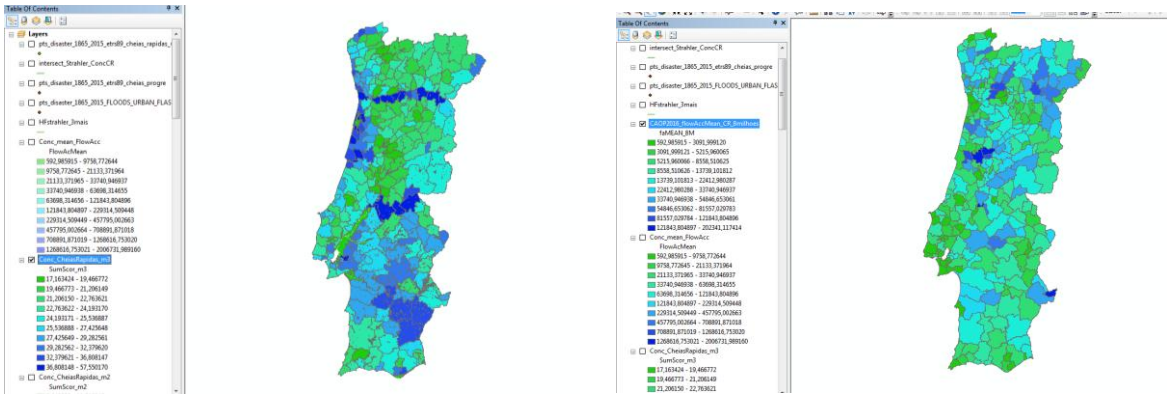
Raw input data for the flash flood susceptibility assessment:
G) alluvial deposits, H) imperviousness (sealing) of artificialized areas, I) high permeability lithological classes.



Métodos • Factores condicionantes

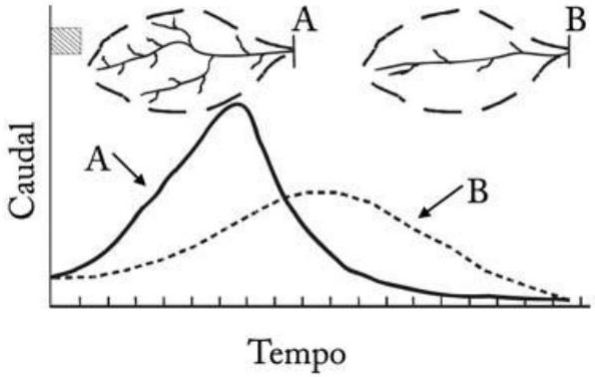
Escoamento acumulado

The contribution of the entire transboundary basins was considered, although, in order to exclude the values related to slow/progressive floods, flow accumulation >$8*10^6$ were excluded.



Densidade de drenagem

Why drainage density (alone, without permeability) is relevant?

