

Internet of Things Development for Flood Early Warning Monitoring System: A Review

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ABSTRACT

The purpose of this study is to conduct a systematic literature review. The process of writing a systematic literature review (SLR) is carried out in accordance with this framework. High rainfall during the rainy season can cause continuous rainfall and increase the volume of water that has the potential to cause flooding. Meanwhile, the community does not receive information or notification directly when this happens. To anticipate these problems, it is effective to develop a water level monitoring system as an IoT-based flood early warning tool. This paper is sourced from various publications on IoT-based flood detection systems. This study discusses the definition and selection of methods used in this study, what is the purpose of this study in developing an IoT-based flood detection system, how the results of the flood detection system that has been implemented are compared. In this paper, we present the results of the development of flood detection systems in each previous study. Therefore, the main purpose of this paper is to review research on the development of IoT-based flood detection systems.

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1. INTRODUCTION

Advances in technology and information are bringing major changes in all areas, including the Internet of Things (IoT). With the emergence of the Internet of Things, the number of devices connected to the Internet, from sensors to smartphones, has increased dramatically. The number of these devices is expected to reach approximately 50 billion by 2020. In the age of technology, the use of social media has become increasingly popular among the public. Social media has become a place to interact with others, follow the latest news, and express one's opinions on a particular topic. One of the current concerns is natural disasters in Indonesia. One of the elements developed in the current digital age is the Internet of Things (IoT), or commonly known as the Internet of Things, a concept that aims to extend the benefits of always-on Internet connectivity. To things that can be unique in a web-based architecture and can be described as virtual representations. Floods are the biggest natural disaster problem in Indonesia[1]. Therefore, research in this area will be useful and many researchers have conducted research in this area.

Technological innovations that can be used in floods are flood early warning systems[2]. Residents also need more information about flood detection to help the community be better prepared at any time. The system aims to warn residents so that they are informed in advance of water levels that may cause flooding[3]. On the other hand, for early warnings to prevent significant material and human losses, disaster warning information must be provided to the public quickly and accurately.

2. RESEARCH METHOD

A systematic literature review (SLR) is a systematic and comprehensive method for identifying, evaluating, and synthesizing all relevant research related to a particular topic or research question. The SLR

process begins with formulating a clear and focused research question. Researchers then develop specific inclusion and exclusion criteria to determine which studies will be included, taking into account factors such as study design, population, intervention, and desired outcomes. A comprehensive literature search is conducted across multiple databases to collect all relevant studies, both published and unpublished, to minimize potential bias. The identified studies are then reviewed based on specific criteria, and this process typically involves multiple reviewers to ensure objectivity. The SLR method involves several steps, such as those shown in Fig. 1 below:



Fig. 1. SLR steps

2.1 Research Question

Research questions (RQ) are crucial to the systematic literature review (SLR) phase since they aid in defining the study's emphasis, direction, and scope. Researchers can create a thorough synthesis by using research questions as a guide to assess and compile the results of pertinent studies. Some important aspects of research questions in the systematic literature review on IoT-based flood detection systems are as follows:

a. Determine the methods used (RQ1)

Understanding and summarizing the approaches taken by different research in developing IoT-based flood detection systems is the goal of this question. This entails recognizing various hardware and software components, communication kinds (such as GSM, Wi-Fi, or other networks), and sensor technologies (such as rain sensors or ultrasonic sensors)[4]. RQ1 aids in highlighting creative and successful methods for creating flood detecting systems.

b. Research objectives in system development (RQ2)

RQ2 explores the main research objectives related to the development of IoT-based flood detection systems. This could include objectives such as providing early warning, improving detection reliability and accuracy, or reducing delays in risk notification. By knowing the objectives raised in previous studies, SLR can help identify the main contributions of current research and understand the direction required for system development.

c. Comparison of results and effectiveness of the system (RQ3)

This question focuses on comparing the results and effectiveness of the flood detection systems that have been tested and implemented. This includes evaluating the accuracy of the system in detecting potential floods, notification speed, energy efficiency, and accessibility for the community. Through RQ3, researchers can identify the advantages and disadvantages of each system and gain insight into the most appropriate technology and methods.

