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Design and Development of Disaster Response Coordination Platform for Enhanced Emergency Management in Zambia

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Abstract

Disaster Response Coordination Platform (DRCP) is a web application that seeks to enhance disaster response in Zambia through the utilization of modern web technologies. With the growing risks of fires, floods, droughts, and pandemics, there is a necessity for efficient communication and resource sharing among response organizations. DRCP bridges this gap by providing a strong, real-time chat platform that supports instant messaging, quick notification, and coordinated response in the event of an emergency. The platform includes a central communications hub with live chat, a request and resource allocation system, and an incident dashboard to enhance decision-making. The front-end is coded using HTML5, CSS, JavaScript, and Bootstrap for a responsive, user-friendly interface that operates seamlessly across different devices, from desktops to mobile phones. This design makes it easy to access across various environments so that all, from administrative personnel to emergency services, can easily and naturally use the system. On the backend side, Python, Flask Framework, MYSQL Database and SQLAlchemy ORM. The modular, stakeholder-centric nature of the system facilitates seamless inter-agency collaboration, with tailored roles and permissions for government agencies, NGOs, and emergency responders. Security measures are applied at every stage of the system to ensure data integrity and protect confidential information. The system is tested in an iterative manner to remain adaptive to Zambia's disaster management agencies' evolving needs, with the ability to change and adapt in addressing multiple scenarios of disasters.

Keywords: Disaster Management, Web-Based System, Coordination Platform, Emergency Response, Zambia

1. Introduction

Zambia has in recent years faced a rising number of climate and technology related disasters, including floods, droughts, fires, epidemics, and industrial accidents (DMMU, 2015; GFDRR, 2017) [10, 11]. These events have exposed long-standing weaknesses in the country's disaster management system, especially in coordination, information sharing, and the mobilization of resources (Chitondo *et al*., 2024) [6]. Much of the current response work still relies on manual reporting and disconnected communication channels, which often leads to delays, duplicated actions, and poor situational awareness when emergencies occur (Alexander, 2015; Haddow *et al*., 2020) [1, 13].

For disaster response to be effective, information must move smoothly among government agencies, emergency teams, humanitarian partners, and affected communities (IASC, 2020) [15]. Recent studies show that digital tools that allow real time reporting and provide structured decision support can significantly improve how quickly and accurately agencies respond to emergencies (Kim & Hastak, 2018; Hassan *et al*., 2017) [17, 14].

The Disaster Response Coordination Platform was designed with this goal in mind. It is a web based system that brings together real time communication, geolocation incident reporting, resource tracking, and a centralized command dashboard (Ocal & Torun, 2025; Aravindis, 2023) [22, 2]. By bringing these functions into one place, the DRCP aims to shorten response times, make resource availability easier to track, and strengthen collaboration among the various agencies involved in Zambia's disaster management efforts.

The objectives of this study are:

- To design and deploy a web based disaster response coordination platform suited to Zambia's emergency management needs.
- To assess the platform's usability, efficiency, and its likely impact on national disaster preparedness and response.

- To examine how the platform could be linked with Zambia's early warning systems, including ZNEWS

This study adds to ongoing research on digital disaster management in developing countries by offering a practical model for improving communication, reporting, and resource coordination in Zambia (Chen & Zhang, 2014; Cutter *et al*., 2016) [5, 9]. Several tools already exist in the country, such as flood alert systems and mobile emergency reporting applications, but they work independently and are not connected. This lack of integration limits their usefulness during emergencies and highlights the need for a centralized platform that supports real time, multi-agency coordination (Chitondo *et al*., 2024; Banda *et al*., 2025) [6, 7].

The study draws on several theoretical perspectives. Systems Theory stresses how different components of a disaster response system must work together (Bertalanffy, 1968). The Shannon Weaver Communication Theory emphasizes the need for clear and timely information during crises (Haddow *et al*., 2020) [13]. The Incident Command System offers a structured way of managing roles, information, and resources during emergencies (ICRC, 2021) [16]. The Diffusion of Innovations Theory explains how new technologies are adopted based on their usefulness and ease of use (Rogers, 2003) [18].

Experiences from other countries also support the value of integrated platforms. For example, the Philippines' Project NOAH and various IoT based public safety systems in smart cities have shown how unified digital tools can improve disaster forecasting, communication, and response coordination (Caballero *et al*., 2016; Hassan *et al*., 2017; Zhang *et al*., 2025; Yadav & Yadav, 2025) [4, 14, 20, 21]. These examples suggest that the DRCP could meaningfully strengthen Zambia's disaster response by bringing communication, reporting, and resource management into a single coordinated system.