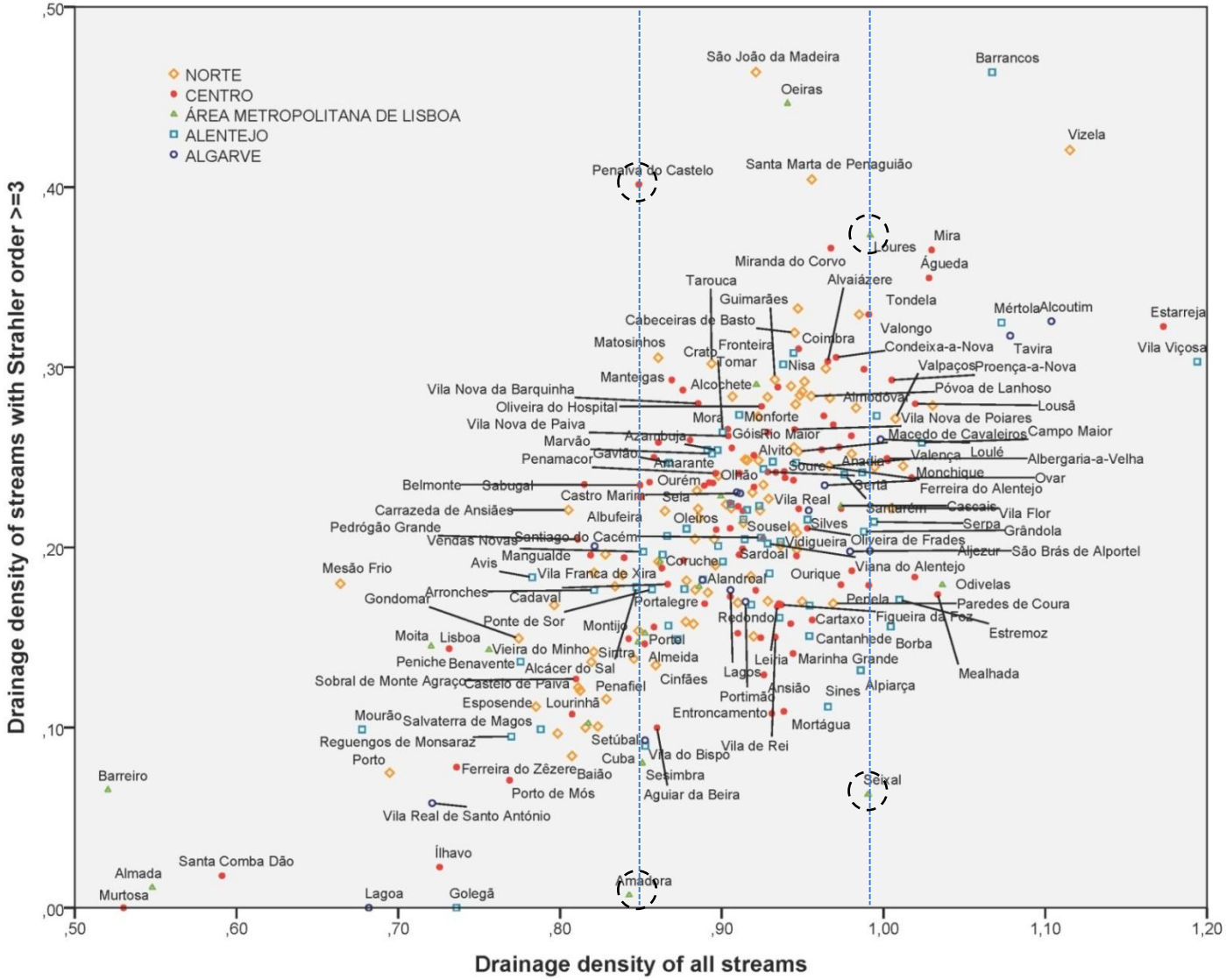


Source: Lima J, Lima I (2010) Conceitos básicos de hidrologia. In Lima J (coord.) Hidrologia urbana – conceitos básicos. Universidade de Coimbra e Entidade Reguladora dos Serviços de Água e Resíduos, Lisboa: 143-175.

Métodos • Factores condicionantes

Densidade de drenagem

Porquê usar as linhas de água de ordem de Strahler ≥ 3 e não toda a rede de drenagem?



Métodos • Valores das variáveis ao nível municipal

Not all the administrative area of the municipalities was accounted for. The excluded areas were: transitional and intertidal areas; dam reservoirs (CLC 512 class); lower sector of the Tagus river floodplain.

All values normalized to the interval [0, 100], except those already expressed as percentages (ex: % of the municipal area covered by impervious areas).

Final set of 9 variables expressed at the municipal level:

FA=Municipal mean flow accumulation (no. of cells of size 250 x 250 m)

DS=Municipal density of streams with Strahler's order equal or higher than 3 (km/km^2)

Rn=Municipal mean of morphological ruggedness (non-dimensional)

S=Municipal area of slope inferior to 2^o (%)

A=Municipal area covered by alluvial deposits (%)

ID=Municipal mean of imperviousness (sealing) degree according to CORINE Land Cover 2012 (%)

HP=Municipal area covered by high permeability lithological classes (%)

LC=Municipal area covered by classes 1, 2, 4, 5, 6, 8 and 9 of Landform Classification (%)

SF=Municipal mean annual stream flow (mm)

Métodos • Multicritério com pesos definidos por AHP

The rank and weight of the nine conditioning factors was evaluated using Analytic Hierarchy Process. Several combinations (experiences) were tested, from which 4 were retained.

