6th EWA / JSWA / WEF Joint Conference
„The Resilience of the Water Sector"
15-18 May 2018, Munich, Germany

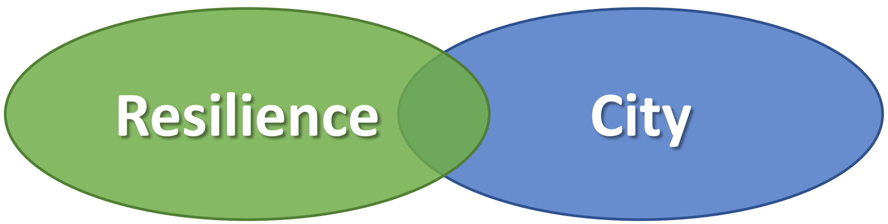
Evaluating city resilience and services cascade effects in flooding scenarios

João Barreiro, Ruth Lopes, Filipa Ferreira,
Rita Brito, José Saldanha Matos

Lisbon, Portugal

1. Introduction

URBAN RESILIENCE



*“Urban resilience is the capacity of <u>individuals, communities, institutions, businesses, and systems</u> within a city to **survive**, **adapt**, and **grow** no matter what kinds of chronic stresses and acute shocks they experience, and even **transform** when conditions require it.”*

Arup & The Rockefeller Foundation, 2015

URBAN DRAINAGE, FLOODS AND CLIMATE CHANGE

Extreme Precipitation Events

- High precipitation intensities
- Concentrated in time and space
- Duration of minutes or few hours

Urban Drainage Problems

- Lack of drainage infrastructures
- Limited hydraulic capacity of the infrastructures
- Reduced capacity of inlets
- Polution loads and restrictions on discharges

Climate Change

- Increase of the intensity and frequency of extreme events
- Increase of the sea level

2. Methodology

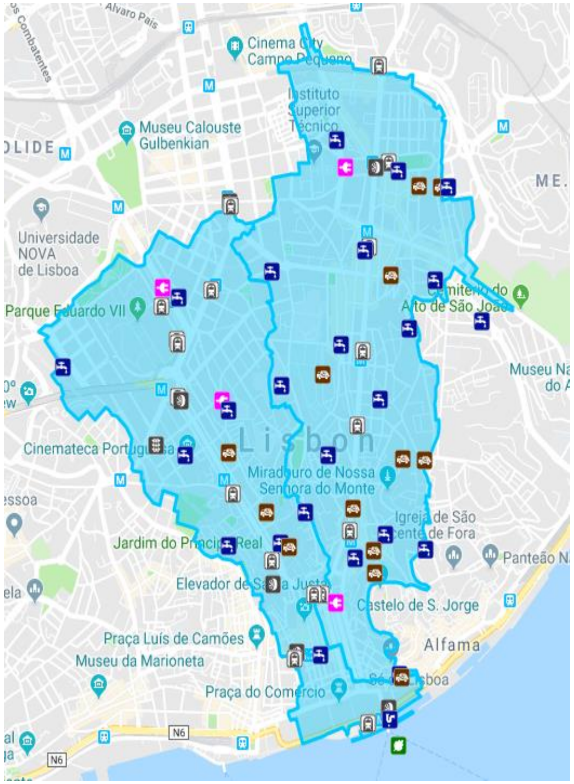
URBAN RESILIENCE ON THE SCOPE OF URBAN FLOODS

- Definition and characterization of the study area
- Application of dynamic 1D/2D models to determine flooded areas and the severity of the floods
- Identification of interdependencies, impacts and cascading effects, taking into account several multisector services
- Evaluation of urban resilience, trough simple quantifiable indicators and a resilience index

