Environmental Hazards and Risk Assessment and Management
www.riskam.ul.pt

Spatial and temporal incidence of disastrous floods and landslides in Portugal during the last 150 years

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Analysis and Mitigation of Risks in Infrastructures INFRARISK-

5th Summer School Workshop

University of Minho, Guimarães, 15th July 2019

Outline:

1. Rationale for the Disaster database
2. Disaster events in mainland Portugal according to the EM-DAT
3. Entry criteria, data sources and key concepts of the Disaster database
4. Method for data collection and storage
5. Results
   a) Geographical distribution of disasters
   b) Temporal trends of disasters
   c) Seasonal distribution
   d) Mortality patterns
   e) Completeness of the Disaster database
   f) Comparison between the Disaster database and the EM-DAT
6. A step forward: the FORLAND project
7. Take-home message

1. Rationale

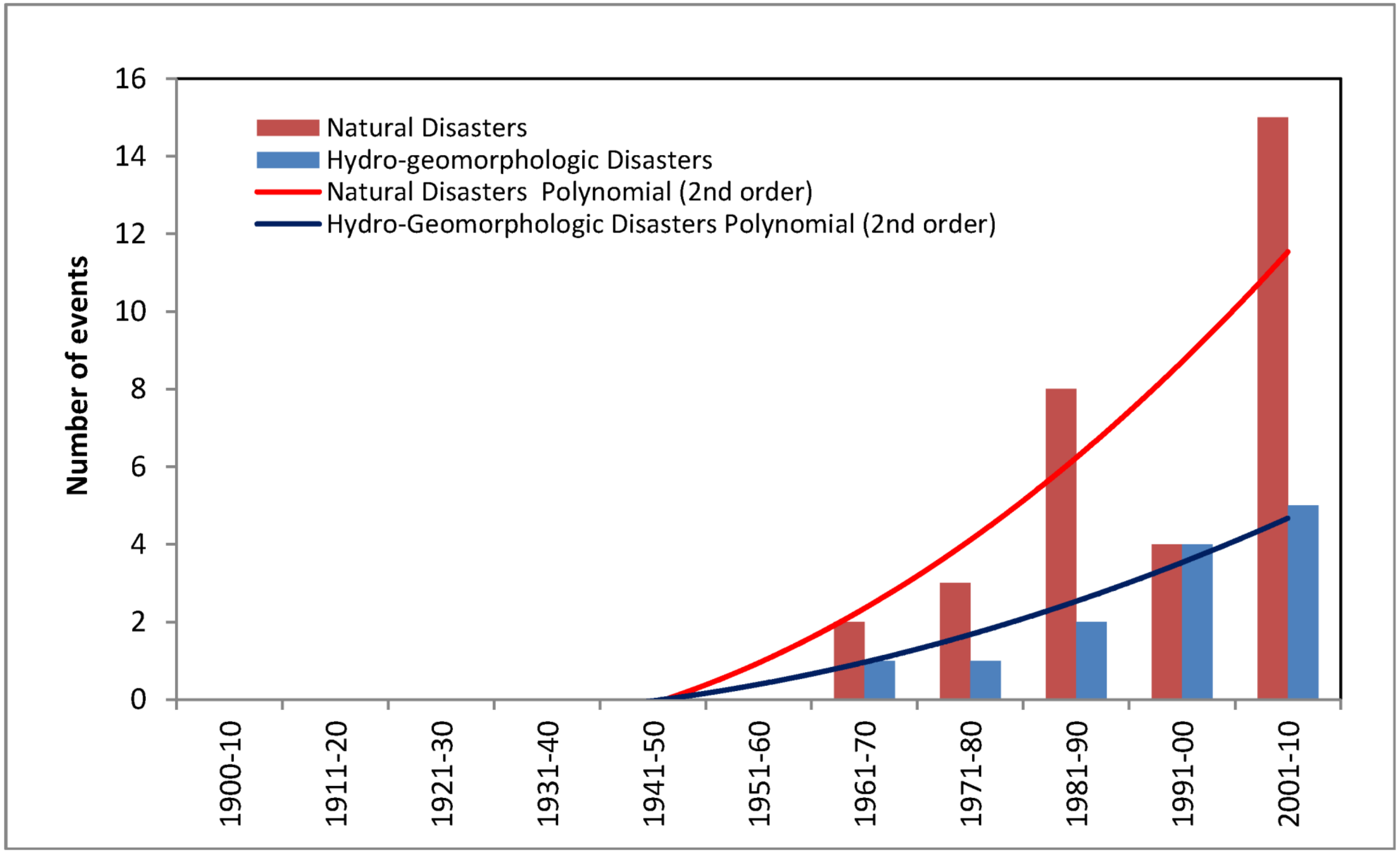
In the last 150 years Portugal was affected by several natural disasters of hydro-geomorphologic origin that often caused high levels of destruction.

However, data on past events related to floods and landslides which occurred in the country was scattered and incomplete.

The DISASTER project [FCT funded] aimed to bridge this gap by creating, disseminating and exploiting a GIS database on disastrous floods and landslides occurred in mainland Portugal since 1865.

http://riskam.ul.pt/disaster/

2. Disaster events in Portugal according to the EM-DAT (1900-2010)



EM-DAT entry criteria:

(i) 10 or more people reported dead;
(ii) 100 or more people reported affected;
(iii) declaration of state of emergency;
(iv) call for international assistance.

3. Entry Criteria, Data Sources and Key Concepts of the DISASTER Database

Entry criteria: any flood or landslide that, independently of the number of affected people, caused either casualties, injuries, or missing, evacuated or displaced people.

We assume that such consequences are relevant enough to be reported by the press, namely **daily newspapers**, which were the **source for data collection** in the DISASTER Project.

KEY CONCEPTS

DISASTER Case: unique hydro-geomorphologic occurrence that fulfills the DISASTER Project database criteria, and is related to a unique space location and a specific period of time (i.e. the place where the flood or landslide harmful consequences occurred in a specific date).

DISASTER Event: set of DISASTER cases sharing the same trigger which can have a widespread spatial extension and a certain magnitude.

November 1967 Disaster Event

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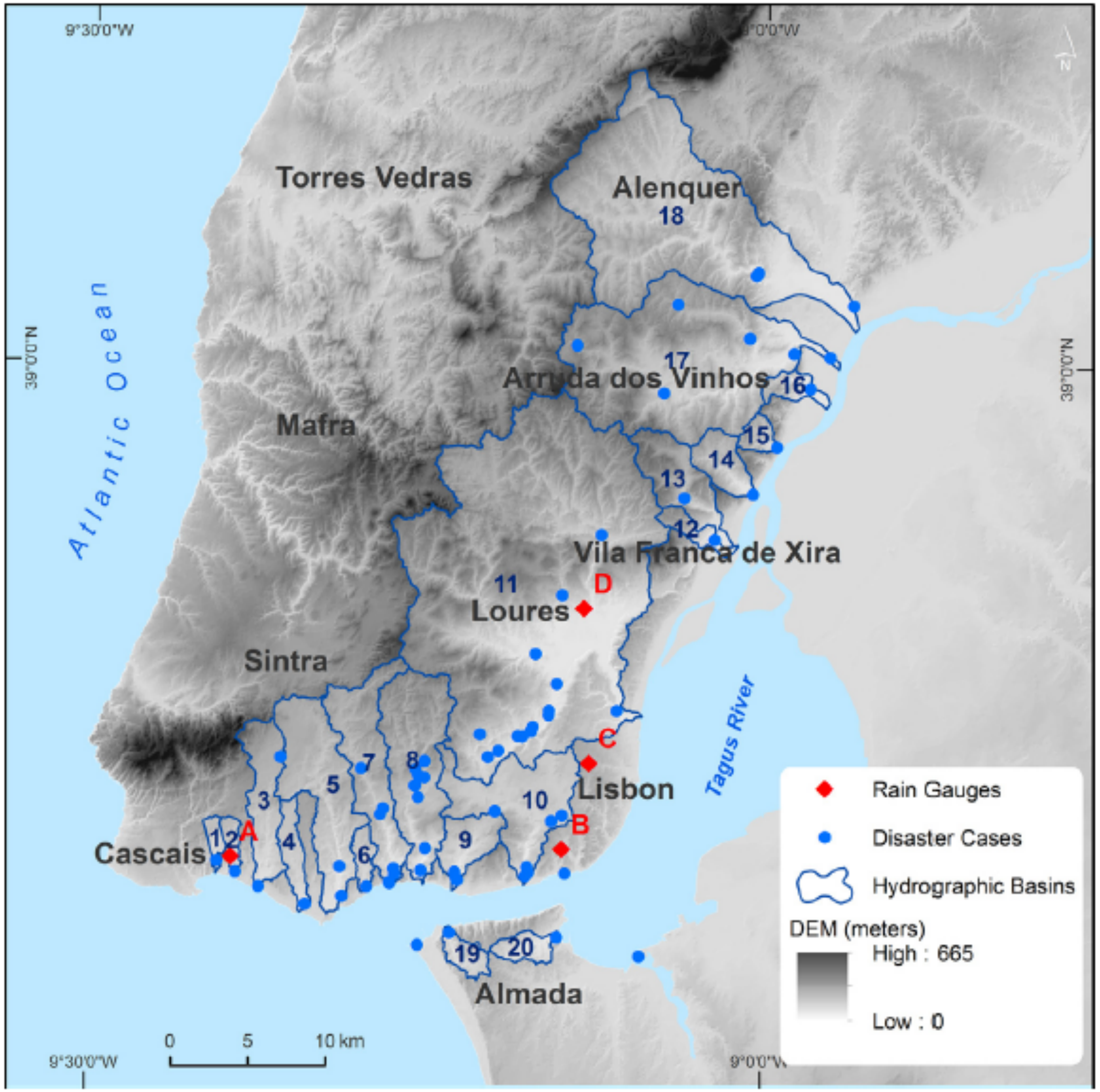
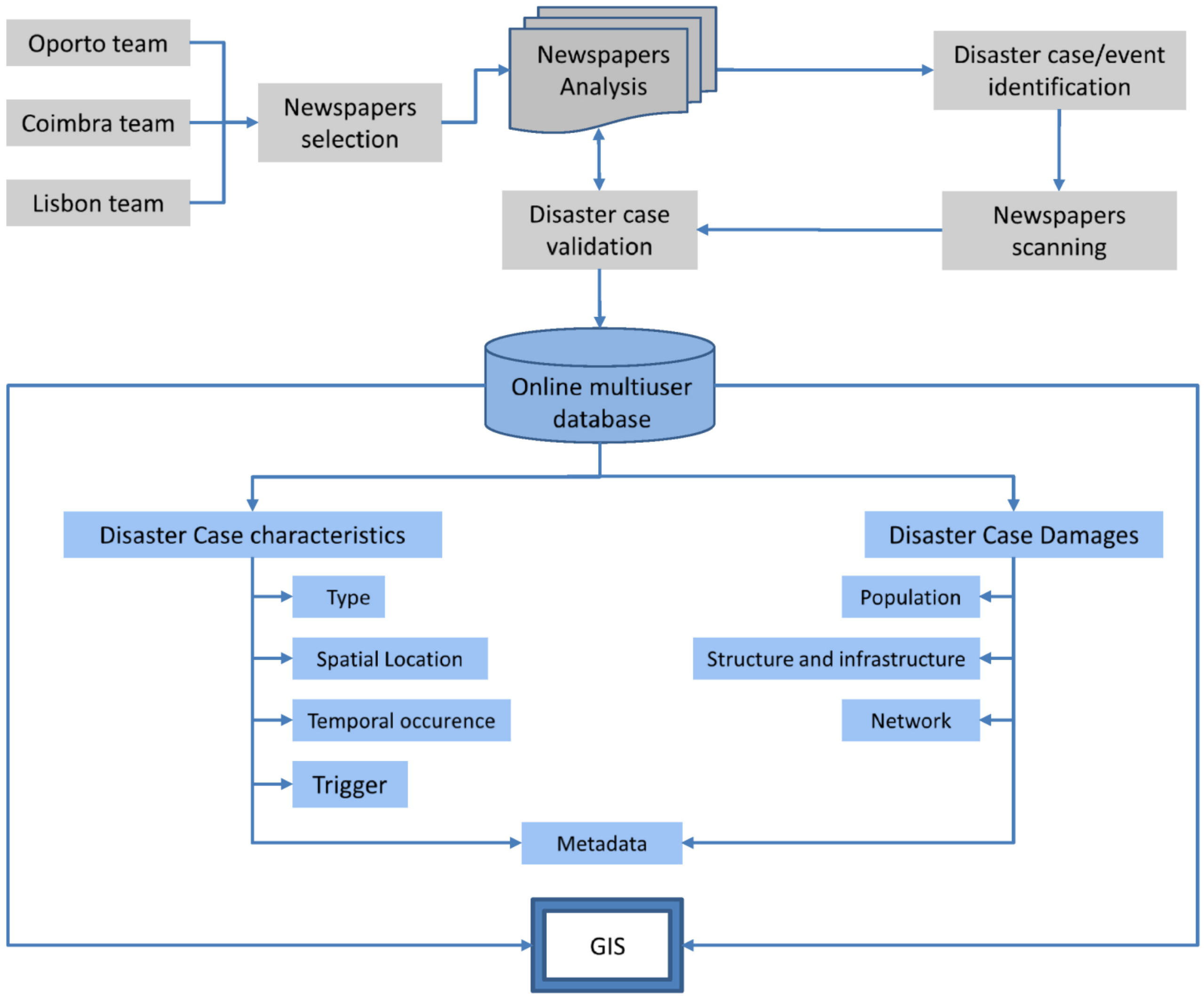


Hydrographic basins:

1 – Monte Estoril
2 – São João do Estoril
3 – Caparide
4 – Marianas
5 – Laje
6 – Porto Salvo
7 – Barcarena
8 – Jamor
9 – Algés
10 – Alcântara
11 – Trancão
12 – Crós Cós
13 – Silveira
14 – Santo António
15 – Santa Sofia
16 – Castanheira
17 – Grande da Pipa
18 – Alenquer
19 – Caneira
20 – Caramujo

4. Method for data collection and storage



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DIRECTOR — ALFREDO DA CUNHA

13:726 — 40.° ANNO — 1904

Diario de Noticias

FUNDADORES — THOMAZ QUINTINO ANTUNES (Conde de S. Marçal) e EDUARDO COELHO

REDACTOR PRINCIPAL — BRITO ARANHA

QUINTA FEIRA 11 DE FEVEREIRO

ASSUMPTOS DO DIA

Chronica agricola

Guerra entre a Russia e o Japão

Terrivel desastre

BOLETIM PARLAMENTAR

JORNAL DE NOTICIAS

15.° ANNO

Porto — Sabbado, 22 de fevereiro de 1902

N.° 45

Tiragem 22:000 EXEMPLARES

O relatorio da Associação Commercial do Porto

A liberdade de Miss Stone

Um punhado de noticias

PELO ESTRANGEIRO

Os motins em Barcelona

A "GREVE".