This research question is important to ensure that the SLR covers key aspects of IoT-based flood detection system development and provides comprehensive guidance for further research as in Table 1 below:

Table 1. PICOC

Population	Early warning system.
Intervention	Flood disaster prediction.
Comparison	Use of sensors and detection systems for flood early warning systems.
Output	Prediction of the accuracy Internet of Things flood early warning systems.
Context	Flood prone environment.

- *RQ 1: How did the authors identify and select the methods used in this study?*
- *RQ 2: What is the purpose of this study in developing an IoT-based flood detection system?*
- *RQ 3: How do the results of the flood detection system that have been carried out compare?*

2.2 Literature Study Research

In the literature search phase of a systematic literature review (SLR), the first step is to identify appropriate keywords and search terms so that the search results are relevant to the research topic. In IoT-based flood detection research, some commonly used keywords include “IoT flood detection system,” “flood early warning system,” “IoT sensor-based flood monitoring,” and flood detection using ultrasonic sensors. Using a combination of these keywords, along with logical operators such as AND, OR, and NOT, helps you narrow or expand your search results as needed. This process is typically done in several academic databases, such as IEEE Xplore, ScienceDirect, SpringerLink, Google Scholar, and the ACM Digital Library, each of which has its own advantages in providing journals and scientific publications related to the field of technology and the Internet of Things.

The next step is to define inclusion and exclusion criteria that aim to filter out publications that are truly relevant to the research topic. Inclusion criteria may include articles published within the past 5-10 years, research involving experiments or implementation of IoT for flood detection, and studies evaluating the effectiveness of early warning systems. In contrast, exclusion criteria included articles that were merely reviews or non-technical reviews, publications that did not focus on flood detection, and studies that did not have field experiments or real-world applications. Articles that passed the initial screening were then screened by reading the abstracts to assess their relevance to the research objectives, and only relevant articles were read in full. The selected publications were then organized and categorized based on the topic, method, or technology used. For example, articles that focused on the use of ultrasonic sensors could be grouped together, while studies that addressed GSM-based communication technology were placed in another category[5]. This step ensured that the SLR process was carried out systematically and comprehensively, so that all studies relevant to the development of IoT-based flood detection systems could be identified, screened, and produced into a useful and informative summary.

3. DISCUSSION

This article highlights some recent advancements in the application of ultrasonic sensors in Internet of Things-based flood detection systems, based on a thorough analysis of the literature. The analysis's findings demonstrate that ultrasonic sensors can assess water levels accurately and in real time. IoT technology also makes it simple to integrate data with other platforms and enables effective remote monitoring and control.

Table 2. Quality Assessment

QA1	Was the literature created in the last 5 years?
QA2	Is there a method for the literature?
QA3	Does the process of interpreting the results cover all relevant aspects, is efficient and consistent?

The following are the research results from several studies taken as in table 3 below:

Table 3. Result of research

No	Article	Title	RQ1	RQ2	RQ3	QA1	QA2	QA3
1	[6]	Flood warning and monitoring system utilizing internet of things technology	NodeMCU and Blynk, Ultrasonic Sensors	Developing an IoT-based real-time flood monitoring system to provide early warnings	The system can detect water level and rain intensity, and send alerts to users.	Y	Y	Y
2	[7]	Wireless Sensor Nodes for Flood Forecasting using Artificial Neural Network	Wireless Sensor Networks and ANN	Improving flood prediction accuracy using wireless sensor networks and Artificial Neural Network (ANN)	Generate accurate flood predictions for early preventive action.	N	Y	Y
3	[8]	Flood level indicator and risk warning system for remote location monitoring using Flood Observatory System	Wireless Sensor Network	Providing real-time flood warnings to communities in remote areas	The system detects water level and gives a danger warning	N	Y	Y
4	[9]	Flood Monitoring and Early Warning System Using Ultrasonic Sensor	Ultrasonic Sensor	Measuring water levels using ultrasonic sensors to detect potential flooding	The system provides real-time data and warnings to the surrounding community.	N	Y	Y
5	[10]	Flood Detection using Sensor Network and Notification via SMS and Public Network	Sensor Networks and SMS	Sending flood warnings via SMS to users in flood-prone areas	Sends early notification via SMS when water reaches dangerous levels	N	Y	Y
6	[11]	Flash Flood Early Warning System in Colima, Mexico	IoT based on GSM and Satellite Communication	Provides flash flood warnings via GSM and satellite networks	Sending early warnings to mobile devices in affected areas	Y	Y	Y
7	[12]	Low Cost IoT based Flood Monitoring	Machine Learning and IoT Sensors	Using machine learning models to	The system provides machine learning-based	Y	Y	Y

