

Vahid Bakhtiari¹, Farzad Piadeh², Kouros Behzadian³

¹ Civil and Environmental Engineering Department, Amirkabir University of Technology (AUT), Hafez St., Tehran 15875-4413, Iran
² School of Physics, Engineering and Computer Science, University of Hertfordshire, Hatfield AL10 9AB, United Kingdom
³ School of Computing and Engineering, University of West London, St Mary's Rd, London, W5 5RF, UK

e-mail: vahidbakhtiari1995@gmail.com
 e-mail: f.piadeh@herts.ac.uk
 e-mail: kouros.behzadian@uwl.ac.uk

Introduction

- In recent years, there has been a discernible trend towards the development of Internet of Things (IoT) technology for establishing flood early warning systems [1].
- The primary objective of these tools is to inform relevant stakeholders involved in flood risk management [2].
- However, the comprehensive investigation of the role of Internet of Things in various stages of flood risk management, namely prevention, mitigation, preparedness, response, and recovery has not been thoroughly explored [3].

Aim and Objectives

This study conducted a bibliometric analysis of recent publications examining the application of Internet of Things technology in various stages of flood risk management to inform stakeholders.

Methodology

- The research database was collected from the Scopus search engine using the recommended method of searching in titles, abstracts, and keywords (Table 1).
- A set of four search and screening strategies (S₁-S₄) were applied to narrow down the search results. Ultimately, 51 studies were selected.
- The search results began with 740 publications in the first stage (S₁), which were gradually narrowed down in steps S₂ and S₃. The selected studies were used for applied approaches for Internet of Things in urban flooding (S₃), investigating the role of research works in the different risk management phases (S₄).

References

- [1] Bakhtiari, V., Piadeh, F., Behzadian, K. (2023). Application of innovative digital technologies in urban flood risk management. *EGU General Assembly 2023, Vienna, Austria*. <https://doi.org/10.5194/egusphere-egu23-4143>.
- [2] Zeng, F., Pang, C., Tang, H., 2023. Sensors on the Internet of Things systems for urban disaster management: a systematic literature review. *Sensors*, 23(17), p.7475.
- [3] Bakhtiari, V., Piadeh, F., Chen, A., Behzadian, K. (2023). Stakeholder analysis in the application of cutting-edge digital visualisation technologies for urban flood risk management: A critical review. *Expert Systems with Applications*, p.121426.

Key Findings

- While articles on the use of IoT technology in flood risk management have been conducted in various countries, East Asian countries are the pioneers in this field as they are more exposed to floods (Figure 1).
- The sensors used for IoT technology in flood risk management can be divided into 5 categories including water quantity, water quality, rainfall intensity, weather conditions, and catchment characteristics (Figure 2 (a)).
- While the application of IoT technology has shown a general upward trend over the past decade, water quantity sensors have emerged as the most commonly used device for this purpose (Figure 2 (a)).
- Although water quantity and weather condition sensors have always been the focus of IoT studies, the use of rainfall intensity and water quality sensors has experienced a growing trend in recent years (Figure 2(b)).
- IoT technology is being developed to tackle the challenges of flood risk management, with an increased emphasis on preparedness and response measures (Figure 2(c)).
- Studies on the application of IoT technology in urban flood risk management indicates that the purpose of using this technology is not just alerting various stakeholders, and the outputs are widely used for flood modeling and visualisation. (Figure 2(d)).