Um destacamento chinez sobre os gêlos na fronteira chino-russa

DE RASPÃO

DIÁRIO DE COIMBRA

DIRECTOR ALVARO DOS SANTOS MADEIRA

Editor: Adriano Lucas

JORNAL REPUBLICANO — ÓRGÃO DO MOVIMENTO REGIONALISTA DAS BEIRAS — ÚNICO DIÁRIO DO CENTRO DO PAÍS

Redacção, Administração e Oficinas — Rua da Sofia, n.° 179

Propriedade de «A TIPOGRÁFICA DAS BEIRAS, LIMITADA»

TELEFONES: 25461 / 25462 PPC — Direcção: 25463

ANO XXXI N.° 10.229

3.ª-feira, 25 de Outubro de 1960

Preço $80

Violenta tromba de água E FURIOSO VENDAVAL

desabaram ontem sobre uma vasta região do Centro do País, onde os prejuízos são de momento incalculáveis

A inclemência do tempo pesou ontem, durante a tarde, duramente, sobre uma vasta zona do Centro do País, de onde nos

Estradas obstruídas, povoações quase submersas, árvores levadas pelo ar, ligações ferroviárias interrompidas

A ALEMANHA ORIENTAL vai fornecer a Israel documentos sobre Eichemann

TELAVIV, 24 — A Alemanha Oriental aceitou fornecer a Israel — com quem não tem relações diplomáticas — documentos acerca do antigo coronel das S. S. Adolf Eichemann que deve ser julgado próximamente em Israel. Os documentos serão entregues pelas autoridades de Pankow aos investigadores israelinos. — F. P.

Epidemia de cólera

CARACHI, 24 — Cento e treze pessoas morreram de epidemia de cólera

Na estrada entre Ançã e Portunhos

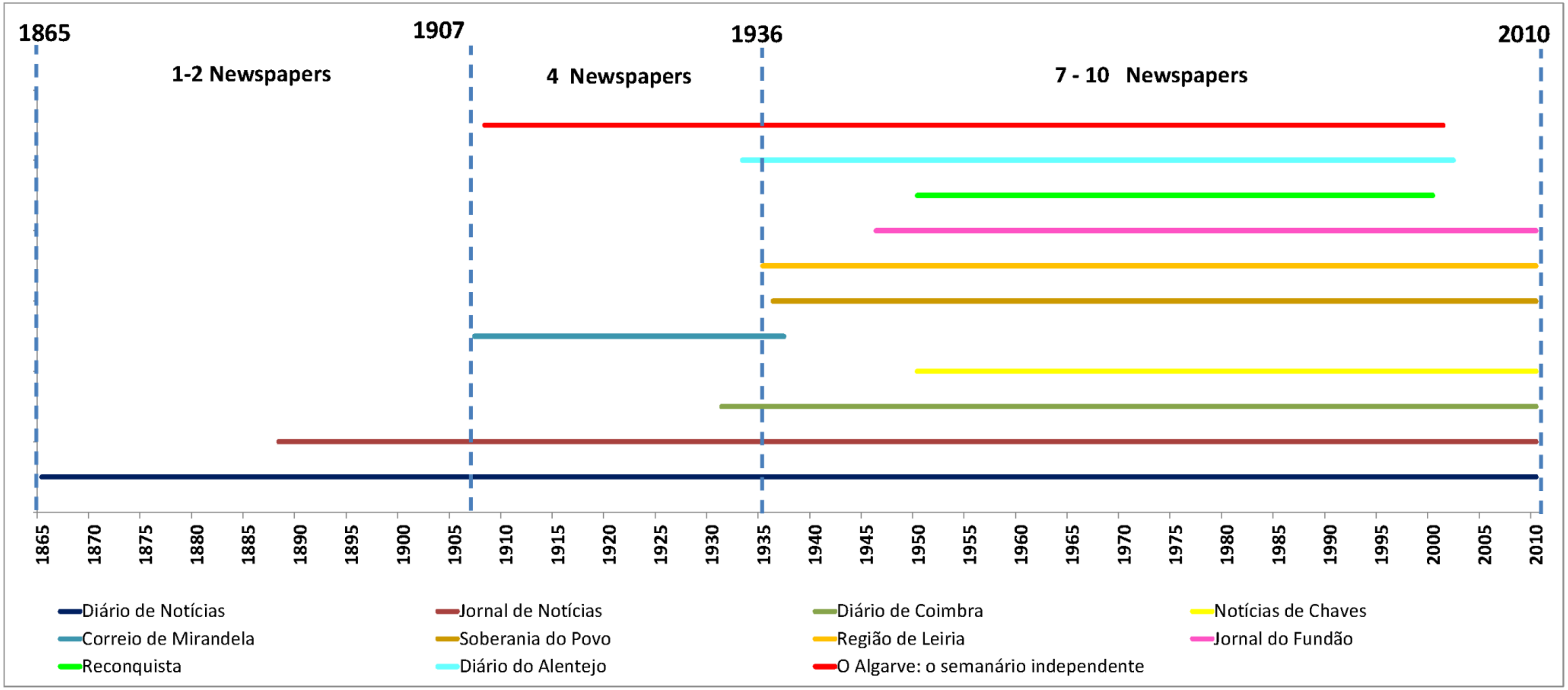
O SECULO

AUSTRIACOS

AS ELEIÇÕES SUPLEMENTARES DE HONTEM

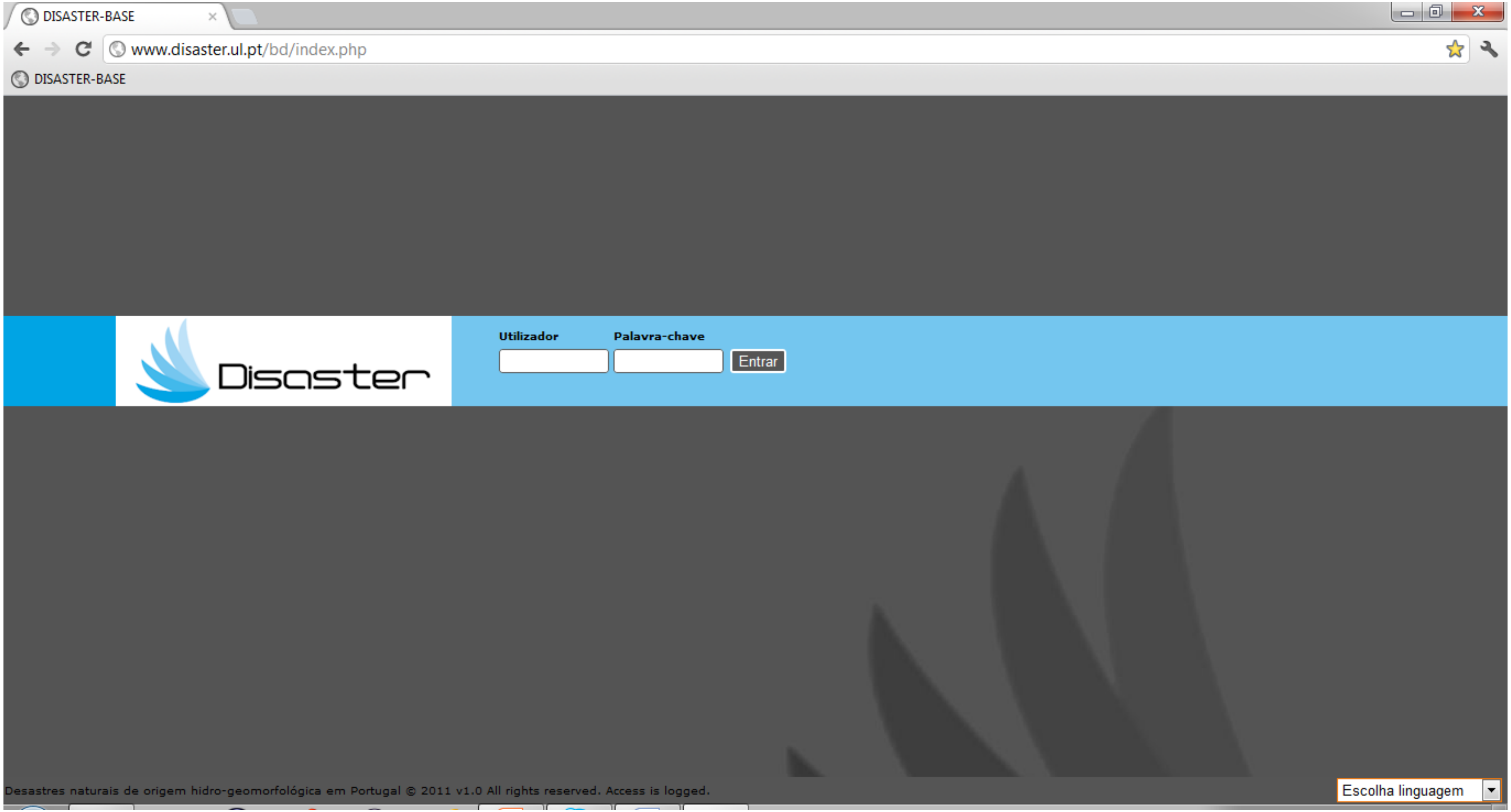
COMO O SOL BAILOU AO MEIO DIA EM FATIMA

Temporal coverage of newspapers used in the data collection for the DISASTER database



11 newspaper systematically surveyed; 5 additional newspapers used for cross checking; around 148,000 newspapers specimens analysed

