Aspects of Urban Flooding: A State of Art of Review

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Abstract:

Urban flooding is the inundation of land in a built environment, most notably in heavily populated areas. It occurs when rainfall or other events exceed the capacity of drainage systems. It is a complex whole that deals with the factors ranging from geology like low relief up to anthropocentric facets like urbanization, faulty drainage, and unscientific waste management. This is a kind of flood which is mostly man-made in nature. Going through literature those have come up with various factors of urban flooding is important for understanding the nature of the flooding and where it is occurring like whether it is coastal city or a hill city or a city in the plains. This paper provides a current literature overview on flood impact assessment in urban environments, including their application and limitations.

Keywords: Urban Flood, climate change, urban drainage, urbanization, review.

1. Introduction:

Flooding is the most prevalent natural disaster that causes enormous devastation. (Jha et al., 2011) Although floods may occur everywhere, from rural Indus River villages to urban areas such as Sendai, Brisbane, New York, Bangkok, Jakarta, and Karachi, the most damage happens in cities because to the larger concentration of property as well as individuals. (Hammond et al., 2015) Urban floods are becoming increasingly widespread in all major cities, particularly in Asian cities, which previously experienced significant water logging and are now confronted with the urban flooding issue. It is the influx of a tremendous amount of water induced by torrential rainfall, as the name implies. It is occasionally accompanied with catastrophic events such as cyclones, but the fundamental cause of urban area is unplanned urban growth, an excessive pace of concretization, slum clustering, development beyond the natural flood barrier, and so on. If trend on the climate of the South-East Asian cities is followed then it can be summarized as:

a. There will be an increase in the number of climatic extreme events.

b. Cities in Asia's low-lying delta will be increasingly affected by climate change.

c. People living in slums and shanties will be disproportionately affected by climate change. [Point:1-3-(Svensson & Whitehead, 2021)]

If different authentic definitions of urban flooding is mentioned,

- '*Urban flooding is significantly different from rural flooding as urbanization leads to developed catchments, which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times. Consequently, flooding occurs very quickly due to faster flow times (in a matter of minutes).*'-(National Disaster Management Authority, 2017)

- *'Urban flooding is not just "flooding that happens in an urban area." This isn't what happens when a river overflows its banks or when a hurricane drives a storm surge across a coastal neighborhood. Instead, it's caused by excessive runoff in developed areas where the water doesn't have anywhere to go. Urban flooding can be linked to a major disaster, like Hurricane Harvey and its 33 trillion gallons of rainfall. But more often it happens during more routine circumstances, appearing in the form of wet basements and sewer backups. Even small amounts of rain can overwhelm the deteriorated or inadequate infrastructure found in many neighborhoods, especially in Impoverished, neglected, and/or socioeconomically isolated urban communities.'*(Weber, 2019)
- *'Urban flooding is defined as the inundation of land or property in the built environment when storm water management systems, like storm sewers, fail. Climate change is bringing increasingly heavy rains. Combining this with the increase in runoff from continued development, we find that outdated municipal drainage systems are unable to keep up. The result is more frequent and intense local flooding, destroying homes and personal property and forcing businesses to close'.*(FEMA (Federal Emergency Managing Authority), 2020)

From the definitions the factors have come up in the following manner:

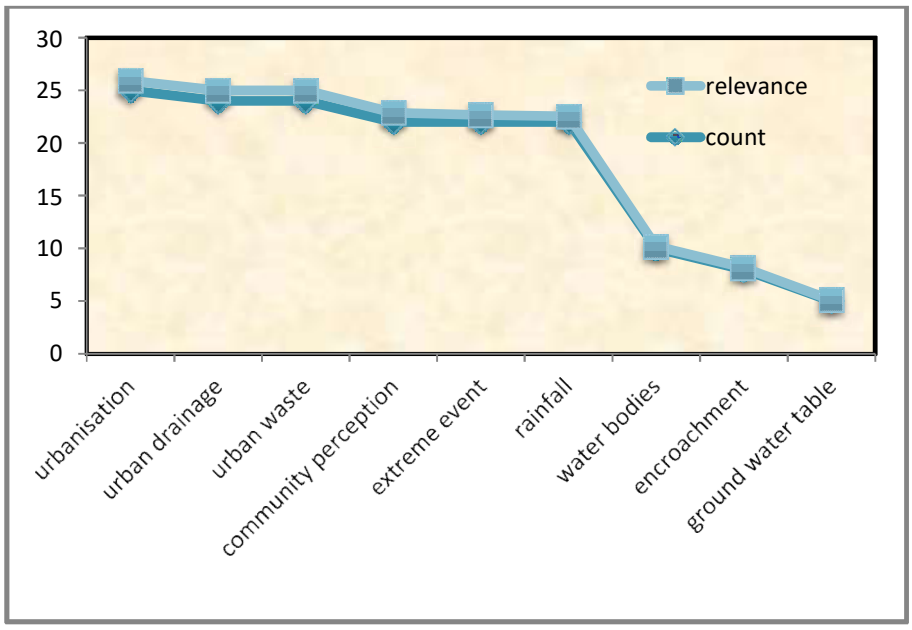

Fig.1, 2. Word cloud on the factors of urban flooding and the occurrences of the factors in terms of relevance

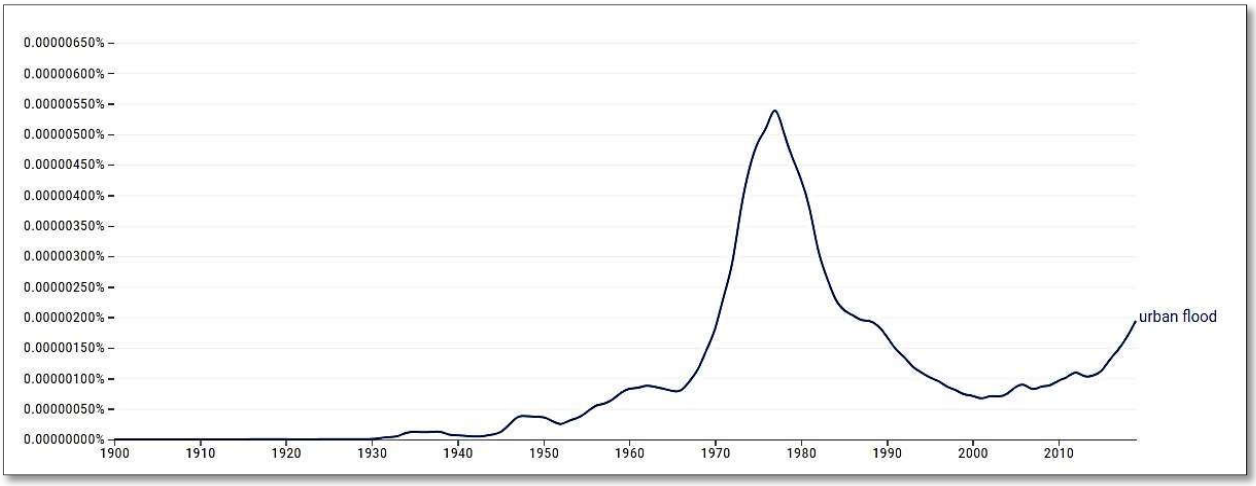

Fig.3 Showing the trend of researches on urban flood.[*Google* Books *Ngram Viewer where X-axis shows the year and Y-axis shows the percentages of the occurrences of the books comprising the key word 'urban flood management' more than 40 times in a specified corpus..(Josund, 2017)*