Conditioning factor	Exper. #2	Exper. #4	Exper. #6	Exper. #7
Municipal mean flow accumulation (no. of cells of size 250 x 250 m)	***0.307***	***0.350***	***0.379***	***0.350***
Municipal density of streams with Strahler's order equal or higher than 3 (km/km^2)	***0.218***	***0.237***	***0.249***	***0.237***
Municipal mean of morphological ruggedness (non-dimensional)	***0.154***	***0.159***	***0.102***	-
Municipal area of slope inferior to 2^o (%)	***0.109***	***0.106***	***0.160***	***0.106***
Municipal area covered by alluvial deposits (%)	***0.076***	***0.070***	***0.065***	***0.070***
Municipal mean of imperviousness degree according to CORINE Land Cover 2012 (%)	***0.053***	***0.046***	***0.043***	***0.159***
Municipal areas covered by high permeability lithological classes (%)	***0.037***	***0.032***	-	***0.046***
Municipal areas covered by classes 1, 2, 4, 5, 6, 8 and 9 of Landform Classification (%)	***0.026***	-	-	-
Municipal mean annual stream flow (mm)	***0.019***	-	-	***0.032***

Summary of input data for the flash flood susceptibility assessment. Most relevant experiments tested after AHP-defined weighting.

- Índice municipal de suscetibilidade a cheias rápidas

$$mFFSI = \sum_{i=1}^{n} s_i \,.\, w_i = \; s_1 . w_1 + \cdots + s_n . w_n$$

Em que:

mFFSI	municipal flash flood susceptibility index
s_i	the score of the parameter *i* in each municipality
w_i	the weight of each parameter *I* in each experience
n	the number of the conditioning factors

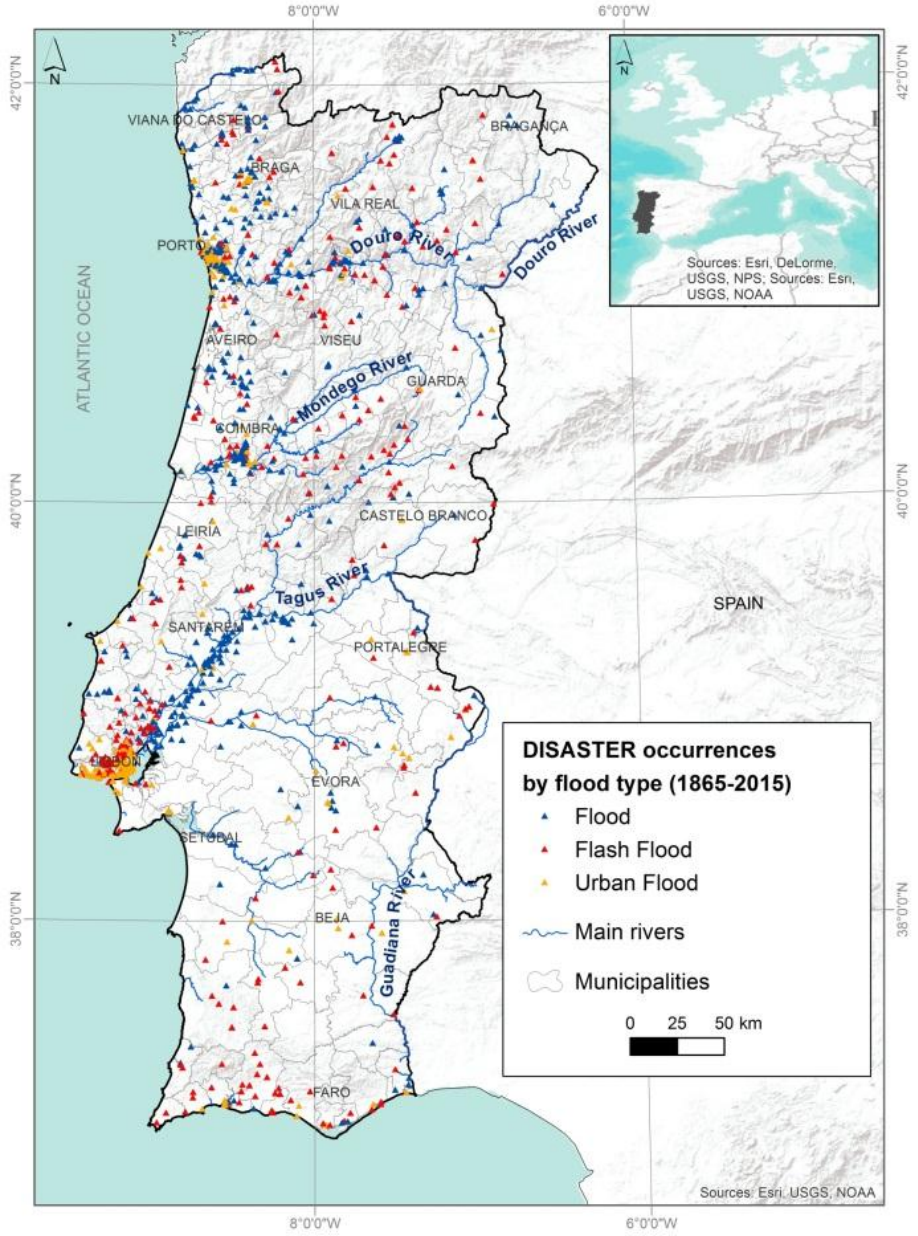
Métodos • Registo histórico de cheias rápidas e urbanas