The DISASTER database



The DISASTER database

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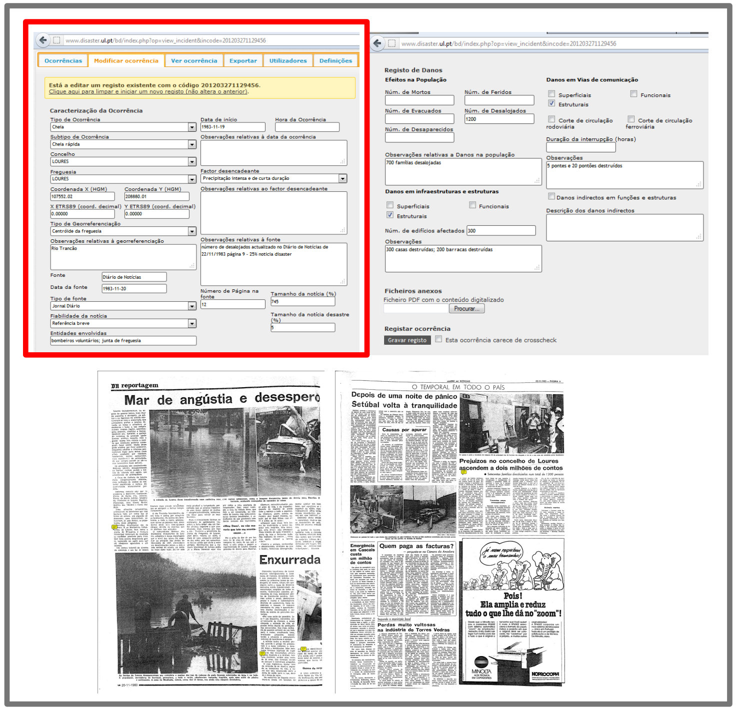
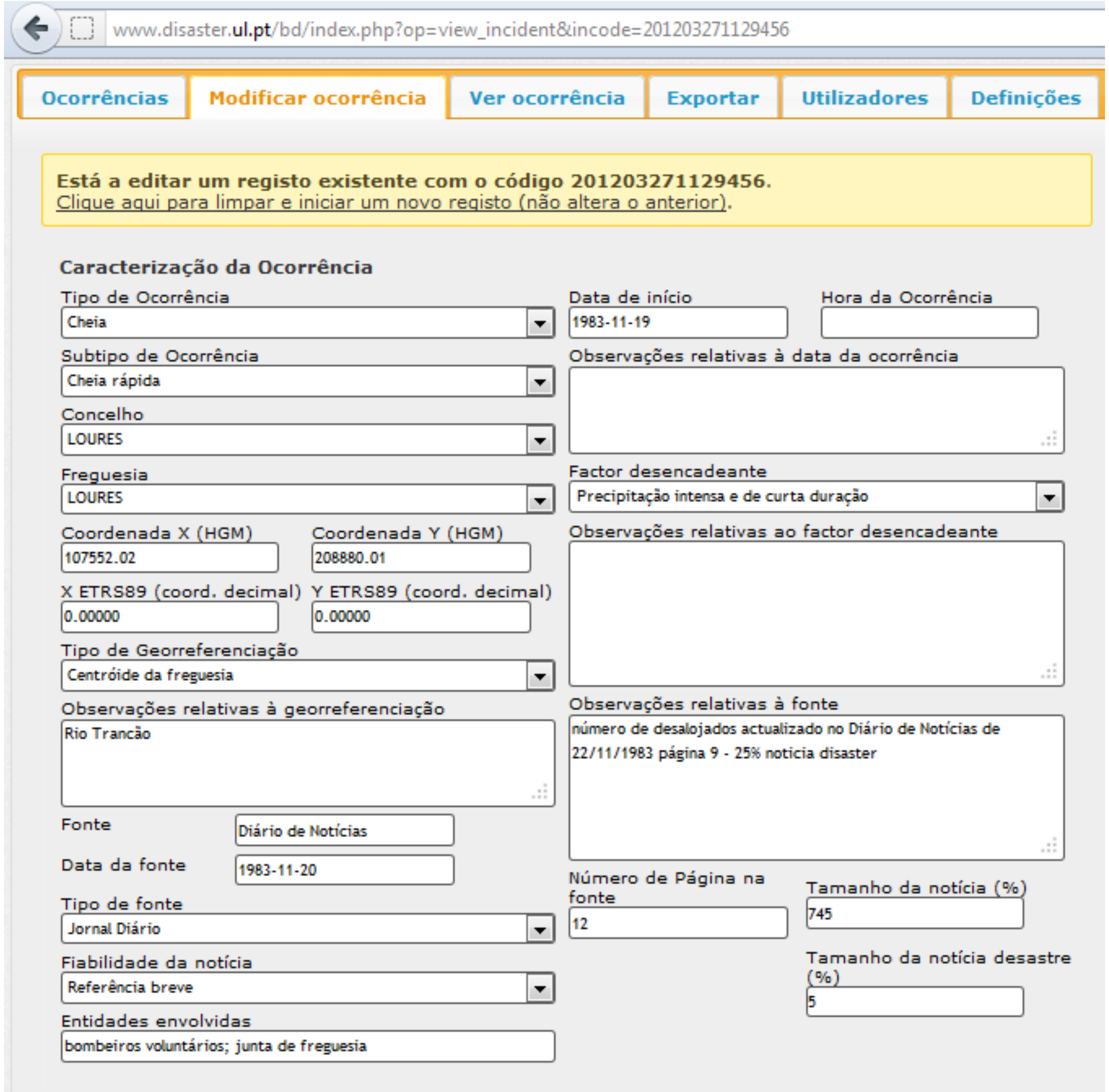
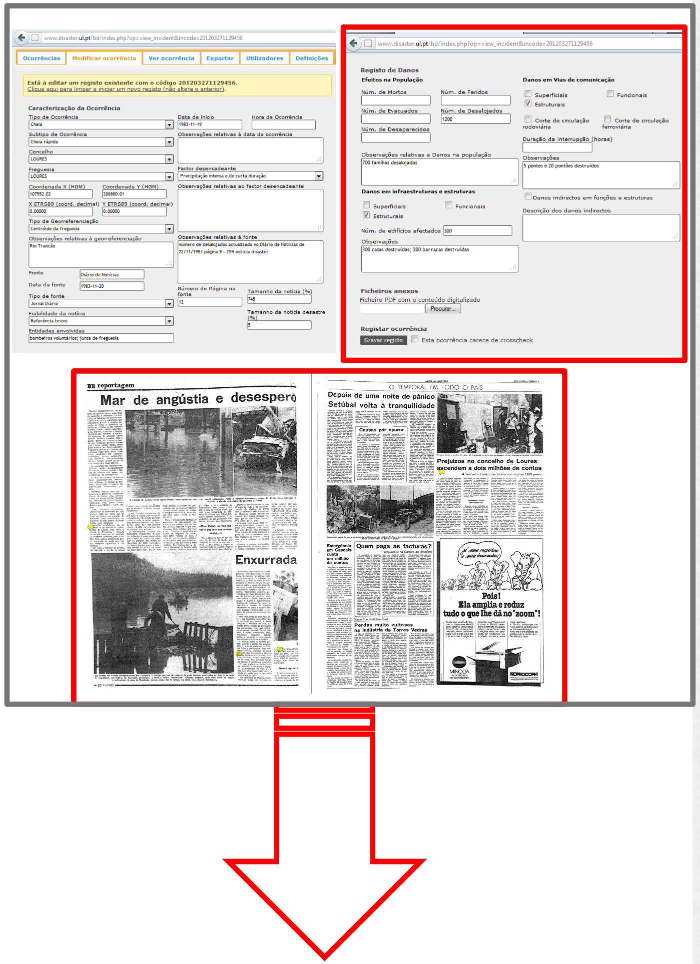
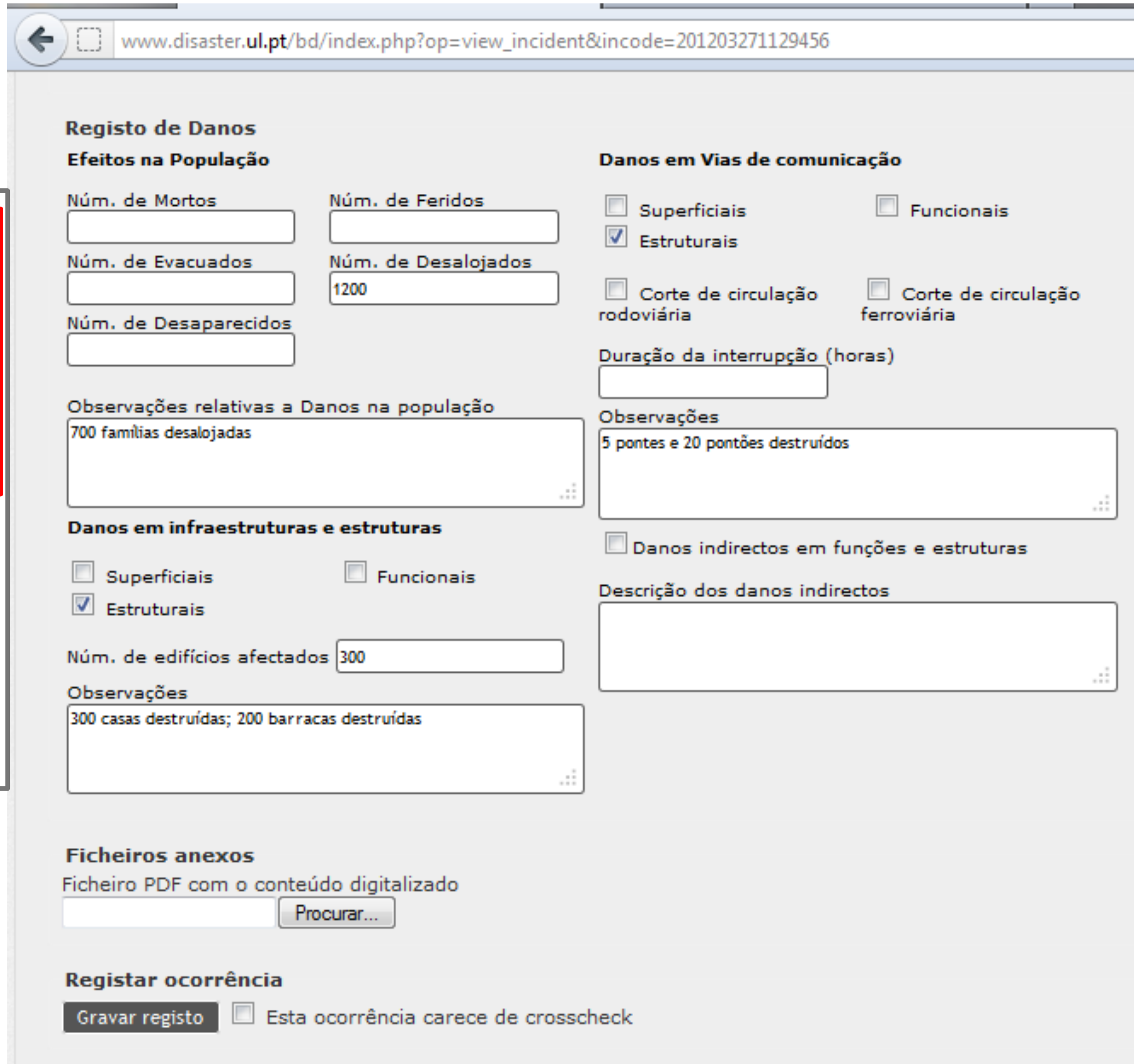




The DISASTER database





www.disaster.ul.pt/bd/index.php?op=view_incident&incode=201203271129456

Registo de Danos

Efeitos na População

Núm. de Mortos:
Núm. de Feridos:
Núm. de Evacuados:
Núm. de Desalojados: 1200
Núm. de Desaparecidos:

Observações relativas a Danos na população: 700 famílias desalojadas

Danos em infraestruturas e estruturas

- [ ] Superficiais
- [ ] Funcionais
- [x] Estruturais

Núm. de edifícios afectados: 300

Observações: 300 casas destruídas; 200 barracas destruídas

Danos em Vias de comunicação

- [ ] Superficiais
- [ ] Funcionais
- [x] Estruturais
- [ ] Corte de circulação rodoviária
- [ ] Corte de circulação ferroviária

Duração da interrupção (horas):

Observações: 5 pontes e 20 pontões destruídos

- [ ] Danos indirectos em funções e estruturas

Descrição dos danos indirectos:

Ficheiros anexos

Ficheiro PDF com o conteúdo digitalizado [Procurar...]

Registar ocorrência

[Gravar registo] - [ ] Esta ocorrência carece de crosscheck

The DISASTER database

DN reportagem

Mar de angústia e desespero

A estrada de Loures ficou transformada num autêntico mar, com carros submersos, como a imagem documenta junto do desvio para Bucelas. E torrente, acabando esmagadas de encontro às casas

«Meu Deus!, eu não mereço que isto me aconteça...»

Enxurrada

As hortas de Loures desapareceram por completo e muitas dezenas de cabeças de gado ficaram enterradas na água e no lodo. A população, servindo-se de barcaças, procurava, a todo o custo, «desbravar» tamanha tragédia, após uma noite de pânico e sofrimento. A zona da Mealhada, ontem, cerca das 13 horas, era ainda esta imagem desoladora

DN 20-11-1983

DIÁRIO DE NOTÍCIAS 22-11-1983 — PÁGINA 9

O TEMPORAL EM TODO O PAÍS

Depois de uma noite de pânico Setúbal volta à tranquilidade

Causas por apurar

Prejuízos no concelho de Loures ascendem a dois milhões de contos

● Setecentas famílias desalojadas num total de 1200 pessoas

Emergência em Cascais custa um milhão de contos

Quem paga as facturas?

— pergunta-se na Câmara da Amadora

Segundo o município local

Perdas muito vultosas na indústria de Torres Vedras

5. Results

Hydrogeomorphological disaster cases and their human consequences in mainland Portugal in the period 1865–2015

	Floods	Landslides	Total
Number of cases	1658	292	1950
Number of deaths	1015	241	1256
Number of missing people	71	23	94
Number of injured people	479	433	912
Number of evacuated people	14061	823	14884
Number of displaced people	40365	1612	41977

5. Results

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Top 10 hydrogeomorphological disaster events occurred in mainland Portugal in the period 1865–2015

Rank	Event type	Date	Affected districts	Event duration (days)	# disaster cases	Fatalities	Injured people	Evacuated people	Displaced people
1	FF; UF	25 Nov 1967	11, 15	2	67	522	330	304	885
2	F; FF; UF; L	20-28 Dec 1909	1, 3, 4, 5,6, 9,10,11,13, 14, 15,16,17,18	9	83	37	4	679	478
3	F; FF	15-17 Feb 1941	11, 15	3	6	33	0	109	0
4	F; L	9-12 Feb 1904	1, 3, 13, 17	4	4	27	1	1	3
5	F; FF	25-26 Nov 1865	11	2	9	21	0	0	0
6	FF; UF; L	18-19 Nov 1983	11, 14	2	37	18	0	255	3239
7	FF; UF	2-9 Nov 1997	2, 8, 14, 15	8	16	11	22	141	134
8	F; FF; L	5-16 Feb 1979	5, 6, 11, 13, 14, 17	12	67	8	3	4244	14322
9	F; UF; L	2-6 Jan 1940	4, 7, 11, 14, 15, 17	5	26	7	3	35	1043
10	F; L	26-27 Jan 2001	1, 3, 6, 9, 10,13, 17, 18	2	28	6	5	402	570

Event type: F (flood); FF (flash flood); UF (urban flood); L (landslide)

Districts: 1 - Aveiro; 2 – Beja; 3 – Braga; 4 – Bragança; 5 - Castelo Branco; 6 – Coimbra; 7 – Évora; 8 – Faro; 9 – Guarda; 10 – Leiria; 11 – Lisboa; 12 – Portalegre; 13 – Porto; 14 – Santarém; 15 – Setúbal; 16 - Viana do Castelo; 17 - Vila Real; 18 – Viseu