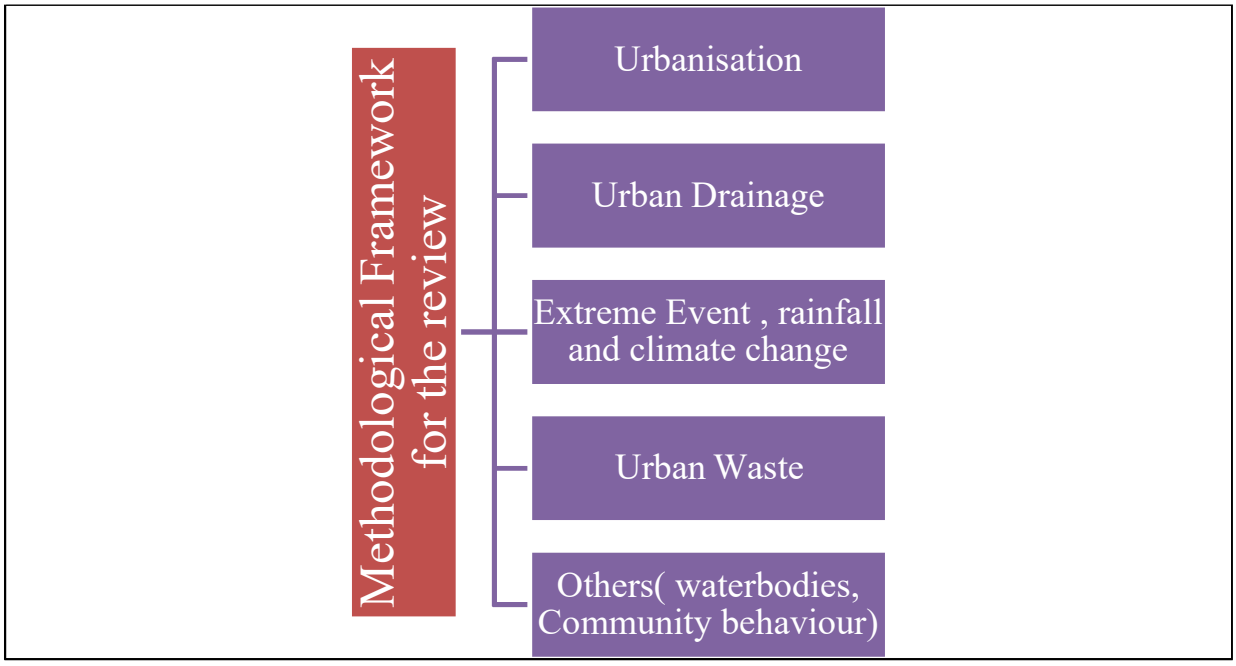

Fig.4 The Methodological Framework for Literature Review

2. Factors of Urban Flooding:

2. A. Urbanization:

Floods have become increasingly dangerous in many places, causing damage a rising number of people each year. (Zambrano et al., 2018) If the global examples are studied, in case of Don Valley watershed, the mechanism for urban flood is perceived as - the rainwater transport and storage at the ground surface within a particular watershed are drastically affected during urbanization due to changes in landscape from natural to man-made. Built impermeable materials prevent natural water penetration, lowering the rate of surface infiltration. When the precipitation rate exceeds the maximum rate of infiltration, extra precipitation will travel swiftly as overland flow into a stream channel and contribute to short-term stream response, potentially resulting in soil erosion and floods like in the case of the. (Feng et al., 2021) That is why, a good understanding of flood responses in locations with varying degrees and expansions of urbanization are critical for regional urban planning. (Du et al., 2019) Ground conditions and the built environment, which is constantly being updated and reshaped by human actions, have a considerable impact on urban flood risk as experienced in three areas on Accra's expanding outskirts. (Andreasen et al., 2022) On the other hand, The United States has become a more urban society over the last century. Flooding is affected by changes in land use linked with urban development in a variety of ways. Increasing flow to streams from rainfall and snowmelt by removing vegetation and soil, grading the land surface, and constructing drainage networks. As a result, the maximum discharge, volume, and frequency of floods in surrounding streams rise. Stream channel changes caused by urban expansion can reduce their capacity to transmit floodwaters. As new construction occurs, roads and structures in flood-prone areas face rising flood threats such as flooding and erosion. Information regarding stream flow and how land use

