Clustering-Based Framework for Assessing Transportation Resilience to Flood Events

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NEURAL INFORMATION PROCESSING SYSTEMS

Motivation

Flood effects are significant global challenge, threatening transportation critical infrastructure

Most affected European country by floods [1]

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[2] Bruneau M et al. (2003) A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities. Earthquake Spectra
[3] Yang Z et al. (2023) Indicator-based resilience assessment for critical infrastructures – A review. Safety Science 160:106049.

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Lack of resilience definition
Do not utilize accurate data,
Tailored to specific regions,
Lack of historical data [3]

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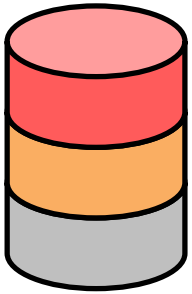
Data Gathering



Economic Losses

Event Magnitude

Supplementary Data

10 years of flood events at the province level in the Spanish transportation system (2,665 events)

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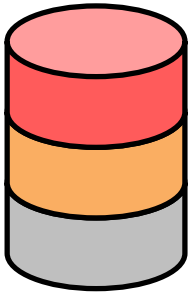

Economic Losses

Event Magnitude

Supplementary Data

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Remove data inconsistencies and correlations

2 sets to test different analysis

Set 1 (S1)

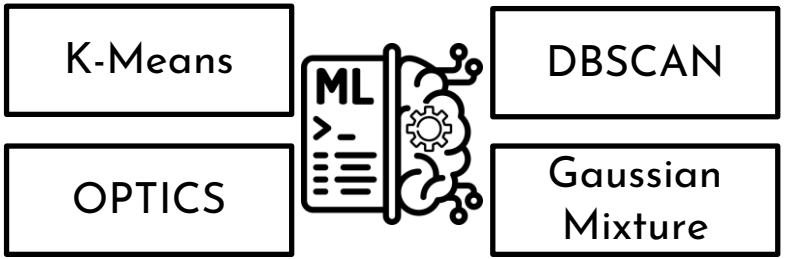
Avg Temp
Wind Speed
Precipitation
Duration
Season
Claims
Total Losses

Set 2 (S2)

Precipitation
Duration
Claims
Total Losses

Cluster Creation

ML clustering used to uncover potential patterns between the variables and generate cluster of the flood events



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K-Means

DBSCAN

OPTICS

Gaussian Mixture

Hyperparameter optimization

Performance measured by Silhouette, Davis-Bouldin, and Calinski-Haranasz

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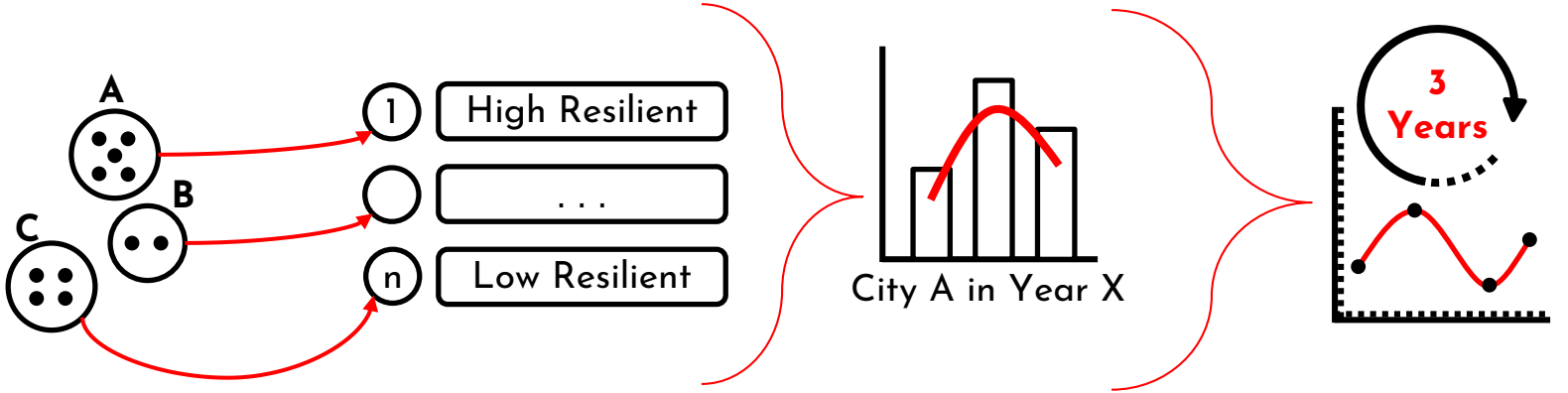
Cluster Method	N° of Clusters	Silhouette	Davis-Bouldin	Calinski-Harabasz
K-Means (S1)	2	0.396	1.122	1682.241
K-Means (S2)	2	0.629	0.698	3211.166
DBSCAN (S1)	3	-0.822	1.705	0.060
DBSCAN (S2)	2	0.713	0.921	619.76
OPTICS (S1)	2	-0.646	2.396	2.103
OPTICS (S2)	7	-0.581	15.064	2.930
GMM (S1)	2	0.469	0.882	2648.115
GMM (S2)	4	0.712	0.943	4887.789

