

**DEVELOPMENT OF A WEB BASED EMERGENCY RESPONSE SYSTEM
FOR FLOOD MANAGEMENT**

BY

AMADI, BLESSING CHINAGOROM, BTech

20164024418


**A THESIS SUBMITTED TO THE POST GRADUATE SCHOOL
FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE
AWARD OF MASTERS OF SCIENCE (MSC) DEGREE IN COMPUTER
SCIENCE**

JULY, 2024


CERTIFICATION

This is to certify that this work "Development of a web-based emergency response system for flood management" was carried out by Amadi Blessing Chinagorom (20164024418) in partial fulfilment of the requirements for the award of Master of Science (M.Sc.) degree in Computer Science in the Department of Computer Science, Federal University of Technology Owerri.



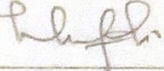
Dr. C. N. Njoku
(Supervisor)

27-08-2024
Date



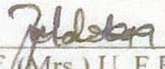
Dr. (Mrs.) U. C. Onyemauche
(Co-Supervisor)

27/08/2024
Date



Dr. (Mrs.) J. N. Odii
(H.O.D, CSC)

10/09/2024
Date



Prof. (Mrs.) U. F Eze
(Dean, SICT)

11-09-24
Date

Prof. (Mrs.) J. N. Nwosu
(Dean, PGS)

Date

Prof. Moses Okechukwu Onyesolu
External Examiner

Date

DEDICATION

This thesis is dedicated to the divine presence that has guided me to achieve this milestone. Additionally, I pay homage to my beloved late parents, Honourable and Mrs. Peter Joseph Amadi, whose unwavering support propelled me to reach this pinnacle.

ACKNOWLEDGEMENTS

I extend my deep appreciation to my supervisors, Dr. C.N. Njoku and Dr. (Mrs.) U. C. Onyemuche, whose dedicated guidance significantly advanced this work.

I am profoundly thankful to Prof. (Mrs.) U. F. Eze, the Dean of the School of Information and Communication Technology (SICT), for her nurturing support during the defense and valuable feedback.

My sincere gratitude also extends to Dr. (Mrs.) J. Odii, the Head of Department, for her steadfast encouragement and backing.

Special acknowledgment goes to Dr. I. I. Ayogu, the current PG Coordinator, for his selfless commitment. I am also indebted to the faculty members of the Computer Science Department for their invaluable teachings and constructive critiques, including Dr. S. A. Okolie, Dr. O. Njoku, Dr. (Mrs.) C. G. Onukwugha, Dr. (Mrs.) J. Odirichukwu, Dr. D. O. Njokwu, and many others.

Additionally, I express my gratitude to Dr. A. M. John-Otumu from the Department of Information Technology, FUTO, for his useful criticisms.

I also thank my siblings for their enduring patience and support throughout my studies, as well as my late parents, Honourable and Mrs. Peter Joseph Amadi, and my colleague. May they be blessed.

Above all, I acknowledge God's provision, protection, and favour throughout this journey.

TABLE OF CONTENTS

TITLE	
CERTIFICATION	ii
DEDICATION	iii
ACKNOWLEDGEMENTS	iv
ABSTRACT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	x
LIST OF FIGURES	xi
Chapter One: Introduction	1
1.1 Background Information	1
1.2 Problem Statement	3
1.3 Objectives of the study	4
1.4 Justification of study	5
1.5 Scope of Study	5
Chapter Two: Literature Review	7
2.1 Conceptual Framework	7
2.1.1 Overview of Decision support system	8
2.1.2 Crisis management	9
2.1.3 Flood management	9
2.1.4 Frequency and regularity of occurrences	10
2.2 Theoretical Framework	11
2.2.1 Crisis Management Theory	11
2.2.2 Information Systems Theory	14

2.2.3	Decision Support Systems Theory	16
2.2.4	Risk Management Theory	17
2.2.5	Technology Acceptance Model (TAM)	19
2.3	Empirical Framework	20
2.4	Summary of Related Works	34
2.4.1	Gap Analysis	37
	Chapter Three: Methodology	38
3.1	Methodology of the Proposed System	38
3.2	Analysis of the Existing System	38
3.2.1	Limitations of the Existing Systems	40
3.2.2	Architecture of the existing system	42
3.3	Analysis of the Proposed System	42
3.3.1	Software Design tools for the Proposed system	43
3.3.2	Front-end Building Tools	43
3.3.3	Advantages of the Proposed System	44
3.4	Methods of Data Collection	44
3.5	Research Design	45
3.5.1	Architecture of the Proposed System	45
3.6	The Use Case Diagram of the Proposed System	48
3.7	Sequence of the Proposed System	49
3.8	Database Design	50
3.8.1	Rescue Team Data Files	51
3.8.2	Incident Data files	52
3.8.3	Location Data files	53

3.8.4	Report List Data File	54
3.9	Software Design Model	56
3.9.1	Advantages of Model Design	57
3.9.2	Disadvantages of Model Design	57
3.10	Choice of Programming Language Used	58
3.11	The System Requirements	58
Chapter Four: Results and Discussion		
4.1	Results Analysis of Data Captured	59
4.2	Interface/Dashboard Developed	63
Chapter Five: Conclusion and Recommendations		67
5.1	Conclusion	67
5.2	Recommendation	68
5.3	Contribution to Knowledge	70
5.4	Future Research Work	71
REFERENCES		72
Appendix 1: Program Source Code		79
Appendix 2: Program Output		87

LIST OF TABLES

Tables	Title	Pages
2.1:	Summary of Related Work	34
3.1:	Flood Emergency Rescue Team Database File	52
3.2:	Flood Incident Details Files	53
3.3:	Flood Emergency Location File	54
3.4:	Report List Data File	55
4.1:	Result of Key Events on the Dashboard	59

LIST OF FIGURES

Figures	Title	Pages
2.1	Decision Process Making Steps	12
2.2:	Decision Support System Model	17
2.3:	Risk Management Theory	18
2.4:	Technology Acceptance Model	20
3.1	Architecture of the Existing System	42
3.2	High-Level Model Diagram of the Proposed System	43
3.3	Data Collection Grouping Extracted from https://nema.gov.ng/	45
3.4	Architecture of the Proposed System	46
3.5	Use Case Diagram for a Decision Support System for Flood Management	48
3.6	Sequence Diagram of the proposed system	50
3.7:	Entity Relationship Diagram for the proposed system	56
4.1:	Graphical Results Based on Key Events on the Dashboard	60
4.2:	Graphical Relationship between Incident and Respondent Types	61
4.3:	Graphical Relationship between Respondent Types and Responders Team	61
4.4:	Graphical Relationship between Responder's Team Available Teams and Unavailable Teams	62
4.5:	Access to the Developed Platform	64
4.6:	The Proposed System Dashboard	65

ABSTRACT

Floods can cause significant damage and disruption, so having an efficient emergency management system is crucial. This study aims to create a user-friendly web-based system to enhance flood emergency response. Using modern technology and strong data management practices, the system features real-time flood monitoring, quick response team deployment, and visual data tools to help users understand and respond to situations effectively. The system is developed with PHP for the backend and Adobe Dreamweaver for the frontend, ensuring it is secure, private, and tailored to different users like emergency responders, government agencies, and the public. After thorough testing, the system has proven to be reliable, scalable, and easy to use, with a dashboard that provides quick access to critical information, enabling well-informed decision-making during floods. This web-based Emergency Response System represents a significant advancement in flood management, promising to improve response efficiency and reduce the impact of floods on communities and infrastructure.

Keywords: Emergency Response System, Flood Management, Web-based Platform, Real-time Monitoring, Decision Support, User-Centric Design.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

In recent years, the world has witnessed a significant rise in flood emergencies, impacting communities worldwide (Schultz, 2006). The terms "flood" and "flooding" carry nuanced meanings, with floods being temporary conditions where surface water exceeds normal levels and flooding involving the breaching of natural boundaries due to heavy precipitation or inadequate drainage (Wang et al., 2022).

While floods pose significant risks in humid regions, they can also have devastating consequences in semiarid areas, where rapid runoff from storms can lead to widespread damage downstream (Yang et al., 2019). Various factors, including rainfall patterns, land use, and water management practices, influence the occurrence and severity of floods. Umar and Gray (2023)

Advancements in technology have revolutionized flood management strategies, encompassing both natural and artificial events (Tyler, Sadiq, & Noonan, 2019). Tools such as the internet, geographical information systems (GIS), remote sensing, and satellite communication play crucial roles in planning, hazard assessment, and disaster response efforts (Turay and Gbetuwa, 2022). Remote sensing technologies enable the identification of hazardous areas and real-time monitoring for early warning systems (Yao et al., 2021).

Communication satellites are essential for disseminating timely information and coordinating emergency responses (Raikes et al., 2019). The internet serves as a vital platform for community engagement and crisis mitigation, offering a cost-effective means of sharing flood management

information globally (Schultz, 2006). However, despite these technological advancements, challenges persist in responding effectively to flood emergencies.

Governments bear the responsibility of addressing the basic needs of their citizens during flooding events (Whitten *et al.*, 2004). Information systems, such as decision support systems (DSS), facilitate government responses by integrating people, data, processes, and technology for informed decision-making (Whitten *et al.*, 2004). While structural interventions like dykes and reservoirs are commonly used for flood protection, they may have limitations in providing comprehensive protection (Bruijn *et al.*, 2001).

Non-structural measures, such as flood forecasting and warning systems, complement structural interventions and play a crucial role in mitigating flood damage and saving lives (Hafiz *et al.*, 2013).

Spatial decision support systems, facilitated by GIS and remote sensing technology, enable informed decision-making by considering spatial variability and relevant data (Ahmad & Simonovic, 2006). These systems assist in developing and implementing interactive decision support systems for flood risk management, encompassing functions such as flood control, forecasting, and operation (Ahmad & Simonovic, 2006).

Efforts to protect against floods have shifted from solely focusing on structural interventions to managing the risks associated with floods (Mostert & Junier, 2009). An effective information system for flood management must provide accurate, timely, and relevant information to support decision-making processes (Dissanayake, 2014).

In essence, technological advancements have significantly improved flood management capabilities, but challenges persist in effectively responding to flood emergencies (Qi & Altinakar, 2011). Governments, supported by information systems and technologies, play a central role in mitigating the impacts of floods and protecting the lives and livelihoods of their citizens (Mostert & Junier, 2009).

1.2 Problem Statement

Floods represent one of the most destructive natural calamities, with their impact projected to intensify in the coming years due to factors such as population growth, urbanization, land subsidence, and the effects of climate change (Premium Times, 2022). Recent reports from Adamawa State illustrate the devastating consequences of floods, where numerous communities were submerged, resulting in significant loss of life, property damage, and disruption to livelihoods (Premium Times, 2022). Similarly, Jigawa State also experienced the adverse effects of flooding, highlighting the need for enhanced infrastructure maintenance and disaster preparedness measures (Premium Times, 2022).

Despite forewarnings and forecasts, the severity of the flood events caught residents and authorities off guard, underscoring the importance of proactive emergency management strategies (Premium Times, 2022). The lack of integrated databases and communication systems further exacerbated the challenges faced by flood management agencies in coordinating response efforts (Premium Times, 2022).

Addressing these issues necessitates the development and implementation of a comprehensive decision support system for flood management, integrating databases, communication protocols, and stakeholder coordination mechanisms (Premium Times, 2022). Given the anticipated increase

in flooding frequency due to climate change and urbanization trends, innovative approaches and strategic planning are imperative (Premium Times, 2022).

Simonovic (2002) delineates three key phases in the flood management process: pre-flood planning, flood emergency management, and post-flood recovery. Effective flood management demands a multifaceted approach encompassing proactive planning, coordinated response mechanisms, and robust recovery strategies (Simonovic, 2002).

The challenges posed by floods necessitate a paradigm shift in disaster management strategies, emphasizing the importance of proactive planning, stakeholder coordination, and the integration of technology-enabled solutions to mitigate the adverse impacts of flooding events.

1.3 Objective

The main aim of this study is to develop a web-based emergency response system for flood management.

The specific objectives are to:

1. develop a responsive web-based interface with accessible design, integrated data ingestion APIs, and secure real-time messaging protocols to enhance communication and coordination among emergency responders and agencies during flood events.
2. implement an automated alerts notification system for timely dissemination of critical information to all stakeholders
3. test and evaluate the system's performance using response metrics such as response time, and resource allocation.

1.4 Justification of the Study

The development of a web-based emergency response system for flood management is essential due to the increasing threat of flood events globally. This study will significantly benefit emergency responders, government agencies, and communities affected by floods. By providing real-time access to critical data; the system enables responders to make quick, informed decisions, reducing the loss of life and damage to infrastructure.

Government agencies will benefit from improved coordination and communication, leading to a more unified and effective response. Communities will experience enhanced resilience and reduced socio-economic impacts as the system allows for better resource distribution and preparedness, ultimately leading to quicker recovery and reduced disruptions.

This research will contribute to more efficient flood management strategies, particularly in the face of environmental changes.

1.5 Scope of the Study

This study centers on the design, development, and deployment of a specialized web-based emergency response system tailored explicitly for flood management. It encompasses several crucial elements:

The research will delve into crafting the structural blueprint and functional components of the web-based platform, ensuring its robustness and effectiveness. A user-friendly interface will be crafted to cater to the diverse needs of stakeholders involved in flood management, fostering ease of access and utilization.

The system will possess the capability to seamlessly amalgamate real-time data from varied sources like weather stations and river gauges, furnishing timely and accurate flood-related

information. Analytical tool will be devised to identify and assess high-risk flood zones, facilitating optimized resource allocation and strategic decision-making.

Secure communication channels will be established to facilitate efficient coordination and exchange of vital information among emergency responders, governmental bodies, and relevant stakeholders.

Additionally, the study will encompass rigorous testing and evaluation phases, wherein the efficacy of the web-based emergency response system will be assessed through simulated scenarios and practical deployment exercises. These evaluations will focus on enhancing flood response efficiency and mitigating associated damages.

However, it is essential to acknowledge potential limitations, such as data availability constraints, technological infrastructure challenges, and operational feasibility issues. Despite these constraints, the study aims to offer a holistic solution aimed at revolutionizing flood management practices through innovative web-based technologies and methodologies.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Framework

This section delves deeper into the fundamental concepts of decision support systems (DSS), crisis management, and flood management, shedding light on their significance and interplay.

Firstly, the elucidation of decision support systems encompasses their pivotal role in aiding decision-making processes within organizations. DSS integrates data, analytical tools, and models to provide insights and support decision-makers in tackling complex problems. These systems facilitate informed choices by presenting relevant information in a structured format, enabling users to evaluate alternatives and anticipate outcomes.

Secondly, the discussion extends to crisis management, a strategic endeavor aimed at effectively addressing and mitigating crises or emergencies. Crisis management involves a coordinated response to unforeseen events that pose significant threats to an organization's operations, reputation, or stakeholders. It encompasses various phases, including preparedness, response, recovery, and mitigation, each requiring proactive planning, resource allocation, and communication strategies.

Lastly, the discourse delves into flood management, a specialized domain within crisis management focused on mitigating the impacts of flooding events. Flood management entails a comprehensive approach to minimize the adverse effects of floods on communities, infrastructure, and the environment. It encompasses measures such as flood risk assessment, early warning systems, floodplain management, and emergency response planning, all aimed at reducing vulnerability and enhancing resilience to flood hazards.

2.1.1 Overview of a Decision Support System

To a layperson, a decision support system (DSS) appears as merely an information system. However, within the realm of information technology and manufacturing systems, advancements like automated data acquisition and the development of technologies such as manufacturing execution systems and resource planning have led to the emergence of decision support system technologies. In this context, a decision support system integrates human expertise with computer capabilities to facilitate efficient management of data, reporting, analysis, modeling, and planning tasks. Decision support systems are adept at handling structured, semi-structured, and unstructured data, as highlighted by (Felsberger et al., 2016).

According to Turban, Rainer, and Potter (2005), a decision support system (DSS) is described as a computer-based information system that leverages models and data to address semi-structured and unstructured problems, often requiring extensive user involvement. Similarly, Power (2002) defines a decision support system as an interactive computer-based system designed to assist users in utilizing computer communications, data, documents, knowledge, and models to resolve problems and make informed decisions. The decision-making process involves transforming information into instructions aimed at influencing system behaviour to enhance system performance, as articulated by (Sharifi, 2004).

Decision Support System (DSS) has four essential components namely;

- i. Language system (LS)
- ii. Presentation system (PS).
- iii. Knowledge system (KS)
- iv. Problem processing system (PPS)

Hence, a language system encompasses all the messages that the DSS is capable of receiving. Similarly, a presentation system encompasses all the messages that the DSS can emit. Lastly, a knowledge system encompasses all the knowledge that the DSS has stored and retained.

2.1.2 Crisis Management

In the contemporary business landscape, organizations necessitate continuous crisis management efforts. Today, managers and decision-makers aim to address potential crises effectively, minimizing losses or preventing crises whenever possible. It is crucial for decision-makers to adopt a proactive stance. Crisis management entails a set of strategies, measures, and methods utilized when traditional managerial skills are inadequate. Given the influence of globalization and rapid market changes, crisis management has become a focal point for organizational decision-makers. In the current environment, crises are perceived as an enduring aspect of business operations (Rais, 2007).

Fragouli and Ibidapo (2015) emphasized that crisis management demands leaders to embrace a mindset that allows them to turn crises into opportunities for organizational advancement, fostering changes that may not be feasible in ordinary circumstances. Civelek *et al.* (2016) similarly characterized crises as occasions for growth. While various societal emergencies such as terrorism, kidnapping, flooding, and on-going violence persist, the focus of my research pertains primarily to flood management.

2.1.3 Flood Management

Flooding has emerged as a significant threat in Nigeria in recent years, driven by factors such as population growth, rapid urbanization, and extreme weather events. Globally, floods contribute to substantial and escalating economic and social damages (Kundzewicz *et al.*, 2014). In Canada, floods have become more frequent and widespread amidst a swiftly changing climate (Whitfield,

2012; Nastev & Todorov, 2013). Between 1990 and 2015, Canada experienced 141 flood disasters, resulting in 21 fatalities, the evacuation of 215,207 individuals, and approximately \$79 billion in damages (Canada Disaster Database, 2016).

As noted by Borga *et al.* (2011), flash floods are characterized by brief yet intense rainfall events, leading to runoff rates that often surpass those of other flood types due to the rapid response of catchments to heavy precipitation.