Geographical distribution of disastrous floods

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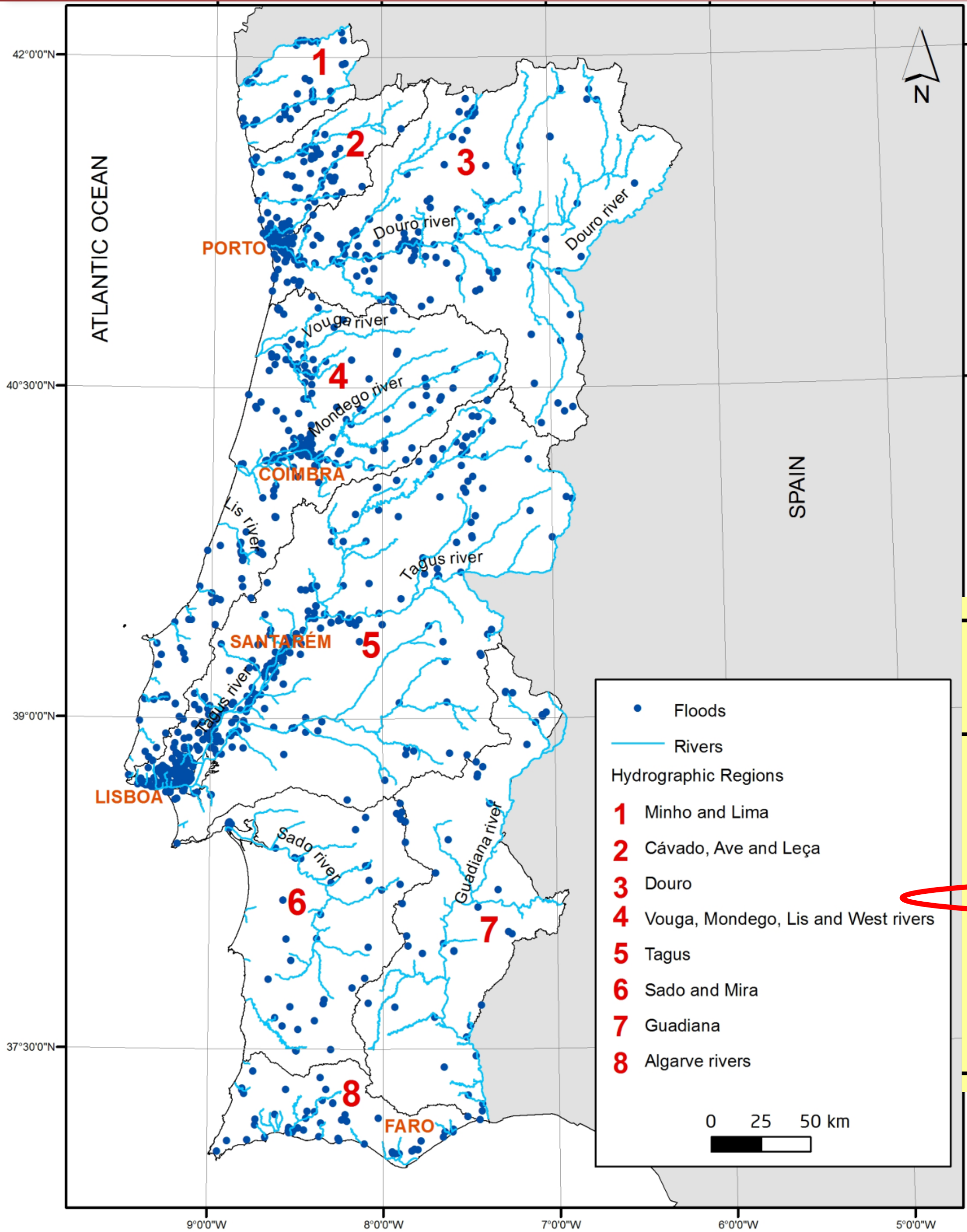

Main flood disaster clusters:

- Lisbon region and the Tagus valley
- Oporto region and the Douro valley
- Coimbra region and the Mondego valley
- Vouga valley

Hydro. Region	Area (%)	DISASTER Cases density (#/10^3km^2)	Death and missing people (%)	Evacuated people (%)	Displaced people (%)
1	2.7	18.7	2.6	1.0	0.0
2	3.8	29.5	3.8	3.6	0.7
3	21.2	18.8	9.5	11.1	35.6
4	15.6	22.3	8.3	14.5	2.7
5	28.2	26.3	67.5	60.0	59.0
6	11.2	5.1	2.8	1.9	0.6
7	13.0	3.6	3.7	0.5	0.4
8	4.3	16.2	1.8	7.4	1.1
Total	100.0	18.2	100.0	100.0	100.0

Geographical distribution of disastrous landslides

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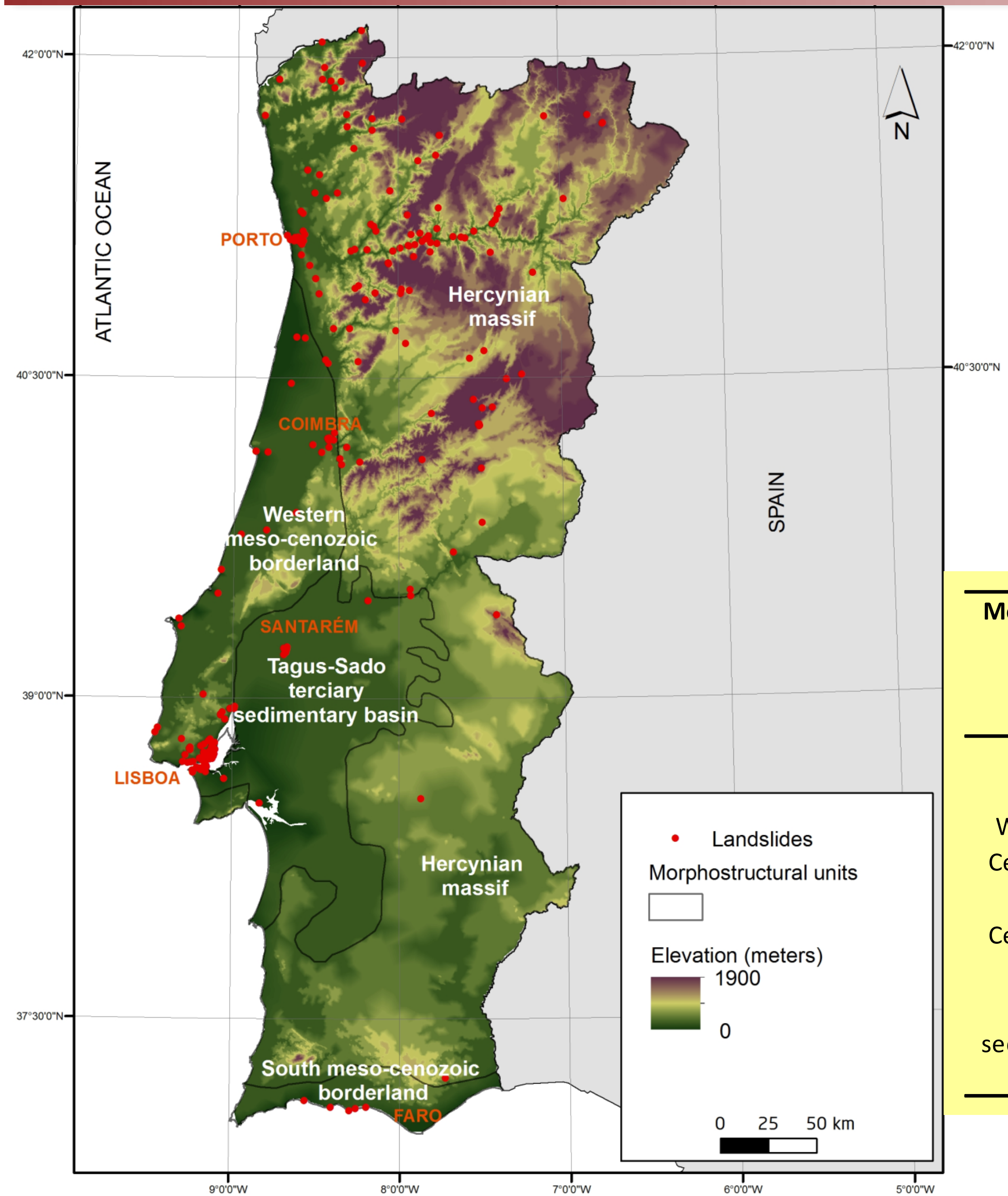

Main landslide disaster clusters:

- Lisbon region
- Porto city
- Douro valley

Morphostructural unit	Area (%)	DISASTER Cases density (#/10³km²)	Death and missing people (%)	Evacuated people (%)	Displaced people (%)
Hercynian massif	84.0	2.3	72.9	21.1	39.7
Western Meso-Cenozoic border.	13.1	10.3	21.0	69.2	37.0
South Meso-Cenozoic border.	2.9	2.2	2.3	0.0	0.0
Tagus-Sado Tertiary sedimentary basin	17.2	1.9	3.8	9.6	23.3
Total	100.0	3.4	100.0	100.0	100.0

Temporal trends of disasters

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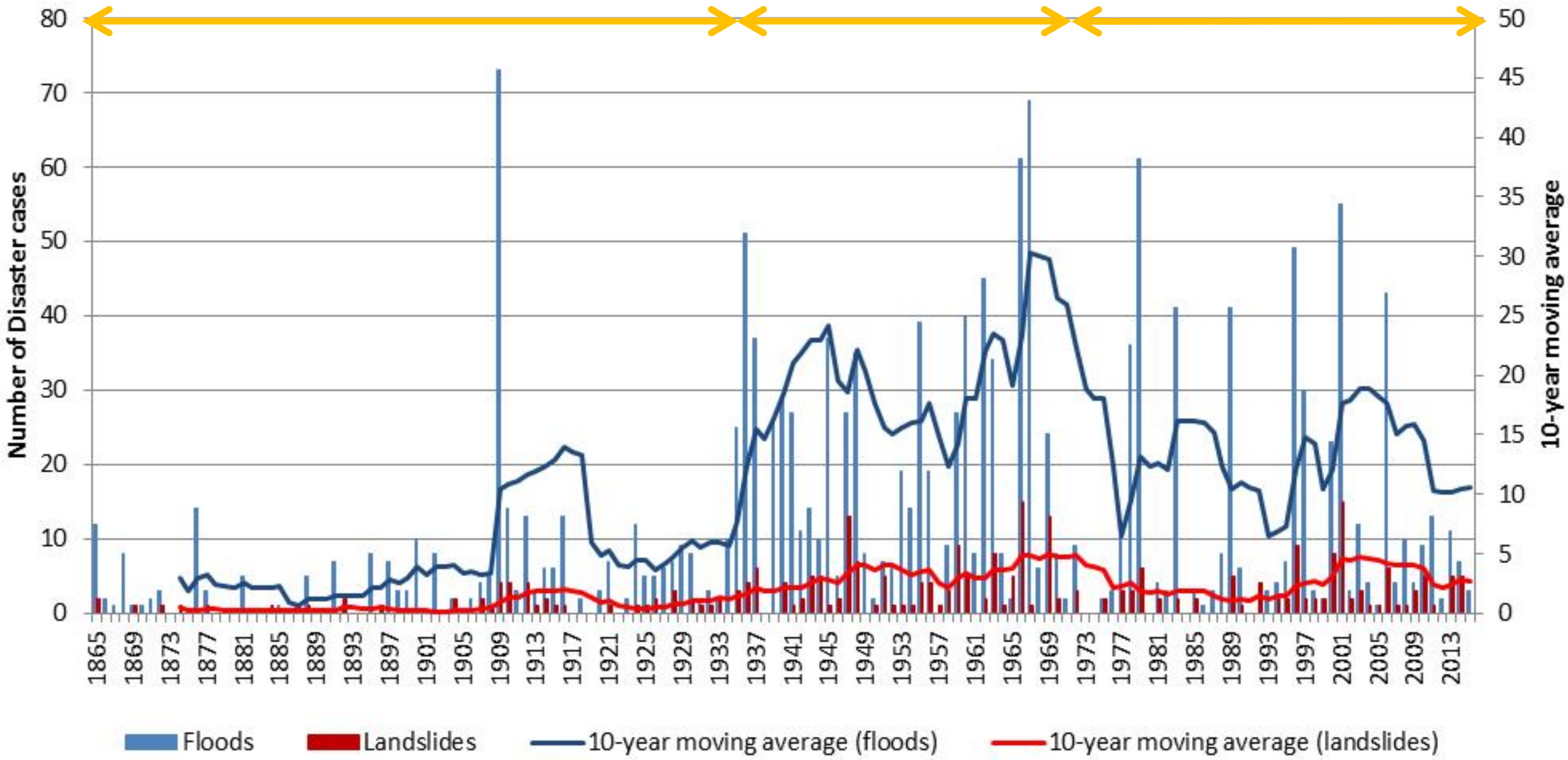
Total series: 10.9 disastrous floods per year; 1.9 disastrous landslides per year

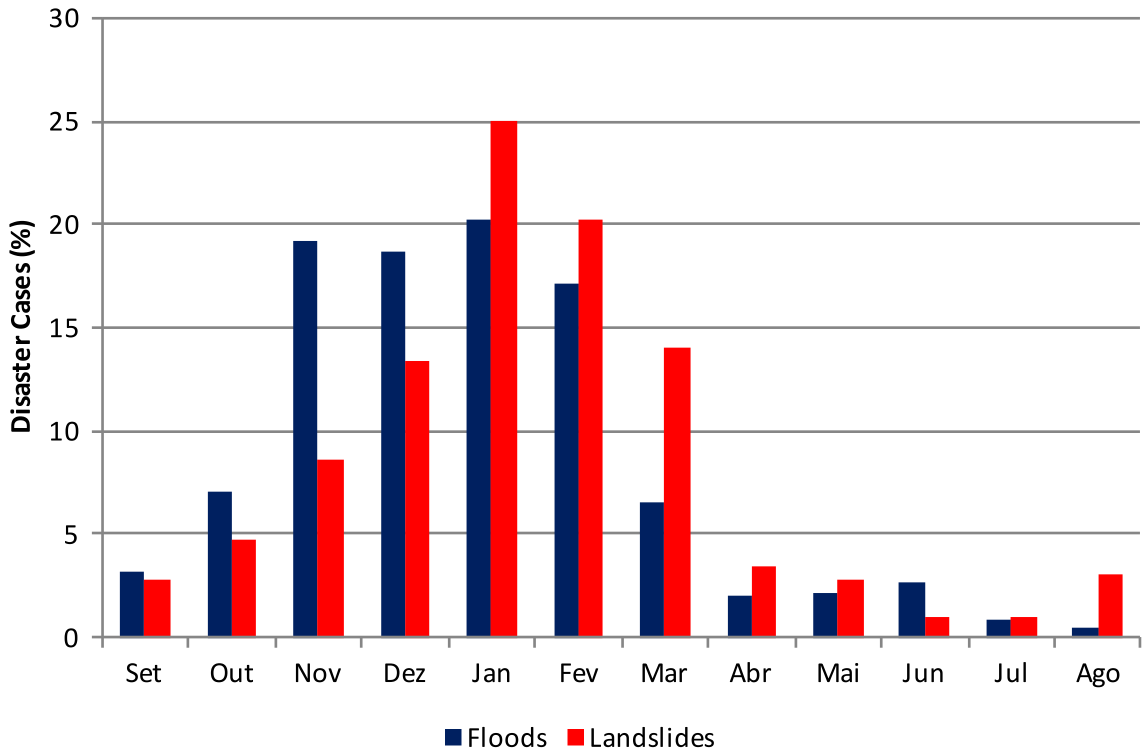
Time period 1 (1865-1934)
4.8 floods; 0.7 landslides/year