Para comparação, das 1602 ocorrências de perdas relativas a cheias registadas na base de dados DISASTER (Zêzere et al., 2014) no período 1865-2015, usaram-se as **791 ocorrências relacionadas com cheias rápidas e urbanas**.

A base de dados inclui ocorrências em que tenha havido uma ou mais vítimas mortais, desaparecidos, feridos, evacuados e desalojados.

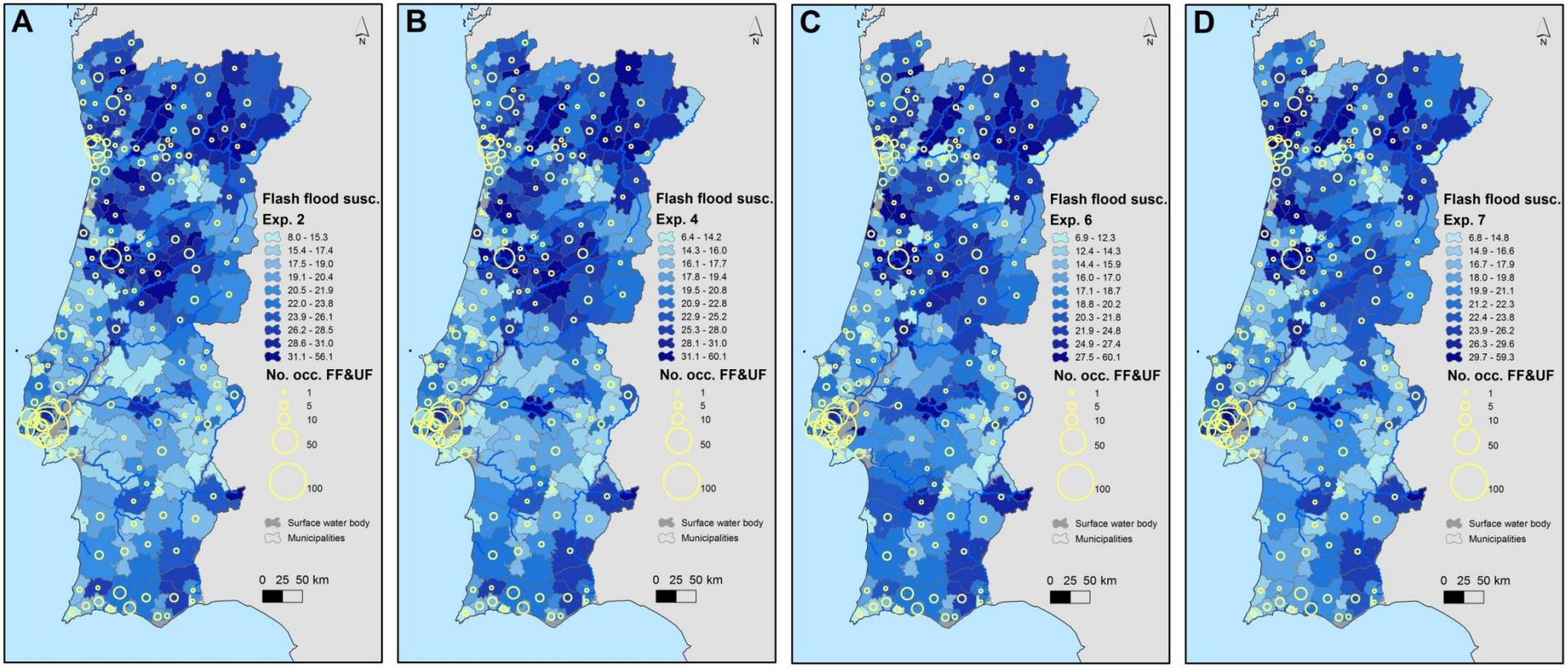
As ocorrências foram agregadas ao município respetivo.