affects it can assist communities in reducing their current and future vulnerability to flooding. (Konrad, 2003) Despite tremendous economic and technological development that has significantly enhanced the quality of human life in recent decades, flooding continues to be the most common natural disaster, affecting a large population worldwide every year. (Ma et al., 2022) Coming to the developing countries like India, in case of population influx, migration plays a huge role within the cities. This Increase in Population which results into more inappropriate urbanization, impervious area, and generates less infiltration and greater surface flow.(N & Kumar, 2020) Here, urban flooding doesn't only occur in the urban areas but also the prime cause to it is the faulty urbanization in the flood plain cities.(R. Samal et al., 2014) Like Sarmah and Das have mentioned urban floods are more manmade in character, with fast and uncontrolled urbanization filling up water bodies, blocking water courses, causing deforestation, and so on. This urban expansion can lead to both local climate change and formation of urban heat island, which are some other important factors for flooding in the cities. The quantification of urban sprawl through land Use and Land Cover Dynamics, Gradient analysis and urban spatial metrics can be done. Based on the result, and with the input of Digital Elevation Model, a proper flood zonation map can be figured out, like it has been shown in the case study of Delhi. (Gaurav et al., 2018)The degree of Urban Sprawl can also be equated with the various entropy indices and parametric and non-parametric tests too.(Jain et al., 2016) These measures would help to manage this irrational growth calling for a proper and scientific urban planning is needed which would take account into the design of urban growth, its causes and solutions. (Rojas et al., 2017)

2. B. Climate Change and Increased Rainfall:

Global growth in urbanization, as well as the increased frequency and intensity of extreme weather events caused by climate change, pose serious challenges for urban floods. (Yang et al.,

2021)Furthermore, they have resulted in tremendous casualties and economic losses. Climate variability has contributed to precipitation uncertainty in many parts of the world, consequently urban flooding. (Thanvisitthpon et al., 2018)Climate change is anticipated to increase the severity and frequency of heavy rainfall events in Europe, which is a driving force behind urban pluvial flooding. Surprisingly, the risk of pluvial floods is expected to rise even further as winters get warmer and wetter, with more rain and less snow. This, together with rising urbanization and population, will almost certainly result in greatly increased urban pluvial flood danger. What is certain is that there is already a significant danger of flooding, and that risk is going to increase further as a result of climate and demographic change. It is critical to increase activities aimed at addressing each component of urban pluvial flood: risk, the exposure, and susceptibility. (Ochoa-Rodríguez et al., 2010) For example, on 20 July 2020, a severe downpour hit Henan Province, China, with a maximum hourly rainfall of 201.9 mm and a maximum 24-hour rainfall of 645.6 mm, killing over 300 people. A continuous rainfall struck western Japan in July 2018, killing more than 200 deaths, making it Japan's worst rainstorm disaster since the Nagasaki flood in July 1982. (Yang et al., 2021)

Hydro meteorological implications of urbanization are always an overly complex factor, increasing the risk and size of floods in small and urban catchments, wreaking havoc on citizens and infrastructure. The nature of the flooding is also dependent whether it is a flash flooding or pluvial flooding, or riverine or coastal floods those inundates the cities. Flooding is directly related to high precipitation; however, climate change, fast urbanization, and uncontrolled urban growth function as catalysts by altering the catchment's hydrological response. (Singh et al., 2018)Climate change has increased the likelihood of higher precipitation both in terms of higher proportion, intensity and occurrences in the twenty-first century by more than 90 percent.

(Ramachandraiah, 2011).The exact forecasting of rainfall, be it high intensity or moderate intensity is needed to deal with the city's vulnerability. The accurate modeling and prediction of rainfall can also capture the reverse-flow phenomenon which is usually found in the urban areas due to heavy storm.(Wang et al., 2019) Extreme precipitation (as in Mumbai in 2005 and the Gujarat flood disasters of 2005 and 2006) is projected to increase significantly over a vast region of the west coast and central India. This will necessitate a considerable overhaul of urban design techniques in order to incorporate flood mitigation and adaptation strategies as well as climate change mitigation and adaptation measures. (Ramachandraiah, 2011)