Time period 2 (1935-1969)
22.3 floods; 3.8 landslides/year

Time period 3 (1970-2015)
11.8 floods; 2.4 landslides/year



Seasonal distribution



Floods - more frequent from November to February (75% of cases)

Landslides – more frequent from December to March (73 % of cases)

Mortality patterns of hydrogeomorphological disasters

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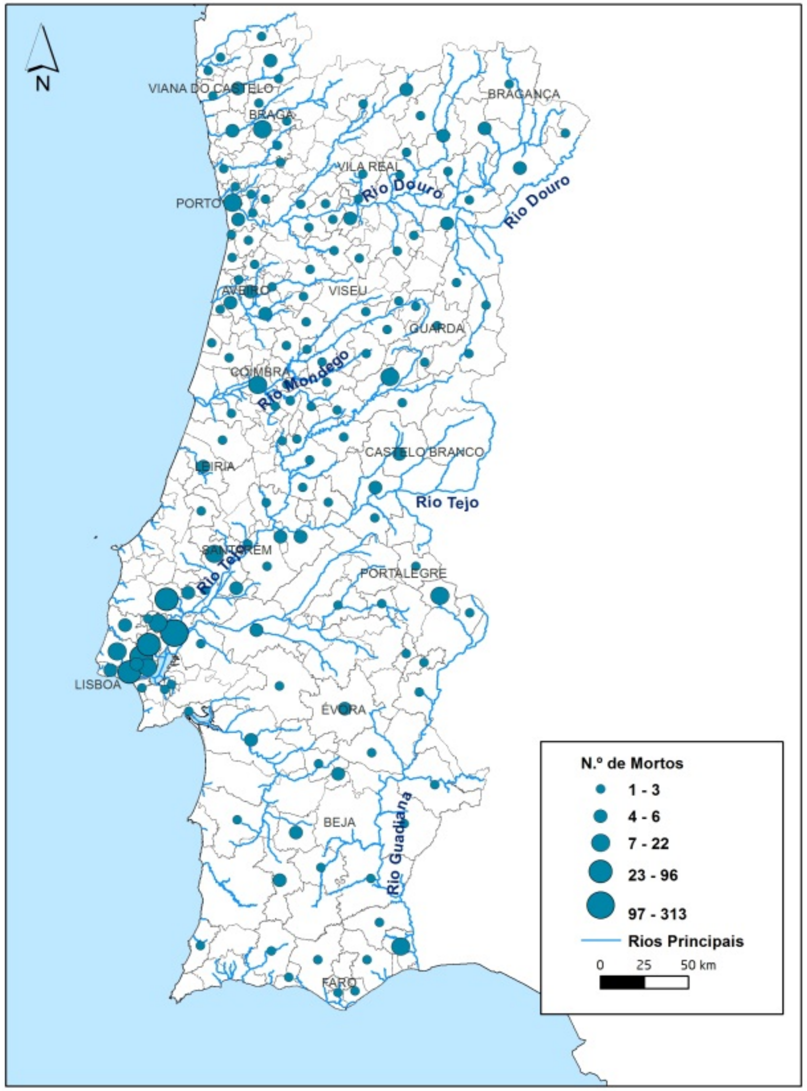

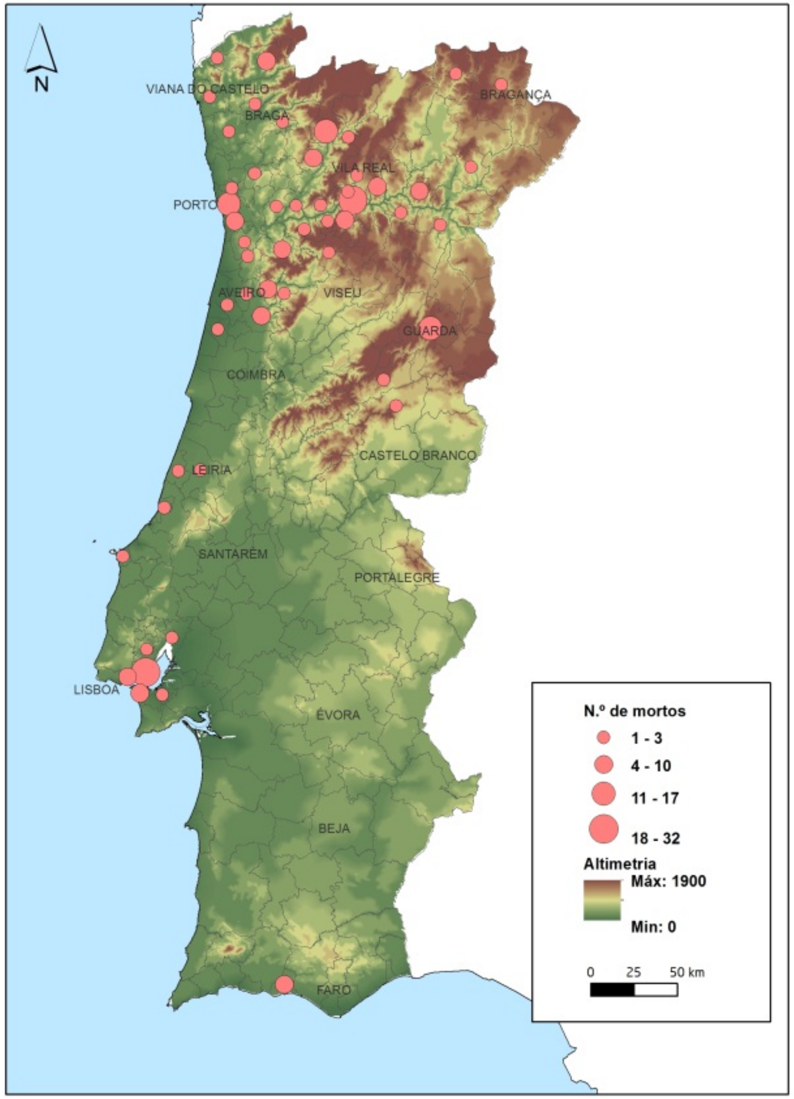

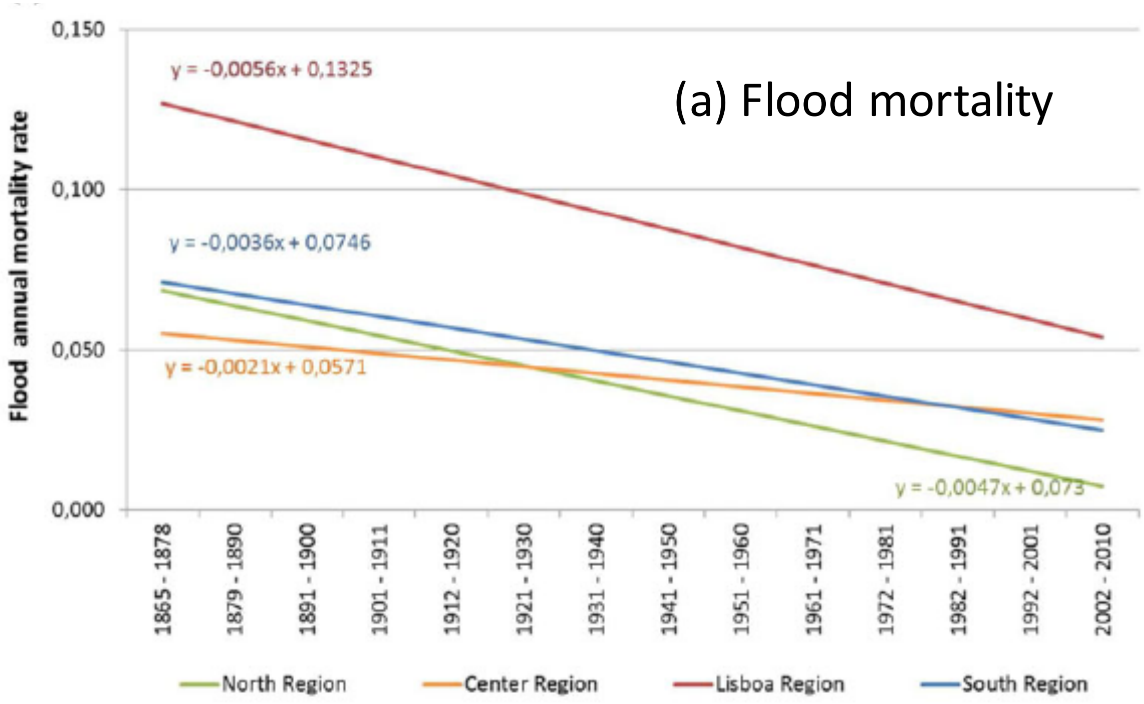

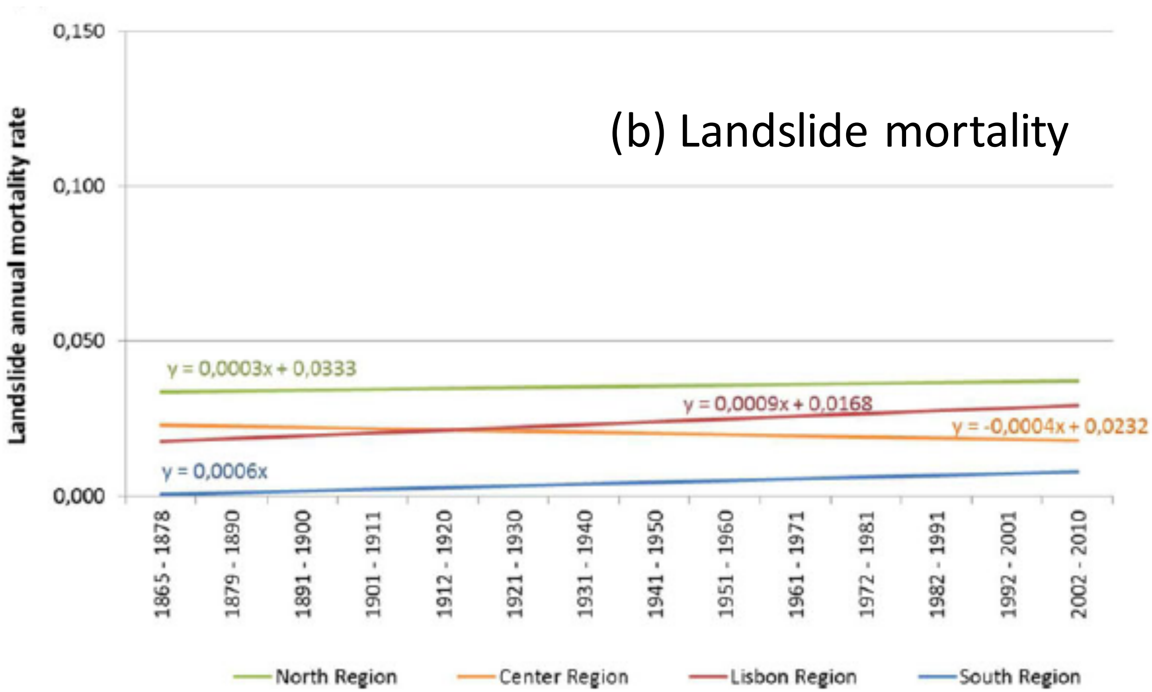

Linear regression of flood (a) and landslide (b) mortality rates per decade for each Portuguese region