Flood disaster cases as recorded on the DISASTER database on the period 1865-2015.



Zêzere, J. L., Pereira, S., Tavares, A. O., Bateira, C., Trigo, R. M., Quaresma, I., Santos. P.P, Santos, M., Verde, J. (2014). DISASTER: A GIS database on hydro-geomorphologic disasters in Portugal. *Natural Hazards*, *72*(2), 503–532. https://doi.org/10.1007/s11069-013-1018-y

Resultados



Flash flood susceptibility at the municipal level (classification in 10 quantiles), upon the combination of weights tested in experiments 2 (A), 4 (B), 6 (C) and 7 (D) and number of flash flood (FF) and urban flood (UF) related cases recorded on the DISASTER database (1865-2015).

Resultados

- Índice municipal de suscetibilidade a cheias rápidas:
  - ➢ Elevado nos municípios incluídos nas bacias dos rios:
    - Ave, Leça, Tâmega, Tua, Vouga, Mondego e Nabão (região Norte e Centro);
    - Trancão e pequenas ribeiras de Cascais e Oeiras (região da Grande Lisboa);
    - Sorraia, Odivelas (B.H. Sado), Ardila e Oeiras (B.H. Guadiana), ribeiras do Algarve.
  - ➢ Reduzido nos municípios incluídos nas bacias dos rios:
    - Vales inferiores dos rios Tejo e Sado (prevalência dos processos de cheia lenta sobre cheia rápida);
    - Cabeceiras de bacias hidrográficas dos rios Távora (B.H. Douro) e Dão (B.H. Mondego): Trancoso, Sernancelhe, Aguiar da Beira; e dos rios Sado e Guadiana: Cuba.

Resultados

Validation with the historical records is undoubtedly marked by exposure patterns and must be used with caution.

R increased when the weight of the degree of sealing (Exp. 7)
&
the p-value became ≤0.05, i.e., the correlation is statistically significant