2.1.4 Frequency and Regularity of Occurrences

Until recently, major flood disasters were infrequent in Nigeria, with recorded incidents dating back to 1963 when the Ogunpa River flooded Ibadan city, leading to loss of life and property. Subsequent floods occurred in 1978, 1980, and notably in 2011.

The 1980 flood, which resulted in significant casualties and property damage, drew attention to the disaster potential of the river, prompting federal risk management responses such as the initiation of the Ogunpa channelization project and public awareness campaigns on flood response measures and property relocation. Despite these efforts, the channelization project was eventually abandoned (Agbola *et al.*, 2010).

The August 2011 flood in Ibadan, while not the city's most intense rainfall event historically, caused unprecedented property damage, prompting the Nigerian government to seek assistance from the World Bank for long-term flood management projects in the city. With Nigeria experiencing rapid urbanization, the vulnerability of urban areas to flooding has increased (Odufu *et al.*, 2019).

Mano and Hubenko-Baker (2002) highlighted technological, sociological, and organizational challenges crucial to developing effective disaster communication systems. Palen, Huts, and Liu (2008) described citizen-led online forums that emerged following disasters such as Hurricane Katrina in 2005, San Bernardino wildfires in 2003, and in preparation for a potential avian flu pandemic.

The focus of this study is the design and implementation of a decision support system for flood management. Globally, floods continue to cause significant economic and social losses (Kundzewicz *et al.*, 2014).

2.2 Theoretical Framework

This section explores several theoretical frameworks relevant to advancing the research goal of creating a web-based emergency response system for flood management. The theories encompass Crisis Management, Information Systems, Decision Support Systems, Risk Management, Disaster Management, Systems Theory, Technology Acceptance Model (TAM), and Community Resilience Theory.

2.2.1 Crisis Management Theory

Crisis Management Theory is a field of study that emerged in the mid-20th century, primarily in response to the need for organizations to effectively address and navigate crises. While there isn't a single founder of the theory, it has evolved through contributions from various scholars across disciplines such as management, psychology, sociology, and communication.

One of the foundational works in Crisis Management Theory is "Managing Crises: Responses to Large-Scale Emergencies" by Ian Mitroff, published in 1988. Mitroff's work emphasized the

importance of organizational preparedness, resilience, and adaptive capacity in responding to crises.

Another influential figure in the development of Crisis Management Theory is Timothy Coombs, whose research focuses on crisis communication and reputation management. Coombs introduced the Situational Crisis Communication Theory (SCCT) in the late 20th century, which provides a framework for understanding how organizations should communicate during crises to protect their reputation.

Crisis Management Theory encompasses various aspects of crisis response, including prevention, preparedness, response, and recovery. It emphasizes the need for organizations to anticipate potential crises, develop proactive strategies to mitigate risks, and effectively manage crises such as flooding when they occur (Akintola *et al.*, 2021).

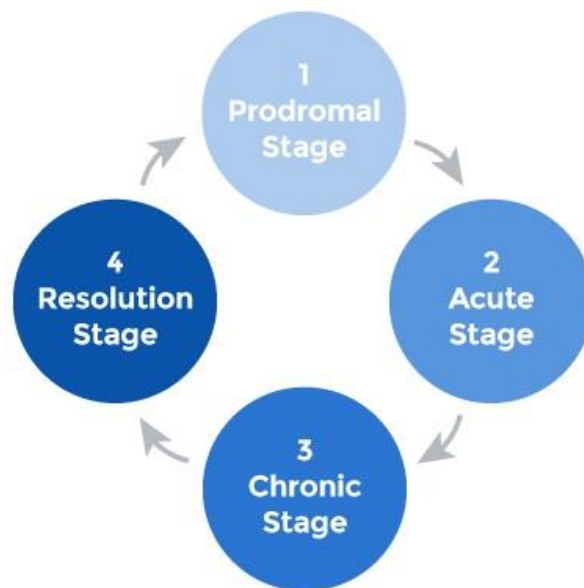


Figure 2.1: Crisis management model (Akintola et al., 2021)

The crisis management model life cycle, as illustrated in Figure 2.1, delineates four distinct phases: prodromal, acute, chronic, and resolution stages. In the context of the "Development of a Web-Based Emergency Response System for Flood Management," this model offers a structured approach to understanding and addressing flood crises. During the prodromal stage, early signs of an impending flood are monitored using the web-based system, enabling proactive measures such as early warnings and preparedness planning. The acute stage marks the onset of the flood crisis, where the system facilitates rapid communication, resource allocation, and evacuation efforts in affected areas (Akintola *et al.*, 2021; Buba *et al.*, 2021)

In the chronic stage, the system supports long-term recovery efforts by providing access to assessment tools, resource databases, and collaboration platforms for rebuilding initiatives. Finally, in the resolution stage, the system aids in post-crisis analysis, evaluation of response strategies, and development of risk reduction measures for future flood events (Buba *et al.*, 2021).

In essence, the crisis management model life cycle, when applied to flood management using a web-based system, provides a structured framework for effective preparedness, response, recovery, and mitigation efforts throughout the various stages of a flood crisis (Akintola *et al.*, 2021; Buba *et al.*, 2021).

In the context of the research work titled "Development of a Web-Based Emergency Response System for Flood Management," Crisis Management Theory can provide valuable insights and guidance in the following areas:

- (a) Preparedness and Prevention: Crisis Management Theory emphasizes the importance of proactive measures to prevent or mitigate the impact of crises. In the context of flood

management, this could involve developing early warning systems, conducting risk assessments, and implementing flood prevention strategies.

- (b) **Response Coordination:** During a flood crisis, effective coordination and communication are crucial for coordinating emergency response efforts. Crisis Management Theory provides frameworks for organizing response teams, establishing communication channels, and making timely decisions in high-pressure situations (Akintola *et al.*, 2021).
- (c) **Recovery and Resilience:** After a flood event, Crisis Management Theory highlights the importance of recovery and resilience-building efforts. This could involve implementing post-disaster recovery plans, providing support to affected communities, and learning from the crisis to improve future response efforts.
- (d) **Crisis Communication:** Effective communication is a central aspect of Crisis Management Theory. In the context of flood management, clear and timely communication with stakeholders, including the public, government agencies, and emergency responders, can help mitigate the impact of the crisis and facilitate recovery efforts (Buba *et al.*, 2021).

2.2.2 Information Systems Theory

Information Systems Theory, as a field, has evolved over-time with contributions from various scholars. One prominent figure associated with this theory is Karl Deutsch, a political scientist who introduced the concept of "social systems" in the late 1950s. However, the modern understanding of Information Systems Theory has been shaped by multiple researchers and practitioners.

In the context of the development of a web-based emergency response system for flood management, Information Systems Theory plays a crucial role in several aspects such as:

1. System Design and Architecture: Information Systems Theory provides principles and frameworks for designing the structure and architecture of the web-based system. It guides decisions on data organization, communication protocols, and user interfaces to ensure efficiency and effectiveness in managing flood-related information and responses (Sari, Susilo, & Susilo, 2013)
2. Data Integration and Management: The theory offers insights into how different data sources can be integrated and managed within the system. It addresses issues such as data quality, interoperability, and scalability, ensuring that relevant information from various sources, such as weather forecasts, flood sensors, and emergency reports, can be effectively utilized in decision-making processes (Zainudini & Sardarzaei, 2023).
3. User Interface Design: Information Systems Theory informs the design of user interfaces that facilitate intuitive interaction with the web-based system. By understanding user needs and preferences, the theory helps in creating interfaces that are user-friendly, accessible, and conducive to efficient navigation and task completion for stakeholders involved in flood management (Ogie, Adam, & Perez, 2019).
4. Communication and Collaboration: Information Systems Theory emphasizes the importance of communication and collaboration mechanisms within the system. It guides the implementation of features such as real-time messaging, notification systems, and collaborative workspaces, enabling effective coordination among emergency responders, government agencies, and affected communities during flood events.
5. Security and Privacy: The theory addresses security and privacy concerns associated with the collection, storage, and transmission of sensitive information within the system. It provides

frameworks for implementing robust security measures, such as encryption, access controls, and data anonymization, to protect against unauthorized access and data breaches.

In all, Information Systems Theory offers a comprehensive framework for the design, implementation, and management of the web-based emergency response system, ensuring that it meets the information needs and operational requirements of flood management stakeholders.

2.2.3 Decision Support Systems Theory

Decision Support Systems (DSS) theory, pioneered notably by Jay F. Nunamaker Jr. in the 1970s, centers on the use of computer-based systems to aid decision-making across various contexts. This involves integrating diverse technologies, data sources, analytical tools, and decision models to furnish decision-makers with the requisite information and insights for making well-informed decisions. In the case of flood management, DSS proves instrumental in amalgamating data from multiple sources pertinent to flood control, such as weather forecasts, river levels, demographic statistics, and infrastructure details, to facilitate thorough analysis and risk assessment.

Furthermore, DSS theory encompasses scenario planning, allowing decision-makers to envisage and evaluate different response strategies, evacuation plans, and resource allocations through simulations. This strategic planning is particularly crucial during flood emergencies, where quick and effective decisions are imperative. Real-time decision support mechanisms embedded within DSS provide timely updates, alerts, and decision-making aids to emergency responders and authorities, aiding in swift and well-informed actions to mitigate disaster impacts.

Moreover, DSS theory aids in optimizing resource allocation during flood management operations by scrutinizing real-time data and projecting the ramifications of various response strategies. By discerning where resources are most needed and allocating them efficiently, decision-makers can

bolster the effectiveness of their flood management efforts. In all, DSS theory furnishes a comprehensive framework and practical tools to enhance decision-making in complex and dynamic scenarios like flood management, harnessing technology and data-driven approaches to address challenges effectively.



Figure 2.2: Decision Support System Model (Abebe & Price, 2005)

2.2.4 Risk Management Theory

Risk Management Theory, although attributed to various scholars across disciplines, finds its roots in the pioneering work of economists like Harry Markowitz, notably for his contributions to portfolio theory in the 1950s. This theory has evolved as a multidisciplinary approach to identifying, assessing, and mitigating risks to achieve organizational goals effectively. In essence, it involves understanding, evaluating, and strategically addressing potential risks to minimize their impact.

In the specific context of the research on "Development of a web based emergency response system for flood management," Risk Management Theory holds significant relevance. It offers structured methodologies for comprehensively assessing risks related to flood management, encompassing factors like flood intensity, frequency, and vulnerabilities such as population density and infrastructure condition in flood-prone areas. This systematic assessment allows decision-makers to prioritize resources and interventions efficiently.

Furthermore, Risk Management Theory provides actionable strategies for mitigating identified risks and enhancing resilience. Whether through structural measures like building flood defenses or non-structural approaches such as land-use planning and early warning systems, the theory offers a framework for proactive risk management. By integrating these strategies into emergency response planning, decision-makers can better prepare for flood-related emergencies, minimize losses, and improve overall disaster response effectiveness.



Figure 2.3: Risk Management Theory (Gilissen et al., 2016)

2.2.5 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) was developed by Fred Davis in 1986 as a theoretical framework to understand and predict user acceptance and adoption of new information technologies. The model posits that perceived usefulness and perceived ease of use are primary determinants of an individual's attitude towards using a technology, which in turn influences their actual usage behaviour. TAM has since been widely used and extended in various fields to assess and explain user acceptance of new technologies.

In the context of the research work on the development of a web based emergency response system for flood management, the Technology Acceptance Model can be applied to understand and enhance the adoption of the web-based emergency response system among relevant stakeholders.

Firstly, TAM can help identify factors influencing the perceived usefulness of the system among users. For example, emergency responders may perceive the system as useful if it provides real-time updates on flood conditions, facilitates efficient communication and coordination among response teams, and offers valuable decision-making support tools (Gilissen et al., 2016).

Secondly, TAM can assess the perceived ease of use of the web-based system. Users are more likely to adopt the system if they find it easy to navigate, understand, and operate. Therefore, aspects such as user interface design, system responsiveness, and intuitiveness of features are crucial in influencing users' perceptions of ease of use.

By applying TAM to the development and implementation of the web-based emergency response system, stakeholders can identify potential barriers to acceptance and adoption early in the process. This allows for targeted interventions to improve the system's design, functionality, and usability,

ultimately increasing its likelihood of successful adoption and effectiveness in flood management scenarios.

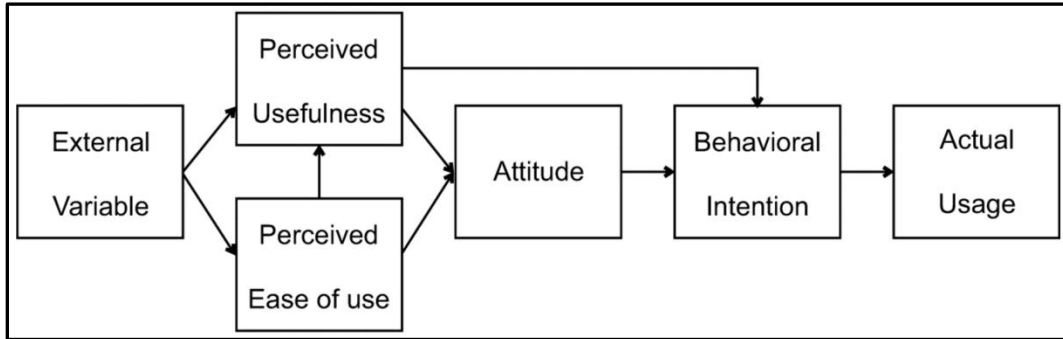


Figure 2.4: Technology Acceptance Model (Gilissen et al., 2016)

2.3 Empirical framework

Flood management, being a significant societal emergency globally, remains a subject of considerable interest and concern among both researchers and non-researchers alike. Numerous authors and diverse methodologies continue to explore flood management extensively, reflecting the on-going dedication to understanding and addressing this critical issue.

Abebe and Price (2005) proposed the development of a decision support system (DSS) tailored for urban flood management. Their focus was on creating a DSS specifically designed for flood warning and the coordination of activities within urban areas. They advocated for the utilization of design tools such as hydrologic and hydraulic forecast models in conjunction with data acquisition networks to enhance the effectiveness of flood management efforts.

Akintola *et al.* (2021) conducted research aimed at improving flood hazard modeling in the Ogunpa river basin, located in south-western Nigeria. Their approach involved integrating hydraulic modeling, analytical processes, and height above nearest drainage (HAND) models.

They utilized multi-criteria decision analysis (MCDA) to analyze their findings. Their study included event-based flood simulations using the FLO-2D model and employed the HAND model for terrain modeling to delineate inundation extents within the basin. Additionally, they integrated seven flood causative factors using analytical hierarchical process (AHP) to identify potential hazard zones.

Buba *et al.* (2021) conducted research on assessing flood vulnerability in various communities in Lokoja, Kogi State. They adopted an approach that integrated geospatial techniques and participatory methods for vulnerability studies, aiming for a proactive bottom-up approach to flood management. Their methodology included using analytical hierarchy participation to assess vulnerability, ensuring consistency in the comparison of criteria. Their results highlighted the significance of factors such as land use and elevation in determining flood vulnerability. They concluded that incorporating the perceptions of affected communities could complement conventional flood research, leading to more effective response and mitigation strategies.

Egbinola *et al.* (2017) addressed the challenges facing flood management in Nigeria in their research. They emphasized the importance of intensifying non-structural strategies in flood management efforts. Their study underscored the need to explore alternative approaches beyond structural interventions to effectively address the complexities of flood management in Nigeria.

Ahmad, Kazmi, and Pervez (2011) asserted that Pakistan, being one of the most disaster-prone countries globally, experienced its worst-ever flood during July-August 2010. They mentioned that recovery from such devastation might take months or even years for the affected people. They pointed out that natural disasters often result in significant material and human losses. Additionally, they emphasized that the dual vulnerability of populations to both natural disasters

and socio-economic challenges presents a formidable challenge to governmental response mechanisms. They observed that insufficient governmental support exacerbates emergency situations, particularly when there is a breakdown in administrative structures, impeding timely assistance and intervention. They likened the challenges faced during natural disasters to those encountered in areas of civil conflict, where displaced individuals confront similar difficulties. They highlighted the immediate aftermath of a disaster, referred to as the "first disaster," which leads to substantial loss of life and property. They further noted that subsequent indirect consequences, termed the "second disaster," unfold as a chain of cause-and-effect events, resulting in heightened health risks, financial losses, and increased incidences of crime. They argued that proactive rehabilitation and care for victims of the first disaster could disrupt this chain of events, mitigating the magnitude of subsequent disasters. They advocated for comprehensive disaster management approaches, particularly in high flood-risk zones, to minimize the impact of subsequent disasters and bolster community resilience.

Islam *et al.* (2016) outlined their objective to analyze flood disaster management mechanisms across Asia, noting floods' status as prevalent natural disasters with significant global impacts. Their study delved into selected Asian countries, including Malaysia, Indonesia, Thailand, Bangladesh, India, Pakistan, Japan, and China, to examine various aspects of flood disaster management. They explored components such as risk assessment, pre- and post-disaster programs, emergency response and recovery, flood mitigation strategies, relief efforts, preparedness initiatives, flood forecasting systems, and policy development. Their research aimed to improve disaster management systems in these countries, enabling more effective responses to disaster risks and minimizing socio-economic losses. They also stressed the need for enhanced data availability

and evaluation, advocating for the integration of diverse information types to strengthen policy-making processes.

Khalid and Shafiai (2015) discussed the issues surrounding the government's delivery system for flood victims in Malaysia, encompassing pre-disaster, during, and post-disaster phases. They observed that the current flood management approach in Malaysia primarily relies on an official strategy centered around technology, emphasizing the utilization of new technologies for flood control, forecasting, warning, and evacuation. Specifically, they highlighted the National Security Council (MKN) as the entity responsible for overseeing the national disaster management system in Malaysia, which includes providing effective relief measures for post-flood recovery. Additionally, the paper aimed to delineate the specific type of flood delivery system employed in Malaysia and to compare it with delivery systems utilized in other countries.

