CIRAC

A multi-criteria approach for flood risk mapping evaluation using depth-damage curves.

The Algés stream case - Portugal.

L. Dias [1,2]; F. Braunschweig [3]; N. Grosso [1]; R. Jacinto [1]; P. Garrett [1]

[1] CCIAM - Climate Change Research Group, Faculty of Ciencies of the University of Lisbon; (FCUL).
[2] Faculty of Architecture, TU Lisbon,(Phd candidate).
[3] Action Modulers, Consultores de Segurança.

Hydropredict, 24 septembre 2012
www.siam.fc.ul.pt/cirac

www.sim.ul.pt/cciam

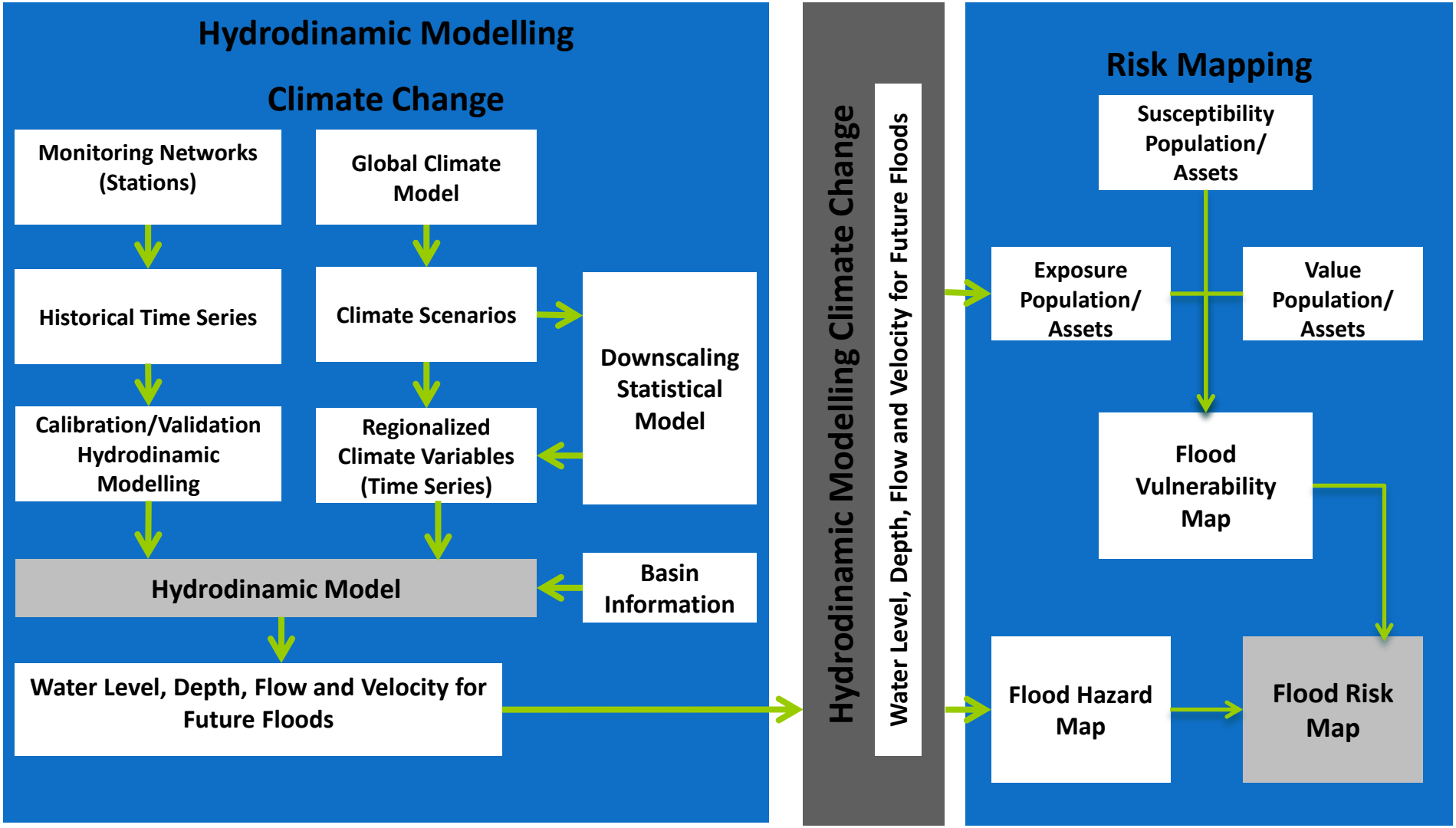
1. Overview

2. Definitions/Concepts

3. Flood Risk Evaluation

4. Next steps

Overview


Hydrodinamic Modelling
Climate Change
Monitoring Networks (Stations)
Global Climate Model
Historical Time Series
Climate Scenarios
Downscaling Statistical Model
Calibration/Validation Hydrodinamic Modelling
Regionalized Climate Variables (Time Series)
Hydrodinamic Model
Basin Information
Water Level, Depth, Flow and Velocity for Future Floods
Hydrodinamic Modelling Climate Change
Water Level, Depth, Flow and Velocity for Future Floods
Risk Mapping
Susceptibility Population/ Assets
Exposure Population/ Assets
Value Population/ Assets
Flood Vulnerability Map
Flood Hazard Map
Flood Risk Map

Definitions/Concepts

Risk = Potential Adverse Consequence × Probability of Occurrence

Where the **Potential Adverse Consequence** is dependent on the flood and takes into account factors such as exposure and vulnerability. Risk is expressed as a potential loss in a particular area (e.g. ha, km2) within a given time period (in general, one year).

Potential Adverse Consequence = V × S (mh) × E

V, **S** e **E** are vulnerability parameters and **mh** represents the potential magnitude of hazard.

E = Exposure.

V = value of the element at risk.

The susceptibility **(S)** is associated with the magnitude of hazard (**mh**), and provides a measure of the damaging effect on the element at risk, ranging from 0 (not susceptible) to 100 (maximum susceptibility).

This parameter is usually determined using damage curves, relating water depth or flood duration weith the potential damages.

Source: ISDR (2004)

Flood Damage Categories

Category	Tangible				Intangible
	Direct		Indirect		
	Primary	Secondary	Primary	Secondary	
Examples	Structures, contents, agriculture	Land and environment recovery	Business Interruptions	Impact on regional and national economy	Health, psychological damage

Flood damages can be primarily classified as tangible and intangible. The tangible damages can be expressed trough monetary value and be further divided in direct and indirect damages.

Source: Dutta *[et. al.]*, (2003)

Component 2:
Land Use

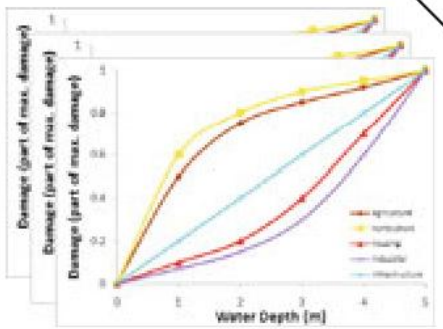
Top10 Vector
CBS2000
CLC2000
RS2000
LGN4

Component 1:
Water Depth

-1.5
0

Component 3:
Depth-Damage Curves

NL Later
Belgian Method
Rhine Atlas



Component 4:
Value of elements at risk

NL Later
Belgian Method
Rhine Atlas

Residential	900 €/m2
Industrial	600 €/m2
Agriculture	25 €/m2
Meadows	10 €/m2
Horticulture	100 €/m2
Nature	5 €/m2

Flood Damage

Fonte: DE Moel, H. and J. Aerts (2010)

Flood Risk Evaluation

N

Legend

Buildings T2

Water Depth T2

- 0,10 - 0,20
- 0,21 - 0,40
- 0,41 - 0,60
- 0,61 - 0,80
- 0,81 - 1,00
- 1,01 - 1,20
- 1,21 - 1,40
- 1,41 - 1,60
- 1,61 - 1,80
- 1,81 - 2,00
- 2,01 - 2,20

CIRAC

SIM

associação portuguesa de seguradores aps

Flood Risk Analysis

Water Depth Map

Coordinate system: *hayford-gauss* **datum 73**

Scale - 0 180 Meters

May 2012

N

Legend

Buildings T5

Water Depth T5

- 0,10 - 0,20
- 0,21 - 0,40
- 0,41 - 0,60
- 0,61 - 0,80
- 0,81 - 1,00
- 1,01 - 1,20
- 1,21 - 1,40
- 1,41 - 1,60
- 1,61 - 1,80
- 1,81 - 2,00
- 2,01 - 2,20