Mortality patterns of hydrogeomorphological disasters

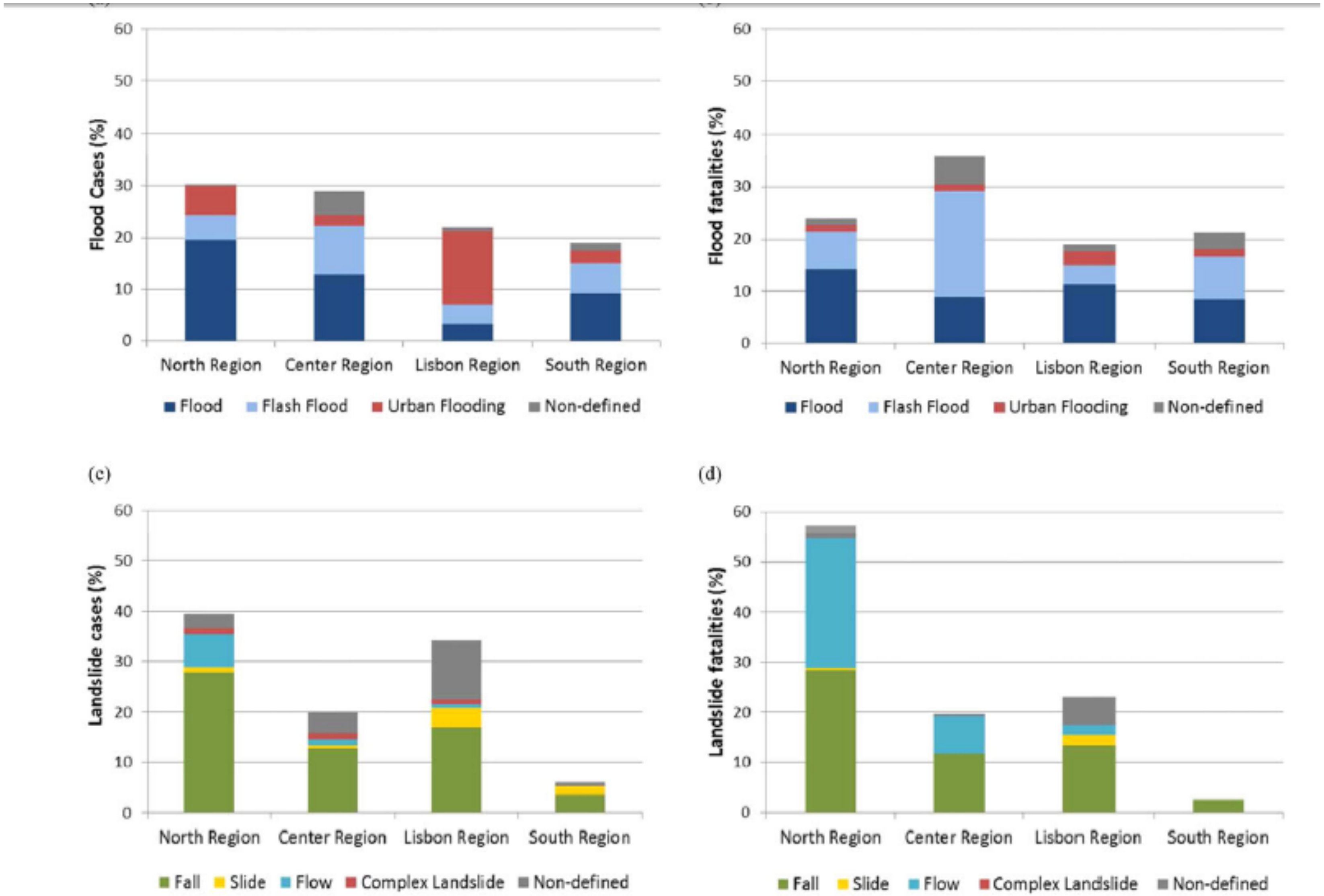

Fig. 9. Frequency of flood DISASTER cases (a) and flood mortality (b) by flood type and frequency of landslide DISASTER cases (c) and landslide mortality (d) by landslide type for each Portuguese region in the period of 1865–2010. The flash flood event of November 1967 was not considered.

Mortality patterns of hydrogeomorphological disasters

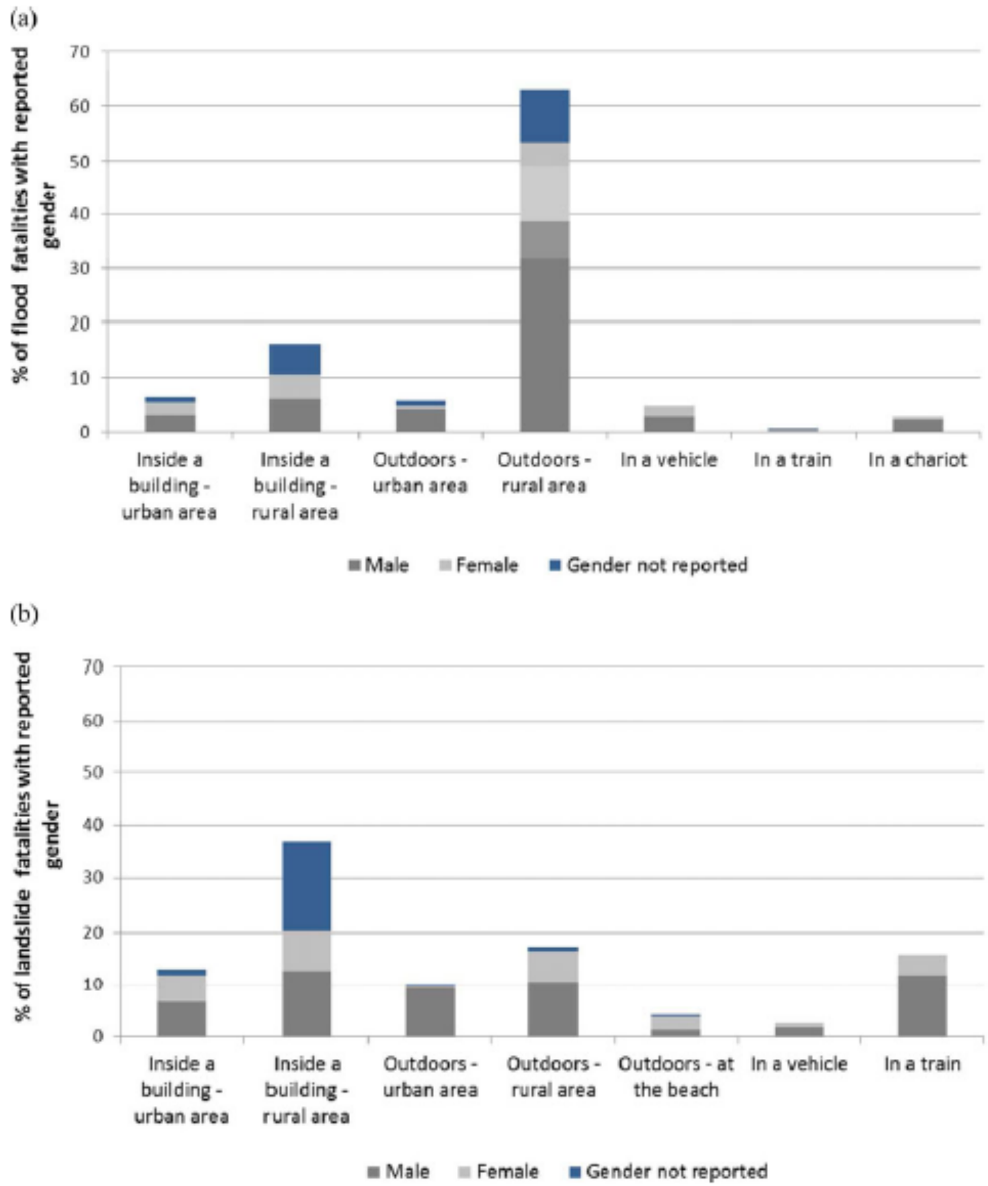

Fig. 12. Circumstances surrounding the flood (a) and landslide (b) fatalities per gender.

Completeness of the Disaster database

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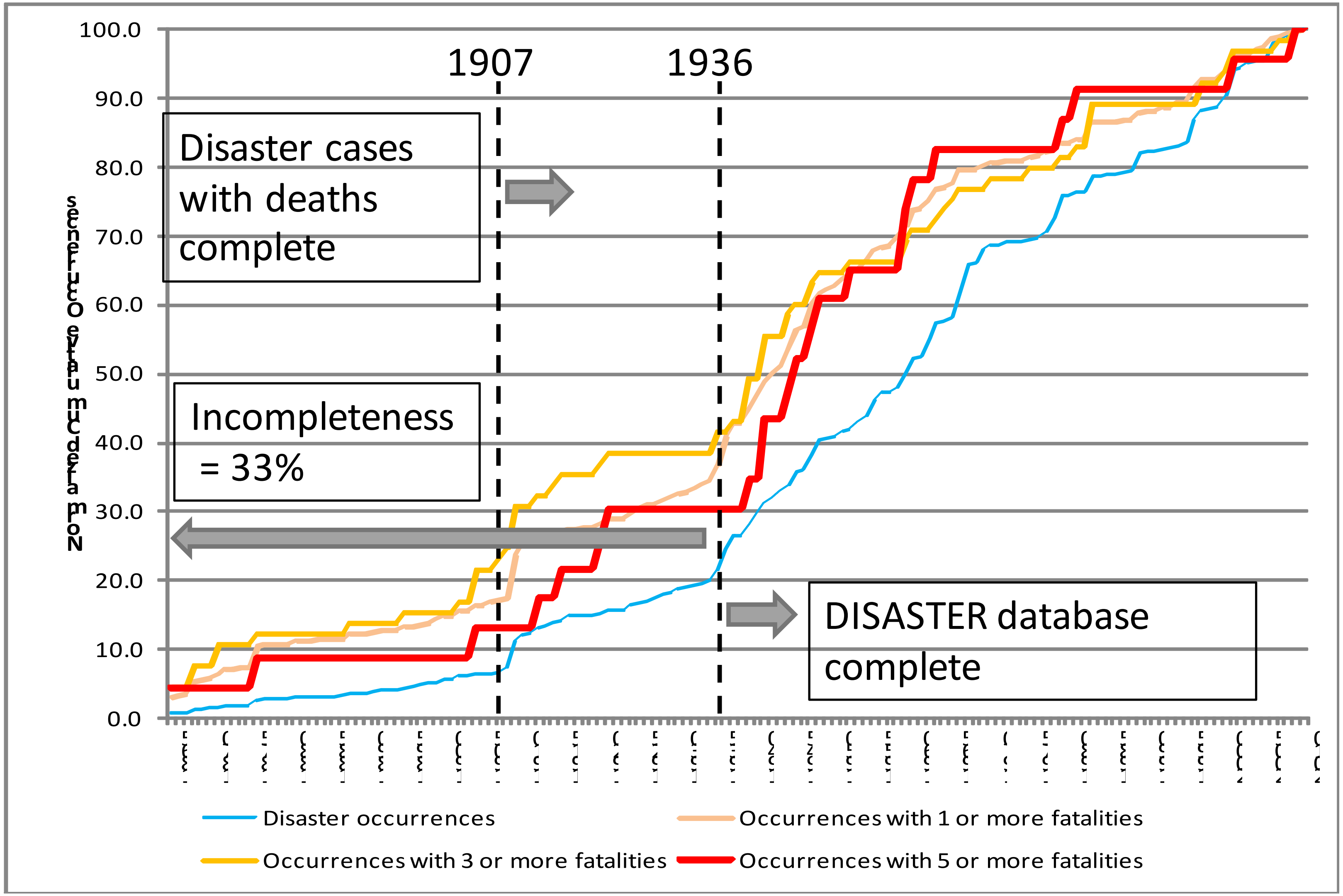

Completeness of the Disaster database

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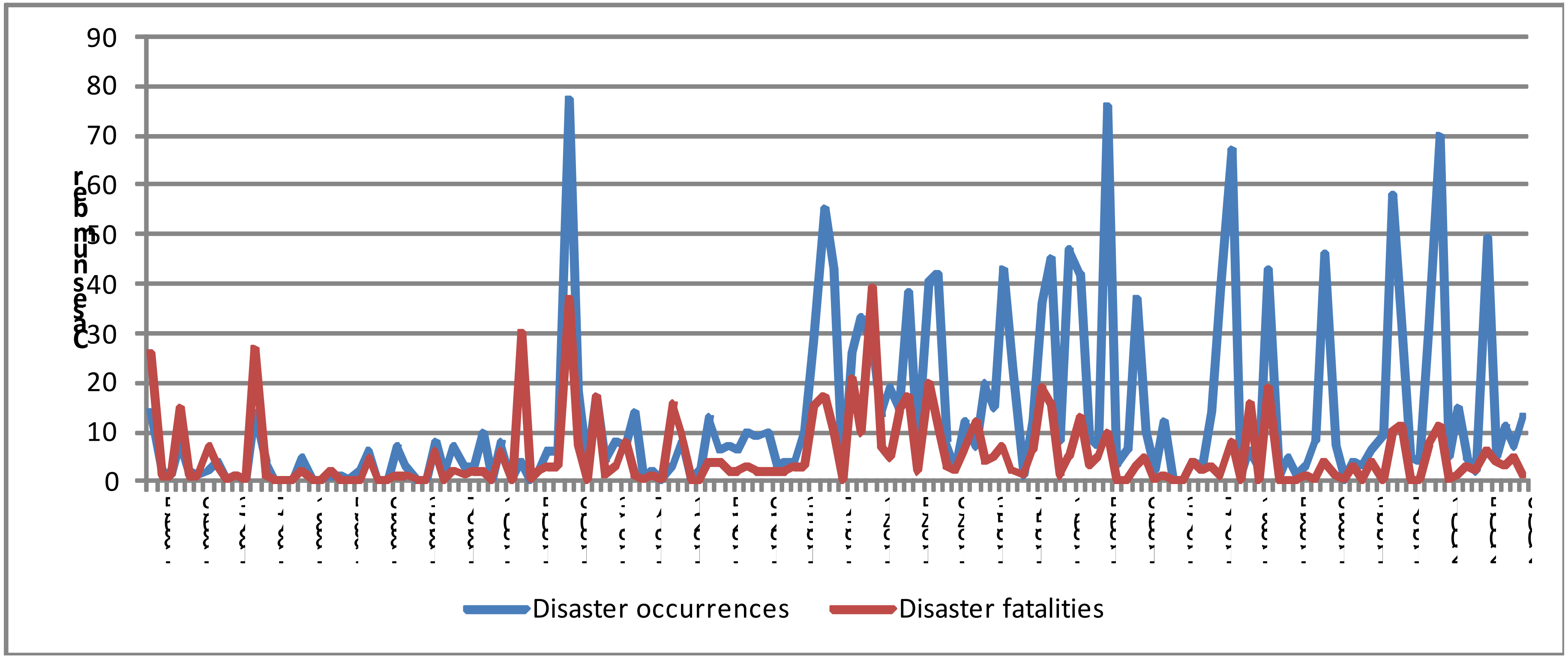

Incompleteness of the Disaster Database:

- The database is incomplete at about **33% in the period prior to 1936** (170 to 180 missing occurrences).
- The missing occurrences are mostly **cases without mortality** (mainly in the period 1907-1936).
- In relative terms, the incompleteness is higher in country **zones located more than 100 km away from Lisbon and Porto**.

