Advances in pluvial flooding modelling for the assessment of risk scenarios: the impact of input data and system description

PhD Days and Marchi lecture

Trieste, 27/28 June 2024

PhD Candidate: Marzia Acquilino[1]

Supervisors: Giorgio Boni[1], Arianna Cauteruccio[1], Ilaria Gnecco[1]

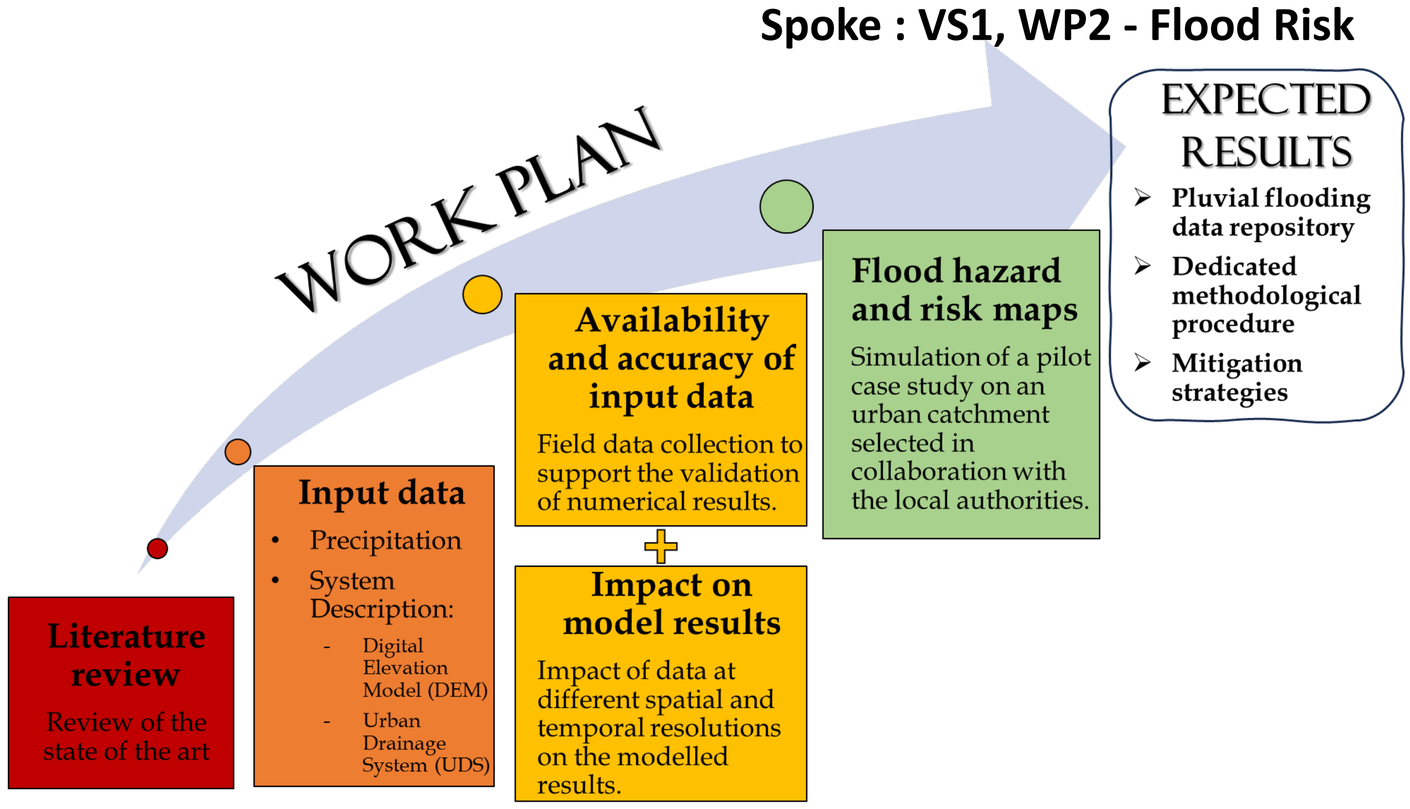
[1] Dept. of Civil, Chemical and Environmental Engineering, University of Genova | Contact: marzia.acquilino@edu.unige.it

Spoke : VS1, WP2 - Flood Risk

PLUVIAL FLOODING

The European Directive 2007/60/CE defines in Art. 2 the term **«flood» as the temporary covering by water of land not normally covered by water. This shall include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas, and may exclude floods from sewerage systems.**