CIRAC

SIM

associação portuguesa de seguradores aps

Flood Risk Analysis

Water Depth Map

Coordinate system: *hayford-gauss* **datum 73**

Scale - 0 180 Meters

May 2012

N

Legend

Buildings T10

Water Depth T10

- 0,10 - 0,20
- 0,21 - 0,40
- 0,41 - 0,60
- 0,61 - 0,80
- 0,81 - 1,00
- 1,01 - 1,20
- 1,21 - 1,40
- 1,41 - 1,60
- 1,61 - 1,80
- 1,81 - 2,00
- 2,01 - 2,20

CIRAC

SIM

associação portuguesa de seguradores aps

Flood Risk Analysis

Water Depth Map

Coordinate system: *hayford-gauss* **datum 73**

Scale - 0 140 Meters

May 2012

N

Legend

Buildings T20

Water Depth T20

- 0,10 - 0,20
- 0,21 - 0,40
- 0,41 - 0,60
- 0,61 - 0,80
- 0,81 - 1,00
- 1,01 - 1,20
- 1,21 - 1,40
- 1,41 - 1,60
- 1,61 - 1,80
- 1,81 - 2,00
- 2,01 - 2,20

CIRAC

SIM

associação portuguesa de seguradores aps

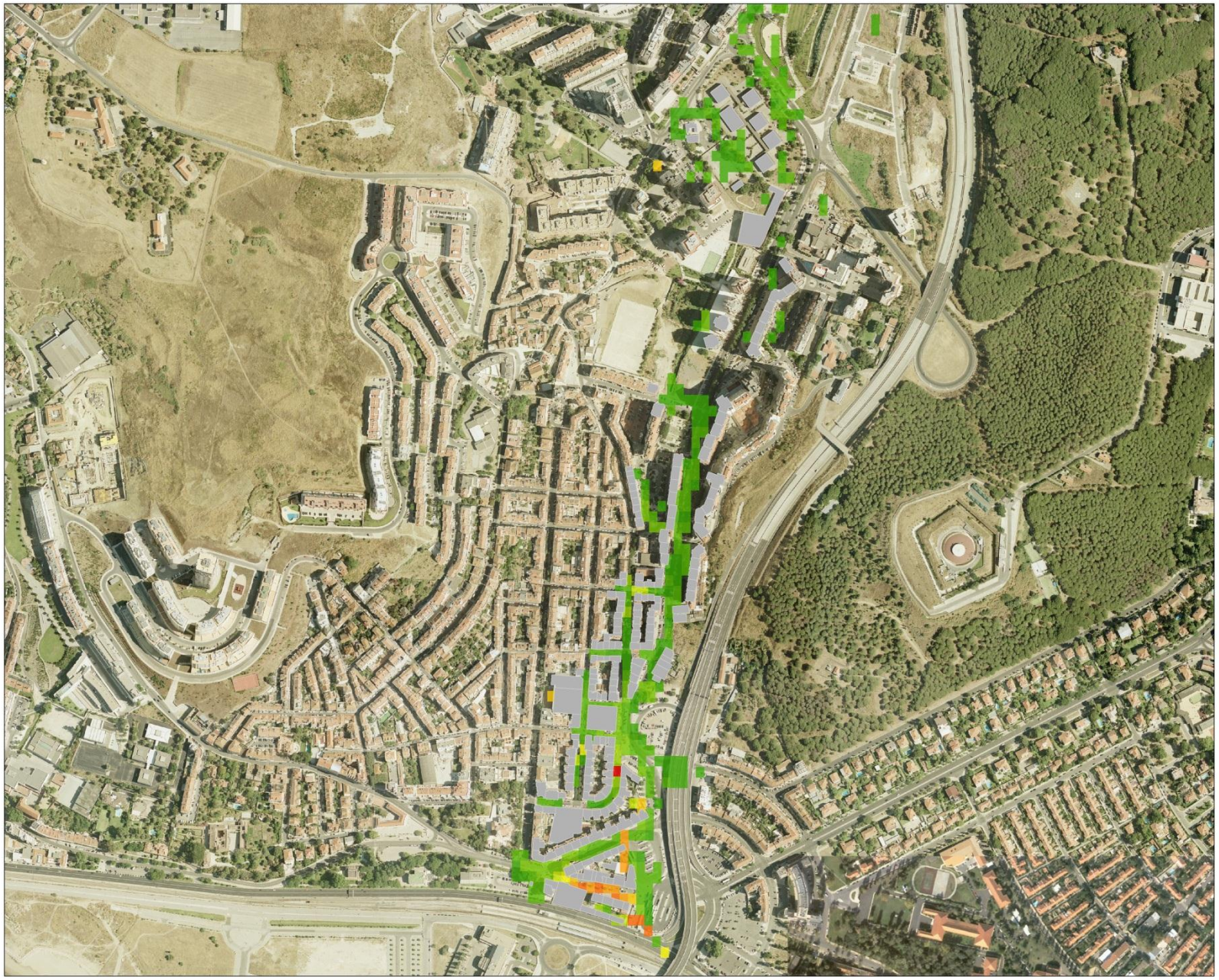
Flood Risk Analysis

Water Depth Map

Coordinate system: *hayford-gauss* **datum 73**

Scale - 0 140 Meters

May 2012



N

Legend

Buildings T50

Water Depth T50

- 0,10 - 0,20
- 0,21 - 0,40
- 0,41 - 0,60
- 0,61 - 0,80
- 0,81 - 1,00
- 1,01 - 1,20
- 1,21 - 1,40
- 1,41 - 1,60
- 1,61 - 1,80
- 1,81 - 2,00
- 2,01 - 2,20