3. Lisbon Downtown Case Study

DEFINITION AND CHARACTERIZATION OF THE STUDY AREA

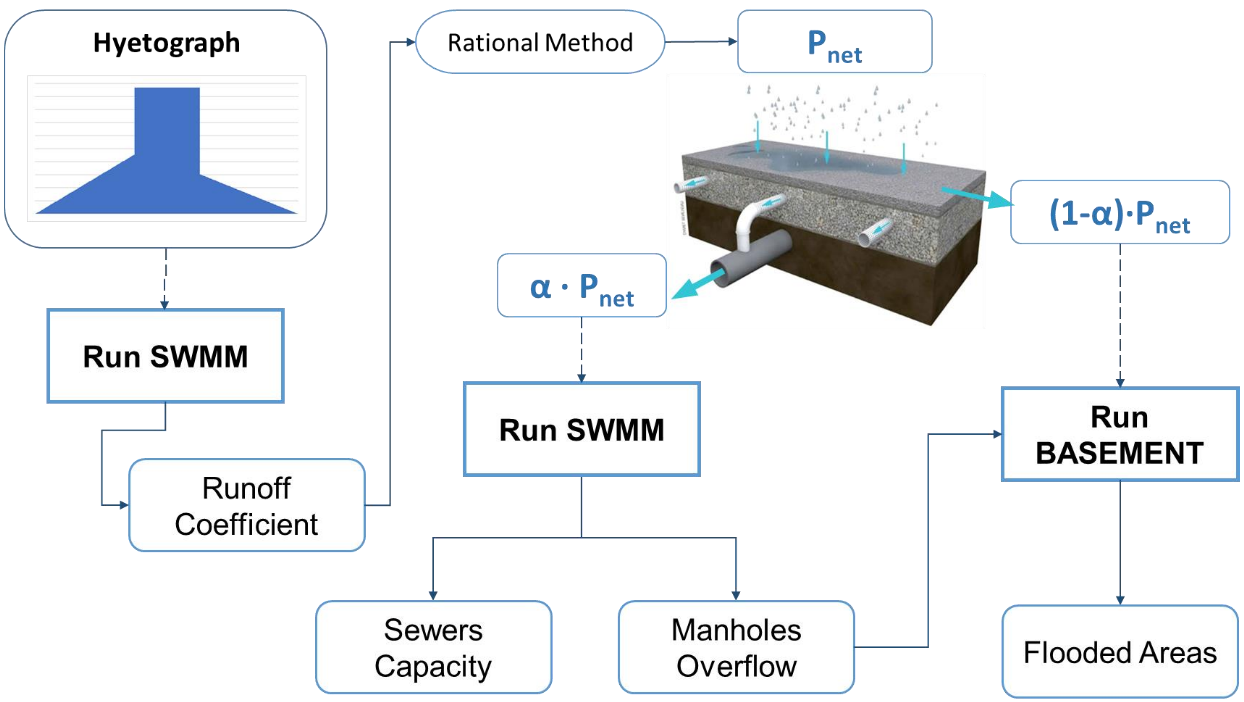
Sector	Service	Infrastructures
Water Sector	Water Distribution	District Metering Areas
	Urban Drainage	Wastewater Pumping Stations Overflows
Power Sector	Secondary Power Distribution	Power substation
Mobility Sector	Subway	Subway stations METRO Power Substation Control Room
	Public Transport Hubs	Hubs
	Bus	Bus Routes
	Traffic Management	Traffic Control Room
Waste Sector	Unselective Municipal Waste Collection	Routes
Telecommunication Sector	Mobile Telecom	Analysed only as a service provider
Environmental Sector	Receiver Waters	Tagus River
	10 Services	130 Infrastructures



APPLICATION OF DYNAMIC 1D/2D MODELS

Combined Model SWMM+BASEMENT

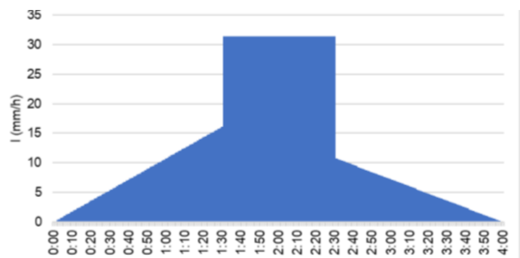
Coupling of SWMM (US EPA) and BASEMENT (VAW Zurich)