Analyzing the Resilience Score



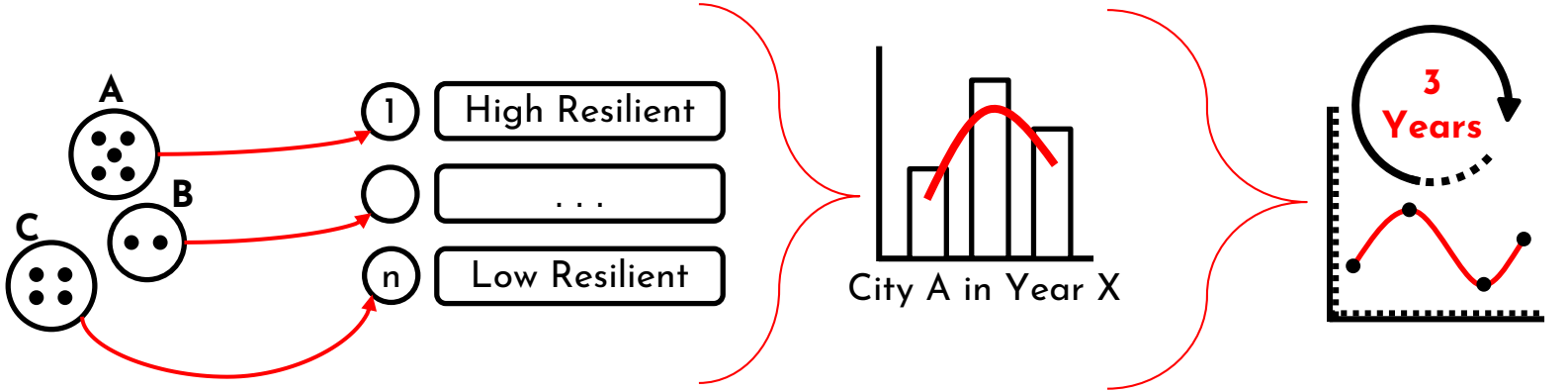
Cluster of Events

Resilience Categorization

Weighted Average of Events Score

3-Year Moving Average

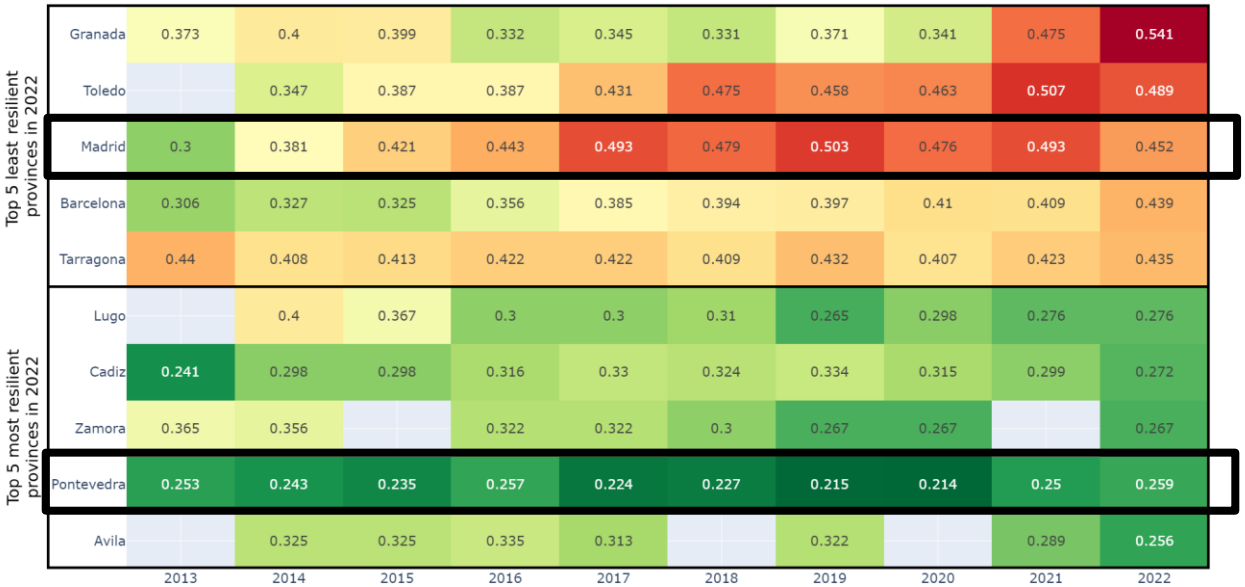
Analyzing the Resilience Score



Cluster of Events | **Resilience Categorization** | **Weighted Average of Events Score** | **3-Year Moving Average**

Resilience Category	Events Quantity
High Resilience (Score 1)	410
Medium-High Resilience (Score 2)	1731
Medium-Low Resilience (Score 3)	310