Table 1. Flowchart of the search strategies in the study

Code	Search and screen strategy	Keywords	Selected research works
S ₁	Finding publications studying urban flooding based on searching in titles, abstracts, and keywords, recommended by Moher <i>et al.</i> (2009)	(Urban OR City OR Domestic) AND (Flood OR Pluvial OR Fluvial OR Storm OR (Extreme AND Weather)) OR (Runoff OR Overflow OR Discharge OR Inundation OR Susceptibility)	740
S ₂	Results were limited to the last decade, English language articles, and journal papers only with searching under titles, keywords, and abstracts.	-	145
S ₃	Results were screened for application of Internet of Things research works.	(Internet) AND (Of) AND (Things) OR (IoT) OR (Early) AND (Warning) AND (System)	43
S ₄	Results were screened for finding risk management stages. Stages are identified inspired by Bhaduri (2019)	Prevention OR Mitigation OR Preparedness OR Response OR Recovery	51
S ₅	Results were screened for stakeholder identification. Stakeholders are identified inspired by Piadeh <i>et al.</i> (2022c)	(Authority OR ((Decision OR Policy) AND Maker) OR Politician) OR (People OR Citizen OR Academic OR (Affected AND population) OR Representative) OR (trustee AND Board) OR Community) OR (Operator OR Expert OR Engineer OR Technician) OR (Business OR Industry OR Commercial)	51