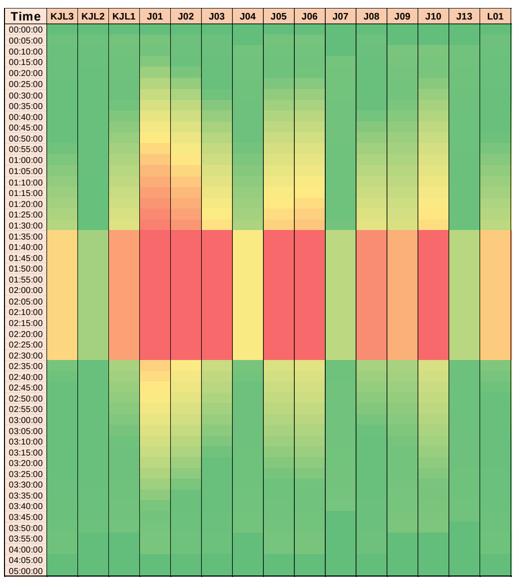


The α parameter reflects the interception capacity of the drainage system inlets

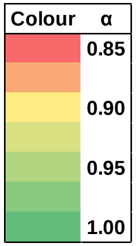
APPLICATION OF DYNAMIC 1D/2D MODELS

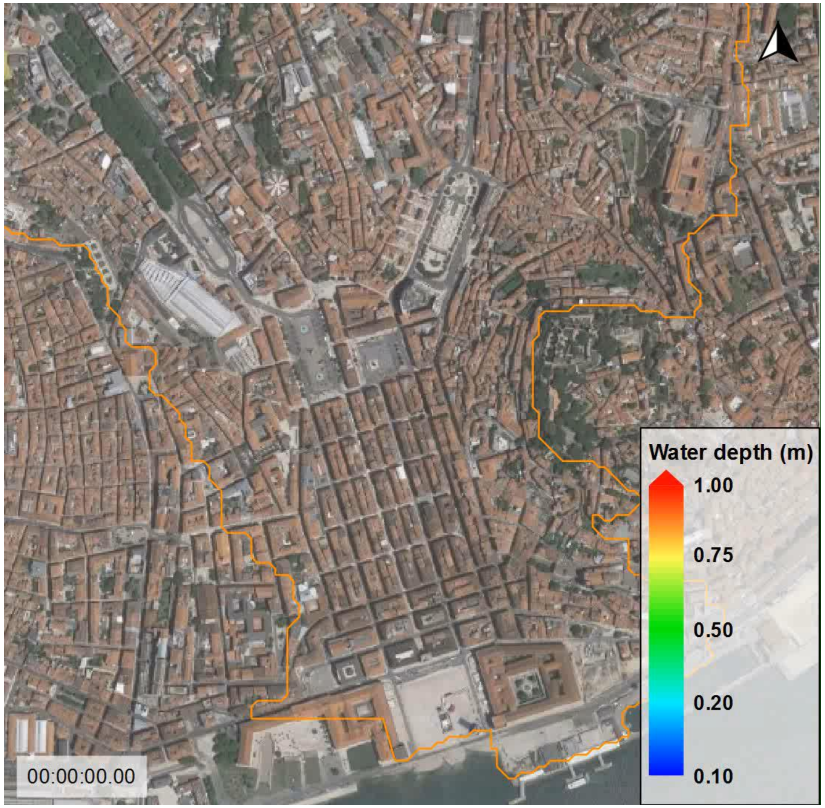
T = 10 years





Typical variation of α parameter





IDENTIFICATION OF INTERDEPENDENCIES, IMPACTS AND CASCADING EFFECTS

Horizon 2020
European Union Funding
for Research & Innovation

RESCCUE
RESILIENCE TO COPE WITH CLIMATE CHANGE IN URBAN AREAS.

→ HAZUR®
RESILIENT SYSTEMS

Field Visits & Interviews	Cross-functional Workshops	Improvement Projects Identification	Report Presentation	Management
ASSESSMENT phase				MANAGEMENT phase
PREASSESSMENT Module - City **data gathering** and **storage**	ASSESSMENT Module **- Data analysis** (interdependencies, redundancies, etc.)	ASSESSMENT Module -**Data visualization** (goals revision) -**Data analysis** (impact analysis)	ASSESSMENT Module - Resilience report includes **data visualization and data analysis**	MANAGEMENT Module -**Data visualization** -**Sensor visualization** -**Simulation** -Crisis Recorder

IDENTIFICATION OF INTERDEPENDENCIES, IMPACTS AND CASCADING EFFECTS

Interdependencies

Donor

No impact on receiver

Receiver at Minimum service

Receiver down

HAZUR® RESILIENT SYSTEMS

Initial matrix

	Receiver Waters	Secondary Power Distribution	Subway	Traffic Management	Unselective MSW Collection
Bus	none		none		none
Mobile Telecom	none	down immediately	none	none	none
Primary Power Distribution	none	none	none	none	none
Public Transport Hubs	none	none	none	none	none
Receiver Waters		none	none	none	
Secondary Power Distribution	none		none	none	none
Subway	none			none	none
Traffic Management	none		none		none
Unselective MSW Collection	none	none	none	none	
Urban Drainage	none		none	none	none
Waste Treatment	none		none	none	none
Waste Vehicles Operation and M...	none		none	none	none