CIRAC

SIM

associação portuguesa de seguradores aps

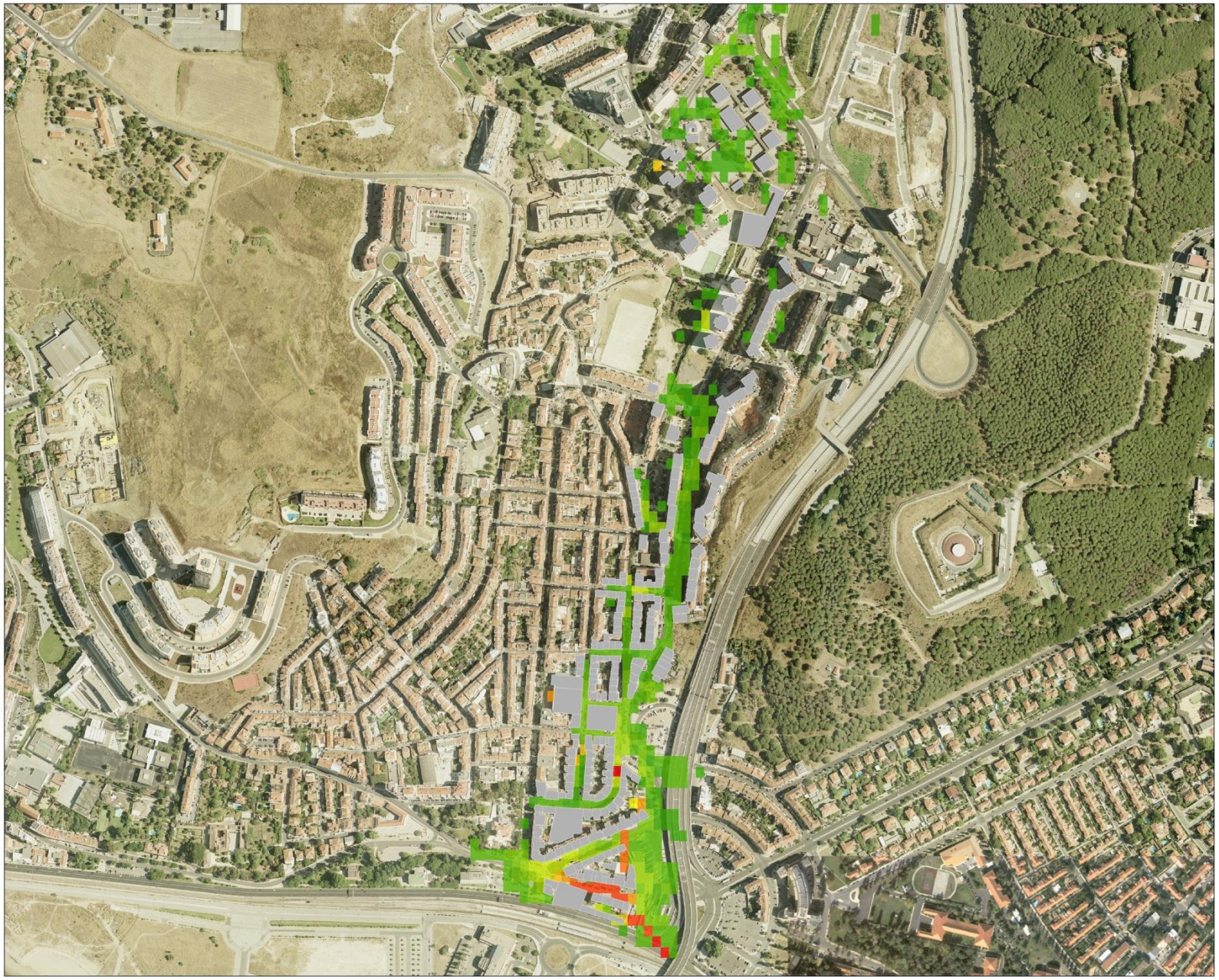
Flood Risk Analysis

Water Depth Map

Coordinate system: *hayford-gauss* **datum 73**

Scale - 0 80 160 Meters

May 2012



N

Legend

Buildings T100

Water Depth T100

- 0,10 - 0,20
- 0,21 - 0,40
- 0,41 - 0,60
- 0,61 - 0,80
- 0,81 - 1,00
- 1,01 - 1,20
- 1,21 - 1,40
- 1,41 - 1,60
- 1,61 - 1,80
- 1,81 - 2,00
- 2,01 - 2,20

CIRAC

SIM

associação portuguesa de seguradores aps

Flood Risk Analysis

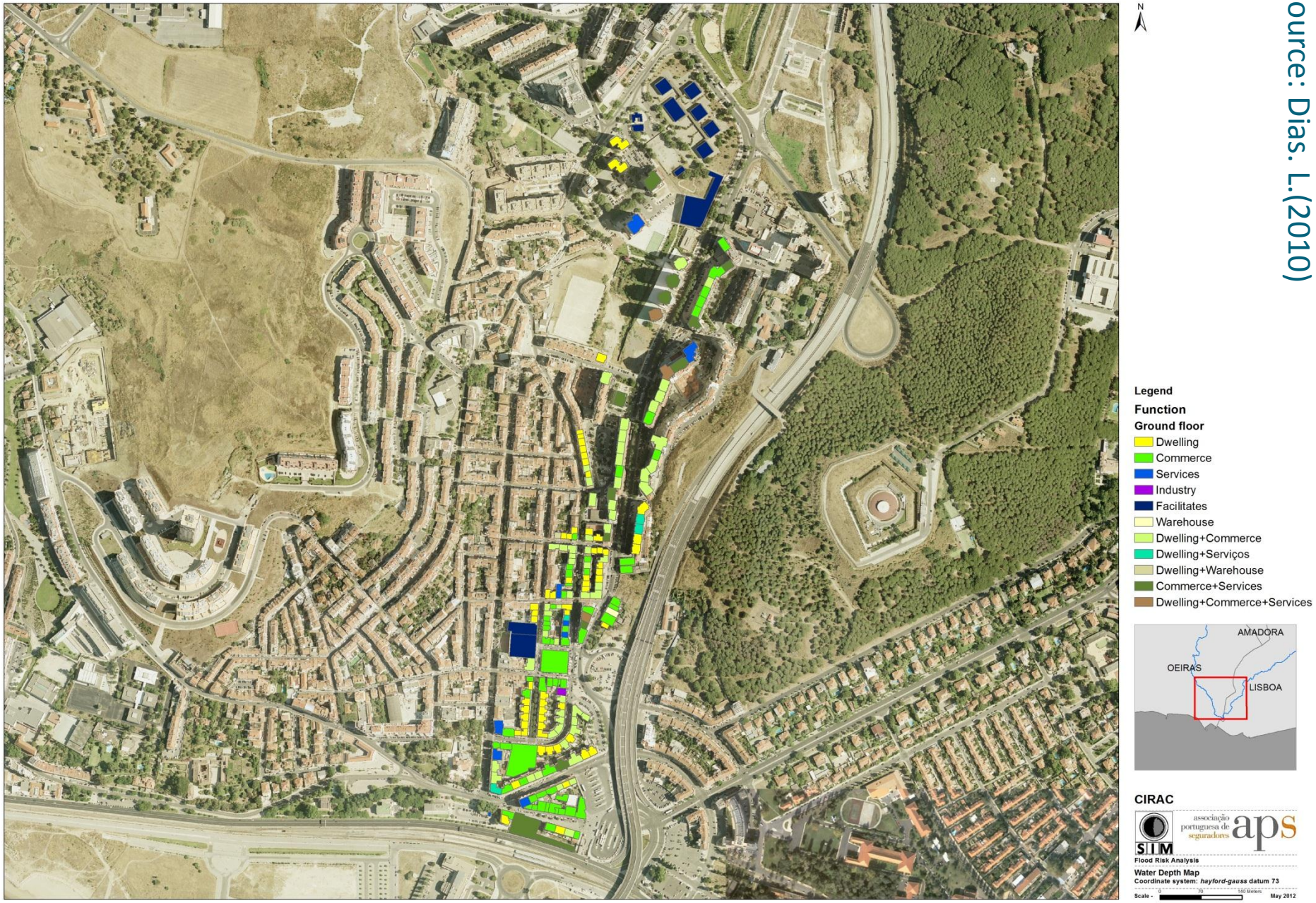
Water Depth Map

Coordinate system: *hayford-gauss* **datum 73**

Scale - 0 80 160 Meters

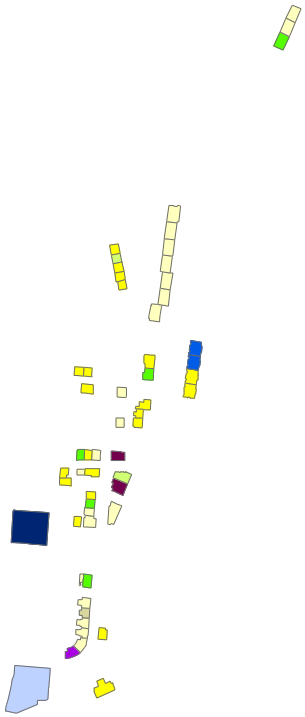
May 2012

Source: Dias. L.(2010)

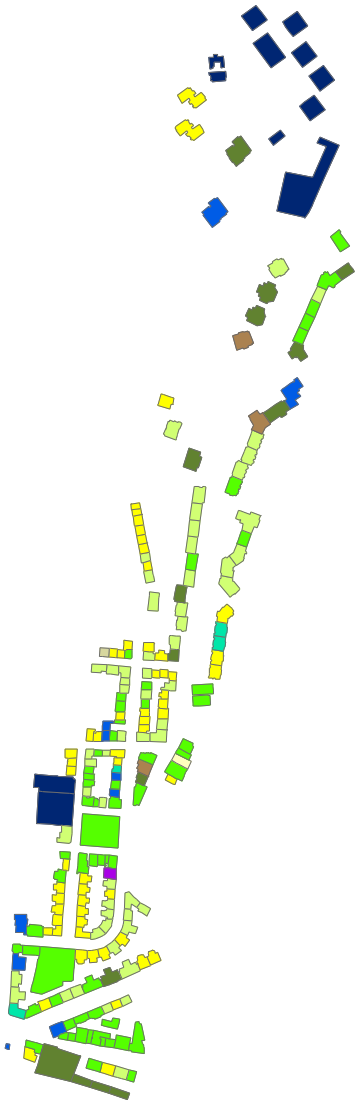


Source: Dias. L.(2010)