Low Resilience (Score 4)	214

Experiment Results



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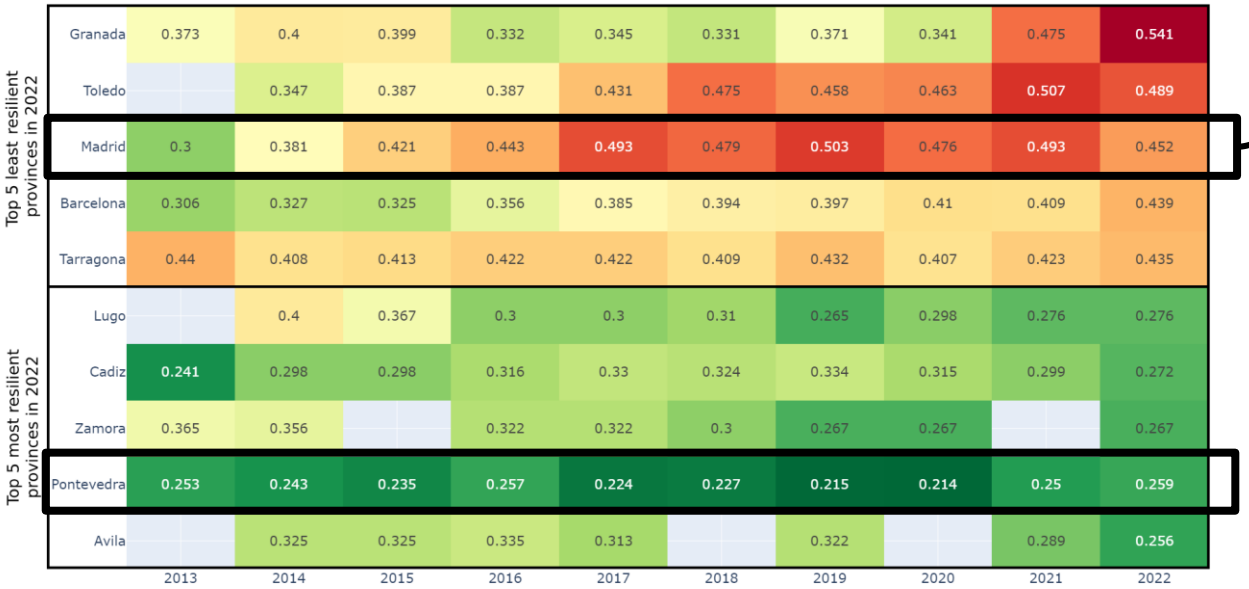

Madrid

Stable (2017–2021)

Decrease(2021–2022)

Development of regulations to enhance the resilience in face of floods [4, 5]

[4] Comunidad de Madrid (2019) Ley 9/2018, de 26 de diciembre, de Presupuestos Generales de la Comunidad de Madrid para el año 2019

[5] Comunidad de Madrid (2015) Plan de Actuación en caso de inundaciones en la Comunidad de Madrid. In: Portal de Transparencia.