Redundancies

Infrastructure A

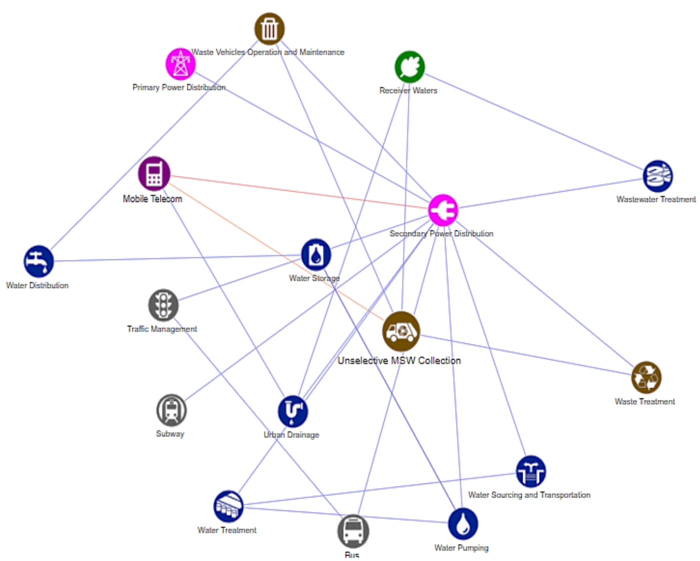
Infrastructure B

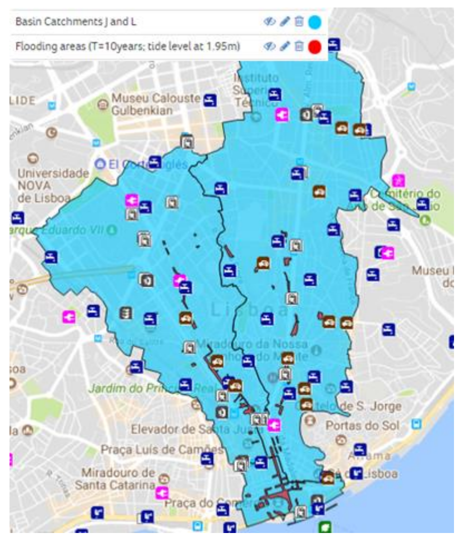
Infrastructure C

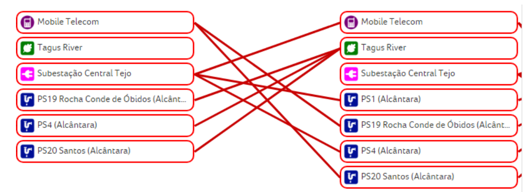
Grid or network services have stronger redundancies such as power distribution and water supply.

6th EWA / JSWA / WEF Joint Conference
„The Resilience of the Water Sector“
15-18 May 2018, Munich, Germany

IDENTIFICATION OF INTERDEPENDENCIES, IMPACTS AND CASCADING EFFECTS







Interdependencies Map + **Critical Areas and Impacts on Services** → **Cascading Effects**

IDENTIFICATION OF INTERDEPENDENCIES, IMPACTS AND CASCADING EFFECTS

Public Transport Hubs

Subway

Bus

Waste Collection

Urban Drainage

WWTP

“End of chain” services

Minor Cascading Effects

Bigger impact on citizens daily life

Interdependencies Map + Critical Areas and Impacts on Services → Cascading Effects

EVALUATION OF URBAN RESILIENCE

	T = 10 years Tide level = 1.95 m	T = 10 years (+5% intensity) Tide level = 2.57 m
I1 - Percentage of volume overflowed by the drainage system	8.6%	12.0%
I2 - Percentage of Flooded Area	4.9%	5.9%
I3 - Percentage of Flood Duration	93.8%	95.8%
I4 - Percentage of Buildings Affected	6.5%	7.8%
I5 - Percentage of Critical Services Affected	35.0%	35.0%
Integrated Urban Resilience Index	70.3%	68.7%