Comparison between the Disaster Database and the EM-DAT

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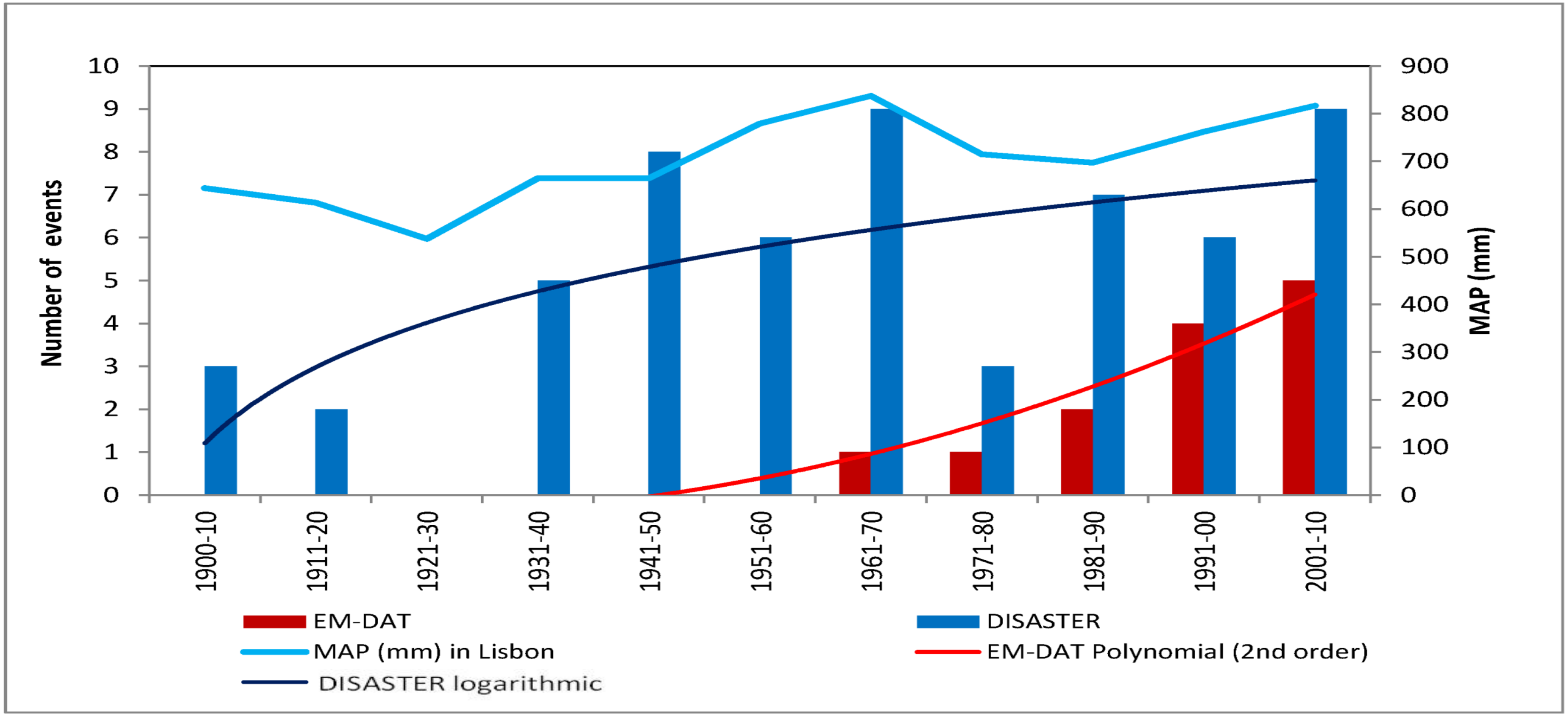
(The DISASTER events fulfill the EM-DAT entry criteria)



	EM-DAT	DISASTER	Difference
Events (N)	13	58	446%
Fatalities (N)	567	865	153%

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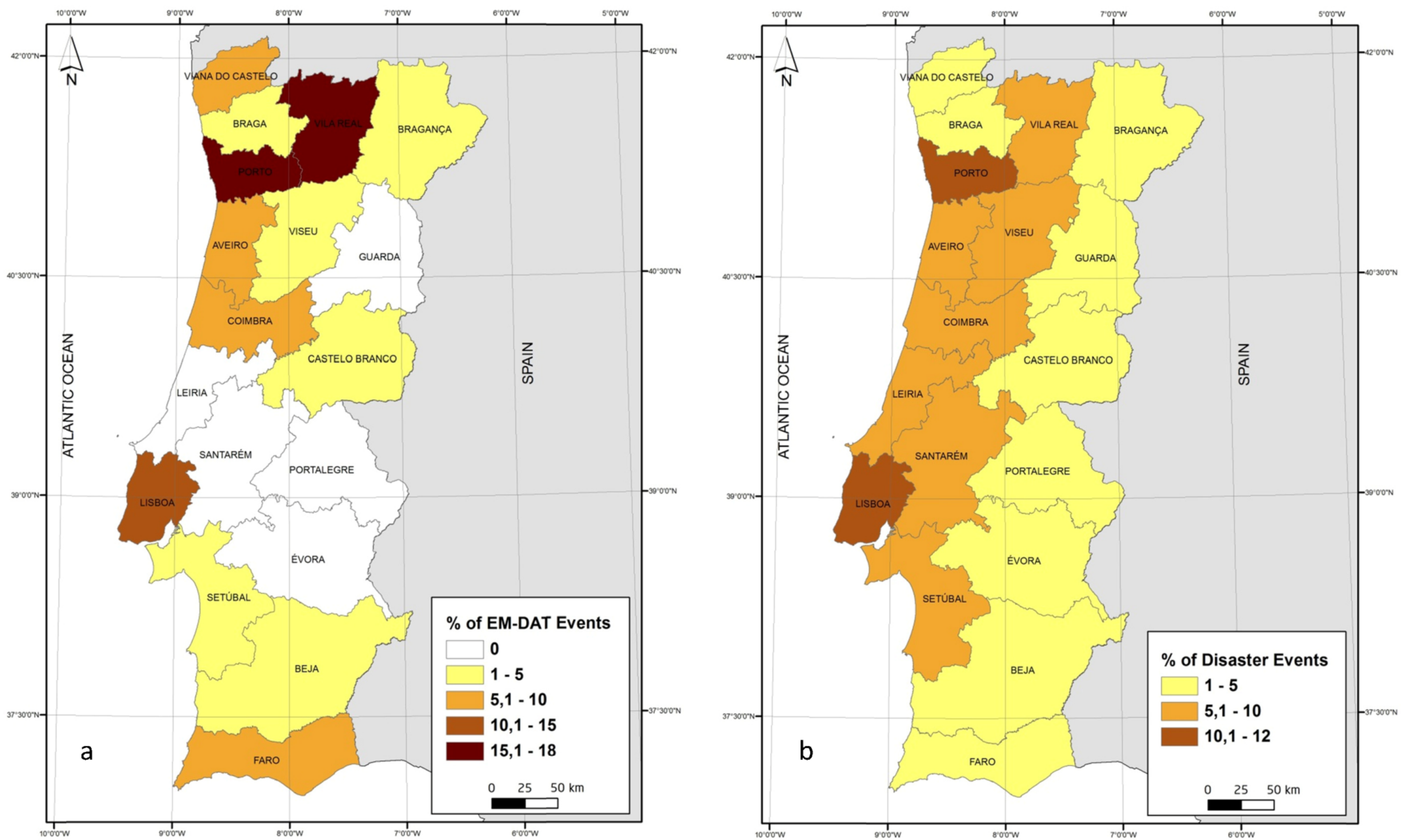
Distribution of hydro-geomorphologic disastrous events (percentage) on Portuguese districts according to the EM-DAT (a) and the DISASTER (b) databases (period: 1900-2010). (the DISASTER events fulfill the EM-DAT entry criteria)



6. A step forward

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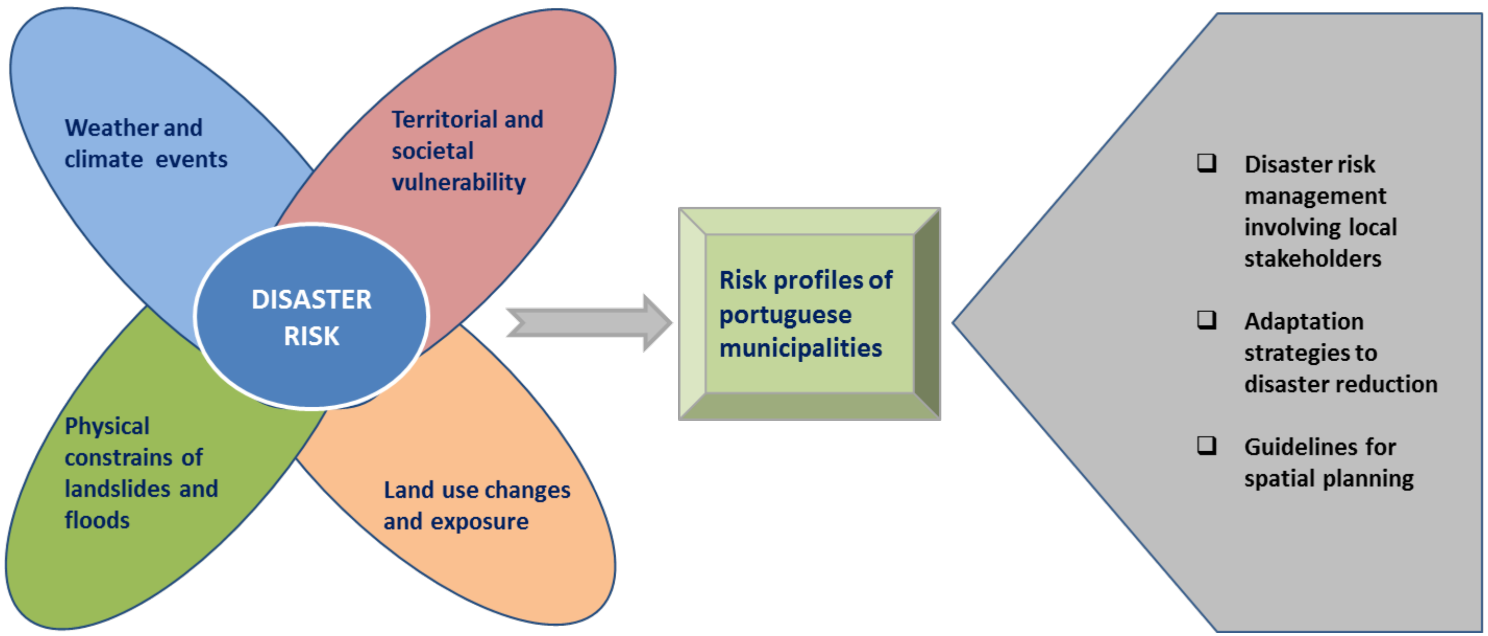
FORLAND

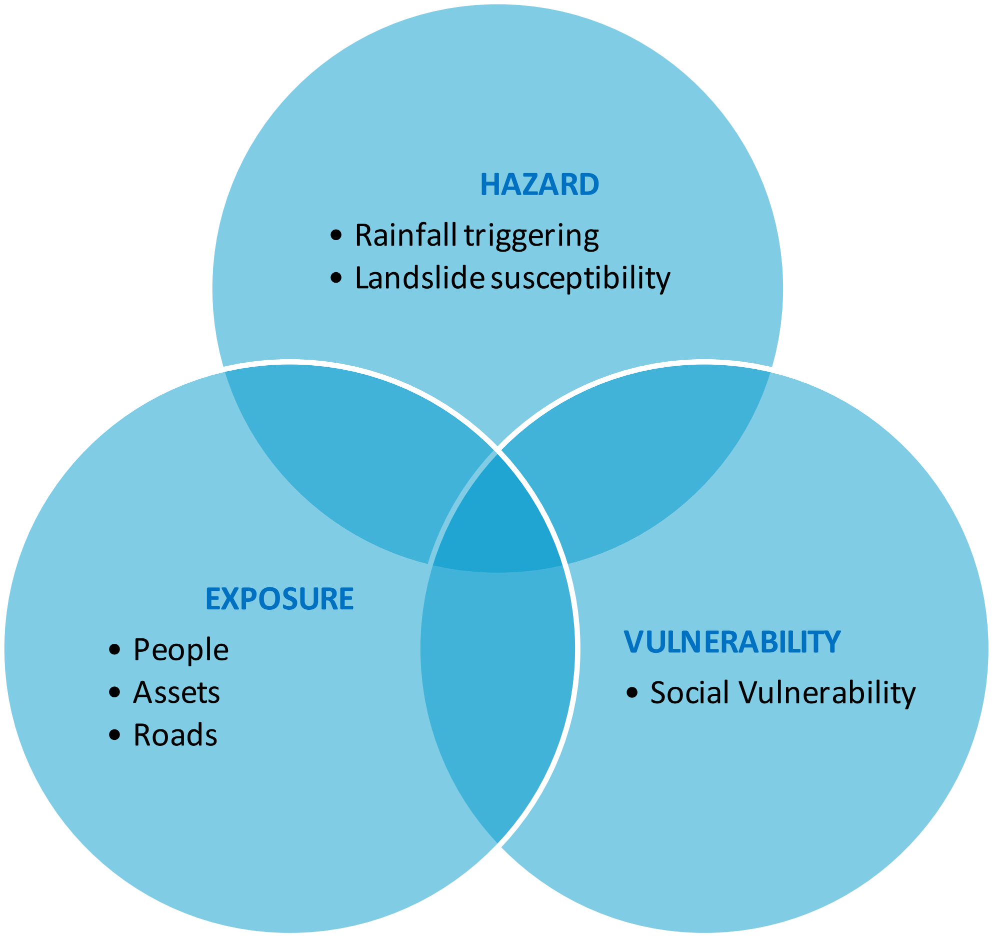
FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

FORLAND - Hydro-geomorphologic risk in Portugal:
driving forces and application for land use planning (2016-2019)