[6] Diario de Pontevedra (2022) El Concello estudiará cómo "mitigar" las inundaciones en Fernando Olmedo. In: Diario de Pontevedra.

[7] Fundacion Biodiversidad (2022) Proyecto de renaturalización mejora de la biodiversidad e incremento de la resiliencia urbana de Pontevedra

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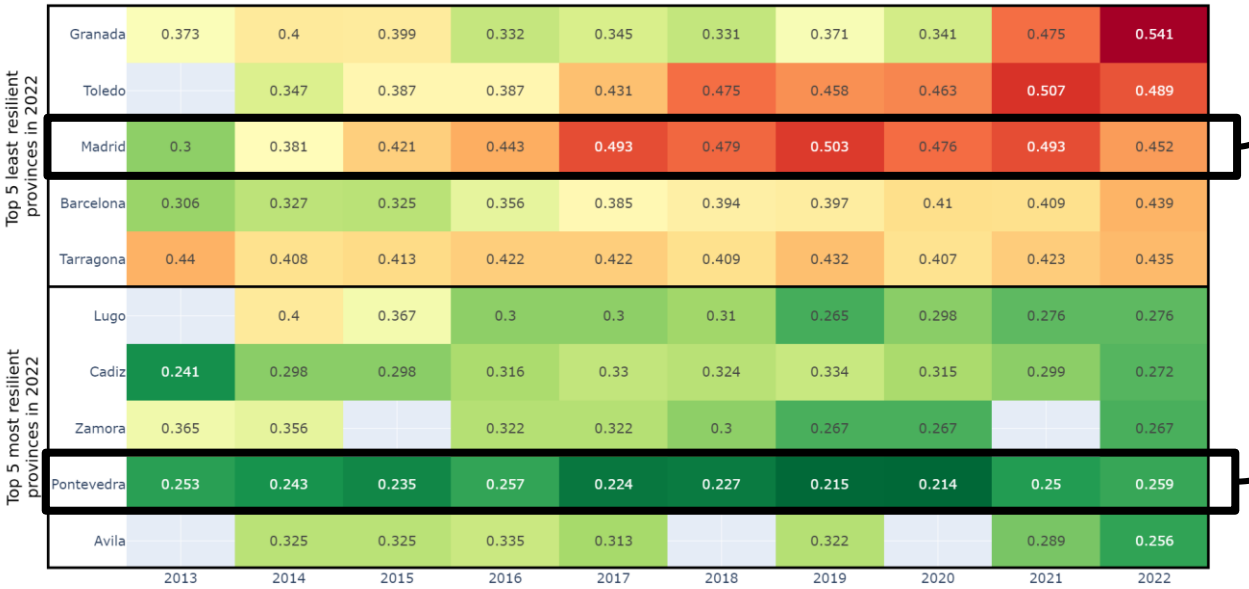

Madrid

Stable (2017–2021)
Decrease(2021–2022)

Development of regulations to enhance the resilience in face of floods [4, 5]

Pontevedra

Stable (2013–2020)
Increase (2020–2022)

Low resilience to floods reported in the news [6], Establishment of projects to enhance the resilience [7]

[4] Comunidad de Madrid (2019) Ley 9/2018, de 26 de diciembre, de Presupuestos Generales de la Comunidad de Madrid para el año 2019
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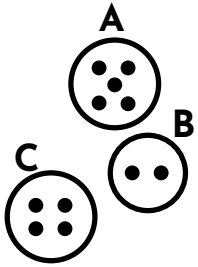
Conclusion



The presented approach can assess the transportation resilience level considering flood events

Enhance the understand of the impact and the insights about potential vulnerabilities and strengths

Future works should enhance the model, and create DataViz to provide straightforward information for decision-makers

Paper pre-print

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