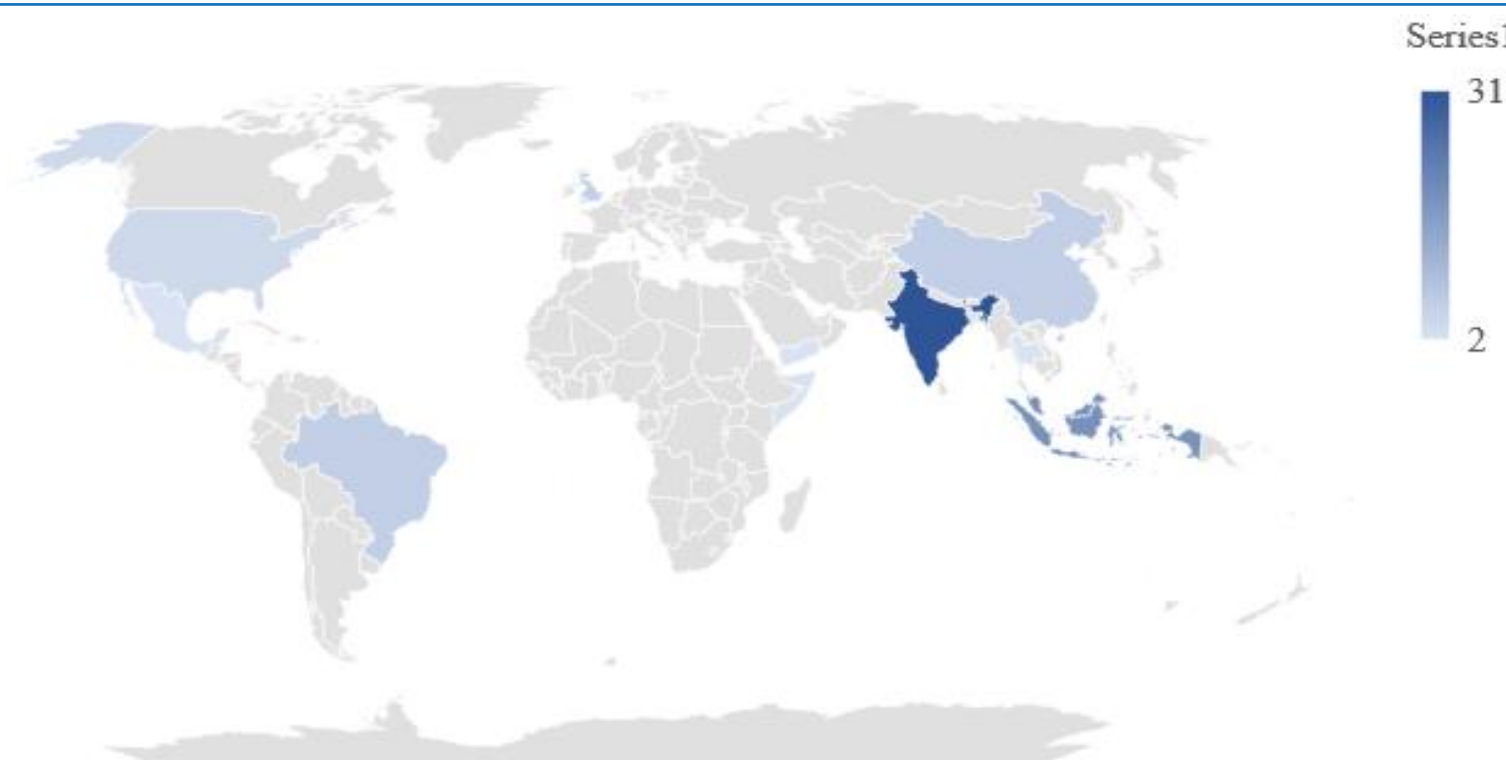


Figure 1. Distribution of papers published/presented on the use of Internet of Things in urban flood risk management in various countries in the last decade