Wang *et al.* (2022) addressed the escalating frequency and severity of floods due to climate change and socioeconomic progress, highlighting flood management as a crucial means to mitigate adverse outcomes. They emphasized the necessity for a more resilient and sustainable approach to flood management in contemporary studies. Employing a comprehensive bibliometric analysis of flood research keywords, terms, and timelines spanning from 2000 to 2021, the study yielded fresh insights into flood research trends. The authors concluded that the trajectory of flood research has shifted from traditional flood control methods towards a focus on flood resilience. They noted a progression from conventional flood management strategies aimed at mitigation towards flood risk management approaches emphasizing adaptation. Furthermore, they highlighted the evolution towards flood resilience management, which advocates for more resilient and sustainable measures to tackle flood disasters. The study provided a thorough overview of flood research, including definitions of risk, risk analysis methodologies, flood management strategies, flood risk management approaches, and flood resilience concepts alongside their corresponding

implementation strategies. The authors advocated for the integration of resilience concepts into risk management frameworks for future flood management endeavors, asserting that this approach would yield more effective outcomes in reducing adverse consequences throughout all stages of disaster preparedness, response, and recovery, guided by principles of risk, resilience, and sustainability.

Yang *et al.* (2019) highlighted the increasing frequency of urban waterlogging events in major cities, which have resulted in significant economic losses and casualties, making it a crucial area of research amid environmental changes. They stressed the need for improved emergency management strategies due to the lack of adequate information in addressing waterlogging crises. Their proposal involves the development of adaptable emergency management patterns tailored to urban waterlogging dynamics, focusing on pre-event, in-event, and post-event phases to facilitate swift responses by management personnel. They underscored the importance of digitalization and visualization in managing urban waterlogging emergencies through customized components and knowledge mapping. By customizing components such as the Beijing emergency plan and historical case analysis, they demonstrated the functionality of an integrated adjustment system in responding effectively to waterlogging emergencies. The implementation of this system enables rapid information utilization, personalized emergency management services, and decision support for management personnel, ultimately improving the efficiency of urban emergency response and flood control efforts.

Tyler, Sadiq, and Noonan (2019) conducted a systematic review of research on community flood risk management in the USA, aiming to pinpoint knowledge gaps and offer practical guidance to flood management decision-makers. They analyzed 60 studies meeting specific criteria, including

English language, empirical nature, and focus on community-level flood risk management in the USA. From their review, the authors distilled seven practical lessons essential for improving understanding of flood risks, reducing flood impacts, and enhancing community resilience. These lessons encompass recognizing the effectiveness of strategies like acquiring open space and conserving wetlands, tailoring development patterns to community flood risks, evaluating participation in FEMA's Community Rating System, engaging community members in planning and recovery, considering socially vulnerable populations, utilizing diverse floodplain management tools, and ensuring comprehensive implementation and continuous revision of flood mitigation plans. Implementing these lessons, the authors argue, could significantly enhance decision-making in community flood risk management, leading to better outcomes in reducing flood losses and improving community resilience to future flood disasters.

Obiora, Obafemi, and Ogoro (2011) discussed the unique flood dynamics in Niger State, Nigeria, highlighting the significant role played by three hydroelectric power (HEP) dams in exacerbating flooding in various parts of the state. The operational management of reservoirs in these dams contributes to flooding alongside rainfall. The establishment of the Hydroelectric Power Producing Area Development Commission (HYPADEC), of which Niger State is a member, aimed to address the detrimental effects of dam-related floodwaters on the ecological balance, livelihoods, and overall well-being of communities both upstream and downstream of the dams. Niger State stands out as the most affected by these dams as it encompasses both upstream and downstream areas and hosts all three major dams: Kainji, Shiroro, and Jebba. This unique geographical positioning makes Niger State particularly vulnerable to flood events resulting from normal dam operations, affecting not only Niger State but also other HYPADEC states, including Kwara, Kogi, and Kebbi, which are either upstream or downstream of the dams. Consequently, there is a pressing need to assess

the vulnerability of different regions within Niger State to floods and propose effective strategies for mitigating the associated risks. Despite numerous studies on flooding in Nigeria, there is a scarcity of research specifically focused on the flood dynamics in Niger State, underscoring the importance of conducting further studies to better understand and address this pressing issue.

Adedeji, Odufuwa, and Adebayo (2012) investigated the state of preparedness and capacity development to address urban flooding in Nigerian cities. The study firstly explored the occurrence, causes, and impacts of urban flood hazards, followed by an analysis of urbanization's role in heightening flood risk for a significant portion of the urban population. Additionally, the vulnerability, preparedness, and coping mechanisms of individuals to these hazards were discussed. Furthermore, the paper examined the significance of spatial planning, sustainable drainage systems, and land use management in enhancing capacities to mitigate flood hazards. The authors concluded that inadequate spatial planning and land use management, compounded by governmental incapacity to ensure effective urban governance, contribute to the escalation of urban flooding in Nigeria. They suggested that employing GIS-based spatial planning and land use management could serve as a versatile tool in enhancing capacities for reducing flood disasters and promoting preparedness, thereby fostering sustainable urban development.

Sari, Susilo, and Susilo (2013) conducted a study aiming to examine the distinct roles played by various stakeholders in flood management within the Ponorogo region of Indonesia. The research sought to elucidate the contributions of stakeholders such as the government, non-governmental organizations (NGOs), academic institutions, and the local community in addressing flood-related challenges. Employing a descriptive qualitative approach, the study utilized survey methods and gathered data through observations, interviews, questionnaires, and document analysis. The

Regional Disaster Management Agency was identified as the central coordinator in flood management activities, responsible for orchestrating the involvement of all stakeholders across different phases of flood management: pre-disaster, disaster, and post-disaster. During the pre-disaster phase, emphasis was placed on flood mitigation measures and the implementation of an early warning system. In the event of a disaster, stakeholders collaborated in emergency response efforts under the coordination of the Regional Disaster Management Agency. Subsequently, during the post-disaster phase, the Agency coordinated stakeholders to undertake rehabilitation and reconstruction efforts aimed at restoring damaged infrastructure and mitigating the aftermath of the flood event. The study underscored the critical role of effective stakeholder coordination and collaboration in achieving comprehensive flood management outcomes, highlighting the importance of proactive measures, swift emergency responses, and robust post-disaster recovery initiatives.

Zainudini and Sardarzaei (2023) conducted a study focusing on flood preparedness and the capacity building needs of civil protection institutions in Iran, particularly in the aftermath of the 2021 Balochestan flood disaster. The research aimed to assess households' perceptions of civil protection institutions' preparedness and identify areas requiring capacity enhancement. Utilizing a 5-point Likert scale, the study measured six key preparedness indicators: emergency plans, early warning systems, evacuation procedures, resource availability, disaster knowledge, and management of relocation camps. Data were collected through a cross-sectional survey involving 1456 household heads randomly selected from affected villages in Konarak. The findings unveiled several gaps in preparedness across various indicators and variables. While some indicators displayed promising levels of development in certain variables, others exhibited a mix of both low and developed aspects. Critical areas requiring immediate attention included the formulation of

emergency plans, evacuation procedures for at-risk populations, and the stockpiling of essential resources. However, the study emphasized that civil protection systems in Iran need comprehensive strengthening across multiple preparedness elements. Consequently, the study recommended prioritizing and reinforcing preparedness activities within civil protection systems to enhance their effectiveness in managing future flood events.

Ogie, Adam, and Perez (2019) conducted a systematic literature review examining the structural approach to flood management in coastal megacities of developing nations (CMDN), where vulnerability to extreme weather events is exacerbated by climate change and weak flood management capacity. Focusing on the period from 1998 to 2018, the review primarily analyzes the reliance on structural measures in flood management within CMDN. The findings highlight two main areas of research focus: the establishment of new flood control projects and the management of existing flood control infrastructure. The review identifies various research directions aimed at guiding future efforts in flood management in CMDN.

Gilissen et al. (2016) proposed a framework for assessing the effectiveness of Flood Emergency Management Systems (FEMS) in Europe, recognizing the evolving threat of flooding due to climate change. While integrated emergency management systems aim to enhance preparedness and response to various hazards, including floods, there is a lack of comprehensive evaluation frameworks specifically tailored to FEMS. To address this gap, the authors develop an evaluation framework and apply it provisionally to FEMS in England (UK), France, the Netherlands, Poland, and Sweden. Their analysis reveals significant differences in the evolution of FEMS across these countries, influenced by political, cultural, administrative, and socio-economic contexts. Through this assessment, they identify opportunities for enhancing FEMS effectiveness in Europe, as well

as constraints to be addressed. The proposed evaluation framework serves as a crucial starting point for further investigation and comparative analysis, providing valuable insights for improving flood emergency management practices across European countries.

Umar and Gray (2023) conducted a review focusing on flooding in Nigeria, analyzing its occurrence, impacts, and methodologies for flood data modeling over the past decade. The study aimed to discern the frequency and distribution patterns of floods in Nigeria and assess the modeling approaches utilized in comparison to global practices. Findings indicate that the northern region of Nigeria experiences more significant flood impacts compared to the south, suggesting a need for prioritized flood management efforts in this area. The predominant method for flood modeling in Nigeria involves the utilization of remote sensing data coupled with Geographic Information System (GIS) techniques. The paper advocates for the adoption of Bayesian and machine learning approaches over process-based models due to their potential effectiveness in flood modeling applications.

Raikes et al. (2019) conducted a systematic review examining pre-disaster planning and preparedness for floods and droughts in developed countries, amidst the escalating frequency and intensity of climate-related disasters. The review of 147 articles revealed several key findings: Firstly, the formal adoption of an integrated system for disaster risk reduction and human development remains disjointed due to inadequate legislative and policy frameworks. Secondly, there is a noticeable shift towards privatization of risk management, with responsibility for disaster liability increasingly devolving to landowners. Thirdly, while planning and preparedness efforts are more prevalent for floods compared to droughts in the literature, flood management is increasingly adopting a risk-oriented approach, whereas drought management still predominantly

operates within a crisis management framework. Lastly, the study emphasizes the necessity for further exploration of integrating pre-disaster planning and preparedness with human development initiatives to effectively advance Sustainable Development Goals (SDGs) on local, national, and international levels. This underscores the urgent need for comprehensive strategies that bridge the gap between disaster risk reduction and human development to address the multifaceted challenges posed by climate-related disasters.

Yao *et al.*, (2021) address the escalating threat posed by floods to the sustainable development of coastal cities in China, exacerbated by global warming and the rapid expansion of the tourism industry. The article presents a methodological approach aimed at evaluating emergency response capabilities, combining flood scenario simulation, traffic big data, and web-based path navigation interfaces. Through an empirical study focusing on Fire and Rescue Service (FRS) emergency responses to tourist hotels in Shanghai, the research findings reveal several key insights. Firstly, the effectiveness of FRS emergency responses is significantly influenced by factors such as transportation conditions, hotel locations, flood inundation intensity, and the distribution of urban FRS facilities. Secondly, the accessibility of cities during emergencies is closely linked to prevailing traffic conditions, with severe congestion exerting a notable impact on spatial accessibility. Thirdly, fluctuations in flood occurrences and real-time traffic conditions can alter the optimal travel routes for FRS, leading to delays in emergency response times. Therefore, selecting the most appropriate travel routes is imperative for improving the emergency response capability of urban areas. The study validates the effectiveness of the proposed approach, offering valuable insights for enhancing the emergency response capabilities of urban tourism sectors in the face of disasters. Ultimately, this approach contributes to bolstering the level of emergency

response preparedness for urban tourism destinations when confronted with unforeseen challenges.

Turay and Gbetuwa (2022) conducted an in-depth examination of disaster management in Sierra Leone, revealing the country's struggle with various disasters amidst ongoing challenges related to climate change, poverty, and governance issues. Despite some progress in disaster management, the degradation of the fragile ecosystem persists, exacerbating the frequency and severity of disasters. To address these concerns, the authors conducted a critical review of 35 publications from scholarly and grey literature sources, aiming to identify implementation drawbacks, research gaps, advances, and prospects in disaster management. The findings highlight significant challenges in data management, professional capacity, and communication efficiency, with inadequate funding remaining a pervasive issue hindering effective disaster management implementation. To address these challenges, the authors recommend routine exposure of first responders to international tabletop exercises and simulated disaster response training to enhance their capacities and learning opportunities. Additionally, they advocate for the involvement of students in relevant disciplines in these exercises to facilitate early learning. Furthermore, the authors emphasize the importance of considering gender equity and the needs of vulnerable groups in disaster management initiatives at all levels of planning and implementation. They also suggest future studies to explore the influence of social media on disaster management research and practice in Sierra Leone, underscoring the importance of leveraging technological advancements for more effective disaster management strategies.

Katuk et al. (2009) proposed using a web-based system to help manage floods in Malaysia. The purpose of their study was to improve how flood response is managed by using a system that makes

it easier to handle data and respond quickly to emergencies. They used a method called "knowledge acquisition" to gather and use expert knowledge, which involved four steps: planning, collecting knowledge, analyzing it, and checking it. The study resulted in a web-based system that helps flood management agencies keep track of flood data and monitor ongoing situations. The system's design was presented in both concept and software models. The findings showed that this system can help flood management agencies by making it easier to manage data and respond to floods. The system's practical value is that it could improve how agencies respond to floods by providing electronic tools that simplify the process. In the future, the system could be enhanced with expert features to make it even more effective. The paper concluded that the system's architecture is valuable for planning future improvements in flood response procedures in Malaysia.

Liu et al. (2018) developed a system called the Flood Prevention and Emergency Response System (FPERS) using Google Earth Engine. They focused on how it helps during three flood stages: before, during, and after floods. For the post-flood stage, FPERS uses different types of remote sensing images, like optical images from Formosat-2, radar images, and high-resolution photos from drones. These images help detect and monitor lakes formed by floods, create flood maps, and assess damage to rivers and structures. For the pre-flood stage, the system integrates large amounts of geospatial data, including typhoon forecasts, disaster prevention and warning data, and other essential data layers. During floods, FPERS implements three strategies to provide real-time information, make recommendations, and support decision-making. The system was tested during Typhoon Soudelor in August 2015, showing how it helped in flood prevention and emergency response from 2013 to 2016. FPERS can switch between different topographic models and manage data through a geospatial database. The study suggests future improvements to enhance the system's capabilities.

Mohanty and Karmakar (2021) proposed a web-based flood risk information system called 'WebFRIS' for the Jagatsinghpur district in Eastern India, a region highly prone to floods. They used open-source web tools like Google Map, PHP, MySQL, and JSON to design WebFRIS. The system was made to be easy for anyone to use, even without technical knowledge. WebFRIS shows village-level maps of flood hazard, socio-economic vulnerability, and flood risk for two different time scenarios. When analyzing these maps, they noticed a significant increase in high and very-high flood hazard (~140%) and vulnerable villages (~68%) in Scenario-I. The number of villages facing combined risk from both flood hazard and vulnerability almost doubled in Scenario-I. Spatial analysis showed major changes in villages in the Balikuda, Ersama, and Tirtol areas. Based on these findings, they suggested engineering, social, and policy measures to improve flood management in the area. WebFRIS is flexible and easy to use, making it a valuable tool for local authorities, planners, water professionals, flood experts, and citizens to understand flood risk management. The system could also be used for other environmental management tasks like land-use planning and community resilience building.

2.4 Summary of related works

Table 2.1 provides an overview of the relevant literature examined to identify existing research gaps.

Table 2.1: Summary of related work

S/N	Author(s)/Year	Domain/Country	Platform Used	Results Obtained	Advantages	Disadvantages
1	Abebe & Price (2005)	Urban Flood Management	Not specified	Proposed DSS for flood warning and urban coordination	Tailored solution for urban flood management	Lack of specific platform mentioned
2	Akintola et al. (2021)	Ogunpa River Basin, Nigeria	FLO-2D model, HAND model	Improved flood hazard modeling, identified potential hazard zones	Utilized MCDA for analysis, integrated multiple flood causative factors	Limited to specific geographical area
3	Buba et al. (2021)	Lokoja, Kogi State, Nigeria	Geospatial techniques, participatory methods	Assessed flood vulnerability, identified key factors	Proactive, community-focused approach	Limited scope to specific communities
4	Egbinola et al. (2017)	Nigeria	Not specified	Emphasized non-structural strategies in flood management	Highlighted alternative approaches to flood management	Lack of specific platform mentioned
5	Ahmad, Kazmi, & Pervez (2011)	Pakistan	Not specified	Analyzed challenges and impacts of floods	Highlighted socio-economic challenges	Lack of focus on specific flood management strategies
6	Islam et al. (2016)	Various Asian countries	Not specified	Analyzed flood disaster management mechanisms	Comprehensive overview of flood management practices	Lack of detailed analysis for specific countries
7	Khalid and Shafiai (2015)	Malaysia	National Security Council (MKN)	Discussed government's flood delivery system	Highlighted utilization of technology in flood management	Limited to specific country

8	Wang et al. (2022)	Not specified	Not specified	Analyzed flood research trends, emphasized resilience	Identified shift towards resilience-based flood management	Lack of specific research methodology mentioned
9	Yang et al. (2019)	Urban areas, China	Not specified	Proposed adaptable emergency management patterns	Emphasized digitalization in emergency management	Lack of specific platform mentioned
10	Tyler, Sadiq, & Noonan (2019)	USA	Not specified	Identified lessons for community flood risk management	Provided practical guidance for flood risk reduction	Lack of specific platform mentioned
11	Obiora, Obafemi, & Ogoro (2011)	Nigerian cities	GIS-based spatial planning	Explored urban flood hazards and management strategies	Emphasized importance of spatial planning	Limited to Nigerian context
12	Sari, Susilo, & Susilo (2013)	Ponorogo region, Indonesia	Not specified	Examined stakeholder roles in flood management	Highlighted importance of stakeholder coordination	Lack of detailed analysis for specific stakeholders
13	Zainudini and Sardarzaei (2023)	Iran	Not specified	Assessed flood preparedness and capacity building	Identified gaps in preparedness, recommended improvements	Lack of specific platform mentioned
14	Ogie, Adam, & Perez (2019)	Coastal megacities of developing nations	Not specified	Conducted literature review on flood management	Identified research directions for flood management	Lack of specific research methodology mentioned
15	Gilissen et al. (2016)	Europe	Not specified	Proposed evaluation framework for flood emergency management systems	Highlighted need for comprehensive evaluation frameworks	Lack of specific platform mentioned
16	Umar and Gray (2023)	Nigeria	Remote sensing data, GIS techniques	Reviewed flood occurrence and modeling methodologies	Advocated for Bayesian and machine learning approaches	Lack of specific platform mentioned

17	Raikes et al. (2019)	Developed countries	Not specified	Conducted systematic review on pre-disaster planning	Identified gaps in pre-disaster planning, proposed solutions	Lack of specific research methodology mentioned
18	Yao et al. (2021)	Coastal cities, China	Not specified	Developed methodology for evaluating emergency response capabilities	Identified factors influencing emergency response effectiveness	Lack of specific platform mentioned
19	Turay and Gbetuwa (2022)	Sierra Leone	Not specified	Conducted critical review of disaster management	Identified challenges and proposed recommendations	Lack of specific platform mentioned
20	Katuk et al. (2009)	Flood Management/Malaysia	Web-based system	Developed a web-based system to manage flood data and monitor ongoing situations.	Improves flood response by making data management easier and enabling quick response to emergencies.	The system may require future enhancements with expert features for better effectiveness.
21	Liu et al. (2018)	Flood Prevention and Emergency Response/Taiwan	Google Earth Engine	Created FPERS for flood management across three stages: before, during, and after floods. Used remote sensing images and geospatial data for monitoring.	Provides real-time information, recommendations, and decision-making support during floods.	May need future improvements to enhance its capabilities.
22	Mohanty and Karmakar (2021)	Flood Risk Management/India	Web-based system using Google Map, PHP, MySQL, JSON	Developed WebFRIS to show village-level flood hazard and risk maps. Found significant increases in flood risk categories and suggested measures for improvement.	Flexible and easy-to-use system for local authorities, planners, and citizens to understand and manage flood risks.	Limited to flood management; may need to be adapted for other environmental management tasks.