Basement



Ground floor

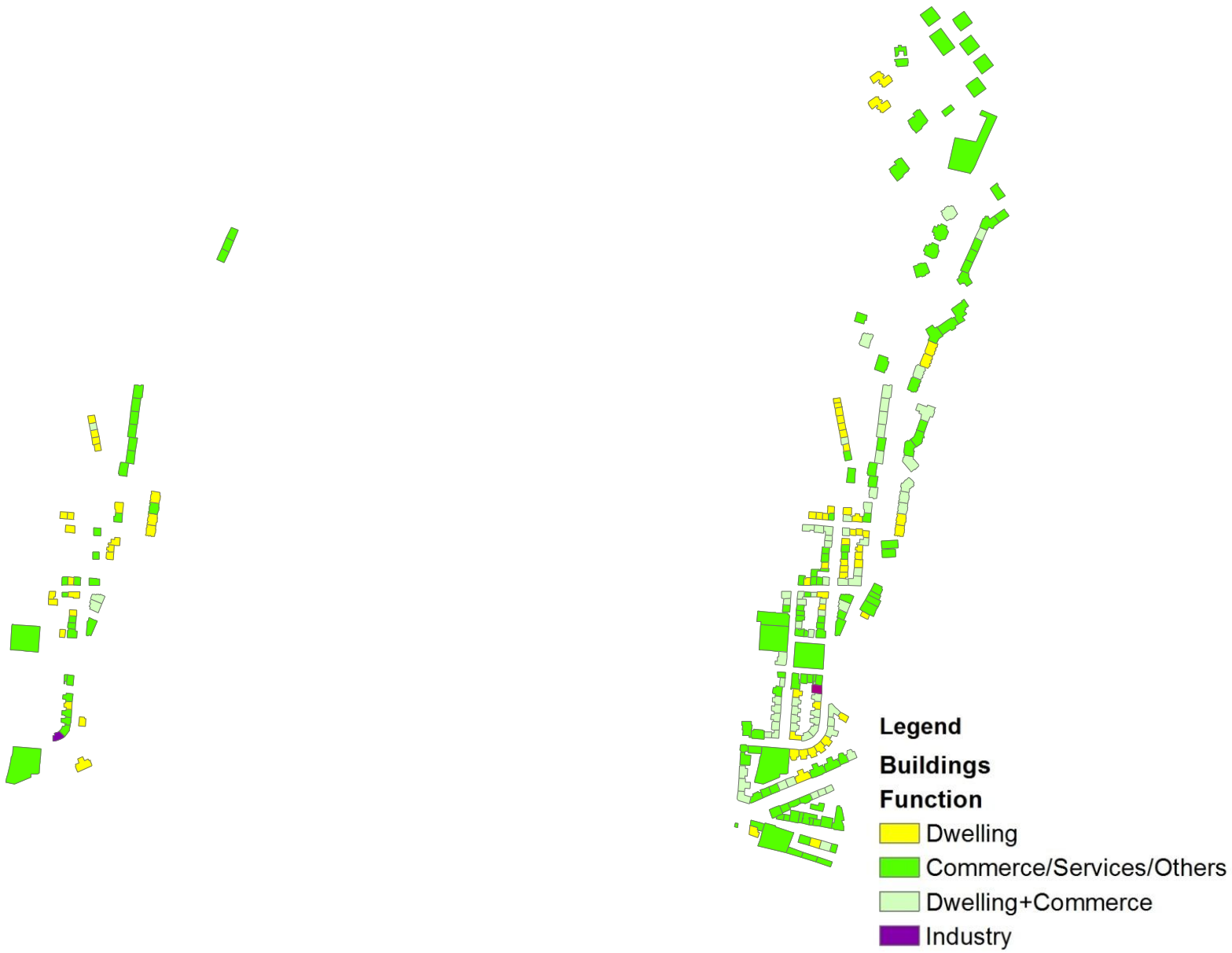


Source: Dias. L.(2010)