		System Using Machine Learning and Neural Networks		improve the accuracy of flood monitoring and warnings	prediction and warning data.			
8	[13]	Computer Vision and IoT-Based Sensors in Flood Monitoring and Mapping: A Systematic Review	Computer Vision with IoT Sensors	Implementing the Otsu method for flood prediction by analyzing the visual conditions of flood-prone areas.	Flood detection based on visual imagery achieves 94% accuracy in certain areas	Y	Y	Y
9	[14]	Smart IoT Flood Monitoring System	Ultrasonic Sensor and ARM Board	Monitor water levels and control alarm signals and water gates on an IoT-based web server	This real-time system notifies users in high-risk flood areas.	Y	Y	Y
10	[15]	A Review of the Internet of Floods: Near Real-Time Detection of a Flood Event and Its Impact	IoT and SAR sensors	Using satellite SAR data to monitor and classify flood areas in real time	Inundation detection and flood development prediction with satellite data analysis	Y	Y	Y

4. RESULT

This systematic literature review (SLR) on Internet of Things (IoT)-based flood detection aims to understand how these detection systems are developed, tested, and implemented in various studies[16]. Some of the key conclusions drawn from the analysis of the relevant studies are as follows:

a. Accuracy and Accuracy of Flood Detection

Most IoT-based flood detection systems use ultrasonic sensors to measure water levels and rain sensors to detect rainfall intensity[17]. These sensors are integrated with microcontrollers such as NodeMCUs to enable real-time data collection and transmission to monitoring centers or mobile applications. The study results show that ultrasonic sensors feature very high accuracy in monitoring water levels, ensuring the reliability of early detection of potential floods[9]. This helps in improving the accuracy of early warning systems, which is very useful for people living in flood-prone areas.

b. Effectiveness of Early Warning Systems

In many studies, mobile applications such as Blynk and messaging platforms such as Telegram are used to directly notify users when water reaches a certain level[18]. These app-based systems are very effective in delivering timely notifications as users can receive notifications directly on their smart devices. The app also supports visual monitoring through regularly updated water level charts, allowing users to proactively monitor flood conditions.

c. Implementation Challenges and System Limitations

Although IoT technology has shown promising results, there are still many challenges and limitations to overcome. A major challenge faced is the battery life of sensors used in IoT systems, especially in remote areas where access is difficult for replacement or charging. In addition, several studies have shown that the dependency on the Internet or GSM networks hinders the provision of timely warnings, especially in areas where communication networks are unstable. Therefore, further developments in the use of energy-efficient

sensors and alternative communication technologies should be considered to increase the robustness and range of the system.

d. Data Integration and Use of Cloud-based Platforms

Most IoT-based flood detection systems integrate data collected from sensors with cloud-based platforms[19]. This integration facilitates access to historical data useful for analysis and long-term decision-making. The results of the study showed that cloud-based platforms not only provide the convenience of real-time case monitoring, but also enable remote monitoring by authorities and the public.

Overall, the results of this discussion indicate that IoT-based flood detection systems have great potential to be implemented as effective and accurate flood early warning solutions[20]. However, further improvements in energy efficiency and network stability are needed to ensure that this system operates optimally under a variety of environmental conditions.

5. CONCLUSION

The preferred spelling of the word “acknowledgment” in America is without an “Flood detection systems using the Internet of Things (IoT) have proven to be effective and efficient in providing early warnings to communities in flood-prone areas. The technology typically uses ultrasonic and rain sensors and allows real-time data collection on water levels and rainfall intensity. Research has shown that integrating IoT with mobile applications such as Blynk and Telegram can provide timely notifications and increase the chances that communities will take preventive measures.

However, there are still some major challenges to overcome, such as relying on battery power for sensors in remote areas and network reliability issues. Solutions to these issues include the use of energy-efficient sensors and the use of alternative, more reliable communication technologies in areas with limited power networks. In addition, the use of cloud platforms in flood detection systems allows better access to remote monitoring and long-term data analysis.

Overall, IoT flood detection systems can be a very useful solution for disaster mitigation. Further improvements in the reliability and scope of this system are expected to provide effective, reliable and widely implemented early warnings, especially in high flood risk areas.

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