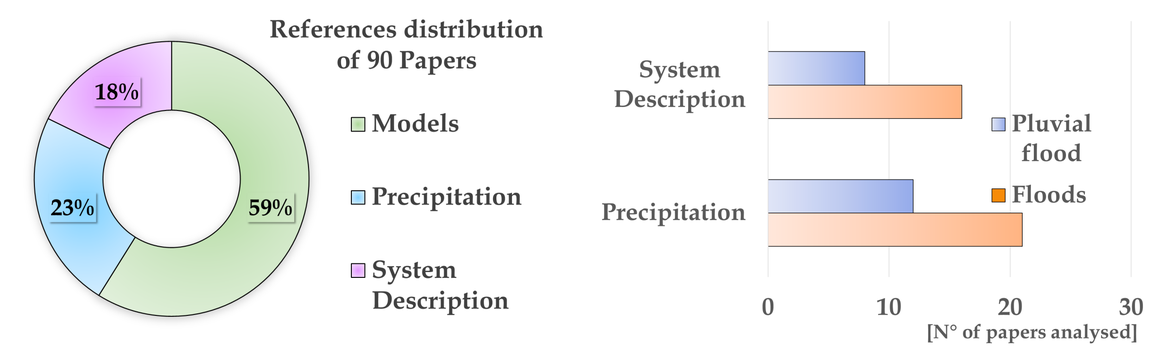
Recognizing its widespread occurrence as a hazard, flooding is typically categorized into three main types: fluvial, coastal, and pluvial. While all types of flooding have the potential to impact urban areas, this research will specifically target pluvial flooding. Pluvial flooding arises from a multitude of factors, such as restricted drainage capacity, urban expansion, the impact of climate change and deficiencies in the maintenance of sewer systems. *(Liu et al, 2020; Wang et al, 2023).*



LITERATURE REVIEW

After a literature review *(Acquilino et al, 2024)* since 2020 [Fig.1], it came out that the research interest of the last years mainly focused on the models' development (60%), while **inaccuracy and gaps in pluvial flood modelling persist** due to a lack of **high-quality** input data and system descriptions, with **appropriate spatial and temporal resolution (40% of the surveyed papers)**. One third of the latter are focused on pluvial flooding.

In this work, the areas where further research and refinement are necessary for a more comprehensive understanding and effective management of pluvial flood risk are addressed.



*[Fig.1]: Analysed literature distribution **since 2020** of a total of 90 papers. The histogram highlights how the questions of system description and precipitation input have been addressed in relation to floods and pluvial floodings.*

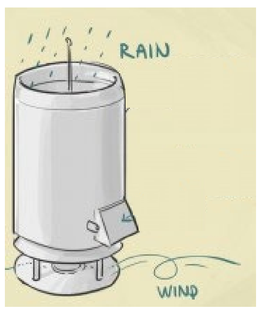
INPUT DATA

PRECIPITATION ? **SYSTEM DESCRIPTION**

A key issue that needs attention is the accuracy and gaps in input data, particularly concerning precipitation. (*Maier et al, 2020; Cristiano et al, 2017*). **The acquisition of such data presents challenges, encompassing instrument calibration, coverage limitations, and the heterogeneous nature of data sources, all of which engender inaccuracies and gaps, even across divergent instrument types.**

RAIN GAUGES

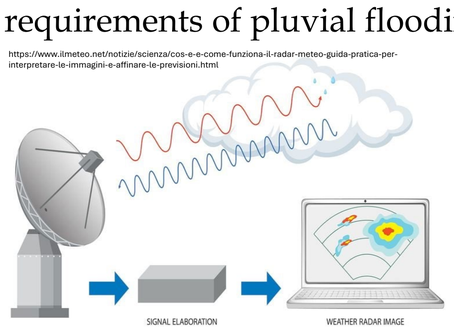
It is still typical to rely on rainfall data collected from a single **rain gauge,** because they provide relatively accurate point rainfall estimates near the ground surface *(Ochoa-Rodriguez et al, 2019).*



https://tahmo.org/sensor-feature-article-a-drip-counting-rain-gauge/

RADAR DATA

Here spatial limitation is solved, but conventional radar systems, do not scan close enough to the surface and their resolution may not meet the requirements of pluvial flooding modelling.



https://www.ilmeteo.net/notizie/scienza/cos-e-e-come-funziona-il-radar-meteo-guida-pratica-per-interpretare-le-immagini-e-affinare-le-previsioni.html

Additionally, the reliability of radar data depends on ground-level rain gauges to calibrate intensity measurements into accurate rainfall volume, which can be compromised *(Maier R. et al, 2020; Ochoa-Rodriguez et al, 2019).*

IMPACT ON

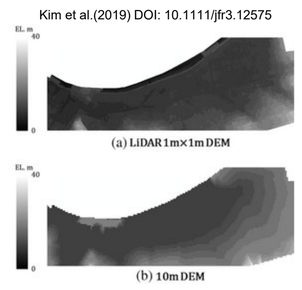
MODELLING

Model categories according to [8]:

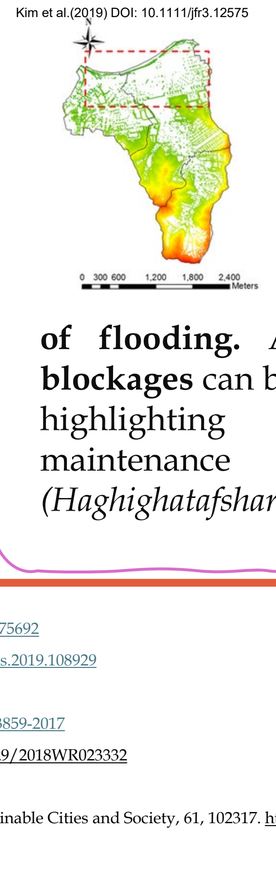
- *rapid flood spreading (RFS)*
- *one-dimensional sewer (1D-S)*
- *one-dimensional overland (1D)*
- *two-dimensional overland (2D)*
- *coupling sewer-overland (1D–1D and 1D–2D)*

DEM

The reliability of simulated water depth is closely linked to **the accuracy and spatial resolution** of the DEM, with higher resolutions better preserving topographical features *(Ghalandari, 2023).*



UDS



Factors such as the **absence of proper UDS mapping, the type and hydraulic capacity of drainage systems, the extent and distribution of impervious surfaces, soil type, initial soil moisture, and terrain properties** (e.g., slope and elevation) **also significantly influence the location, spatial extent, depth, onset speed, and duration of flooding.** Also, the **gully pot/inlet blockages** can be cause of pluvial flooding, highlighting the importance of maintenance and rehabilitation *(Haghighatafshar et al., 2020)*

Selected references

1. Wang, Z., Lyu, H., & Zhang, C. (2023). Pluvial flood susceptibility mapping for data-scarce urban areas using graph attention network and basic flood conditioning factors. Geocarto International, 38(1). https://doi.org/10.1080/10106049.2023.2275692
2. Liu, J., Shao, W., Xiang, C., Mei, C., & Li, Z. (2020) Uncertainties of urban flood modeling: Influence of parameters for different underlying surfaces. Environmental Research, Volume 182 (108929), ISSN 0013-9351, https://doi.org/10.1016/j.envres.2019.108929
3. Maier, R., Krebs, G., Pichler, M., Muschalla, D., & Gruber, G. (2020) Spatial Rainfall Variability in Urban Environments—High-Density Precipitation Measurements on a City-Scale. Water. 12(4):1157. https://doi.org/10.3390/w12041157
4. Cristiano, E., ten Veldhuis, M.C., & van de Giesen,N. (2017) Spatial and temporal variability of rainfall and their effects on hydrological response in urban areas– a review. Hydrol. Earth Syst. Sci., 21, 3859–3878. https://doi.org/10.5194/hess-21-3859-2017
5. Ochoa-Rodriguez, S., Wang, P., Willems, P., & Onof, C. (2019). A Review of Radar-Rain Gauge Data Merging Methods and Their Potential for Urban Hydrological Applications. Water Resources Research, 55(8), 6356-6391. https://doi.org/10.1029/2018WR023332
6. Ghalandari, S. (2023). A Compilation of Benchmark Pluvial Flood Datasets. European Journal of Development Studies, 3(6), 68–78. https://doi.org/10.24018/ejdevelop.2023.3.6.321
7. Haghighatafshar, S., Becker, P., Moddemeyer, S., Persson, A., Sörensen, J., Aspegren, H., & Jönsson, K. (2020). Paradigm shift in engineering of pluvial floods: From historical recurrence intervals to risk-based design for an uncertain future. Sustainable Cities and Society, 61, 102317. https://doi.org/10.1016/j.scs.2020.102317
8. Bulti, D.T., Abebe, B.G. A review of flood modeling methods for urban pluvial flood application. Model. Earth Syst. Environ. 6, 1293–1302 (2020). https://doi.org/10.1007/s40808-020-00803-z
9. Acquilino, M., Boni, G., Cauteruccio, A. & Gnecco, I. (2024). The Impact of input data and system description on modelling of pluvial flooding: A literature Review Workshop RETURN, Cagliari 5-7 Giugno 2024.

Finanziato dall'Unione europea NextGenerationEU

Ministero dell'Università e della Ricerca

Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

This study was carried out within the RETURN Extended Partnership and received funding from the European Union Next-Generation EU (National Recovery and Resilience Plan – NRRP, Mission 4, Component 2, Investment 1.3 – D.D. 1243 2/8/2022, PE0000005)