Causes, Impacts, and Mitigation Strategies of Urban Pluvial Floods in India: A Systematic Review

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Introduction

Few studies have considered the direct risk to urban areas from 'pluvial' (rainfall-runoff) floods, despite several studies indicating that it is likely to pose a threat to human-environment systems.

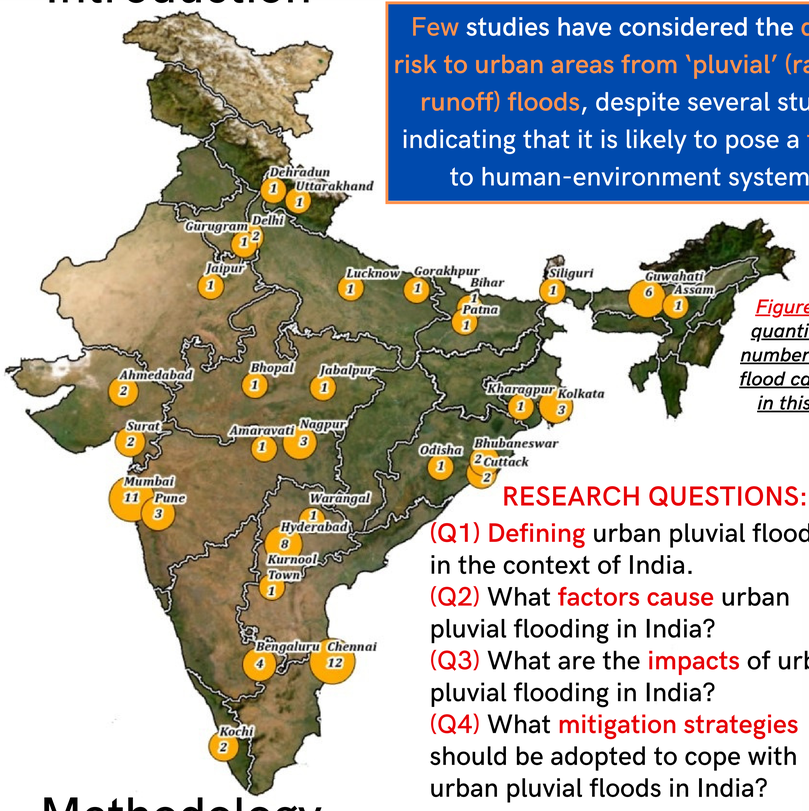


Figure 1: Map quantifying the number of pluvial flood case studies in this review.

RESEARCH QUESTIONS:

(Q1) Defining urban pluvial flooding in the context of India.
(Q2) What factors cause urban pluvial flooding in India?
(Q3) What are the impacts of urban pluvial flooding in India?
(Q4) What mitigation strategies should be adopted to cope with urban pluvial floods in India?

Results

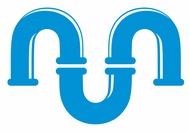
(Q1) Upon examining how scholars describe urban pluvial flooding in India we propose a reasonable definition to be: "floods that are caused by intense and frequent rainfall events during the Indian summer monsoon season in growing urban centers exacerbated by inadequate and congested stormwater drainage. These factors lead to waterlogging and increased surface runoff in Indian cities."

(Q2) Factors causing urban pluvial flooding in India:

Extreme Rainfall (n=51)

Urbanization (n=44)

Topography *(n=34)*



Drainage *(n=33)*

Waste *(n=13)*

Soil Type (n=7)

Management Issues *(n=7)*

(Q3) Direct Impacts (n= 33): damages to formal and informal settlements, human casualties, damaged transportation systems, loss of household items, loss of livelihood.
Indirect Impacts (n=15): damage from waterlogging, human and livestock displacement, water distribution and service connection hold ups, looting, increased risk of water and vector-borne diseases, long term illnesses, unequal access to relief, damage to local industries, lack of access to cultural places, social conflicts among family members, exposure to snakes and other harmful insects.

(Q4) Mitigation strategies that can be adopted to cope with urban pluvial floods:

Proactive (n=57)
- Develop equitable loss redistribution networks.
- Maintenance of existing drainage systems.

Reactive (n=6)
- Stricter implementation of Standard Operating Procedures.
- Improve warning systems.

Recovery (n=10)
- Coordinate the distribution of relief materials.
- Create a plan to provide legal assistance.

Methodology

Table 1: Literature screening process inspried by PRISMA guildlines.

Stage	Selection Process	Number of Articles
Stage 1	Search academic databases SCOPUS, Web of Science, Springer, and Google Scholar for studies published after the year 2010 using keywords "India" AND "flood" AND "urban" AND "adaptation" AND "causes" AND "mitigation" AND "impacts" OR "effects"	1578
Stage 2	Remove duplicates in EndNote	1440
Stage 3	Remove irrelevant publications based on the following inclusion criteria: 1) Focus on India or any regions in India; 2) analyze pluvial or "rainfall-driven" flooding; 3) floods occur in urban settings	138
Stage 4	Obtain full text downloads and review content for causes, impacts, and mitigation strategies of urban pluvial floods in India	125
Stage 5	Final set of articles included in the study	62

Qualitative Coding

NVIVO

DATA SUMMARY

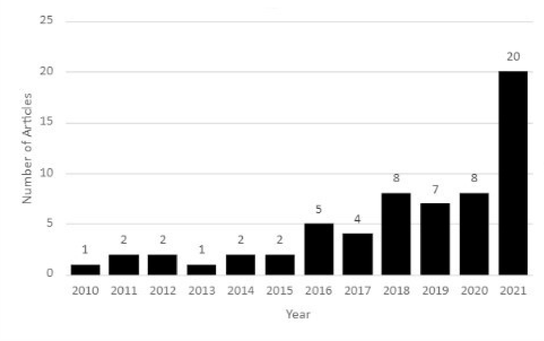


Figure 2: Distribution of articles over the past decade that were included in this review.

Conclusion

Over the last decade, we found increased attention on the subject among scholars, with most of the research articles focusing on growing urban agglomerations such as Chennai, Mumbai, Hyderabad, Guwahati, and Bengaluru. The findings of this study will inform future research directions and enhance not only India's but also other global urban center's resilience to urban pluvial flooding events.

LIMITATIONS

Due to the nature of searching academic databases, it is possible that some relevant studies on "causes, impacts, and mitigation strategies" were omitted.