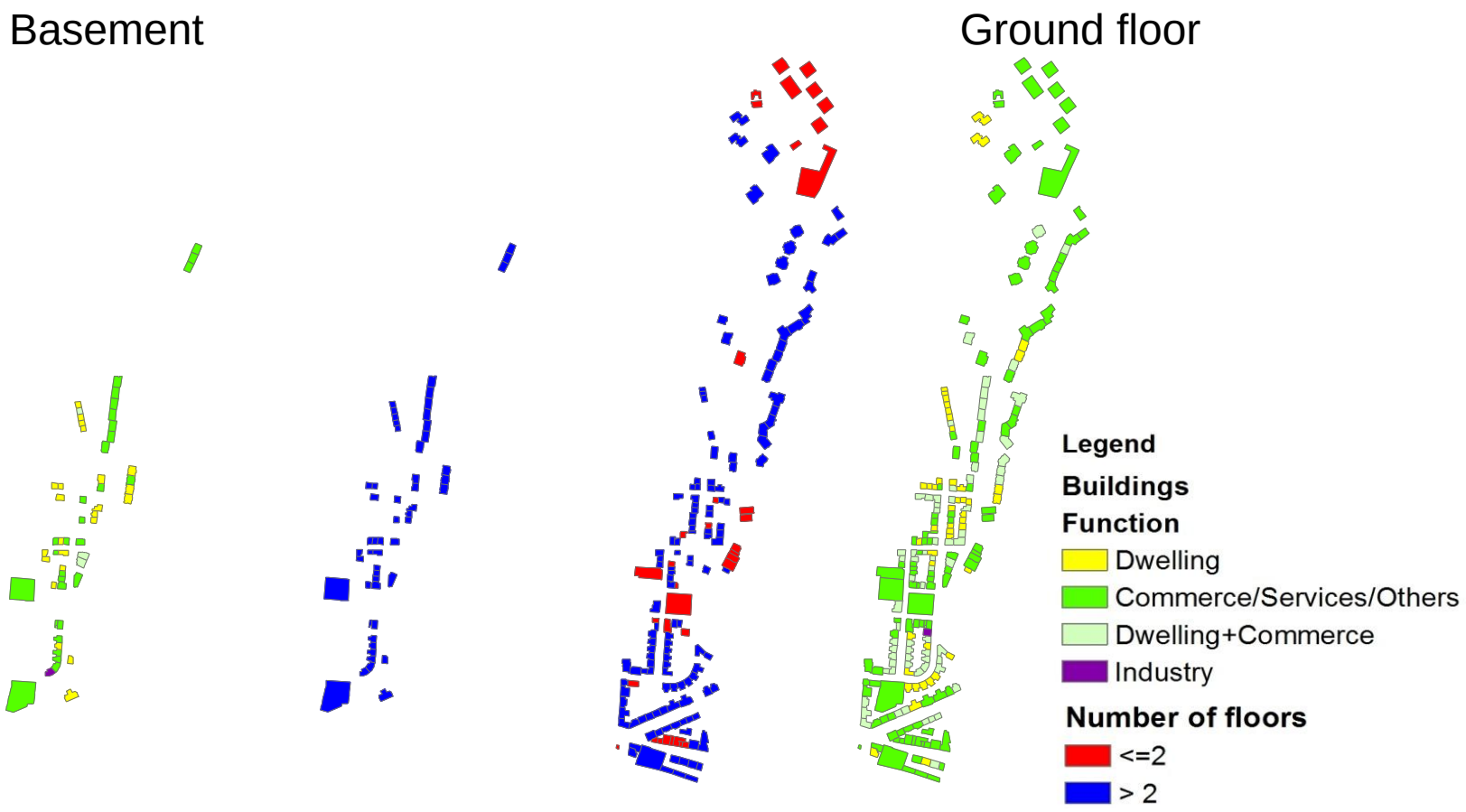
APS insurance categories

Basement

Ground floor

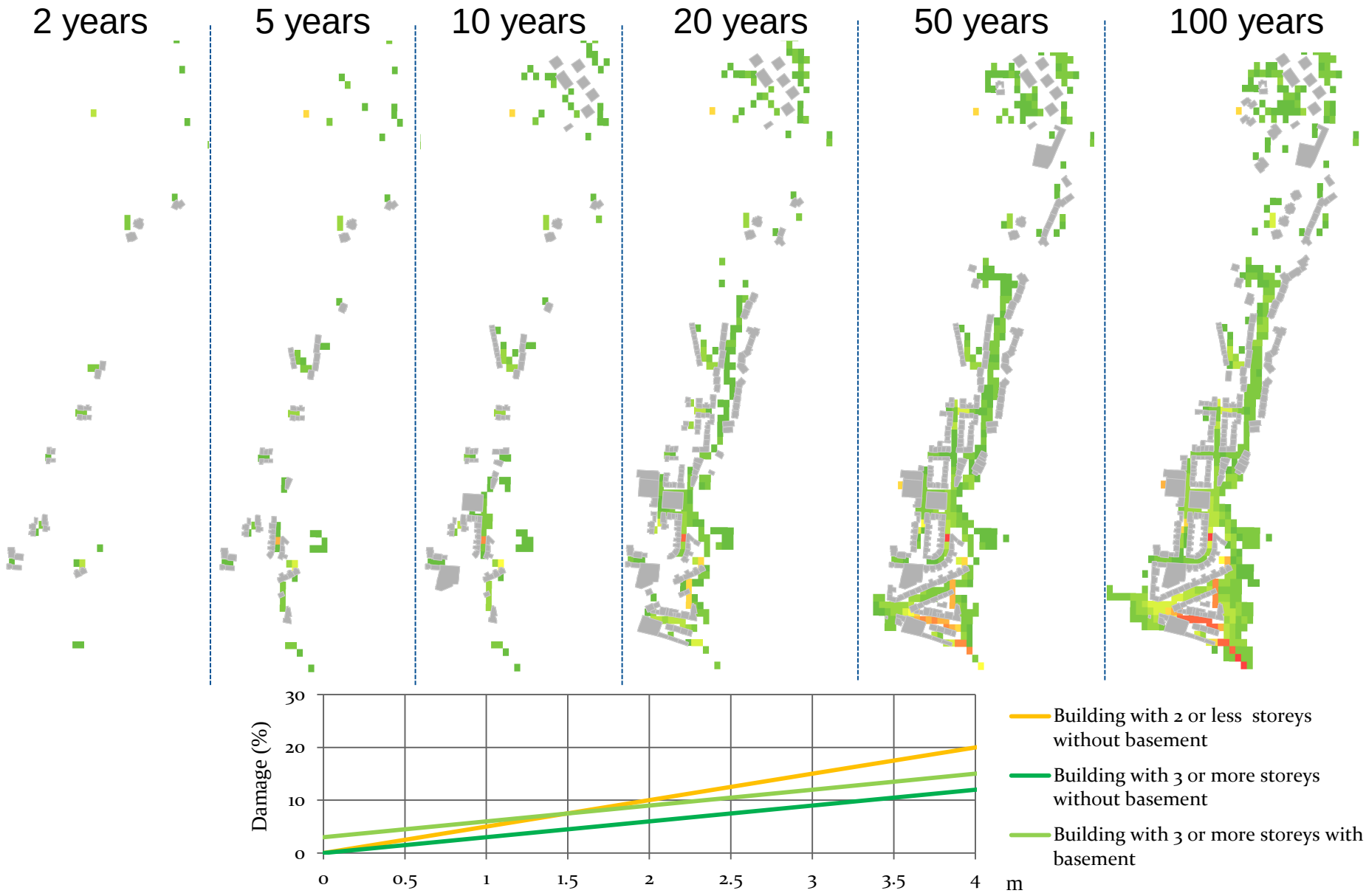


Damage in Building Structure

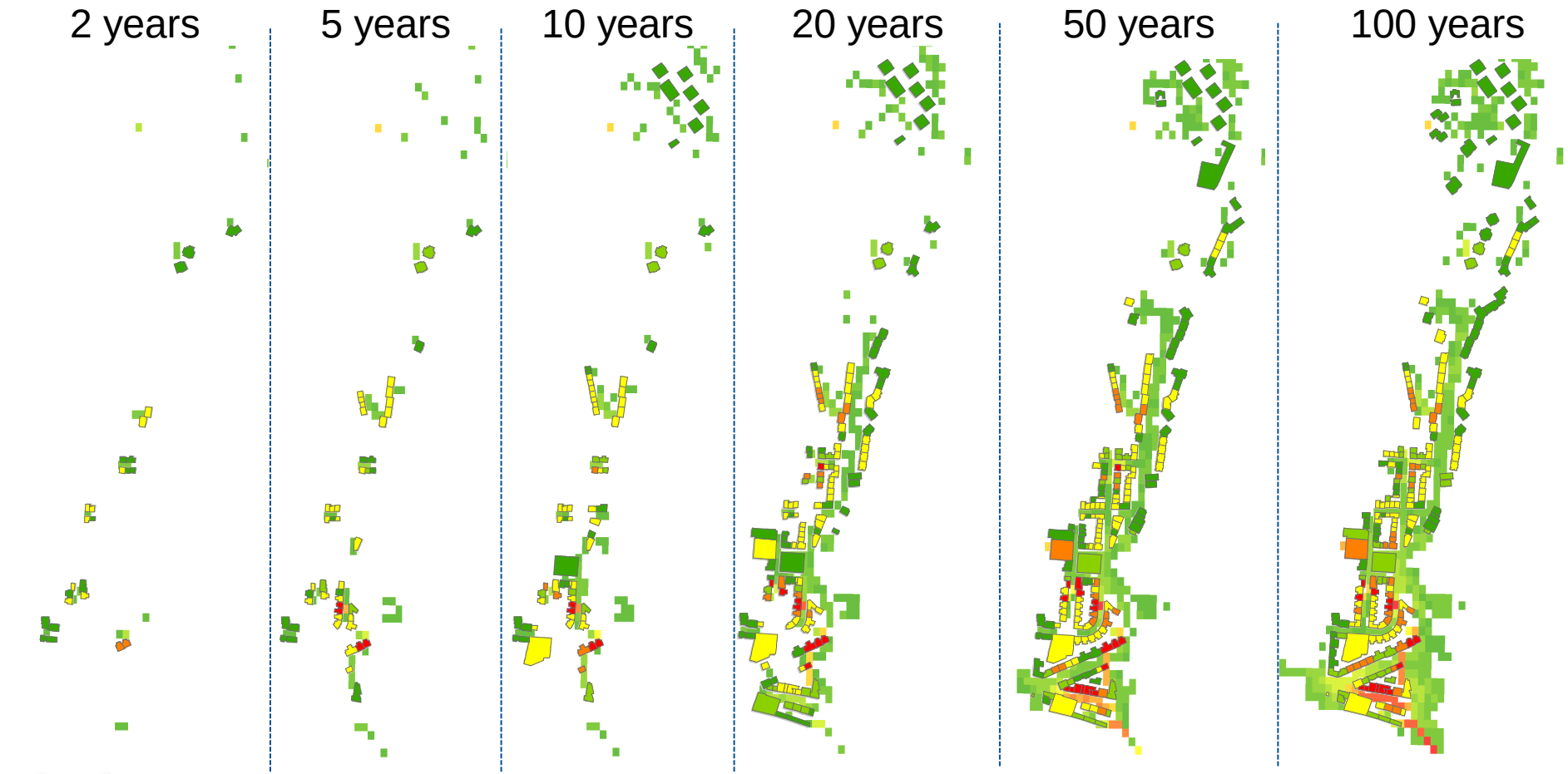


	Funcion
Building with 2 or less storeys **without** basement	$Y = 5x$
Building with 2 or less storeys **with** basement	$Y = 3 + 5x$
Building with 3 or more storeys **without** basement	$Y = 3x$
Building with 3 or more storeys **with** basement	$Y = 3 + 3x$