2. C. Urban Drainage:

Urban floods are produced by an increase in population density, the construction of urban infrastructure without proper regard for drainage issues, and an increase in paved surfaces. (Rangari & Sai Prashanth, 2018)The following processes of the urban hydrological cycle have been influenced by urbanization: (a) expanding impervious surfaces, such as sidewalks and constructions, may increase the amount of surface runoff and reduce recharge of groundwater; (b) lowering surface roughness by reducing vegetation distribution and flattening the surface could speed up the surface runoff process; (c) stiffening river bottoms may accelerate the river confluence process. Using Handan City as an example, it showed urban floods under varied land use and drainage system conditions and characterized the process of historical ground-underground building and its influence on spatial differences in waterlogging. (Liu et al., 2022)The design of urban drainage plays an important role like the presence and the layout of the major drainage system (Open nallah, natural surface drains) and minor (network of underground pipes and canals) drainage system and also their competence to channelize the excess storm

water.(Butler & Davies, 2020) In Burdwan Municipality urban drainage systems generally perform poorly, mostly as a result increased population and haphazard urbanization. Solid garbage (such as plastic, packages, and aluminum cans) clogs the majority of open surface drains. Therefore, regular flow is severely hindered. In the monsoon season, this stagnant liquid waste causes foul odors, pathogens, and urban floods (Dutta & Mistri, 2016).

2. D. Urban Waste:

Another important factor is - Conservancy services, by a Municipal body or a Town means conservation of urban environment in a sustainable clean manner by including the services like rubbish pickup and removal, road cleaning and sweeping, tree trimming and cutting, dead animal lifting, and so on. In one simple sentence, it is the services that make city garbage free.(Kumar & Goel, 2009) The major portion of this city conservancy services is performed by the removal and management of Municipal Solid Waste (MSW). Most of the cities of today are growing at a much faster rate than flood risk control techniques and infrastructure are being developed. Furthermore, existing systems are ill-equipped to deal with changing and expanding runoff patterns caused by climate change and increased impervious surfaces. These stresses are felt most acutely in the informal settlements of developing cities, where impromptu buildings commonly spread into flood-prone, low-lying zones or existing drainage systems Meanwhile, industrialization increases and diversifies waste production per capita, resulting in a waste output rate that exceeds actual urbanization Municipal and residential trash are likely the most abundant of these urban waste groups Yet that, only about 30% of urban garbage in underdeveloped

countries is collected. Due to a lack of waste collection services and an understanding of health and sanitary concerns, residents turn to dumping these wastes into nearby drains, streams, and open areas. Inside drains, open dumpsites (Mokuolu et al., 2022) During a flood, trash and other material gathered by floodwaters can cause additional property damage and result in higher flood losses following a flood, waste deposition can impede access and serve as a source of toxins and a breeding ground for disease. Floods can also disrupt waste management systems, causing contaminants to leak into groundwater (Lamond et al., 2012) On the other hand, towns and cities in the developing nations are acting as hubs of solid waste generation as an outcome of immense population growth and haphazard urbanization. Poor solid waste management (SWM) has become a burden for governments in developing Asia and Africa, as it is critical to public health, safety, and the environment. Uncollected rubbish piles in the streets, obstructed drainage channels, or deposited in watercourses constitute a significant public health risk, and unmanaged disposal of waste can harm water supplies and pose serious environmental health risks to people who live nearby. Workers in solid waste and rubbish collection confront severe occupational health and safety risks. (Ferronato & Torretta, 2019)Thus, solid waste must be handled in a way that minimizes environmental and human health concerns, which has consequences for its storage, collection, and safe disposal. The National Action Plan for Municipal Solid Waste Management Act 2000 and Solid waste management rules,2016 (India) both put an emphasis the duty of an Urban local body to deal with the municipal solid waste management starting from its generation to its recycling processes.(Ministry of Environment Forest and Climate Change, 2016)

2. E. Other Factors:

Floods in various cities, including Mumbai, Hyderabad, Surat, and Bangalore, suggest encroachment and loss of water sources, the cities which were once endowed with water bodies. (Chigurupati, 2008) Also, there has been a scarcity of research on community resilience to urban floods, particularly among transient people, therefore more empirical investigations are needed to increase our understanding and find effective treatments.(Xu et al., 2020)

3. Conclusions:

The gap between disaster occurrence and precaution is always filled with casualties and the one stakeholder that is always first to suffer is the community or the local people.. While numerous climate change prevention and adaptation methods have been implemented in recent years, many have progressively come to the conclusion that developing community resilience is critical when responding to climate change, particularly urban flooding. Floods in metropolitan settings are the result of a complex socio-ecosystem process with numerous factors, so micro-level urban watershed planning including the local citizens is the most convenient step at this hour.