2.4.1 Gap analysis

The review of related works reveals several notable research gaps in the field of flood management. Firstly, there is a recurring lack of specificity regarding the platforms utilized for implementing flood management solutions across various studies. While researchers propose tailored systems and methodologies, they often omit details regarding the specific technological platforms or tools employed, hindering the replicability and scalability of their proposed solutions. This absence of platform specificity limits the practical applicability of the proposed flood management approaches, especially in contexts where technological infrastructure varies.

Secondly, many studies exhibit a limited scope, focusing solely on specific geographical areas or communities. While these localized studies provide valuable insights into flood management challenges and strategies within those contexts, they often fail to address broader regional or national needs. This narrow focus restricts the generalizability of findings and hinders efforts to develop comprehensive flood management strategies applicable across diverse landscapes and communities.

Lastly, there is a notable absence of detailed research methodologies in several literature reviews and empirical studies. While researchers present findings and propose recommendations, they often overlook providing comprehensive descriptions of the methodologies employed in their research. This lack of methodological transparency undermines the rigor and reproducibility of their findings, making it difficult for other researchers to assess the validity and reliability of the results. Consequently, there is a pressing need for future studies to prioritize methodological clarity and detail to ensure the credibility and trustworthiness of research outcomes in the field of flood management.

CHAPTER THREE

METHODOLOGY

3.1 Methodology of the Proposed System

The research employs the Object-Oriented Analysis and Design Methodology (OOADM), a technique within software engineering for analyzing, designing, and creating software systems utilizing object-oriented programming principles. It centers on representing a system as a set of interconnected objects that contain both data and functionality.

3.2 Analysis of the existing System

In this phase of the OOADM utilized in the study, an analysis of the existing emergency response domain was conducted. This involved examining current processes, workflows, and the stakeholders involved to identify the key components of the system. These components, such as emergency events, resources, responders, and decision-makers, were delineated in terms of their attributes and relationships. Additionally, interactions among these components and the flow of data and information within the system were thoroughly considered during this phase.

According to Adedeji, Odufuwa and Adebayo (2012), the agency tasked with flood management in Nigeria is the National Emergency Management Agency (NEMA). NEMA operates as a governmental organization under the Ministry of Humanitarian Affairs, Disaster Management, and Social Development. Although NEMA's primary responsibility lies in coordinating disaster management efforts nationwide, it also plays a pivotal role in managing and responding to flood-related incidents.

NEMA works in collaboration with various stakeholders, including state emergency management agencies, to minimize the impact of floods and orchestrate response efforts during flood disasters.

Among NEMA's key duties in flood management are coordinating relief activities, disseminating relevant information to the public, and organizing emergency response teams to address flood-related challenges such as:

1. **Early Warning Systems:** NEMA collaborates closely with meteorological agencies like the Nigerian Meteorological Agency (NMA) and hydrological organizations to monitor weather patterns and water levels nationwide. Through this collaboration, they issue timely early warnings and alerts to communities and relevant authorities in flood-prone areas, facilitating preparedness and response measures.
2. **Flood Preparedness and Planning:** NEMA engages in comprehensive flood risk assessments, contingency planning, and the formulation of flood management strategies. They identify areas vulnerable to flooding and develop measures to mitigate its impact, which may include establishing emergency shelters, devising evacuation plans, and coordinating relief efforts effectively.
3. **Response Coordination:** In the event of a flood disaster, NEMA assumes a central role in coordinating response activities at the national level. This involves mobilizing various resources such as personnel, relief supplies, and equipment to support affected communities. NEMA collaborates closely with state emergency management agencies, security bodies, and humanitarian organizations to ensure a cohesive and efficient response.
4. **Search and Rescue Operations:** NEMA takes charge of coordinating search and rescue operations during flood emergencies. Working in tandem with agencies like the Nigerian Navy, Nigerian Air Force, and State Emergency Management Agencies, they conduct

rescue missions to assist individuals stranded in flooded areas and provide aid to affected communities.

5. **Damage Assessment and Recovery:** Following a flood event, NEMA conducts thorough assessments to ascertain the extent of damage incurred. This information guides the recovery process, during which NEMA collaborates with relevant government bodies and humanitarian organizations to deliver relief materials, temporary shelter, and rehabilitation assistance to communities in need.

It is worth noting that while NEMA assumes a primary role in flood management, other entities such as the Ministry of Water Resources, the Nigeria Hydrological Services Agency (NIHSA), and state-level emergency management agencies also contribute significantly to flood mitigation efforts across Nigeria.

3.2.1 Limitations of the Existing System

Flood management agencies in Nigeria encounter numerous constraints and hurdles in their endeavors to efficiently handle and mitigate floods. These challenges encompass:

1. **Infrastructure Deficiencies:** The inadequacy of infrastructure like drainage systems, flood control structures, and flood-resistant housing heightens communities' susceptibility to flooding. Limited funding and insufficient maintenance exacerbate these challenges for flood management agencies.
2. **Urban Planning Shortcomings:** Poorly planned urban development, including encroachments on floodplains and construction in flood-prone zones, amplifies the flood risk. Weak enforcement of building regulations and deficient urban planning aggravate vulnerability to floods.

3. **Climate Change Impact:** Climate change-induced phenomena, such as heightened frequency and intensity of extreme weather events like heavy rainfall and flooding, pose significant challenges. Flood management agencies must adapt strategies to incorporate climate resilience amid shifting climate patterns.
4. **Forecasting and Warning System Inadequacies:** Inadequate meteorological and hydrological data, along with outdated or insufficient forecasting and warning systems, impede accurate and timely flood predictions. Limited monitoring stations and data collection gaps hinder the provision of early warnings and preparedness measures.
5. **Public Awareness and Preparedness Shortfalls:** Limited public awareness and understanding of flood risks, coupled with inadequate community-level preparedness measures, contribute to the obstacles faced by flood management agencies. Educating the public on flood risks, promoting early warning systems, and fostering community resilience are vital yet challenging endeavors.
6. **Institutional Coordination and Collaboration:** Effective flood management necessitates robust coordination and collaboration among various stakeholders, including government entities, local communities, and non-governmental organizations. However, coordination issues and a lack of interagency collaboration often impede the implementation of integrated flood management approaches.

Mitigating these challenges demands concerted efforts from the government and relevant stakeholders to invest in infrastructure development, enhance data collection and forecasting capabilities, improve urban planning practices, raise public awareness and preparedness, secure adequate funding, and bolster institutional coordination. However, the research at hand concentrates on enhancing forecasting capabilities through a data-driven approach.

3.2.2 Architecture of the existing system

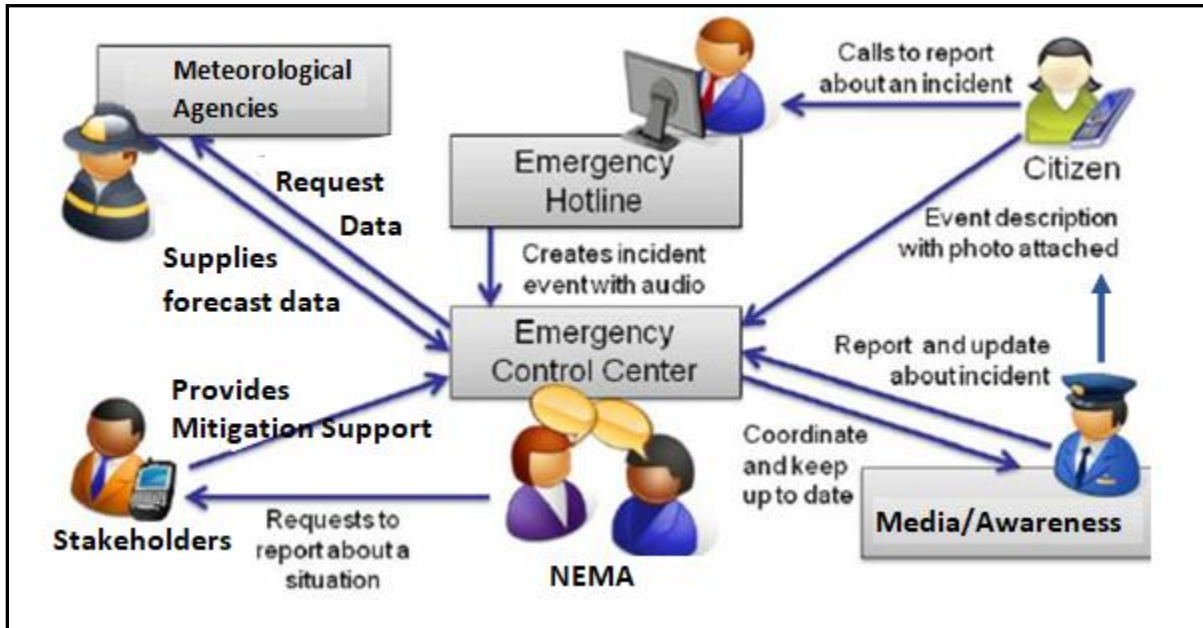


Figure 3.1: Architecture of the existing system

Figure 3.1 depicts the architecture of the current system. Building upon the assertion regarding the current system, it is crucial to note the absence of a widely accessible distributed data warehouse concerning flood emergencies in Nigeria, apart from information published on the NEMA website or disseminated by the media. This study posits that such a strategy is insufficient for individual research endeavours and findings. Therefore, it suggests the creation of a web-based emergency response database within the existing architecture as an alternative.

3.3 Analysis of the Proposed System

This study investigates the deployment of a web-based emergency response system aimed at managing floods. It introduces distributed data records of flood occurrences to provide data-driven insights over time. The system was constructed for a web platform hosted on a local server using XAMPP, which stands for cross-platform, Apache, MySQL, PHP, and Perl. The high-level model diagram is depicted in Figure 3.2.

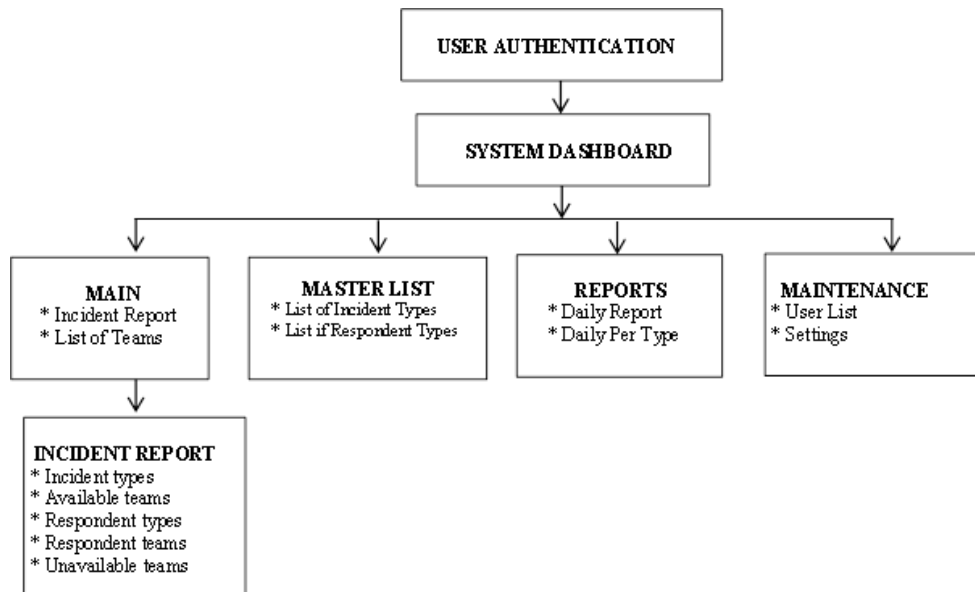


Figure 3.2: High-Level Model Diagram of the Proposed System

Figure 3.2 illustrates the overarching model for the proposed system, comprising five primary components: User Authentication, System Dashboard, Reports, User List, and Maintenance. User Authentication likely operates as a login mechanism, granting access exclusively to authorized users. Following successful authentication, the System Dashboard serves as the central interface, potentially providing an overview of the system or essential flood-related information.

3.3.1 Software Design Tools for the Proposed System

The recommended system employed Adobe Dreamweaver, an all-in-one Integrated Development Environment (IDE), as its principal software design tool. It encompasses two components: the frontend and backend, each equipped with its distinct design tools.

3.3.2 Front-end building tools

The frontend acts as the interface through which users interact with the system. When constructing the frontend, which constitutes the interface, users can observe the tools utilized for such web-based applications. These tools include Adobe Dreamweaver, HTML, JavaScript, and CSS.

Dreamweaver, an integrated development environment (IDE), stands out as one of the most commonly available tools for developing this system.

(a) Adobe Dream Waver

This is a website creation tool suitable for both individuals with no programming background and experienced website developers. It is specifically designed for designing and constructing visually appealing, user-friendly websites and web pages without requiring an understanding of HTML.

(b) Benefits of Adobe Dream Waver

- (i) Visual page building. Using a text editor helps to punch out the HTML code for your webpages, you should know the form to add up a simple item like a photograph to a web page.
- (ii) Complex interactivity, simply. it is easy to use and innovative.
- (iii)Round trip code. What you see is what you code.
- (iv)It is a site management tool.

3.3.3 Advantages of the proposed system

The proposed system generates an effective serialization order for incoming information, facilitated by an intelligent query system. This system processes jobs by sequentially sorting them one after another.

3.4 Methods of Data Collection

The foundational data for this system were collected from the official website of the National Emergency Management Agency (NEMA). According to NEMA's incident records up to 2022, a total of 4,877,280 individuals were impacted by flood incidents. These statistics served as the primary data for modeling the proposed system.

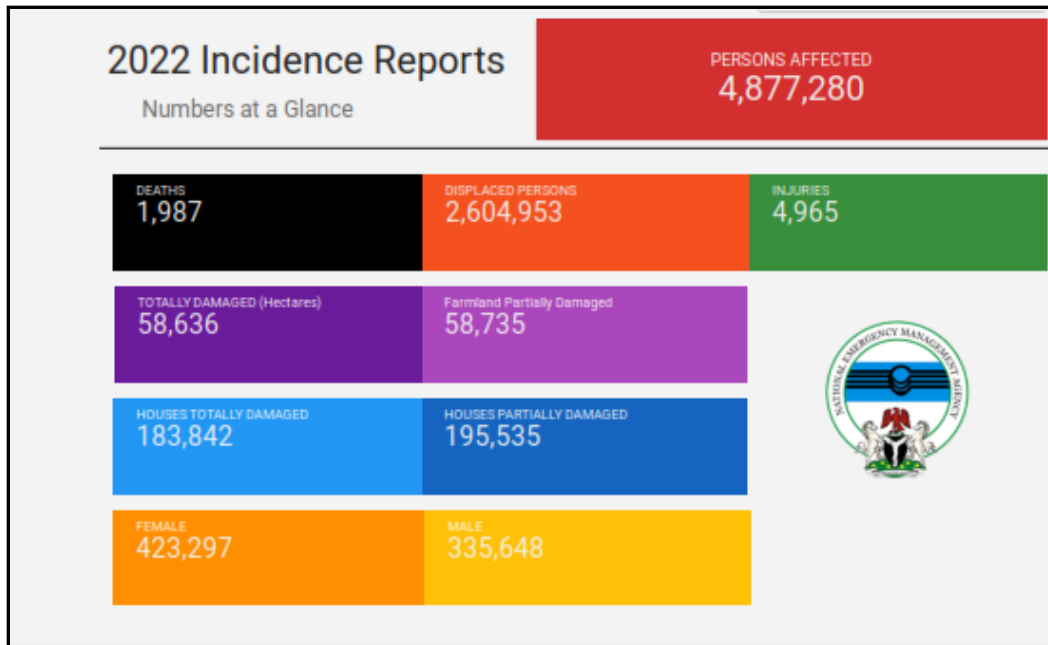


Figure 3.3: Data Collection grouping (Available on <https://nema.gov.ng/>)

3.5 Research Design

A research design is the structured framework used to conduct research, encompassing the blueprint for collecting, measuring, and analyzing data. It outlines the researcher's activities, from acquiring information to data analysis (Kothari, 2004). The research plan for this study comprised two phases. In the initial phase, the focus was on examining the challenges encountered by flood management authorities in implementing a web-based emergency response system. Subsequently, in the second phase, the researcher formulated and validated a model architecture for these authorities.

3.5.1 Architecture of the Proposed System

The architecture of the proposed system aims to address certain shortcomings of the current system while fulfilling the study's objectives. A new component, termed "distributed data records," is

introduced above the Emergency Control Center (ECC). This layer receives data directly from the ECC to create Data feeds accessible to the general public through the system.