4. Main conclusions

$$\downarrow Risk = \frac{Hazard \times Vulnerability \times Exposure}{\uparrow Resilience}$$

Structural Measures

↑ Hydraulic Capacity of Infrastructures

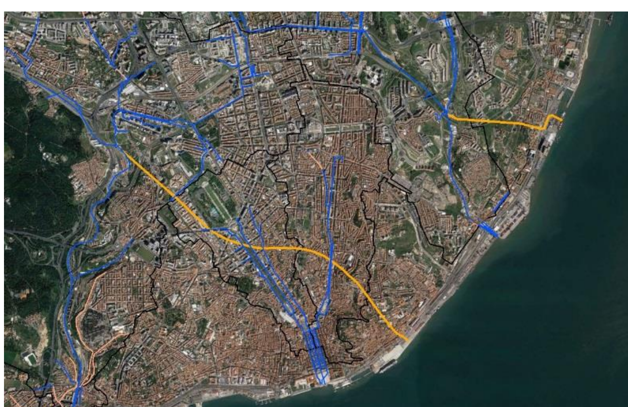
↓ Affluent flows to the system (Source Control)

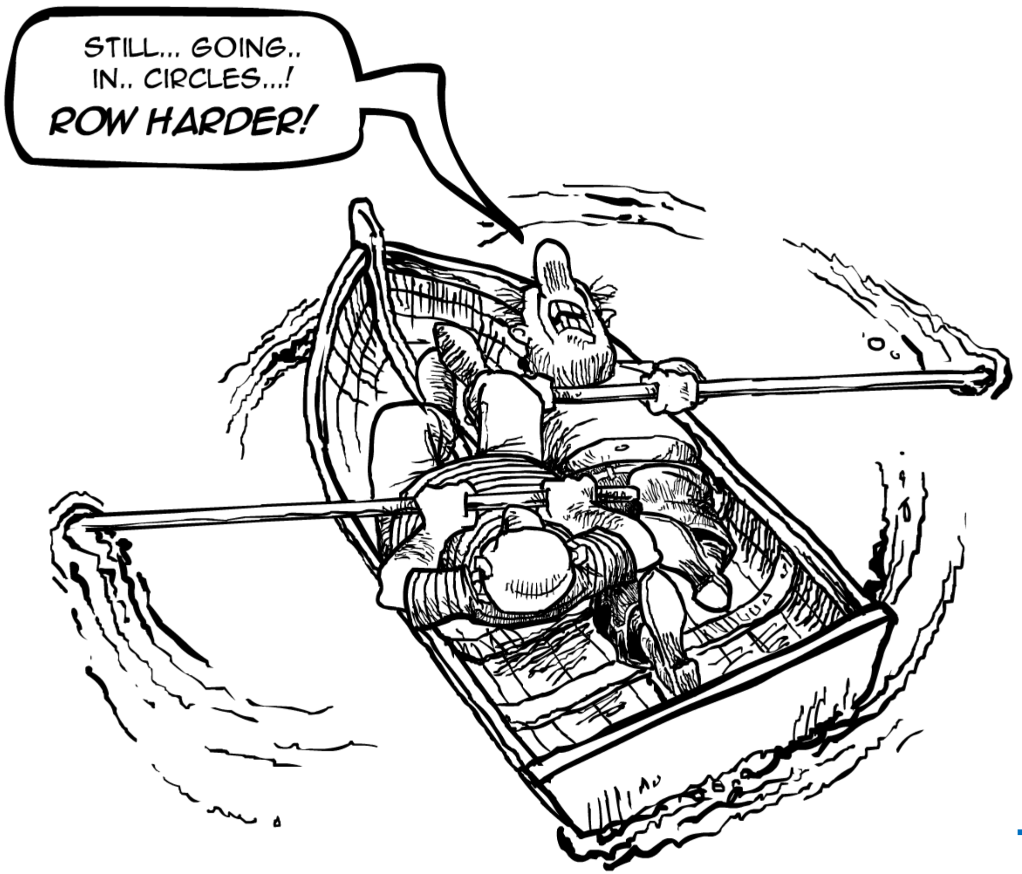
Non-structural and Resilience Management Measures

+ Monitoring and warning systems

+ Modellation, simulation and evalutaion tools

↑ Multisectoral cooperation





Thank you!