References:

Andreasen, M. H., Agergaard, J., Allotey, A. N. M., Møller-Jensen, L., & Oteng-Ababio, M. (2022). Built-in Flood Risk: the Intertwinement of Flood Risk and Unregulated Urban Expansion in African Cities. *Urban Forum*, *0123456789*. https://doi.org/10.1007/s12132-022-09478-4

Butler, D., & Davies, J. (2020). Urban drainage systems. *Urban Drainage*, 37–47. https://doi.org/10.1201/b13173-6

Chigurupati, R. (2008). *Urban growth, loss of water bodies and flooding in Indian cities* (pp. 121–125). https://doi.org/10.1201/9780203884102.ch13

Du, J., Cheng, L., Zhang, Q., Yang, Y., & Xu, W. (2019). Different Flooding Behaviors Due to Varied Urbanization Levels within River Basin: A Case Study from the Xiang River Basin, China. *International Journal of Disaster Risk Science*, *10*(1), 89–102. https://doi.org/10.1007/s13753-018-0195-4

Dutta, S., & Mistri, B. (2016). *Solid Waste Management and Sewerage Condition in Barddhaman Municipal Solid Waste Management and Sewerage Condition in Barddhaman Municipal Area , West Bengal- An Environmental Overview*. *January 2016*, 1–16.

FEMA (Federal Emergency Managing Authority). (2020). *Types of Floods and Floodplains*.

Feng, B., Zhang, Y., & Bourke, R. (2021). Urbanization impacts on flood risks based on urban growth data and coupled flood models. *Natural Hazards*, *106*(1), 613–627. https://doi.org/10.1007/s11069-020-04480-0

Ferronato, N., & Torretta, V. (2019). Waste mismanagement in developing countries: A review of global issues. *International Journal of Environmental Research and Public Health*, *16*(6). https://doi.org/10.3390/ijerph16061060

Gaurav, S., Shafia, A., & Bharath, H. A. (2018). Urban growth pattern with urban flood and temperature vulnerability using {AI}: a case study of Delhi. *{IOP} Conference Series: Earth and Environmental Science*, *169*, 12092. https://doi.org/10.1088/1755-1315/169/1/012092

Hammond, M. J., Chen, A. S., Djordjević, S., Butler, D., & Mark, O. (2015). Urban flood impact

assessment: A state-of-the-art review. *Urban Water Journal*, *12*(1), 14–29. https://doi.org/10.1080/1573062X.2013.857421

Jain, M., Dimri, A. P., & Niyogi, D. (2016). Urban sprawl patterns and processes in delhi from 1977 to 2014 based on remote sensing and spatial metrics approaches. *Earth Interactions*, *20*(14). https://doi.org/10.1175/EI-D-15-0040.1

Jha, A., Bloch, R., & Davies, J. (2011). *Five Feet High and Rising Cities and Flooding in the 21 st Century* (Issue May 2011).

Josund, K. (2017). *Dating Text From Google NGrams*. 1–11.

Konrad, C. P. (2003). Effects of Urban Development on Floods. *U.S. Geological Survey*, *d*(November), 1–4.

Kumar, K. N., & Goel, S. (2009). Characterization of Municipal Solid Waste (MSW) and a proposed management plan for Kharagpur, West Bengal, India. *Resources, Conservation and Recycling*, *53*(3), 166–174. https://doi.org/https://doi.org/10.1016/j.resconrec.2008.11.004

Liu, B., Xu, C., Yang, J., Lin, S., & Wang, X. (2022). Effect of Land Use and Drainage System Changes on Urban Flood Spatial Distribution in Handan City: A Case Study. *Sustainability (Switzerland)*, *14*(21). https://doi.org/10.3390/su142114610

Ma, Y., Cui, Y., Tan, H., & Wang, H. (2022). Case study: Diagnosing China's prevailing urban flooding—Causes, challenges, and solutions. *Journal of Flood Risk Management*, *15*(3), 1–13. https://doi.org/10.1111/jfr3.12822

MINISTRY OF ENVIRONMENT FOREST AND CLIMATE CHANGE. (2016). Solid Waste

Management Rules 2016. *MOEF, Government of India*, 787–790.