Damage in the Buildings Structure



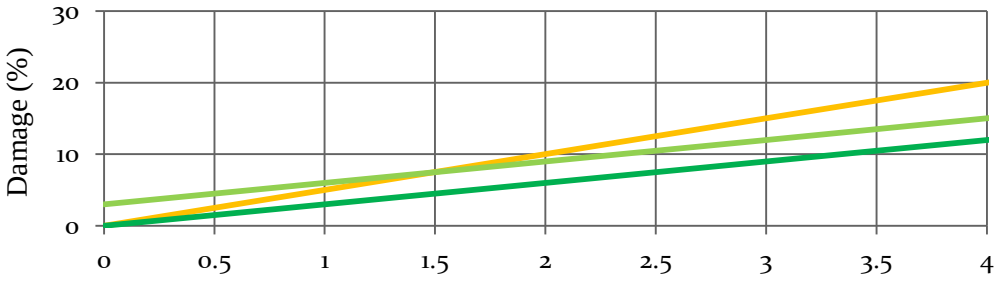
Damage in the Buildings Structure



Legend

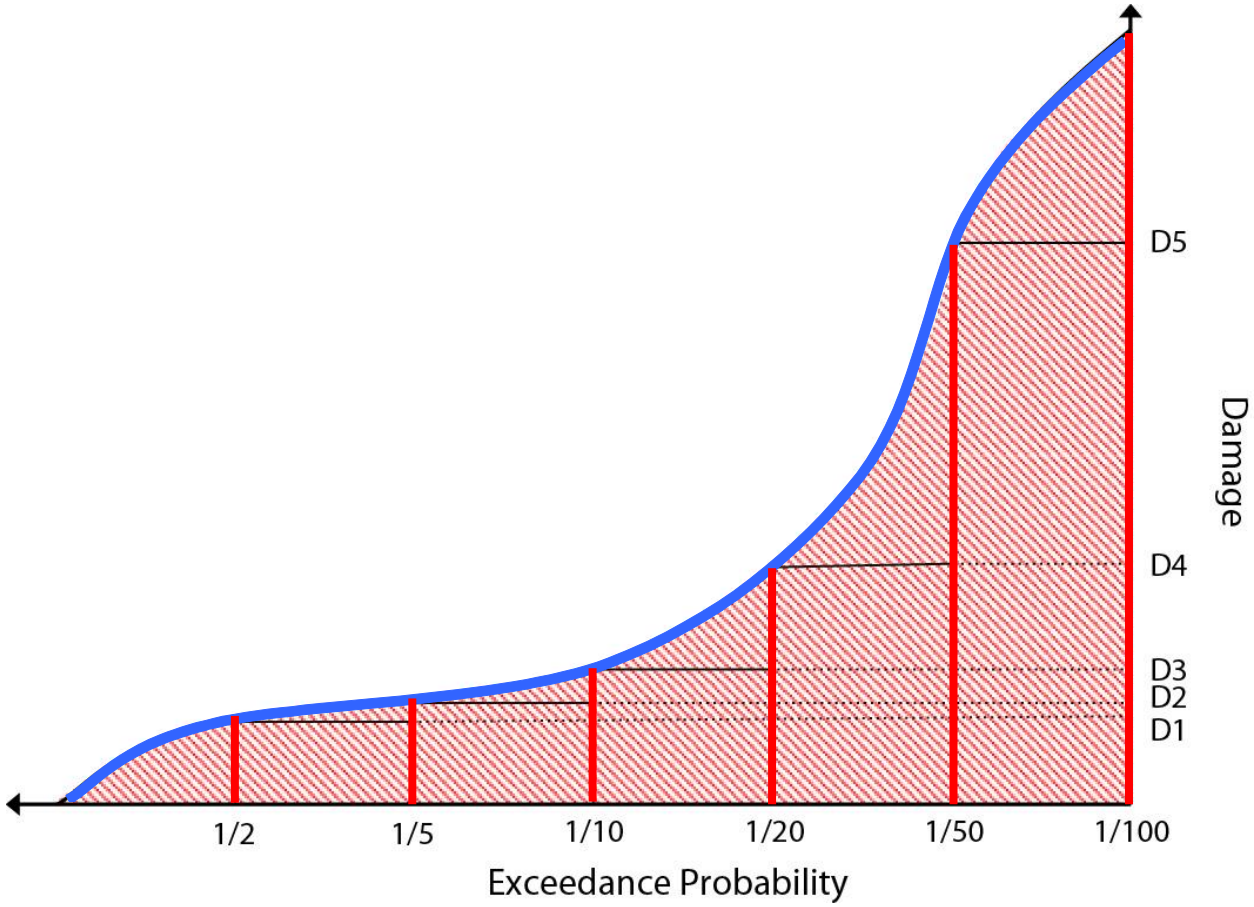
Damage (%)

- 0.1 - 1.339650
- 1.339651 - 2.898000
- 2.898001 - 4.461399
- 4.461400 - 5.053500
- 5.053501 - 9.569750



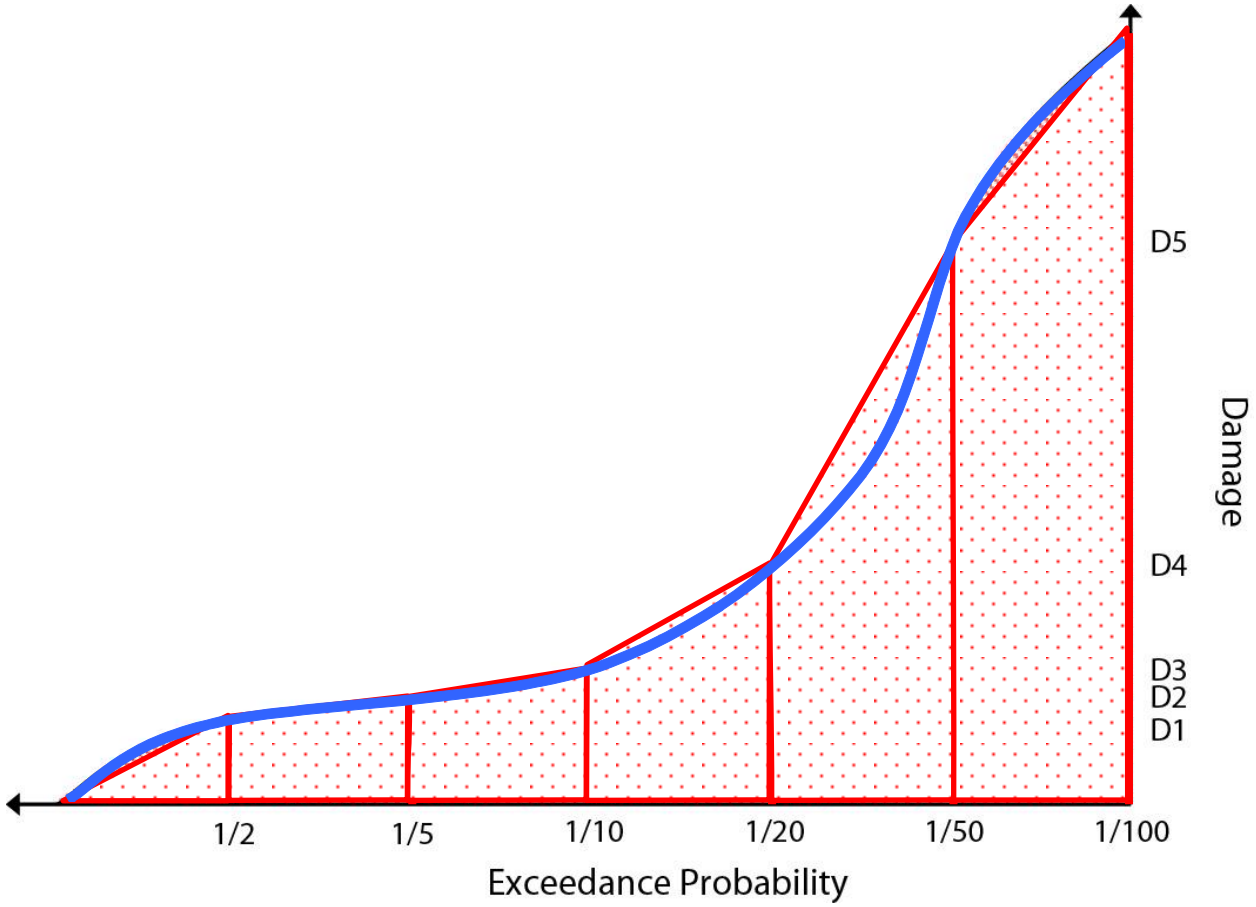
- Building with 2 or less storeys without basement
- Building with 3 or more storeys without basement
- Building with 3 or more storeys with basement

Damage in the Buildings Structure



Source: Meyer, V., S. Scheuer, *[et al.]* (2009)