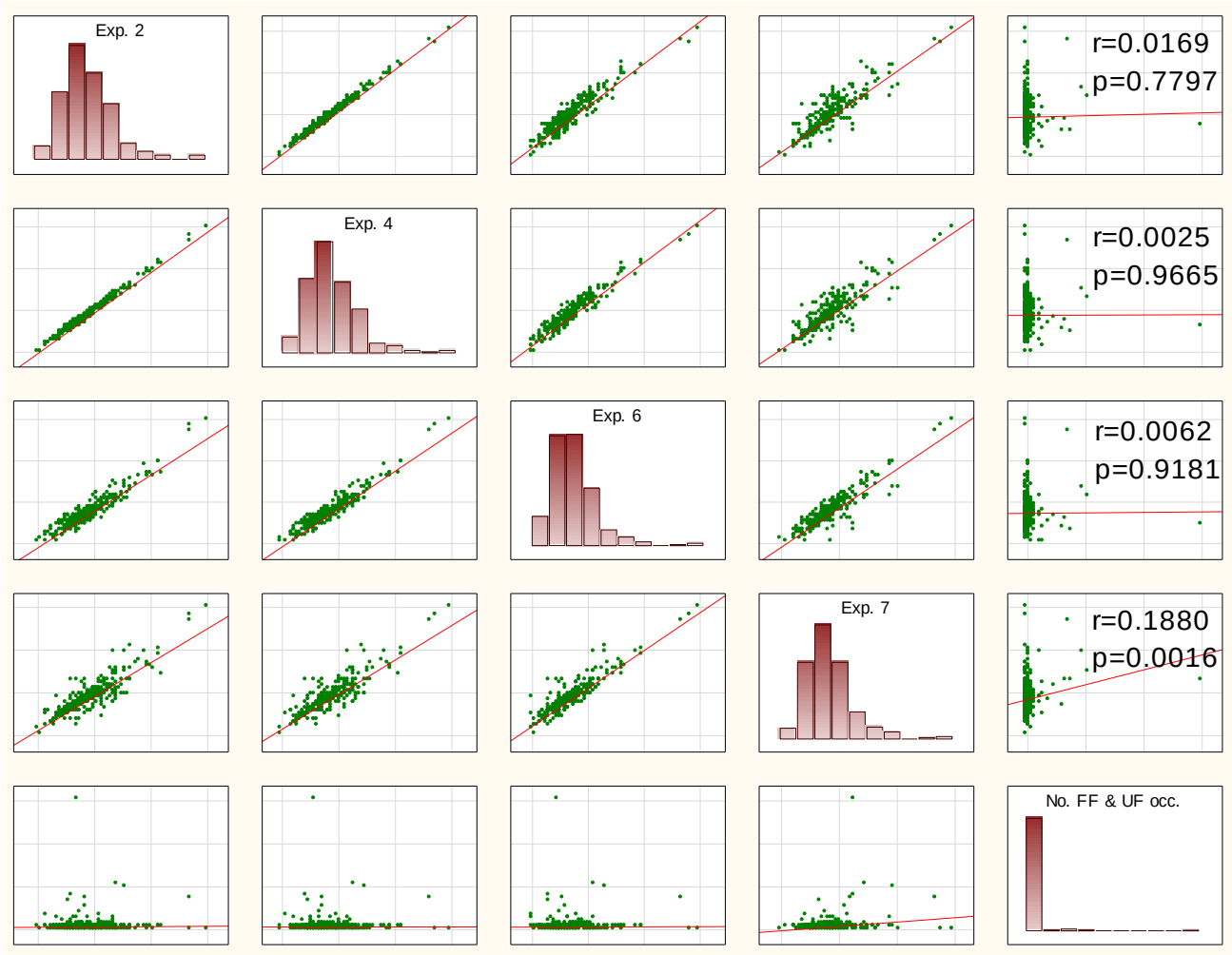


Figure 6 *Matrix scatter plot of flash flood susceptibility scores by municipality, of experiments 2, 4, 6 and 7 and the number of flash flood and urban occurrences.*

Notas finais

A metodologia definida permite a diferenciação dos municípios de Portugal Continental em termos de:

Capacidade para gerar cheias rápidas;

Propensão para sofrer inundação por cheias rápidas.

Notas finais

Compreender os contextos territoriais dos desastres por cheia rápida

- At which extent the cartography of disastrous flood cases have been controlled by natural constraints?
- Why do we have municipalities with high susceptibility and a scarce historical record of flood losses?

Municipal risk profiles

Classification of municipalities according to their susceptibility, exposure and vulnerability

Vale do Rio Tejo perto de Santarém

Rio de Onor, Bragança

Cidade do Cabo, África do Sul

Left: https://sicnoticias.sapo.pt/pais/2016-05-12-Elevada-probabilidade-de-cheias-no-rio-Tejo-hoje Middle: https://contramapa.com/2017/10/03/rio-de-onor/
Right: https://www.idealista.pt/news/imobiliario/internacional/2016/06/28/30956-cenarios-de-desigualdade-a-linha-tenue-que-separa-os-bairros-mais-ricos-e-pobres

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Obrigado pela atenção!

http://www.ceg.ulisboa.pt/forland/

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