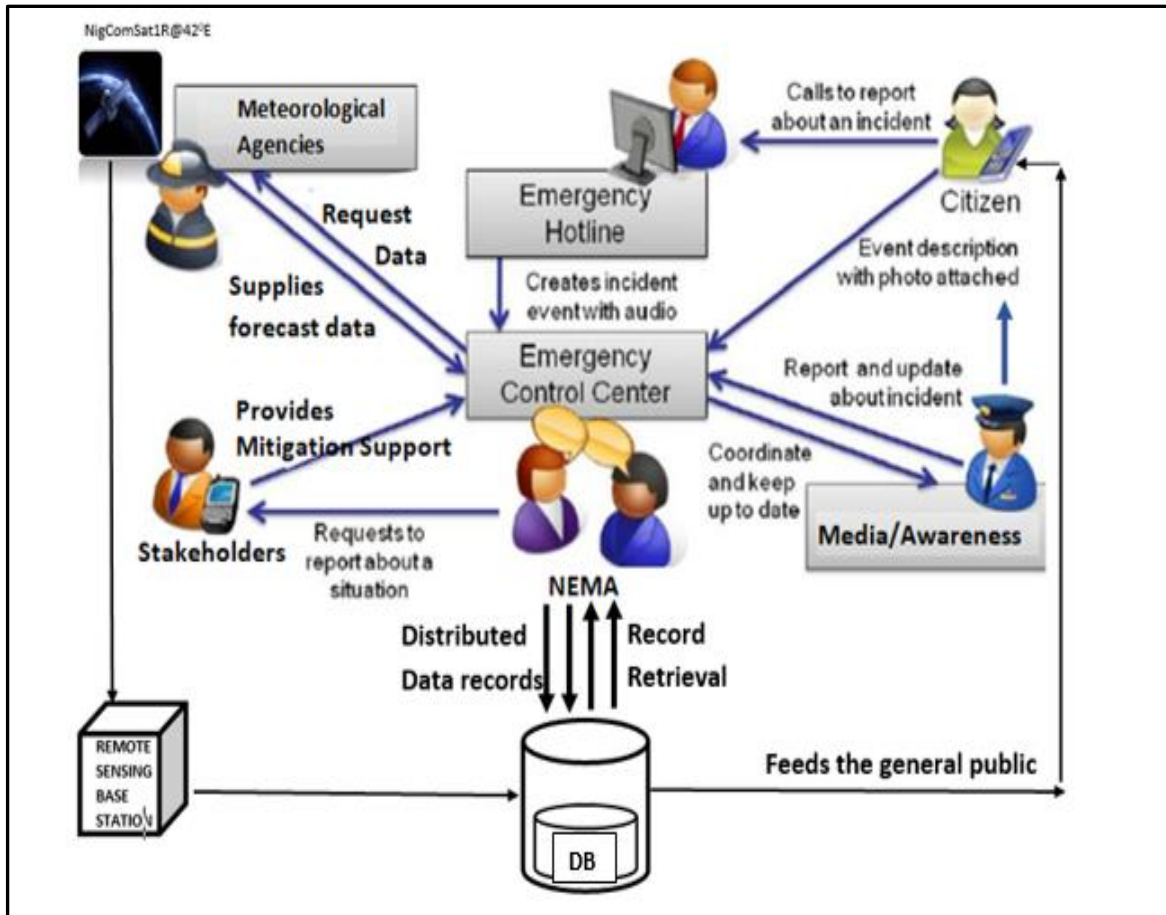


Figure 3.4: Architecture of the Proposed System

Figure 3.4 illustrates the architecture of the proposed web-based emergency response system for flood management, which comprises various functional components collaborating to enhance emergency response and decision-making efficiency. Among the crucial functional components outlined in this study are:

1. **Data Integration:** This element is focused on gathering and merging data from diverse origins, including meteorological data, geographic information systems (GIS), sensor networks, and historical data. It encompasses activities such as data collection, quality control, and fusion techniques to ensure the accuracy and reliability of the gathered information.
2. **Decision Support System (DSS):** The DSS component utilizes the integrated data to offer decision-making support to emergency responders and decision-makers. It incorporates analytical models, algorithms, and visualization tools to analyze data, extract insights, and aid in making informed decisions during emergency scenarios.
3. **Emergency Alert and Communication:** This aspect facilitates the timely dissemination of pertinent alerts and information to emergency responders, stakeholders, and the general public. It encompasses communication channels such as SMS alerts, email notifications, mobile applications, and public announcement systems to ensure effective communication during emergencies.
4. **Resource Management:** This component is dedicated to efficiently managing and allocating resources during emergency responses. It involves monitoring and managing resources like personnel, equipment, medical supplies, and transportation assets. The system may feature tools to optimize resource allocation based on the severity and location of the emergency.
5. **Risk Assessment and Planning:** The risk assessment and planning component evaluate potential risks and vulnerabilities within a specified area. It entails analyzing historical data, mapping hazards, and utilizing risk modeling techniques to identify high-risk zones and develop suitable mitigation and response plans.

6. Reporting and Documentation: This feature facilitates the creation of reports and documentation concerning emergency response activities. It includes functionalities for capturing incident particulars, recording response actions taken, documenting resource utilization, and conducting post-incident analysis. These reports serve as valuable resources for future planning, assessment, and enhancement of emergency response strategies.

3.6 The Use-case Diagram of the Proposed System

The use case diagram serves as a visual depiction illustrating the functionalities of the system. It outlines the interactions between the system and users, delineating the actions performed by the system.

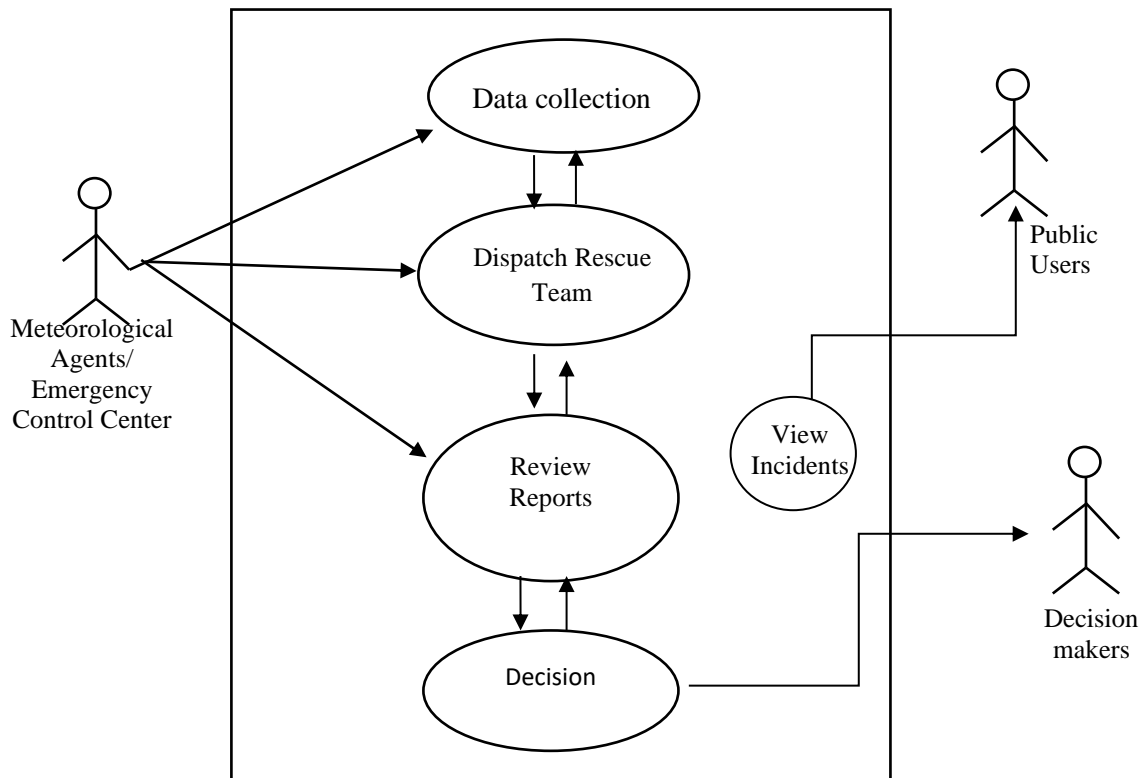


Figure 3.5: Use case diagram for the proposed system development

3.7 Sequence of the Proposed System

A sequence diagram is a type of interaction diagram that illustrates how processes or objects within a system interact with each other in a sequential manner over time. It depicts the sequence of messages exchanged between different components or objects within the system, providing a detailed view of the flow of control or data during the execution of a particular scenario or use case.

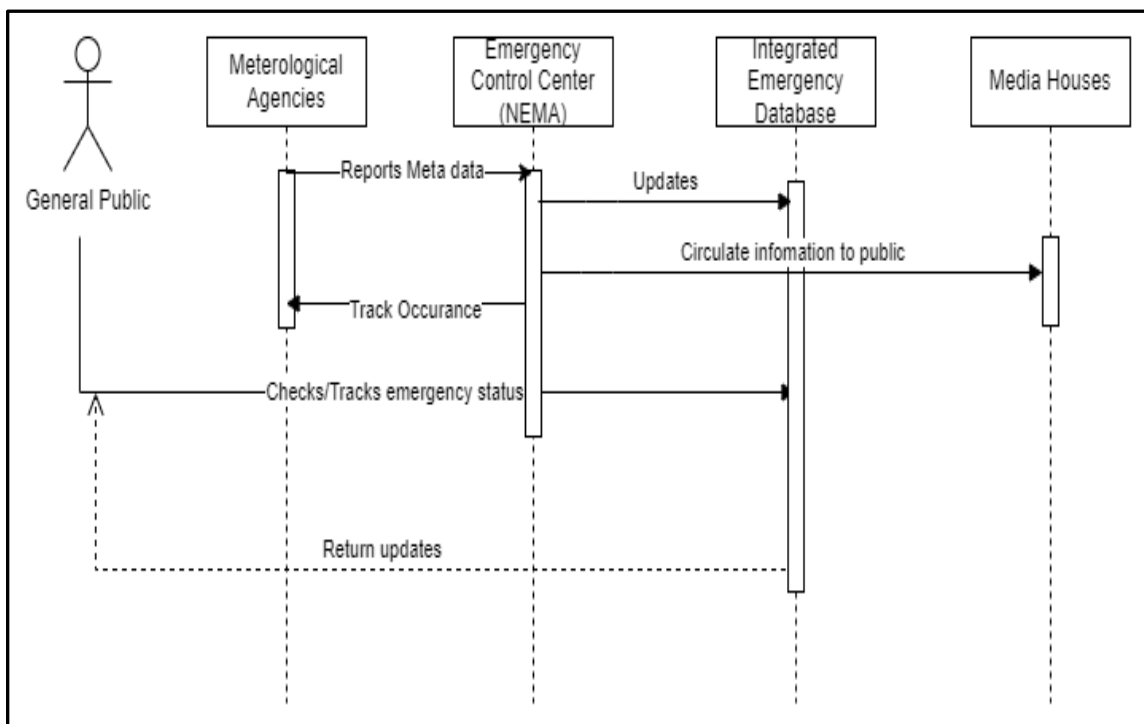


Figure 3.6: Sequence diagram of the proposed system

Figure 3.6 illustrates the sequence diagram of the proposed system, demonstrating the interaction among five primary components: the general public, meteorological agencies, the emergency control center (NEMA), the integrated emergency database, and media outlets.

3.8 Database Design

Database design refers to the process of creating a structured framework for organizing and managing data within a database system. It involves defining the structure of the database, including tables, fields, relationships, and constraints, to ensure efficient data storage, retrieval, and manipulation. Database design typically entails several key steps, such as requirements analysis, conceptual design, logical design, and physical design, to translate business needs into a well-organized and optimized database schema. The goal of database design is to create a reliable, scalable, and maintainable database system that meets the needs of its users and applications.

In the context of computer network nodes, the configuration of data and programs revolves around utilizing a database that comprises records, each characterized by attributes like Field Name, Data Type, and Length. Within this structure, Field Name includes various instances, such as Incident Number.

Therefore, the database files used in the design includes:

1. Flood Respondent files which is made up of names, zones, types, address of respondents. Who are those agents such reports should be made. The agents such reports should be made are the flood emergency response agencies. This includes police, fire brigade or fire service, National emergency management agency (NEMA).
2. Handling Agents: collects or receives information from the incident victims/people on the scene and forward to flood management respondents. The flood emergency response information includes names of victims, zone or Area of flood occurrence, phone number, Address of the flood area / victims.

3.8.1 Rescue Team Data Files

The Rescue team datafile maintains and records information about responding agents tasked with addressing flood emergencies. Within this system, a critical attribute known as "status" is stored, providing real-time updates on the status of an emergency incident.

Table 4.1 outlines the structure of the Flood Emergency Rescue Team Database File, offering a systematic arrangement of fields essential for managing information related to rescue teams tasked with addressing flood emergencies. The inclusion of fields such as Team Id and Team Code facilitates the unique identification and classification of rescue teams, ensuring efficient organization within the database. Additionally, fields like Status and Created Date provide crucial real-time updates on the status of rescue operations and the timeline of record creation, aiding in monitoring and tracking the progress of emergency response efforts. Moreover, the presence of the Delete Flag field suggests a mechanism for managing data integrity, allowing for the identification of records marked for potential deletion while maintaining data consistency and reliability.

This structured database file serves as a vital tool for coordinating and managing flood emergency response activities. By delineating key attributes such as team identification, status updates, and record timestamps, the database enables effective tracking and monitoring of rescue team operations. Furthermore, the inclusion of text fields like Description allows for detailed documentation of rescue team characteristics or mission objectives, enhancing situational awareness and facilitating informed decision-making during emergency scenarios. Overall, the structured layout of the database file supports the efficient management and coordination of rescue efforts, contributing to more effective and timely responses to flood emergencies.

Table 3.1: Flood emergency rescue team database file

S/N	File name	Field type	Size
1	Team Id	INT	5
2	Team code	VARCHAR	3
3	Description	TEXT	4
4	Status	VARCHAR	20
5	Created Date	DATE	10
6	Updated Date	DATE	10
7	Delete _flag	VARCHAR	10

3.8.2 Incident Data Files

The incident data record contains details of every instance of flooding that occurs within the country. As the database follows normalization principles, additional sub-data records have been derived from this file. These sub-data records consist of Location, User, and Team lists, as illustrated in Table 3.2.

Table 3.2 presents the Flood Incident Details Files, which encapsulate crucial information about each flooding incident occurring within the country. The inclusion of fields such as Incident Id, Team Id, User Id, and Location Id facilitates the unique identification and categorization of incidents, as well as the assignment of relevant rescue teams, users, and locations to each incident. Additionally, the Name field allows for the designation of a descriptive title or label for each incident, enhancing clarity and ease of reference. The Created Date field provides a timestamp indicating when each incident record was created, aiding in tracking and monitoring the chronology of flood occurrences.

Furthermore, the database employs normalization techniques to streamline data management, resulting in the creation of sub-data records from the Incident Details File. These sub-data records, including Location, User, and Team lists, serve to organize and categorize incident-related

information more efficiently. Each sub-data record corresponds to a specific aspect of the incident, such as its location, associated rescue team, or involved users. This structured approach enhances data integrity and accessibility, facilitating comprehensive analysis and decision-making processes during flood emergency responses. Additionally, the presence of fields like Delete_Flag and Description offers mechanisms for managing data integrity and providing additional contextual information about each incident, further enhancing the overall utility and effectiveness of the database in supporting flood management efforts.

Table 3.2: Flood Incident details files

S/N	File name	Field type	Size
1	Incident Id	INT	5
2	Team Id	INT	5
3	User Id	INT	5
4	Location Id	INT	25
5	Name	VARCHAR	50
6	Created Date	DATE	25
7	Delete_flag	VARCHAR	25
8	Description	TEXT	15
9	Incident _status	VARCHAR	50

3.8.3 Location Data Files

The Location data file contains geographic details regarding every instance of flooding within the country. This information holds significant importance for stakeholders as it guides their decision-making processes.

Table 3.3 outlines the structure of the Flood Emergency Location file, which encompasses essential geographical information pertaining to flood occurrences. Each entry in this file is characterized by fields such as Location Id, Name, LGA (Local Government Area), City, and Country. The Location Id field serves as a unique identifier for each geographic location associated

with flood emergencies, facilitating efficient organization and retrieval of information within the database. Additionally, fields like Name, LGA, City, and Country provide detailed descriptive data about the location of each flood occurrence, offering stakeholders valuable insights into the geographic context of flood events.

The structured layout of the Flood Emergency Location file enables stakeholders to access and analyze critical geographical information relevant to flood emergencies. The inclusion of fields like LGA, City, and Country allows for a comprehensive understanding of the location-specific factors influencing flood occurrences. Moreover, the utilization of a standardized format for storing geographical data enhances consistency and interoperability across various applications and decision-making processes. In essence, the Flood Emergency Location file plays a pivotal role in supporting informed decision-making and effective flood management strategies by providing stakeholders with accurate and comprehensive geographic insights.

Table 3.3: Flood Emergency Location file

S/N	Field name	Field type	Size
1	Location Id	INT	5
2	Name	VARCHAR	25
3	LGA	VARCHAR	30
4	City	VARCHAR	10
5	Country	VARCHAR	10

3.8.4 Report List Data File

The report data file contains information pertaining to data collected by handling agents during inspections. These reports serve as valuable sources of information that can guide the development of policies aimed at preventing or mitigating future occurrences.

Table 3.4 outlines the structure of the Report List Data File, which holds important information regarding reports generated by handling agents during inspections. Each entry in this file is characterized by fields such as Report Id, User Id, Remark, Team Id, and Location Id. The Report Id field serves as a unique identifier for each report, facilitating efficient tracking and retrieval of information within the database. Additionally, the User Id field links each report to the handling agent responsible for its creation, enabling accountability and traceability in the inspection process. The Remark field allows agents to provide descriptive comments or observations regarding their findings during inspections, providing valuable context for decision-making and policy formulation.

The inclusion of fields like Team Id and Location Id further enhances the utility of the Report List Data File by associating each report with the relevant rescue team and geographic location. This information enables stakeholders to contextualize inspection findings within specific operational contexts and geographical areas affected by flood incidents. Moreover, the structured format of the data file ensures consistency and standardization in storing and managing inspection reports, facilitating systematic analysis and interpretation of the data for policy development and decision-making purposes. In all, the Report List Data File plays a crucial role in providing valuable insights into inspection activities and informing evidence-based policies aimed at preventing or minimizing the impact of future flood occurrences.

Table 3.4: Report list data file

S/N	File name	Field type	Size
1	Report Id	INT	5
2	User Id	INT	5
3	Remark	Text	30
4	Team Id	INT	5
5	Location Id	INT	3

3.9 Software Design Model

This project utilized the Object-Oriented Analysis and Design Model (OOADM) to establish a structured workflow for the project. Object-oriented analysis and design is a systematic approach to analyzing and designing a system by incorporating object-oriented concepts and creating a series of graphical system models throughout the software development lifecycle.