Damage in the Buildings Structure

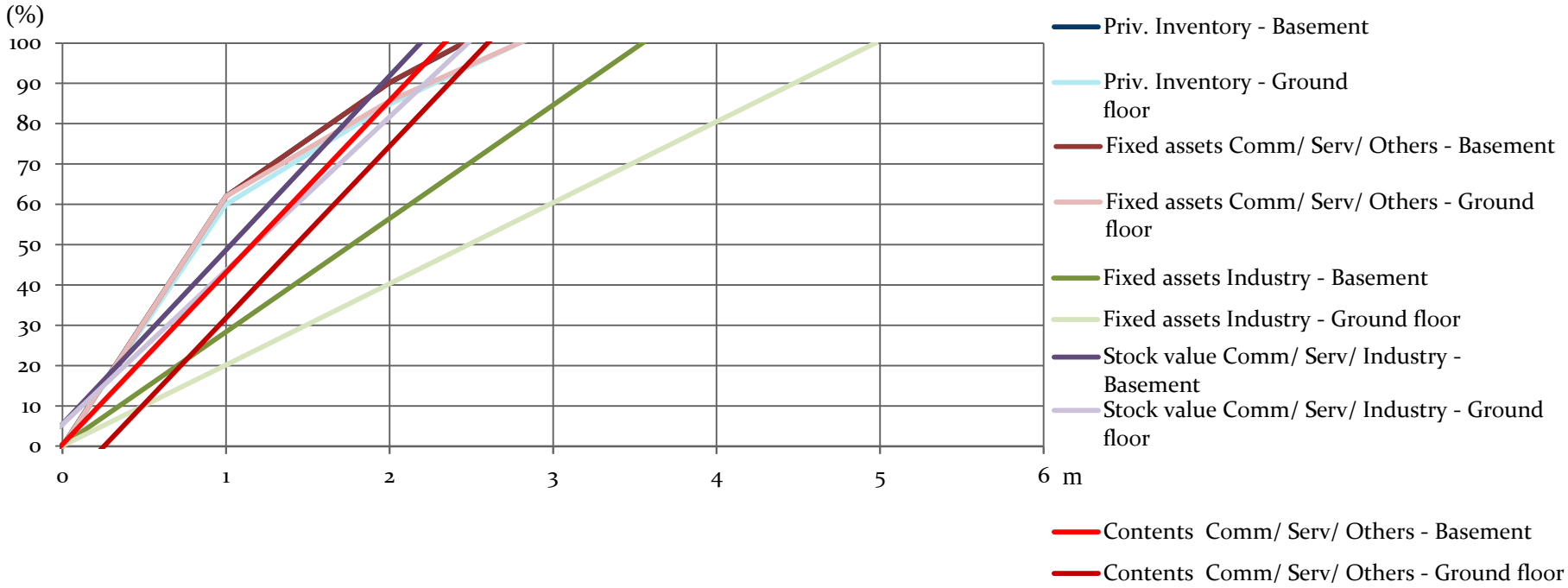


$$\sum_{x=1}^{x} D[i] \times (\Delta P_i - P_{i-1}) = annual\ average\ damage \qquad D[i] = \frac{D(P_{i-1}) + D(P_i)}{2}$$

Source: Meyer, V., S. Scheuer, *[et al.]* (2009)

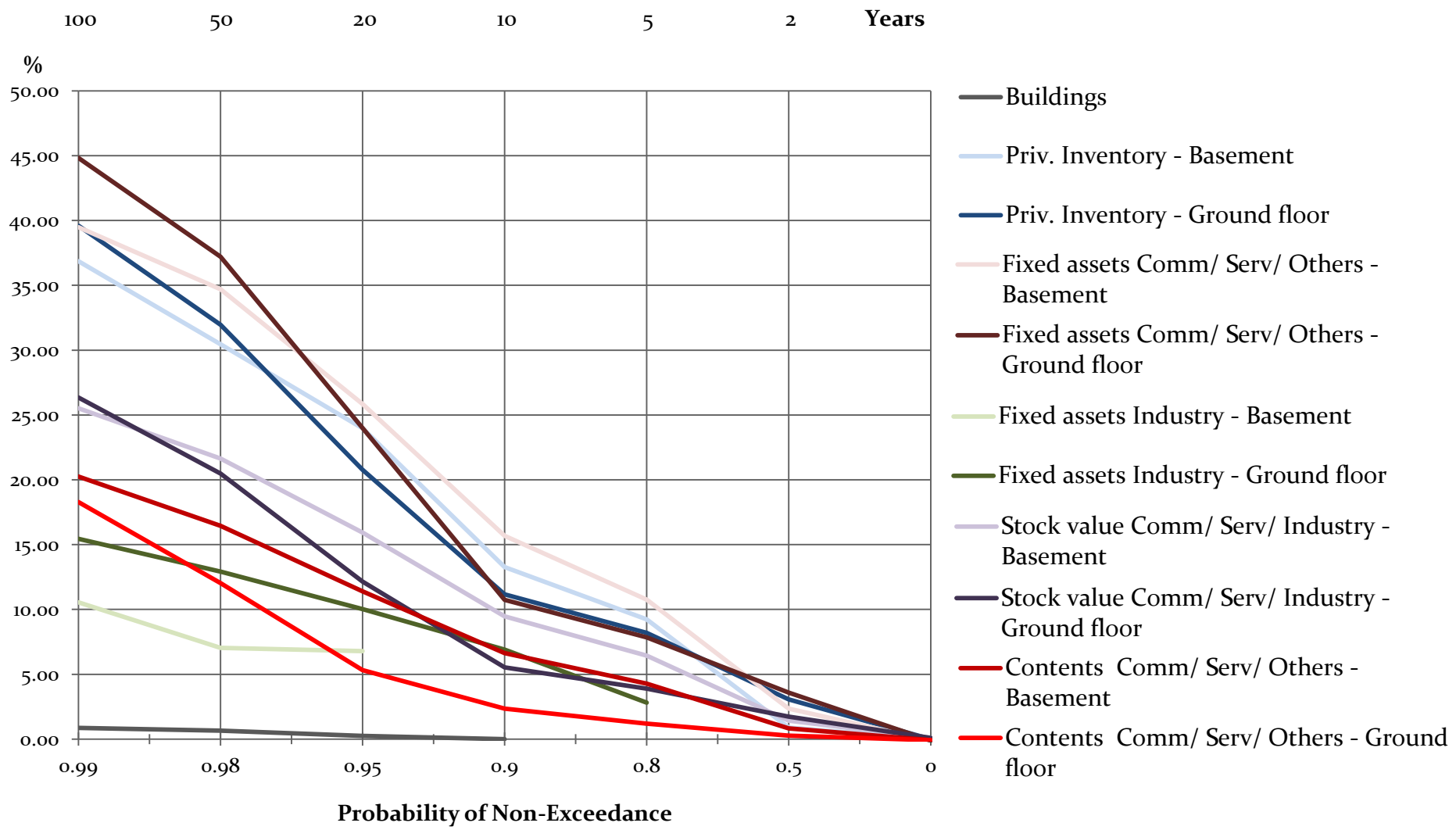
Damage in Inventory, Fixed assets and stocks

	Basement	Ground floor
Priv. Inventory	$Y = 68\sqrt{x} - 6$	$Y = 60\sqrt{x}$
Fixed assets Comm/ Serv/ Others	$Y = 68\sqrt{x} - 6$	$Y = 57\sqrt{x}$+5
Fixed assets Industry	$Y = 28x$	$Y = 20x$
Stock value Comm/ Serv/ Industry	$Y = 5 + 43x$	$Y = 5 + 38x$
Contents Comm/ Serv/ Others	$Y = 11{,}25 + (0{,}4239x - 0{,}1125) \times 100$	$Y = (0{,}4239x - 0{,}1125) \times 100$



Source: Meyer. V and Messner, F. (2005)

Probability-Damage Curves



Probability-Damage Curves

	Average Annual Damage for Algés (%)
Building	0.43
Priv. Inventory – Basement	4.78
Priv. Inventory – Ground floor	5.35
Fixed assets Comm/ Serv/ Others – Basement	6.25
Fixed assets Comm/ Serv/ Others - Ground floor	5.80
Fixed assets Industry - Basement	0.47
Fixed assets Industry - Ground floor	1.84
Stock value Comm/ Serv/ Industry - Basement	3.71
Stock value Comm/ Serv/ Industry - Ground floor	2.84
Contents Comm/ Serv/ Others - Basement	2.63
Contents Comm/ Serv/ Others - Ground floor	1.13

N

Nota Explicativa:
Estrutura do Edifício
0.1
Habitação/Dano Inventário
0.2
Comercio/outros –
Dano Activos Fixos
0.3
Comércio - Stock
0.4

Legenda

Risco de Inundação

- 0.008 - 0.014
- 0.015 - 0.057
- 0.058 - 0.065
- 0.066 - 0.072
- 0.073 - 0.079
- 0.080 - 0.089
- 0.090 - 0.109
- 0.110 - 0.122
- 0.123 - 0.161
- 0.162 - 0.656