Mokuolu, O. A., Odunaike, A. K., Iji, J. O., & Aremu, A. S. (2022). Assessing the Effects of Solid Wastes on Urban Flooding: A case study of Isale Koko. *LAUTECH Journal of Civil and Environmental Studies*, *9*(1), 22–30. https://doi.org/10.36108/laujoces/2202.90.0130

N, H. I. V., & Kumar, A. (2020). Causes and Impacts of Urban Floods in Indian Cities: A Review. *International Journal on Emerging Technologies 11(4):*, *11*(4), 140–147.

National Disaster Management Authority, G. (2017). *Urban Floods*. Natural Hazards.

Ochoa-Rodríguez, S., Smith, D. K. M., Pina, R., & Mijic, D. A. (2010). *Urban pluvial flooding and climate change: London (UK), Rafina (Greece) and Coimbra (Portugal)*. Grantham Institute – Climate Change and the Environment.

R. Samal, N., K. Roy, P., Majumadar, M., Bhattacharya, S., & Biswasroy, M. (2014). Six Years Major Historical Urban Floods in West Bengal State in India: Comparative Analysis Using Neuro-Genetic Model. *American Journal of Water Resources*, *2*(2), 41–53. https://doi.org/10.12691/ajwr-2-2-3

Rangari, V. A., & Sai Prashanth, S. (2018). Simulation of Urban Drainage System Using a Storm Water Management Model (SWMM). *Asian Journal of Engineering and Applied Technology*, *7*(1), 7–10. https://doi.org/10.51983/ajeat-2018.7.1.872

Rojas, O., Mardones, M., Rojas, C., Martínez, C., & Flores, L. (2017). Urban Growth and Flood Disasters in the Coastal River Basin of South-Central Chile (1943–2011). *Sustainability*, *9*(2). https://doi.org/10.3390/su9020195

Singh, P., Sinha, V. S. P., Vijhani, A., & Pahuja, N. (2018). Vulnerability assessment of urban

road network from urban flood. *International Journal of Disaster Risk Reduction*, *28*, 237–250. https://doi.org/https://doi.org/10.1016/j.ijdrr.2018.03.017

Svensson, A., & Whitehead, L. (2021). *IPCC REPORT REINFORCES NEED FOR MORE INVESTMENT IN FLOOD RESILIENCENo Title*. UNDRR.

Thanvisitthpon, N., Shrestha, S., & Pal, I. (2018). Urban Flooding and Climate Change: A Case Study of Bangkok, Thailand. *Environment and Urbanization ASIA*, *9*, 097542531774853. https://doi.org/10.1177/0975425317748532

Wang, X., Kinsland, G., Poudel, D., & Fenech, A. (2019). Urban flood prediction under heavy precipitation. *Journal of Hydrology*, *577*, 123984. https://doi.org/https://doi.org/10.1016/j.jhydrol.2019.123984

Weber, A. (2019). *What Is Urban Flooding?* NRDC.

Xu, W., Xiang, L., & Proverbs, D. (2020). Assessing community resilience to urban flooding in multiple types of the transient population in china. *Water (Switzerland)*, *12*(10). https://doi.org/10.3390/w12102784

Yang, Q., Zheng, X., Jin, L., Lei, X., Shao, B., & Chen, Y. (2021). Research progress of urban floods under climate change and urbanization: A scientometric analysis. *Buildings*, *11*(12). https://doi.org/10.3390/buildings11120628

Zambrano, L., Pacheco-Muñoz, R., & Fernández, T. (2018). Influence of solid waste and topography on urban floods: The case of Mexico City. *Ambio*, *47*(7), 771–780. https://doi.org/10.1007/s13280-018-1023-1