Figure 3.7: Entity Relationship Diagram for the proposed system

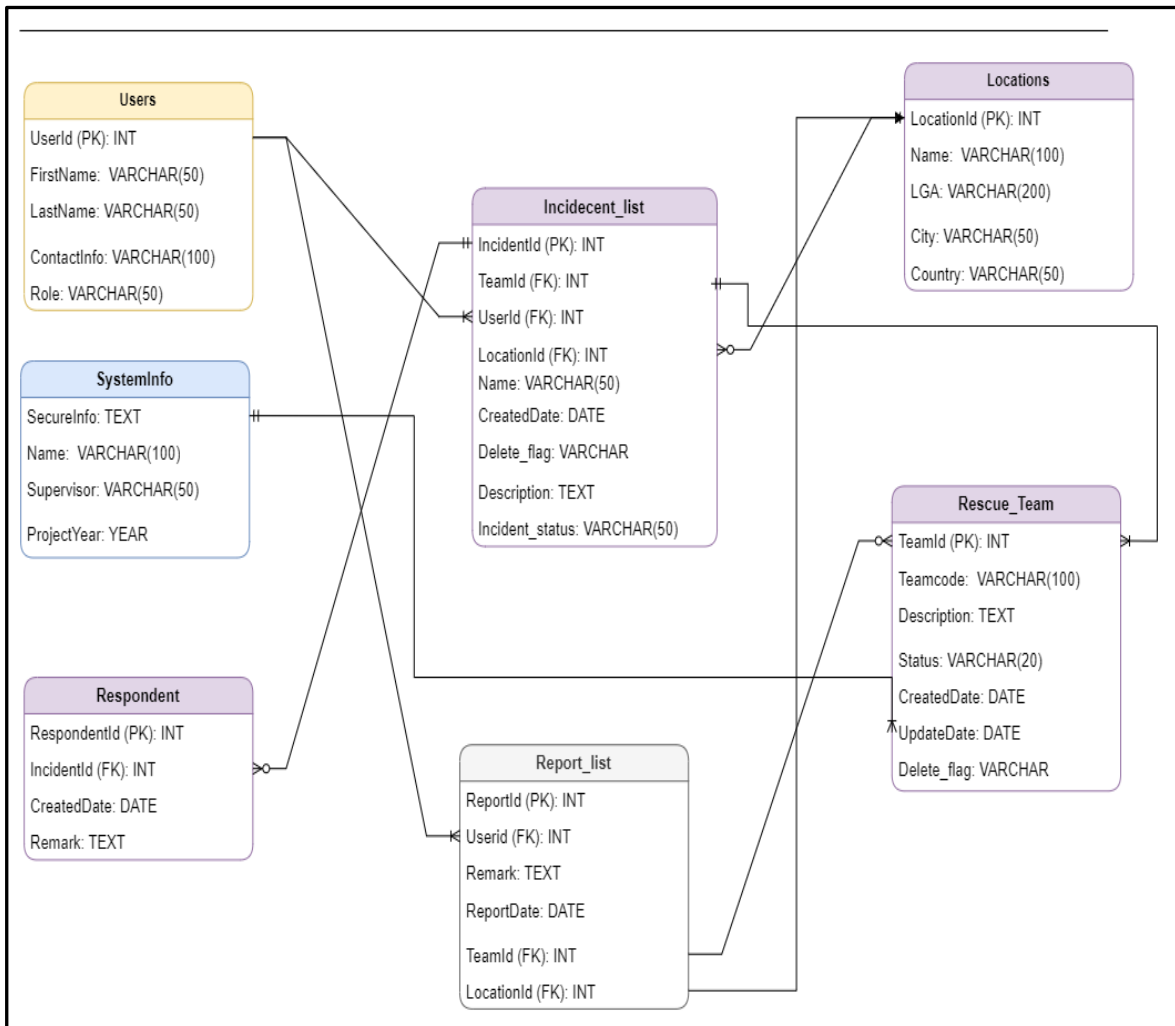


Figure 3.7 provides an overview of the Entity Relationship Diagram (ERD) tailored for the Emergency Response System aimed at flood management. The ERD visually maps out the relationships between different entities or data elements within the system. In the context of flood

management, it likely showcases how various entities like incidents, responders, locations, and resources are interconnected and influence one another. Through a thorough examination, the discussion delves into the entities featured in the diagram and their attributes, shedding light on the connections and cardinalities between them. For instance, it may elucidate how incidents correspond to specific locations and responders, or how resources get allocated to incidents based on priority or availability. Grasping the intricacies of this ERD is crucial for system developers, stakeholders, and users alike, as it unveils the fundamental data structure, facilitating a better understanding of how information flows and is organized within the system. Such comprehension is pivotal for guiding the system's design, implementation, and usability, thereby enhancing its effectiveness in managing flood-related emergencies.

3.9.1 Advantages of Model Design

1. Easy to understand: It is used by most people to deal with complexity.
2. It encourages planning and development of systems that are truly independent of one another
3. Increased data re-use: The code can be modified without altering the old one.
4. Re-useable: This enables re-use of old data in new applications whereas messages offer a predefined platform to the object's functionality.
5. Provides a Highly competitive advantage to organization that uses it.
6. It reduces time and resources required to maintain existing application.

3.9.2 Disadvantages of Model Design

1. Too complex for simple application. They are not ideal for simpler Projects.

2. It is suitable to procedural applications. This is because procedural applications are often logically bound concepts of scope and modularity.

3.10 Choice of Programming Language Used

In developing the software prototype in this research work, PHP (Hypertext Preprocessor) was selected as the programming language. PHP is a programming language used by developers to provide instructions for specific processes to be executed by a computer. The decision to use PHP was based on its fundamental principles of inheritance, encapsulation, and polymorphism. These characteristics allowed for the encapsulation of related application data, facilitating easier code maintenance. Additionally, Dreamweaver was chosen as the development environment due to its user-friendly interface and its capability to easily debug errors.

3.11 The System Requirements

The system requirements necessary for operating this project encompass the following: Microsoft Windows (Vista, XP, 7, 8, 10) operating system, PHP/MYSQL server 2005 or later versions, a Pentium or later generation microprocessor (400 MHz or faster), at least 256MB of RAM, a minimum of 1GB of hard disk space, and a capable video graphics card with a minimum image resolution of 800 by 600 pixels.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results Analysis of Data Captured

This section examines the analysis of results based on captured data, which is vital for assessing how well the system performs. It involves reviewing data gathered from various sources integrated into the system, like flood emergency rescue teams, incident details, and emergency locations. Analyzing this data helps researchers and stakeholders understand flood events' dynamics, including their size, duration, and spatial distribution. This information is crucial for making decisions, such as issuing alerts, allocating resources, and coordinating responses during emergencies. Additionally, analyzing results enables the identification of patterns, trends, and irregularities in flood occurrences, which can improve the system's ability to predict and respond to floods effectively. Furthermore, the insights gained from this analysis contribute to continuously enhancing and optimizing the web-based emergency response system, ensuring its relevance and effectiveness in addressing the changing landscape of flood management challenges.

Table 4.1 displays key event results on the dashboard for flood management. It outlines incident, respondent, and responder team counts, with 5 incident types and 6 respondent types recorded. Additionally, 8 responder teams are available, indicating preparedness for deployment, with no teams marked as unavailable. This overview assists stakeholders in assessing the system's readiness and facilitates strategic resource allocation during flood emergencies.

Table 4.1: Result of key events on the dashboard

Incident Types	Respondent Types	Responders Team	Available Teams	Unavailable Teams
5	6	8	8	0

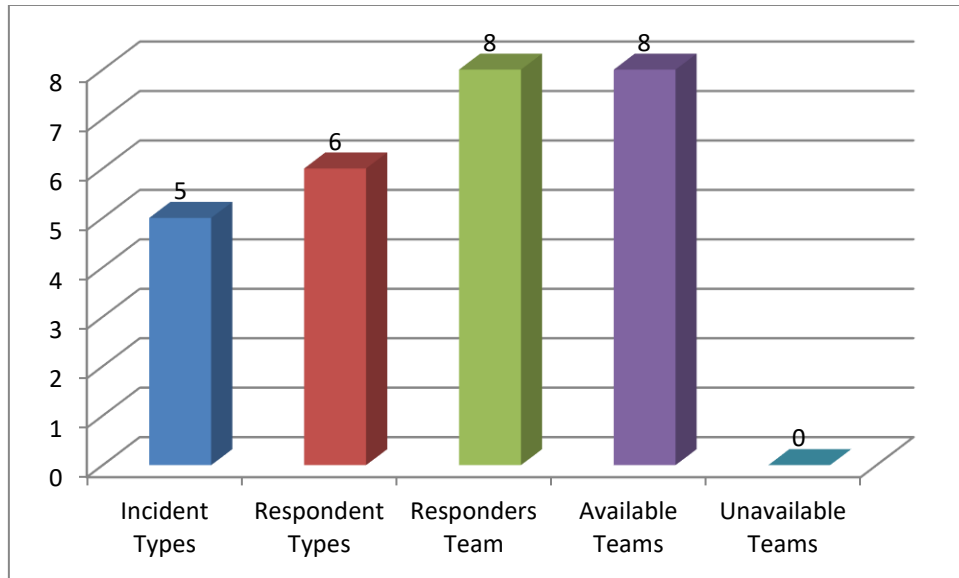


Figure 4.1: Graphical results based on key events on the dashboard

Figure 4.1 illustrates graphical results based on key events presented on the proposed system dashboard. The data depicted includes incident types, respondent types, responder teams, available teams, and unavailable teams. Incident types likely refer to different categories or classifications of flood-related incidents, while respondent types could denote the various entities or individuals involved in responding to these incidents. The responder teams indicate the number of teams available for deployment in emergency situations, while available teams show the count of teams ready for immediate action. The absence of unavailable teams suggests that all teams are currently accessible and ready for deployment. This graphical representation on the dashboard provides stakeholders with a quick overview of critical metrics related to flood response, enabling them to make informed decisions and allocate resources effectively during flood events.

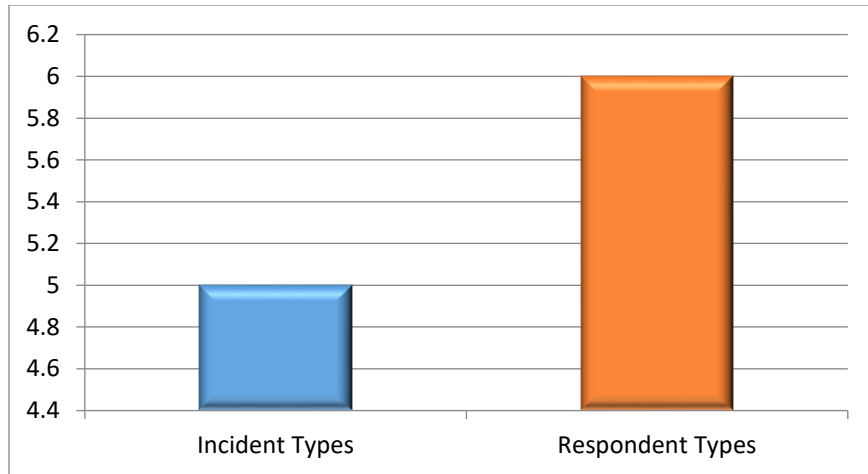


Figure 4.2: Graphical relationship between incident and respondent types

Figure 4.2 illustrates the graphical relationship between incident and respondent types within the proposed system. The data presented indicates that there are 5 incident types and 6 respondent types. This graphical representation likely shows how different types of incidents correspond to various categories of respondents. For instance, certain incident types may require specific types of responders or response strategies. Analyzing this relationship visually on the system's dashboard allows stakeholders to understand the distribution of incidents across different respondent types, facilitating more targeted and efficient allocation of resources and response efforts during flood events.

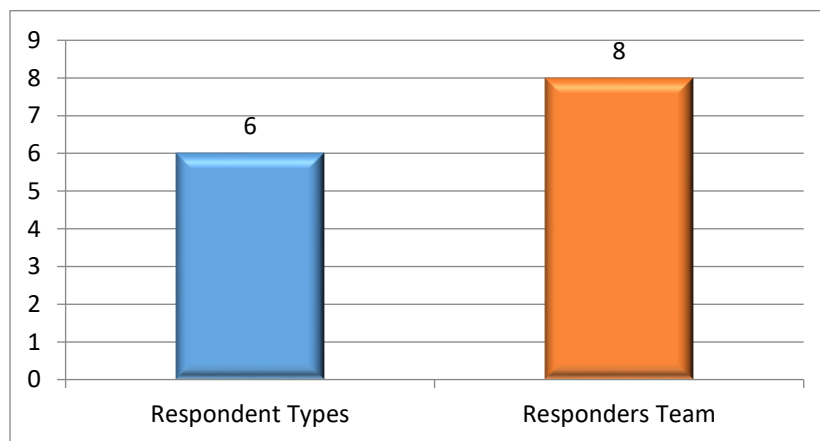


Figure 4.3: Graphical relationship between respondent types and responders team

Figure 4.3 illustrates the graphical relationship between respondent types and responder teams within the proposed system. The data shows that there are 6 types of respondents and 8 responder teams available. This graphical representation likely demonstrates how different types of respondents are associated with or assigned to specific responder teams. For example, certain respondent types, such as medical personnel or search and rescue teams, may be affiliated with particular responder teams tasked with addressing their specific needs or expertise. Visualizing this relationship on the system's dashboard enables stakeholders to understand how respondent types are distributed across responder teams, facilitating effective coordination and deployment of resources during flood emergencies.

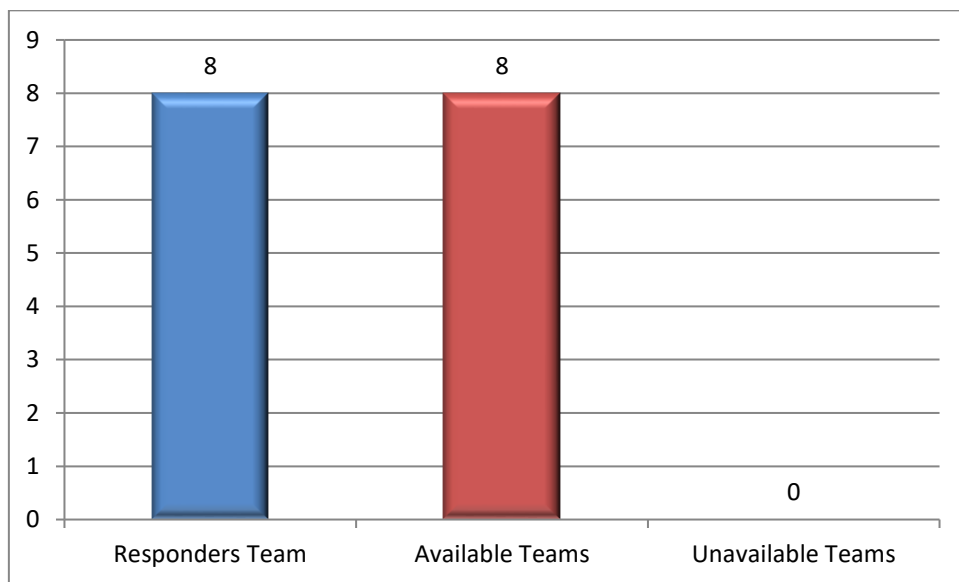


Figure 4.4: Graphical relationship between responder’s team, available teams and unavailable teams

Figure 4.4 visually represents the relationship between responder teams, available teams, and unavailable teams within the proposed system. The data indicates that there are 8 responder teams in total. Among them, all 8 teams are currently available, with none marked as unavailable. This graphical depiction serves to illustrate the readiness and capacity of responder teams for

deployment during flood emergencies. By showing the availability status of each team, stakeholders can quickly assess the system's readiness to respond to various incidents. The absence of unavailable teams suggests that the system is fully prepared with all necessary teams ready for immediate action, which is crucial for effective and timely flood management. This graphical representation on the system's dashboard provides stakeholders with a clear and concise overview of the current status of responder teams, enabling them to make informed decisions and allocate resources efficiently during flood events.

4.2 Interface/Dashboard Developed

This section discusses the development of the various interfaces/dashboard within the framework of a web-based emergency response system for flood management. It highlights the crucial role of the interface/dashboard as a central hub for accessing critical information and functionalities during flood events. The discussion covers various aspects such as the functionality overview, user-centric design, integration with data sources, accessibility, scalability, testing, and evaluation. Emphasis is placed on the interface/dashboard's ability to provide real-time monitoring, communication channels, data visualization, and decision support. Additionally, the text underscores the importance of usability testing and stakeholder feedback in refining the interface/dashboard. In essence, the interface/dashboard serves as a vital tool for enhancing flood management efforts, with potential for further improvement and future research in the field.

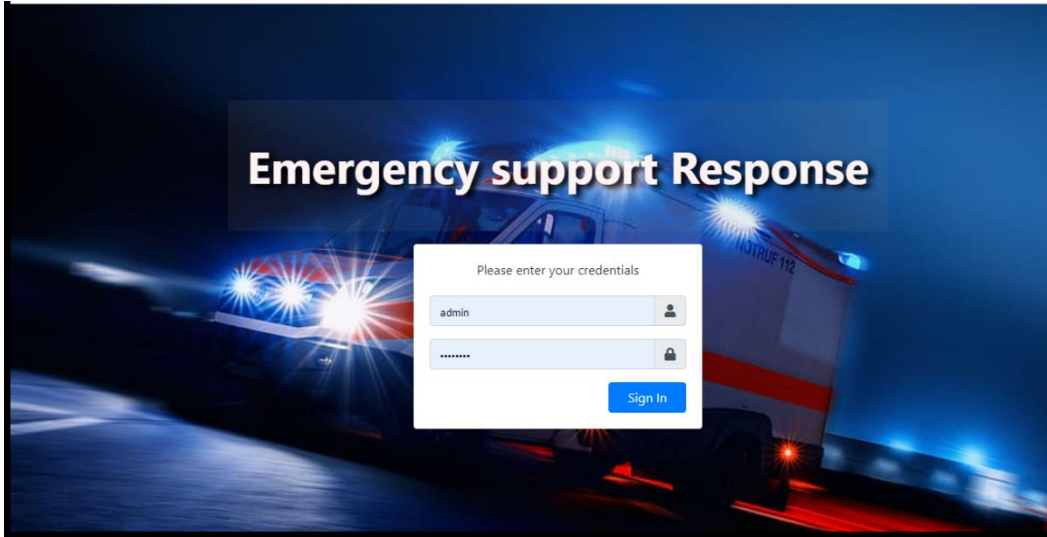


Figure 4.5: Access to the developed platform

Figure 4.5 portrays the login access interface of the proposed system or developed platform. The dashboard provides a clear insight into its functionalities. On the left side, there is a black pane serving as the menu, showcasing main options like "Main," "Master List," "Report," and "Maintenance," each with submenu options. The center pane of the system offers a summary of crucial data records, such as the total count of incident types and handling agents, providing users with a quick overview of essential system information. This layout facilitates easy navigation and access to key features and data within the system. The menu structure allows users to navigate between different sections seamlessly, while the summary pane provides instant access to vital information, enhancing the user experience and efficiency in utilizing the system for flood management tasks.