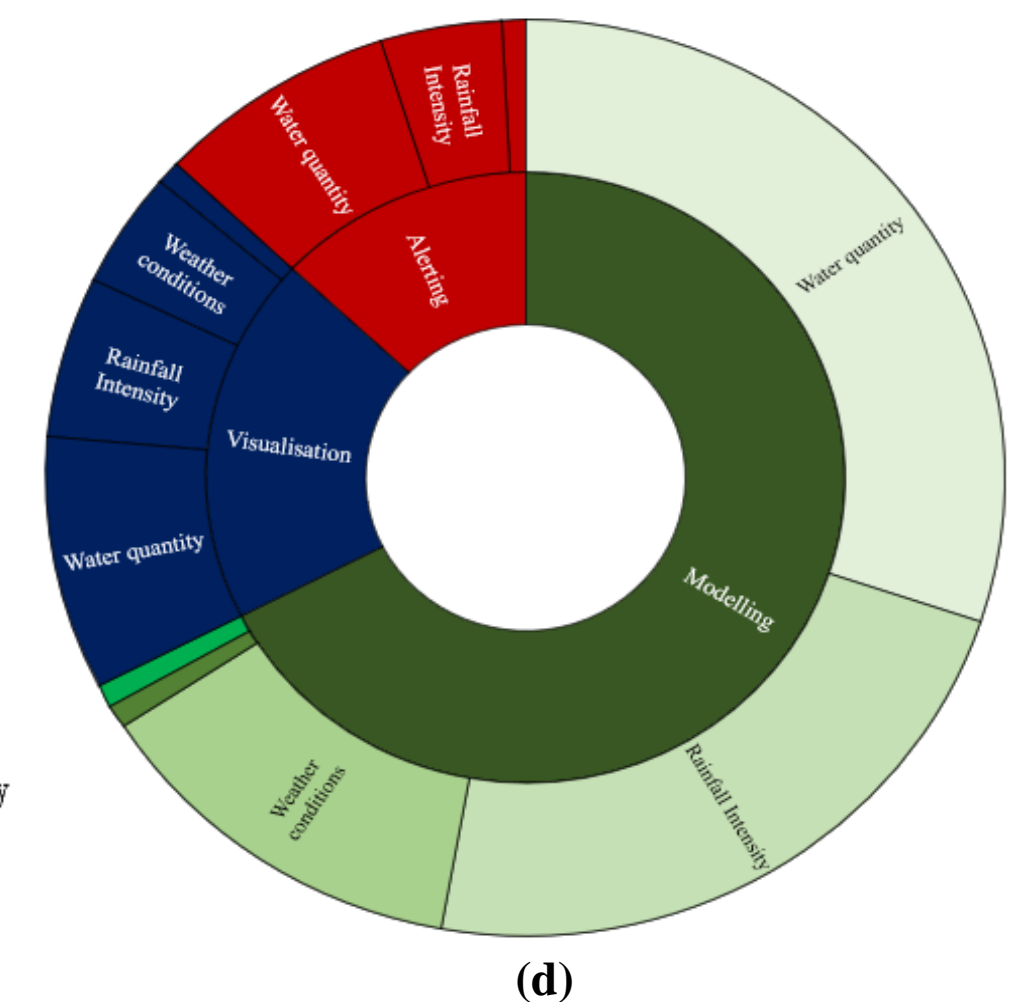
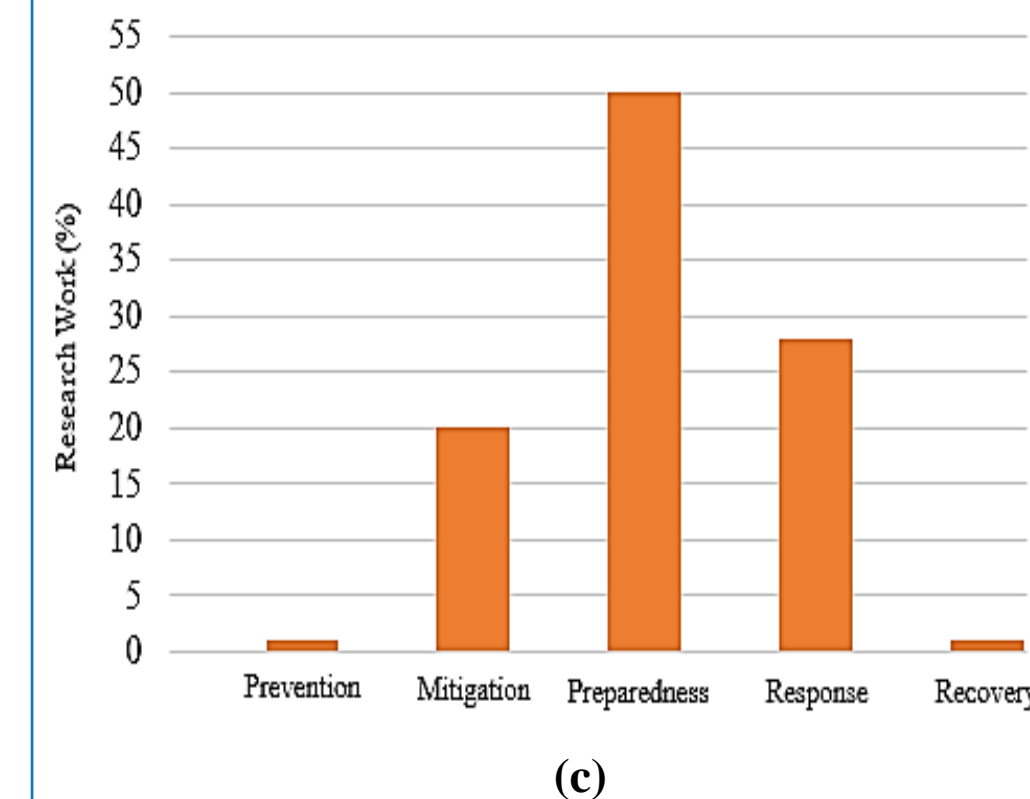
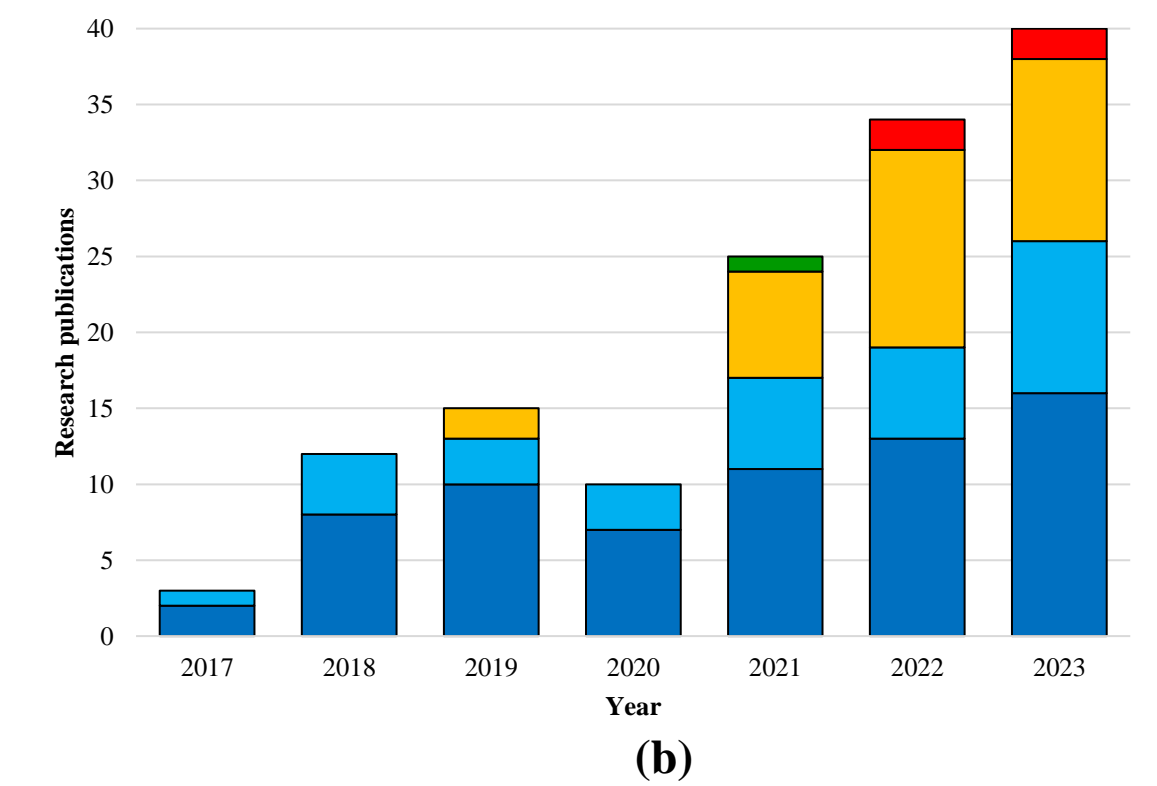
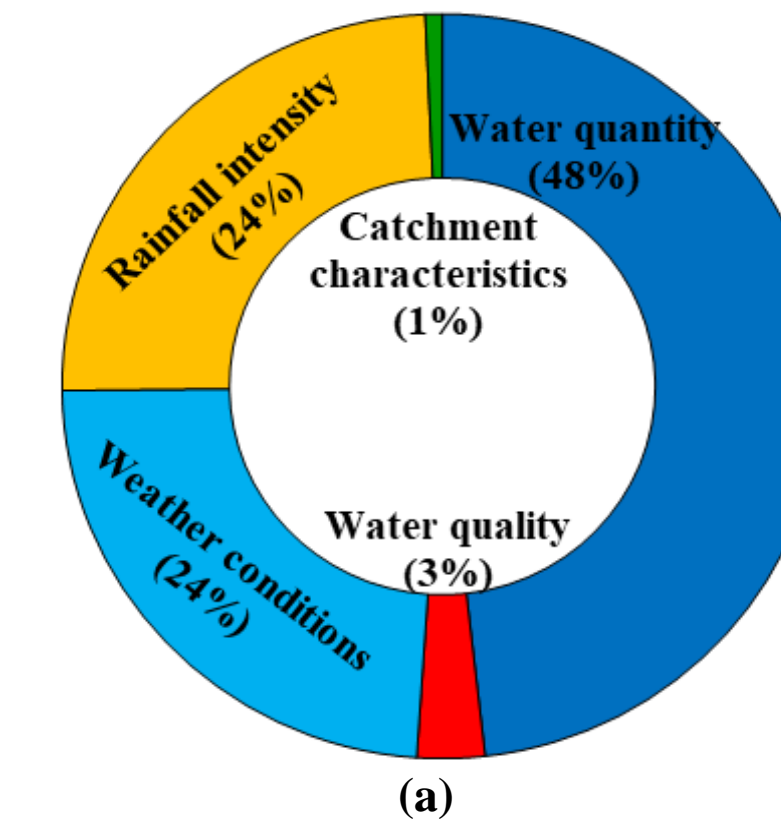


Figure 2. Dashboard of the IoT application for flood risk management: (a) IoT sensors proportional breakdown, (b) timeline distribution, (c) across risk management stages, (d) application distribution