CIRAC

SIM

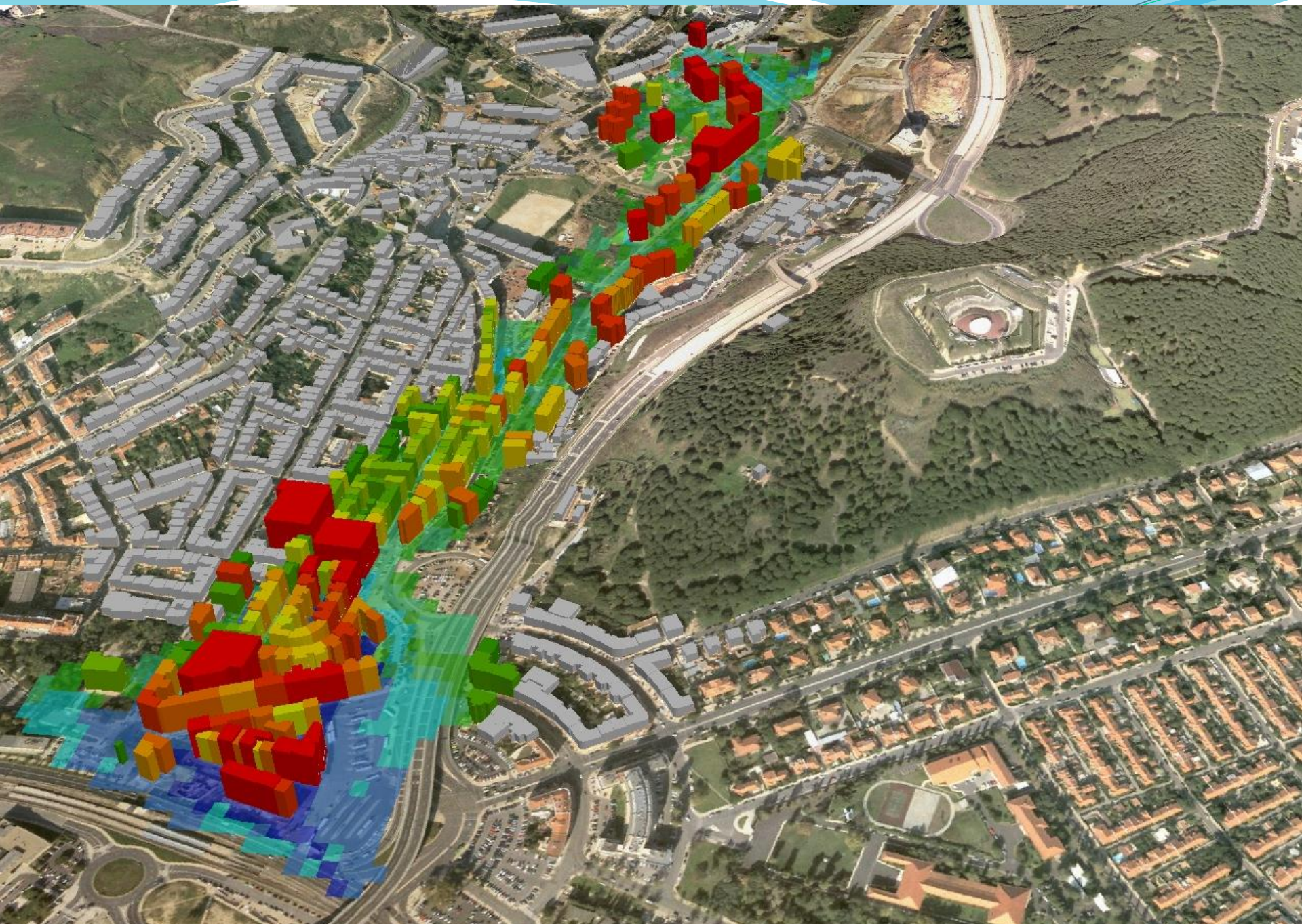
associação portuguesa de seguradores aps

Avaliação de Risco de Inundação

Mapa de Risco de Inundação
Perdas na strutura do Edificado

Escala - 0 50 100 Metros

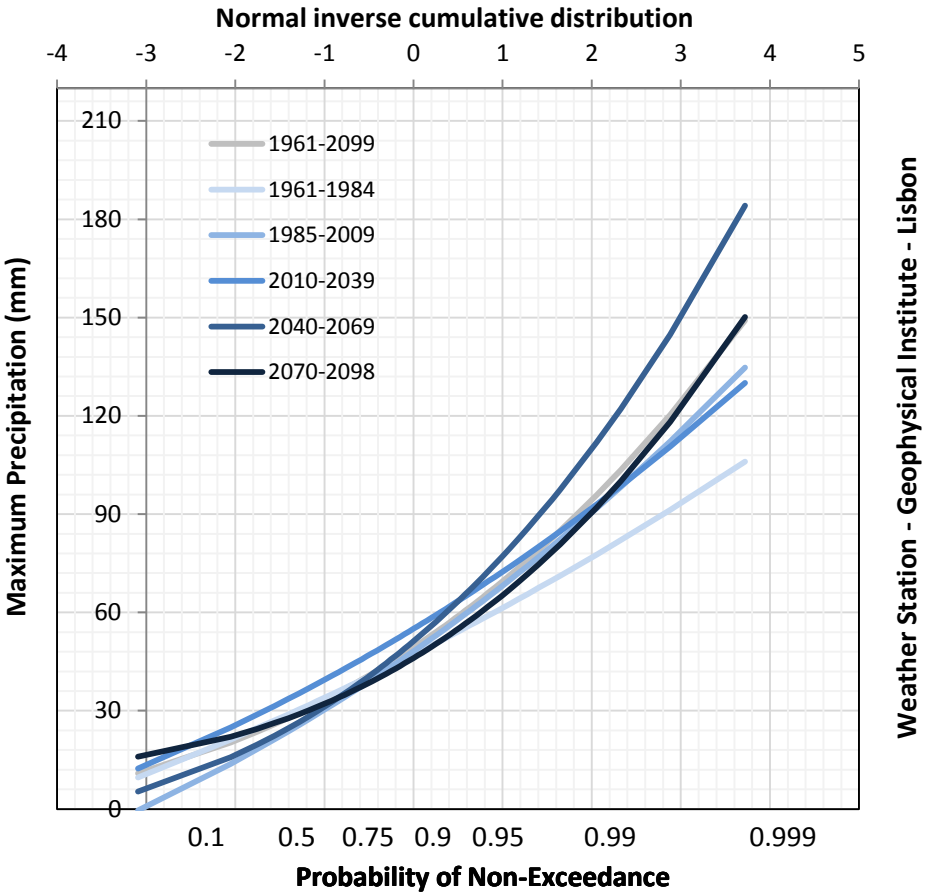
Novembro de 2011



Next Steps


Water Column [m]
> 1.0
0.9 - 1.0
0.8 - 0.9
0.7 - 0.8
0.6 - 0.7
0.5 - 0.6
0.4 - 0.5
0.3 - 0.4
0.2 - 0.3
0.1 - 0.2
%Drainage System
1.00
0.75
0.50
0.25
0.00
0m
500m
1 000m
N
MOHID
STUDIO
Lisbon (100 years flood)
Overland Flow and Drainage System
02:20:00
16-03-2012

Climate Change Scenarios



Aggregation of information to create risk maps

Delphi method

Pairwise comparison method

	Damage in building (a)	Priv. Inventory (b)	Fixed assets Comm/ Serv/ Others (c)	Fixed assets Industry (d)	Stock value Comm/ Serv/ Industry (e)
Damage in Building (1)	0	-	-	-	-
Priv. Inventory (2)	+	0	-	-	-
Fixed assets Comm/ Serv/ Others (3)	+	+	0	-	-
Fixed assets Industry (4)	+	+	+	0	-
Stock value Comm/ Serv/ Industry (5)	+	+	+	+	0
Position	∑a	∑b	∑c	∑d	∑e

Criterion	Classification	Domain	Weight
Damage in Building (1)	∑a	∑a/(nc-n)	∑a/∑Domain
Priv. Inventory (2)	∑b	∑b/(nc-n)	∑b/∑Domain
Fixed assets Comm/ Serv/ Others (3)	∑c	∑c/(nc-n)	∑c/∑Domain
Fixed assets Industry (4)	∑d	∑d/(nc-n)	∑d/∑Domain
Stock value Comm/ Serv/ Industry (5)	∑e	∑e/(nc-n)	∑e/∑Domain
		∑Domínio	∑Peso = 1

$$nc=\sum a+\sum b+\sum c+\sum d+\sum e$$

Thank you for your attention