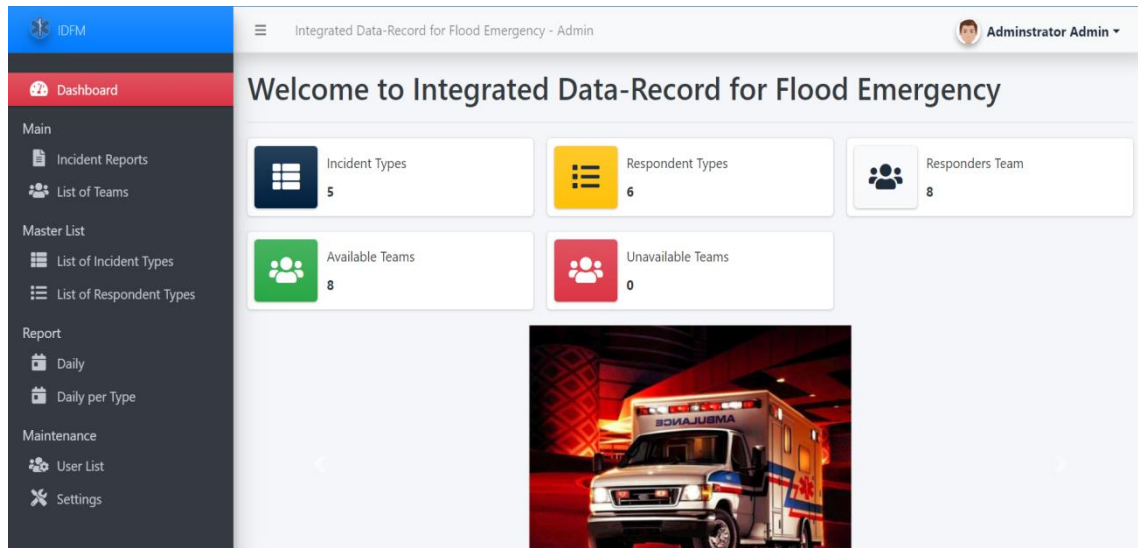


Figure 4.6: The proposed system dashboard

Figure 4.6 displays the dashboard of the proposed system, showcasing its functionalities. Users can easily monitor event counts, including incident types, respondent types, responder teams, available teams, and unavailable teams. The left-hand black pane serves as the menu, featuring main options such as "Main," "Master List," "Report," and "Maintenance," each containing a list of submenu options. In the centre pane, users find a summarized overview of critical data records, like the total count of incident types and handling agents, providing immediate insight into essential system information. This layout simplifies navigation and access to key features and data within the system. With its intuitive menu structure and summarized data display, the dashboard enhances user experience and operational efficiency in managing flood-related tasks.

It was also noted that the proposed system effectively stored numerous flood incidents reported by NEMA for the year 2022. The system was lauded for not just presenting these records in a tabular format but also for indicating the status of each incident, whether completed, pending, or inconclusive and displaying the team of handling agents involved in managing each situation.

These unique features set the system apart from existing ones, providing enhanced functionality and usability. Importantly, different levels of privileges are assigned to users, with the general public being granted only view access. They can access reports on any incident, using filter parameters such as dates, location, and time to refine their search. Over time, the system would evolve into a comprehensive repository of data, offering valuable insights that can inform proper decision-making processes.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This research work proposes the development of a web-based emergency response system tailored specifically for flood management. The benefits of such a system are extensive, offering decision-makers comprehensive and timely information essential for making informed decisions and taking swift, effective action during flood emergencies. By optimizing resource allocation and response strategies, the system enhances the overall efficiency of emergency operations, leading to improved outcomes and increased resilience. However, addressing these limitations necessitates collaborative efforts from both government entities and relevant stakeholders.

It entails investments in infrastructure development, enhancements in data collection and forecasting capabilities, improvements in urban planning practices, increases in public awareness and preparedness, securing adequate funding, and strengthening institutional coordination for effective flood management in Nigeria.

In essence, this research exemplifies the importance of adopting an object-oriented analysis and design model (OOADM) in developing a web-based emergency response system for flood management. By leveraging object-oriented concepts and creating graphical system models throughout the development lifecycle, we systematically analyzed and designed a robust system capable of effectively addressing the challenges inherent in flood emergency management.

Utilizing PHP as the programming language provided a stable foundation for implementing the system's functionalities, utilizing principles like inheritance, encapsulation, and polymorphism to

streamline code maintenance and enhance efficiency. Additionally, the selection of Dreamweaver as the development environment proved invaluable in simplifying the coding process and facilitating error debugging, thereby contributing to the overall effectiveness and productivity of the development efforts. The outlined system requirements ensure accessibility across various Microsoft Windows platforms and hardware configurations, while the structured database files enable efficient organization and management of critical data related to flood occurrences, rescue team activities, and inspection reports.

These files serve as invaluable repositories of information, guiding decision-making processes and informing the development of policies aimed at mitigating the impact of flood emergencies. Looking ahead, the insights gleaned from this project serve as a solid foundation for future enhancements and refinements to the web-based emergency response system. Continuous evaluation and feedback from stakeholders will be vital in identifying areas for improvement and implementing additional features to further enhance the system's functionality and usability. Overall, this research project marks a significant advancement in leveraging technology to bolster flood management and emergency response efforts, ultimately contributing to the resilience and safety of communities vulnerable to flooding.

5.2 Recommendations

The web-based emergency response system serves as a vital tool for facilitating seamless communication and collaboration among various stakeholders involved in emergency response efforts, encompassing emergency management agencies, first responders, healthcare providers, and public safety organizations. By providing a distributed platform for sharing critical information, coordinating response efforts, and disseminating real-time updates to relevant parties, the system plays a pivotal role in enhancing the overall effectiveness of emergency response

operations. Leveraging advanced technologies and data-driven decision support mechanisms, the proposed system has the potential to revolutionize emergency response efforts, leading to improved outcomes and increased preparedness for future crisis situations.

To ensure the continuous improvement of the web-based emergency response system, it is recommended that stakeholders undertake regular evaluations, gather feedback from users, and incorporate new technologies and methodologies to address emerging challenges and requirements in flood management. This iterative process of improvement will enable the system to adapt to evolving needs and enhance its functionality and effectiveness over time. Additionally, providing comprehensive user training and support materials is essential for ensuring the successful implementation and utilization of the system. Training sessions can help users familiarize themselves with the system's features and functionalities, while ongoing support services can address any issues or concerns that may arise during operation, ensuring smooth and efficient system usage.

Efforts should also be made to integrate the web-based emergency response system with existing systems and platforms used by relevant stakeholders, such as government agencies, emergency services, and non-governmental organizations. This integration will facilitate seamless data exchange and collaboration, enhancing the overall effectiveness of flood management efforts. Furthermore, implementing robust data security measures is imperative to safeguard sensitive information stored and processed by the system. Encryption protocols, access control mechanisms, regular security audits, and compliance with relevant data protection regulations are essential to protect against unauthorized access, data breaches, and cyber threats.

Designing the system with scalability and flexibility in mind is crucial to accommodate future expansions, upgrades, and changes in requirements without significant disruptions to operations. Building a modular architecture that can adapt to evolving needs will ensure the long-term viability and sustainability of the system. Additionally, engaging local communities and stakeholders in the development and implementation of the system fosters ownership, trust, and collaboration, ultimately leading to more effective and sustainable flood management practices.

Regular maintenance and updates are essential to ensure the continued reliability and functionality of the system. Monitoring system performance, addressing software bugs and glitches, applying security patches, and implementing new features and improvements based on user feedback and evolving technology trends are vital to maintain the system's effectiveness over time. Finally, investing in research and innovation initiatives can drive ongoing improvements and advancements in flood management technology, exploring new data analytics techniques, remote sensing technologies, predictive modeling approaches, and other innovative solutions to enhance the accuracy, efficiency, and effectiveness of flood response and mitigation efforts. By implementing these recommendations, stakeholders can optimize the performance and impact of the web-based emergency response system for flood management, building a more resilient and adaptive flood management infrastructure that protects lives, property, and ecosystems in the face of increasing flood risks.

5.3 Contribution to Knowledge

A significant novel contribution arising from this research is creating a specialized web-based emergency response system designed explicitly for flood management. While existing emergency response systems serve various purposes, their adaptation to effectively address the specific challenges presented by flood emergencies remains limited. This study bridges this gap by

introducing a tailored system that fosters seamless communication, collaboration, and data exchange among stakeholders engaged in flood management activities. Through the utilization of advanced technologies and data-driven decision support mechanisms, the newly proposed system presents a fresh perspective on optimizing the efficiency and efficacy of flood response endeavors. Ultimately, this innovative approach holds promise for yielding superior outcomes and bolstering resilience in regions susceptible to flooding.

5.4 Future Research Work

A key aspect of the future roadmap entails incorporating real-time data feeds and advanced analytics capabilities into the emergency response system. This involves leveraging data from diverse sources such as meteorological agencies, geographic information systems, and sensor networks to furnish decision-makers with timely and precise information crucial for informed decision-making during flood emergencies. Additionally, the deployment of predictive modeling and data analytics techniques facilitates proactive planning and resource allocation, thereby aiding in mitigating the impact of floods and enhancing overall preparedness. This integration of data-driven insights and predictive capabilities signifies a substantial advancement in flood management technology, contributing significantly to the evolving understanding of utilizing technology to tackle intricate emergency response challenges.

REFERENCES

- Abebe, A. J., & Price, R. K. (2005). Decision support system for urban flood management. *Journal of Hydroinformatics*, 7(1): 3-15.
- Adedeji, O. H., Odufuwa, B. O., & Adebayo, O. H. (2012), Building capabilities for flood disaster and hazard preparedness and risk reduction in Nigeria: Need for spatial planning and land management, *Journal of Sustainable Development in Africa*, 14(1), 45 – 58.
- Agbola, B., Ajayi, O., Taiwo, O. & Wahab, B. (2011). August Flood in Ibadan, Nigeria.
- Ahmad, F., Kazmi, S. F., & Pervez, T. (2011), Human response to hydro-meteorological disasters: A case study of the 2010 flash floods in Pakistan, *Journal of Geography and Regional Planning*, 4(9), 518 – 524.
- Akinlola A. K., Idowu, E., Olurunfemi, I. J., Jesutofunmi, A. A. (2021). Modelling earth systems and environment, 967-981.
- Alles, M., Kogan, A., & Vasarhelyi, M. (2003). Black box logging and tertiary monitoring of continuous assurance systems. *Information Systems Control Journal*, 1: 37-41.
- Awojobi, S. & Onuoha, P. (2014). Posit the high rate of poverty in Nigeria, “NEMA report on insurgency in Nigeria, 15, 40.
- Barriet, E. C., Beaumont, M, J. & Herschy, R. W. (1990). Satellite Remote sensing for operational hydrology, present needs and future opportunities, *Remote Sensory Review*, 42: 431-466.
- Bieber, M., Hiltz, S. R., Stohr, E. A., Englebart, D., Noll, J., Turoff, M., Furuta, R., Precce, J. & VandeWalle, B. (2002). Towards virtual community knowledge evolution, *Journal of management information systems*, Spring 2002.
- Bonczek, R. H., Holsapple, C. W., & Whinston, A. B. (1980). The evolving roles of models in decision support systems. *Decision Sciences*, 11(2): 337-356.

- Bouwer, L. M., Bubeck, P., Wagtendonk, A. J., & Aerts, J. C. (2009). Inundation scenarios for flood damage evaluation in polder areas. *Natural hazards and earth system sciences*, 9(6): 195-200.
- Buba, F. N., Ojinnaka, O. C., Ndukwu, R. I., Agbaje, G. I., & Orofin, Z. O. (2021). Assessment of flood vulnerability in some communities in Lokoja, Kogi State, Nigeria, using Participatory Geographic Information Systems. *International Journal of Disaster Risk Reduction*, 55, 102111.
- Civelek, M. E., Çemberci, M., & Eralp, N. E. (2016). The role of social media in crisis communication and crisis management. *International Journal of Research in Business & Social Science*, 5(3): 47-61.
- De Bruijn, K. M. & Klijn, F. (2001). Resilient flood risk management strategies. In *IAHR congress* (pp. 450-457). Tsinghua University Press.
- Egbinola, C. N., Olaniran, H. D., & Amanambu, A. C. (2017). Flood management in cities of developing countries: the example of Ibadan, Nigeria. *Journal of Flood Risk Management*, 10(4): 546-554.
- Felix, N. B., Oliver, C. O., Raphel, I. N., Ganly, I. A. & Zacharia, O. O. (2021). International Journal of flood vulnerability in some communities in Lokoja, Kogi State.
- Felsberger, A., Oberegger, B., & Reiner, G. (2016). A Review of Decision Support Systems for Manufacturing Systems. In *SAMI@ iKNOW* (p.8).
- Forgionne, G. A. (2003). An architecture for the integration of decision-making support functionalities. In *Decision-Making support systems: achievements and challenges for the new decade* (pp. 1-19). IGI Global.

- Fragouli, E., & Ibidapo, B. (2015). Leading in crisis: Leading organizational change & business development. *International Journal of Information, Business and Management*, 7(3): 71.
- Gilissen, H. K., Alexander, M., Matczak, P., Pettersson, M., & Bruzzone, S. (2016). A framework for evaluating the effectiveness of flood emergency management systems in Europe. *Ecology and Society*, 21(4), 1 – 16. <https://doi.org/10.5751/ES-08723-210427>
<https://doi.org/10.5751/ES-08723-210427>
- Hafiz, I., Nor, N. D. M., Sidek, L. M., Basri, H., Hanapi, M. N., & Livia, L. (2013). Application of integrated flood analysis system (IFAS) for Dungun River Basin. In *IOP Conference Series: Earth and Environmental Science* (Vol. 16, No. 1, p. 012128). IOP Publishing.
- Harrald, J., & Belardo, M. S. (2002). A frame work for the application of decision support systems to the problem of planning for catastrophic events, *IEEE transaction on engineering Management*, 39:4, 400.
- Islam, R., Kamaruddin, R., Ahmad, S. A., Jan, S. J., & Anuar, A. R. (2016), A Review on Mechanism of Flood Disaster Management in Asia, *International Review of Management and Marketing*, 6(1), 29 - 52.
- Katuk, N., Ruhana Ku-Mahamud, K., Norwawi, N. and Deris, S. (2009), "Web-based support system for flood response operation in Malaysia", *Disaster Prevention and Management*, 18(3), 327-337. <https://doi.org/10.1108/09653560910965673>
- Khalid, M. S. B., and Shafiai, S. B. (2015), Flood Disaster Management in Malaysia: An Evaluation of the Effectiveness Flood Delivery System, *International Journal of Social Science and Humanity*, 5(4), 398 – 402. DOI: 10.7763/IJSSH.2015.V5.488
- Kundzewicz, Z. W., Kanae, S., Seneviratne, S. I., Handmer, J., Nicholls, N., Peduzzi, P., Mechler, R., Bouwer, L.M., Arnell, N., Mach, K., Muir-Wood, R. & Sherstyukov, B. (2014). Flood

risk and climate change: global and regional perspectives. *Hydrological Sciences Journal*, 59(1): 1-28.

Kureuther, H. & Lerner-lam, A. (2002). Risk Assessment and Risk management strategies in an uncertain world, Executive summary, Columbia Wharton Roundable.

Linsley, R. K., Franzini, J. B. & Freyberg, D. L. (1992). Tchobanoglous. *Water Resources Engineering*, 269-308.

Liu, C.-C., Shieh, M.-C., Ke, M.-S., and Wang, K.-H. (2018), Flood Prevention and Emergency Response System Powered by Google Earth Engine. *Remote Sensor*, 10, 1283. <https://doi.org/10.3390/rs10081283>

Mohanty, M. P., and Karmakar, S. (2021). WebFRIS: An efficient web-based decision support tool to disseminate end-to-end risk information for flood management. *Journal of environmental management*, 288, 112456. <https://doi.org/10.1016/j.jenvman.2021.112456>

Mork, L. (2002). Technology tools for crisis response, risk management, *October*, 49(10): 44-50.

Nastev, M., & Todorov, N. (2013). Hazus: A standardized methodology for flood risk assessment in Canada. *Canadian Water Resources Journal*, 38(3): 223-231.

Obiora, O. C., Obafemi, A., & Ogoro, M. (2011), An insight on flood management, risk and control measures in Niger state, *Global Scientific Journal*, 9(11), 2291 – 2322.

Ogie, R. I., Adam, C., & Perez, P. (2019), A review of structural approach to flood management in coastal megacities of developing nations: current research and future directions. *Journal of Environmental Planning and Management*, 1(1), 1 - 21. <https://doi.org/10.1080/09640568.2018.1547693>.