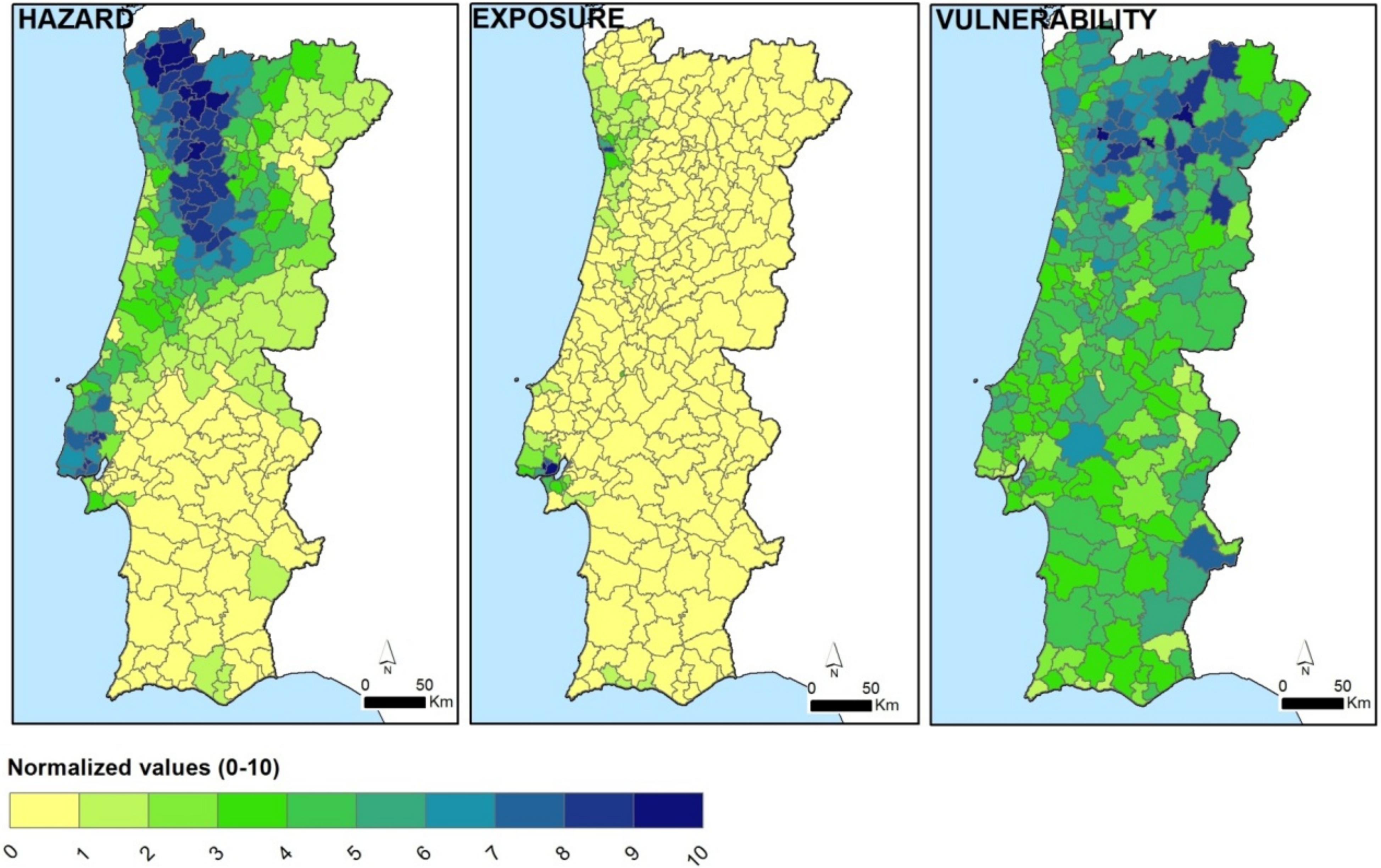
HYDRO-GEOMORPHOLOGIC DISASTER RISK SYSTEM

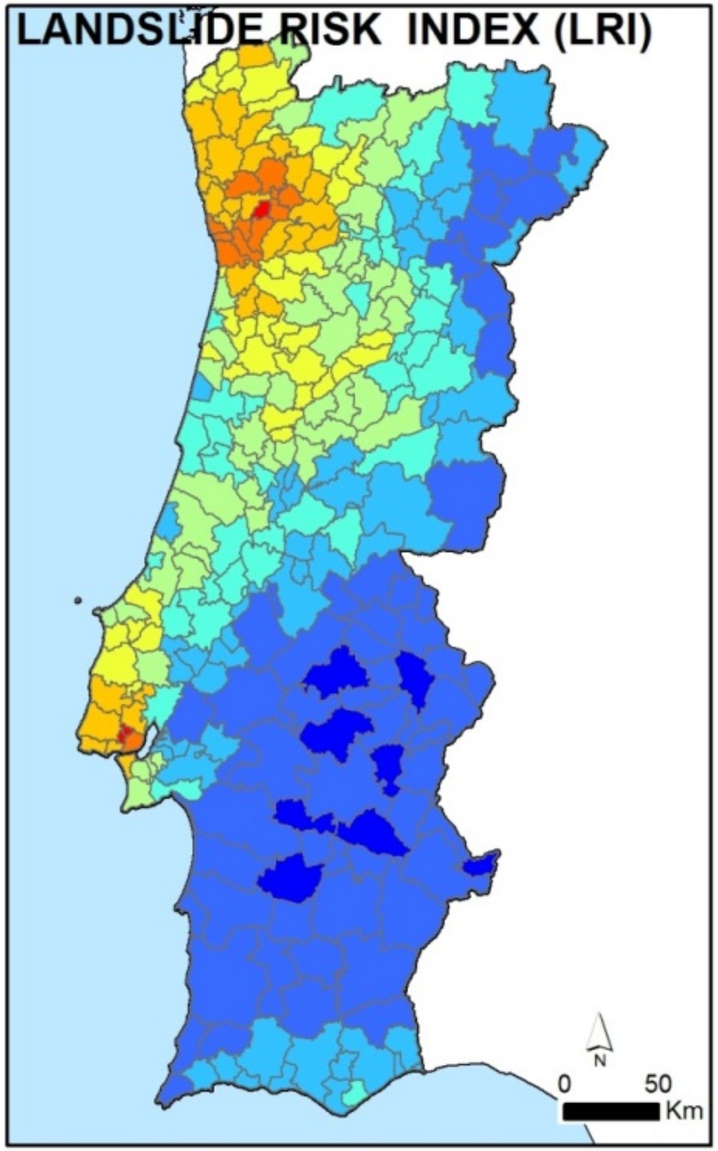
ADAPTATION AND MITIGATION TO MUNICIPAL LEVEL





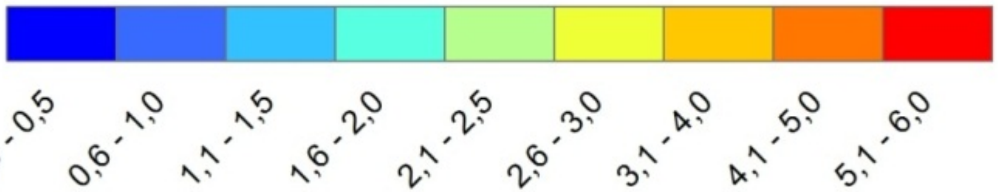
LANDSLIDE RISK INDEX= $(\text{HAZARD}^{1/3})*(\text{EXPOSURE}^{1/3})*(\text{VULNERABILITY}^{1/3})$


HAZARD
EXPOSURE
VULNERABILITY
N
0 50
Km
Normalized values (0-10)
0
1
2
3
4
5
6
7
8
9
10



LRI = (HAZARD^1/3) * (EXPOSURE^1/3) * (VULNERABILITY^1/3)

Landslide Risk Index (LRI)



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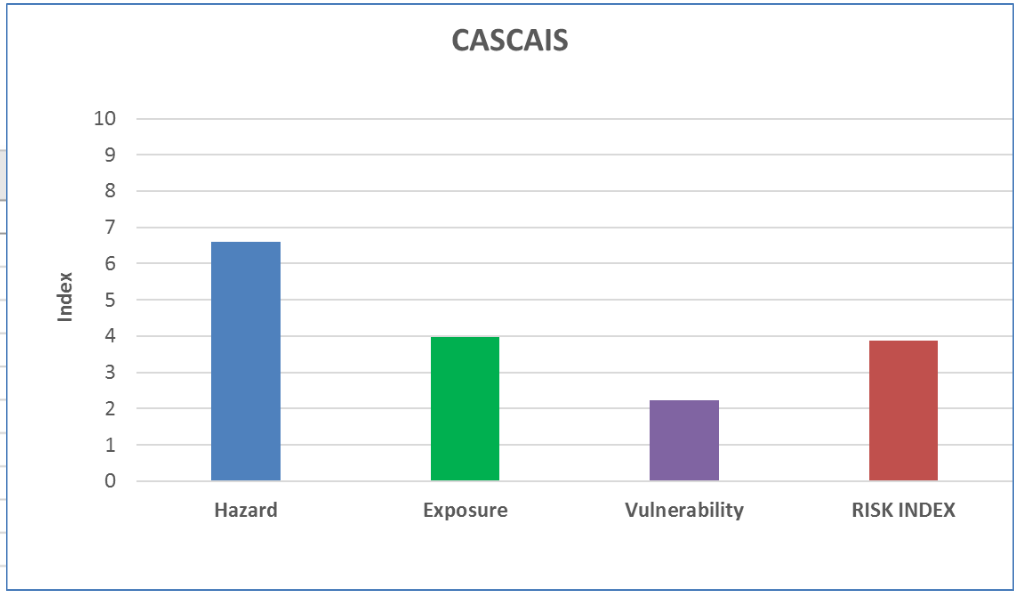
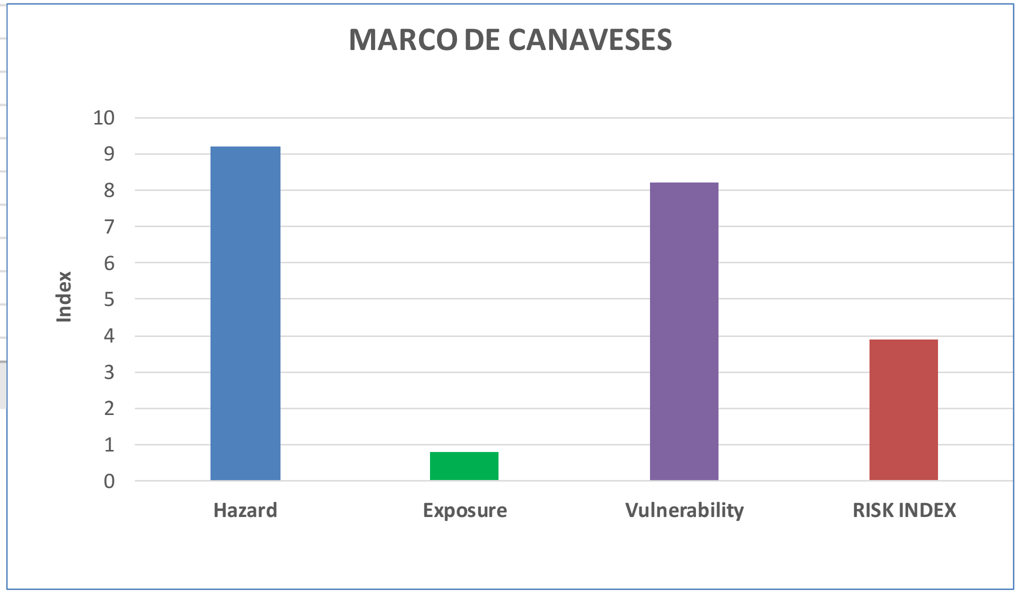
Landslide Risk Profile of Portuguese municipalities

cod_conc	Hazard	Exposure	Vulnerability	RISK INDEX
AMADORA	8.29	9.37	2.85	6.05
ODIVELAS	8.25	7.60	2.71	5.54
PAÇOS DE FERREIRA	8.21	2.02	7.63	5.02
MATOSINHOS	6.16	5.37	3.42	4.84
VIZELA	9.14	1.81	6.51	4.75
PORTO	6.92	8.89	1.65	4.67
LOUSADA	8.63	1.29	9.04	4.65
VALONGO	6.78	2.85	5.16	4.64
VILA NOVA DE FAMAL	7.44	1.99	5.74	4.39
PAREDES	7.31	1.86	6.20	4.39
VILA NOVA DE GAIA	4.83	3.44	4.68	4.27
LISBOA	7.24	9.33	1.14	4.26
FELGUEIRAS	8.85	1.17	7.18	4.21
GONDOMAR	5.05	2.41	5.87	4.15
GUIMARÃES	8.20	1.61	5.18	4.09
CASCAIS	6.61	3.97	2.23	3.88
MARCO DE CANAVESE	9.23	0.77	8.20	3.87
FAFE	9.48	0.79	7.74	3.87
SANTO TIRSO	6.44	1.48	6.05	3.86
BRAGA	7.10	2.27	3.55	3.85
PENAFIEL	8.60	0.94	6.77	3.80
LOURES	6.51	2.63	3.13	3.77
CELORICO DE BASTO	8.99	0.76	7.74	3.75

TABELA COMPLETA | LDR | LDI





7. Take-home message

- For the first time in Portugal, the DISASTER project created a comprehensive GIS database on disastrous floods and landslides.

- The spatial and temporal trends observed on disastrous floods and landslides reflect the distribution of predisposing factors, the temporal incidence of triggering factors, but also the evolution of the exposure and the vulnerability of people, structures and infrastructures.

- It is not evident any exponential growth tendency of the hydro-geomorphologic events with time, although the increasing number of disaster events consisting of several disaster cases after the late 1970's may be related with the increasing occurrence of rainfall extreme events related with climate change.

- This database allows for the knowledge of the disaster drivers and their distinct incidence both in time and in space, which should be considered by stakeholders responsible for civil protection and spatial planning in order to manage and reduce disaster risk.

8. References

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Thank you for your attention!

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