- Power, D. J. (2002). *Decision support systems: concepts and resources for managers*. Greenwood Publishing Group.
- Qi, H., & Altinakar, M. S. (2011). A GIS-based decision support system for integrated flood management under uncertainty with two dimensional numerical simulations. *Environmental Modelling & Software*, 26(6): 817-821.
- Raikes, J., Smith, T. F., Jacobson, C., & Baldwin, C. (2019), Pre-disaster planning and preparedness for floods and droughts: A systematic review, *International Journal of Disaster Risk Reduction*, 3(2), 1 – 32. <https://doi.org/10.1016/j.ijdr.2019.101207>
- Sari, N. A., Susilo, A., & Susilo, E. (2013), The Role of Stakeholders in Flood Management: Study at Ponorogo, Indonesia Annisa, *The International Journal of Engineering and Science (IJES)*, 2(10), 1 – 10.
- Schultz, B. (2006). Flood management under rapid urbanisation and industrialisation in flood-prone areas: a need for serious consideration. *Irrigation and Drainage: The journal of the International Commission on Irrigation and Drainage*, 55(S1): S3-S8.
- Simon, H. A. (1991). Bounded rationality and organizational learning. *Organization Science*, 2(1): 125-134.
- Simonovic et al. (2006). Flood emergency management and post-Flood recovery.
- Simonovic, S. P. (2002). World water dynamics: global modelling of water resources. *Journal of Environmental Management*, 66(3): 249-267.
- Sprague Jr, R. H. & Carlson, E. D. (1982). *Building effective decision support systems*. Prentice Hall Professional Technical Reference.

- Thomas, D. S., Cutter, S. L., Hodgson, M., Gutekunst, M., & Jones, S. (2002). Use of spatial data and geographic technologies in response to the September 11 terrorist attack. *Natural Hazards Research and Applications Information Center*.
- Turay, B., and Gbetuwa, S. (2022), A state-of-the-art examination of disaster management in Sierra Leone: the implementation drawbacks, research gaps, advances, and prospects, *Geoenvironmental Disasters*, 9(22), 1 – 15. <https://doi.org/10.1186/s40677-022-00224-3>
- Turban, F., Rainer, S. & Potter, H. (2005). Introduction to information technology. John Wiley and sons, inc. copyright 2005
- Turoff, M. (1991). Computer-mediated communication requirements for group support. *Journal of Organizational Computing and Electronic Commerce*, 1(1), 85-113.
- Turoff, M. (2002). Past and future emergency response information systems communication of the ACM, 45:4, 29-30.
- Tyler, J., Sadiq, A., & Noonan, D. S. (2019), A review of the community flood risk management literature in the USA: lessons for improving community resilience to floods, *Natural Hazards*, 96(3), 1223 – 1248. <https://doi.org/10.1007/s11069-019-03606-3>
- Umar, N., and Gray, A. (2023), Flooding in Nigeria: a review of its occurrence and impacts and approaches to modelling flood data, *International Journal of Environmental Studies*, 80(3), 540 – 561. <https://doi.org/10.1080/00207233.2022.2081471>
- Wang, L., Cui, S., Li, Y., Huang, H., Manandhar, B., Nitivattananon, V., Fang, X., & Huang, W. (2022), A review of the flood management: from flood control to flood resilience, *Heliyon*, 8, 1 – 12.
- Yang, S. Y., Jiang, R. G., Xie, J. C., Yu, X., Liang, J. C., & Lian, Y. N. (2019), Research on the emergency management pattern and adjustment system for urban waterlogging, *The 5th*

International Conference on Water Resource and Environment (WRE 2019). 344, 1 – 7.
doi:10.1088/1755-1315/344/1/012094

Yao, Q., Lin, J., Shi, Y., Chen, Z., & Wang, Q. (2021), The Emergency Accessibility Analysis based on Traffic Big Data and Flood Scenario Simulation in the context of Shanghai Hotel industry, Natural Hazards and earth Sciences, 1 – 23.
<https://doi.org/10.5194/nhess-2021-368>

Zainudini, M. A., and Sardarzaei, A. (2023), A Review of the Flood Hazard and Risk Management in the South Iran Region, Particularly Konarak, Makoran in Balochestan, British Journal of Earth Sciences Research, 11 (1), 31 – 43. doi:
<https://doi.org/10.37745/bjesr.2013/vol11n13143>

Zipf, A. & Leiner, R. (2004). Mobile internet GIS based flood warning and information Systems, 2nd Symposium on location Based Services and Telecartography, Vienna, Austria

APPENDIX I

Program Source code

```
<?php if($_settings->chk_flashdata('success')): ?>
<script>
    alert_toast("<?php echo $_settings->flashdata('success') ?>", 'success')
</script>
<?php endif;?>
<?php
$date = isset($_GET['date']) ? $_GET['date'] :date('Y-m-d');
?>
<div class="card card-outline rounded-0 card-navy">
    <div class="card-header">
        <h3 class="card-title">Daily Incident Report</h3>
        <div class="card-tools">
        </div>
    </div>
    <div class="card-body">
    <div class="container-fluid">
        <fieldset class="border">
            <legend class="w-auto px-2">Filter</legend>
            <form action="" id="search-filter">
                <div class="row align-items-end mx-0">
                    <div class="col-lg-4 col-md-6 col-sm-12 col-xs-12">
                        <div class="form-group">
                            <label for="date" class="control-label">Choose Date</label>

```

```

        <input type="date" name="date" class="form-control form-
control-sm" value="<?= $date ?>" required>
    </div>
</div>
<div class="col-lg-4 col-md-6 col-sm-12 col-xs-12">
    <div class="form-group">
        <button class="btn btn-flat btn-primary btn-sm me-2"><span
class="fas fa-filter"></span> Filter</button>
        <a href="javascript:void(0)" id="print" class="btn btn-flat
btn-light border btn-sm"><span class="fas fa-print"></span> Print</a>
    </div>
</div>
</div>
</form>
</fieldset>
</div>
<div class="clear-fix mb-2"></div>
<div class="container-fluid" id="printout">
    <table class="table table-hover table-striped table-bordered" id="list">

<colgroup>

<col width="5% ">

<col width="15% ">

<col width="20% ">

```

```
<col width="20%">
```

```
<col width="30%">
```

```
<col width="10%">
```

```
</colgroup>
```

```
<thead>
```

```
<tr>
```

```
<th>#</th>
```

```
<th>Report DateTime</th>
```

```
<th>Incident</th>
```

```
<th>Location</th>
```

```
<th>Dispatched Teams</th>
```

```
<th>Status</th>
```

```
</tr>
```

```
</thead>
```

```
<tbody>
```

```
<?php
```

```
    $i=1;
```

```
        $qry = $conn->query("SELECT r.*, i.name as `incident` from `report_list` r  
inner join incident_list i on r.incident_id = i.id where date(report_datetime) =  
'{$date}' order by unix_timestamp(r.report_datetime) desc ");
```

```
while($row = $qry->fetch_assoc()):
```

```
    $teams = "";
```

```
        $team_query = $conn->query("SELECT concat(rt.name,' ', t.code) as `team`  
from team_list t inner join respondent_type_list rt on t.respondent_type = rt.id  
where t.id in (SELECT team_id from `report_teams` where report_id =  
'{$row['id']}') order by `team` asc");
```

```
if($team_query->num_rows > 0){
```

```
    $teams = array_column($team_query->fetch_all(MYSQLI_ASSOC),'team');
```

```
    $teams = implode(", ", $teams);
```

```

    }

    ?>

<tr>

    <td class="text-center"><?php echo $i++; ?></td>

    <td><?php echo date("Y-m-d H:i",strtotime($row['report_datetime']))
?></td>

    <td><?php echo $row['incident'] ?></td>

    <td><?php echo $row['location'] ?></td>

    <td><p class="m-0"><?php echo !empty($steams) ? $steams : "N/A"
?></p></td>

    <td class="text-center">
        <?php if($row['status'] == 0): ?>
            <span class="badge badge-secondary px-3 rounded-
pill">Pending</span>
        <?php else: ?>
            <span class="badge badge-success px-3 rounded-
pill">Done</span>
        <?php endif; ?>

```

```

                </td>

        </tr>

    <?php endwhile; ?>
        <?php if($qry->num_rows < 1): ?>
            <tr>
                <td class="px-2 py-1 text-center" colspan='6'>No data</td>
            </tr>
        <?php endif; ?>

    </tbody>
</table>
</div>
</div>
</div>
</div>
</div>
</div>
<noscript id="print-header">
<div class="d-flex w-100 align-items-center">
    <div class="col-2 text-center">
        
    </div>
    <div class="col-8">
        <div style="line-height:.5em">
            <h4 class="text-center m-0"><b><?= $_settings->info('name')
?></b></h4>

```

```

<h3 class="text-center m-0"><b>Daily Incident Report</b></h3>
<div class="text-center">as of</div>
<h5 class="text-center m-0"><b><?= date("F d, Y", strtotime($date))
?></b></h5>
</div>
</div>
</div>
<hr>
</noscript>
<script>
$(document).ready(function(){
    $('table td,table th').addClass('py-1 px-2 align-middle')
    $('#search-filter').submit(function(e){
        e.preventDefault()
        location.href = "./?page=reports/daily_report&" + $(this).serialize()
    })
    $('#print').click(function(){
        var h = $('head').clone()
        var ph = $('noscript#print-header').html().clone()
        var p = $('#printout').clone()
        h.find('title').text("Daily Incident Report - Print View")
        start_loader()
        var nw = window.open("", "_blank", "width=950, height=900")
        $(nw.document).find('head').append(h.html())
        $(nw.document).find('body').append(ph)
        $(nw.document).find('body').append(p)
        nw.document.close()
    })
})

```

```
setTimeout(=>{
  nw.print()
  setTimeout(=>{
    nw.close()
    end_loader()
  },300)
},300)

})
})
</script>
```

APPENDIX II

Program Output

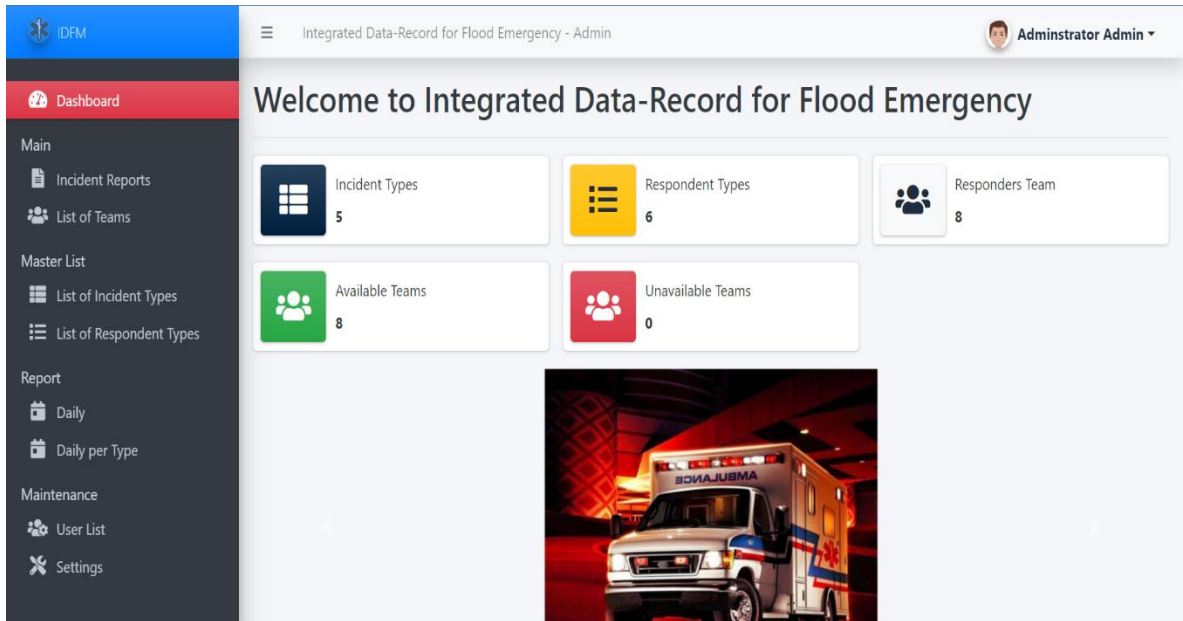


Figure A1: The dashboard of the proposed system, with its functionalities. The black pane at the left is the menu featuring main, master list, report and maintenance sub menu, with each containing a list of featured menus. The center pane of the system presents at glance a summary of important data records contained in the system such as total number of incident type, handling agents etc.

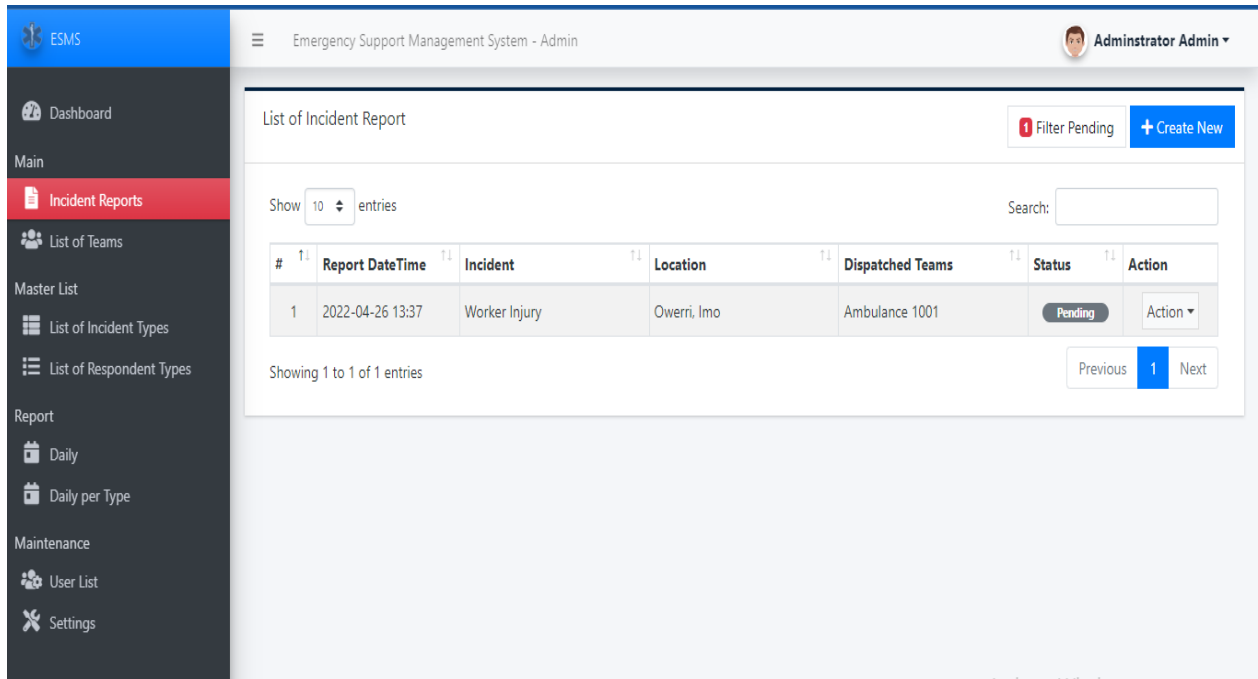


Figure A2: Shows the list of incident report which is accessed through the *Incident Reports* sub menu on the left part of the system. Each incident report has a unique status feature which reads either pending or completed.

The screenshot displays the ESMS Admin interface. The top navigation bar shows the system name and the user 'Administrator Admin'. The left sidebar contains a menu with categories: Main (Incident Reports, List of Teams), Master List (List of Incident Types, List of Respondent Types), Report (Daily, Daily per Type), and Maintenance (User List, Settings). The 'Daily per Type' option is highlighted in red. The main content area is titled 'Daily Incident Report' and features a 'Filter' section. This section includes a 'Choose Date' field with the value '24/06/2023' and an 'Incident Type' dropdown menu set to 'Fire'. There are 'Filter' and 'Print' buttons. Below the filter is a table with the following structure:

#	Report DateTime	Incident	Location	Dispatched Teams
No data				

Figure A3: Shows how the system reports on daily basis on incident cases. The report is dated and tagged to each occurrence in the system. This daily report is presented in a table format with Date, incident, location and handling agents as attributes.

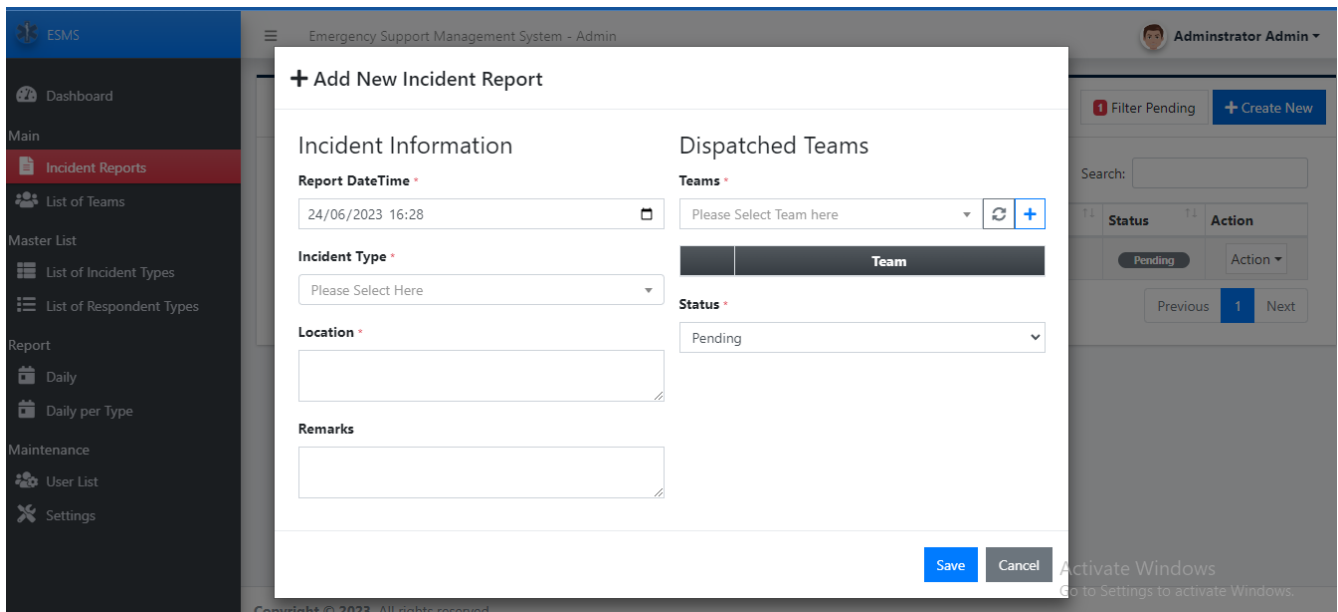


Figure A4: Shows how to add a new incident report by the handling agents. The system stores vital information during this process such as date, incident type, location, remarks and if course status of each occurrence. Once this data is saved, and user can have access and real-time feed on the status of each occurrence recorded.