2. Methodology

The mixed-methods approach was employed in this study for the design, development, and evaluation of the Disaster Response Coordination Platform (DRCP) for Zambia. The aim was to collect quantitative and qualitative data to ensure the platform would be both functional for disaster management agencies and user-friendly for responders and the community.

2.1 Research Design

A mixed-methods design combined quantitative measures (surveys, resource tracking metrics) with qualitative insights (interviews, focus groups). This approach enabled data triangulation, improving reliability and validity (Creswell & Plano Clark, 2018) [8]. Practical observations during simulation exercises were also incorporated to assess usability and operational efficiency in real-world scenarios.

2.2 Data Collection

Data collection employed five main methods:

Surveys

Surveys were distributed to emergency responders, government officials, NGOs, and community representatives, with 120 responses collected (45 responders, 30 officials, 25 NGO staff, 20 community members). Surveys addressed:

- Obstacles in disaster response
- Knowledge of digital tools
- Desired platform features and ease of use

Willingness to adopt DRCP

A Likert scale measured perceptions of usability, communication efficiency, and resource tracking. Open-ended questions captured insights on current response challenges.

Interviews

Semi-structured interviews were conducted with 15 key informants, including DMMU officials, local coordinators, and NGO leaders. Each session lasted 45–60 minutes and covered:

- Agency coordination
- Resource allocation inefficiencies
- Perceived benefits and challenges of digital platforms
- Training and technological capacity

Focus Group Discussions

Two focus groups of 8–10 emergency responders discussed:

- Communication challenges during disasters
- Desired platform features
- Reporting and alert expectations

Document Analysis

Policy documents, disaster reports, and early warning bulletins were reviewed, including:

- Zambia's Disaster Management Operations Manual (DMMU, 2015) [10]
- ZNEWS reports

Historical disaster response records (10 years)

The review identified structural gaps, reporting inefficiencies, and recurring issues.

Observations

Field notes were taken during two simulation exercises involving flood and fire scenarios, recording:

- Response speed
- Communication accuracy
- Coordination issues

2.3 Development Approach

The Waterfall Model guided DRCP development due to its sequential, structured process:

- Analysis of Requirements: Derived from surveys, interviews, focus groups, and document review
- System Design: Wireframes, workflows, and data models
- Execution: Python Flask, MySQL, HTML5, CSS, JavaScript
- Integration and Verification: Unit, system, and usability testing with real users
- Release: Deployed on a research project server for trial testing
- Support: Monitoring, bug fixing, and scheduled updates

The model was chosen because requirements were clearly defined, enabling rigorous testing at each stage.

2.4 Data Analysis

Quantitative Analysis: Survey data were analyzed using Excel and Power BI, generating dashboards showing:

- Respondent demographics
- Reported challenges
- Satisfaction with current practices

Expected benefits of DRCP adoption:
For example, 78% reported delays in resource allocation, and 92% supported real-time messaging.
Qualitative Analysis: Thematic analysis of interview and focus group transcripts produced codes for

- Communication inefficiencies
- Reporting delays
- Demand for mobile-friendly interfaces
- Resource tracking

Themes were mapped to system features to ensure user priorities were addressed.
Observation Analysis: Structured tables captured response times, information accuracy, and coordination issues during informing updates to the real-time reporting module and command dashboard.

2.5 Ethical Considerations

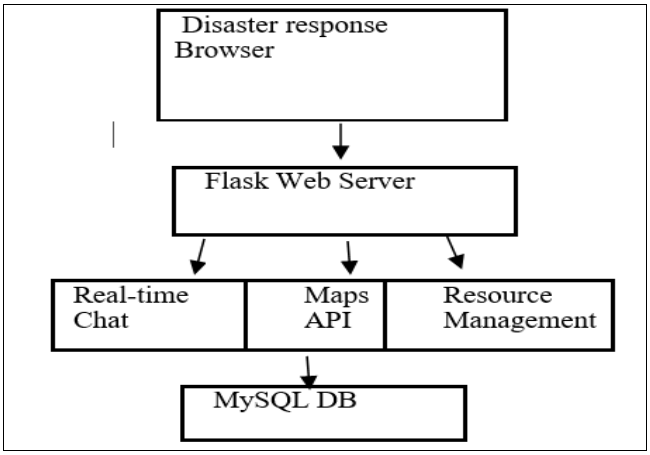
The Information and Communications University Research Ethics Committee approved the study. Participants were informed about:

- Study objectives
- Voluntary participation
- Confidentiality of responses

2.6 System Design and Development

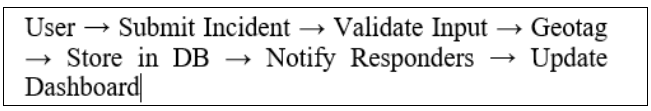
The DRCP was built with:
Backend: Python Flask, SQLAlchemy ORM
Database: MySQL
Frontend: HTML5, CSS, JavaScript, Bootstrap
APIs: Google Maps/Location API for geolocation
Communication: WebSockets for real-time messaging

System Architecture
DRCP system architecture.



System Archtecure
Source: Author: 2025

Fig 1: DRCP System Architecture



Incident Flow
Source: Author: 2025

Fig 2: DRCP Incident Reporting Workflow

Key Features

- Real-Time Chat System: facilitates communication between responders, coordinators, and local authorities.
- Incident Reporting Module: supports text descriptions, photos, and automated geolocation tagging.
- Resource Management: enables allocation and tracking of supplies, equipment, and personnel.
- Incident Command Dashboard: aggregates real-time data for decision-makers.
- User Access Control: role-based permissions: officials, responders, community users.

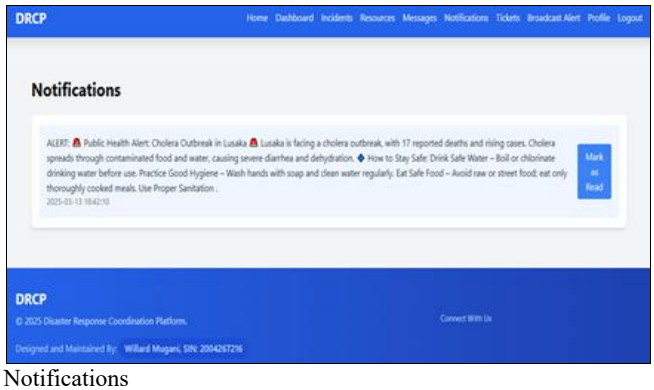
DRCP Images

Incident
Source: Author: 2025

Fig 3: Incidents Status

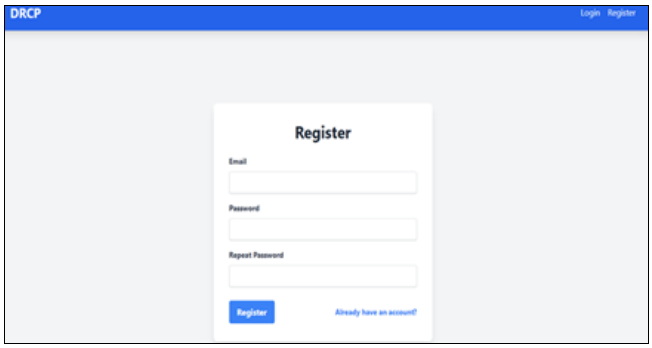
Broadcast Alerts
Source: Author: 2025

Fig 4: Broadcast Alert



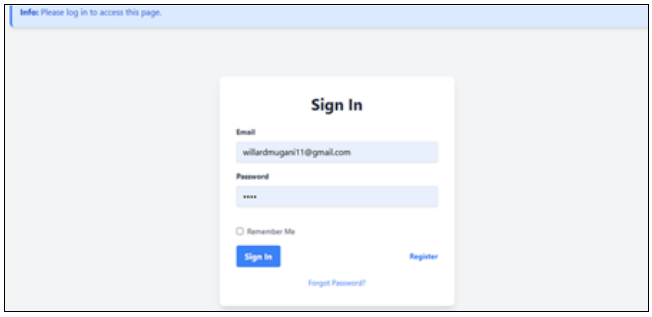
Notifications
Source: Author: 2025

Fig 5: Notifications



User Registration
Source: Author: 2025

Fig 6: User Registration



User Sign in
Source: Author: 2025

Fig 7: User Sign in

Security

- HTTPS encryption
- Role-based access control
- Secure password hashing
- Controlled database access

3. Results

Pilot testing of the Disaster Response Coordination Platform (DRCP) was conducted with local officials and community representatives to evaluate usability, operational efficiency, and the platform's impact on coordination during simulated emergency scenarios. Feedback indicated notable improvements in communication speed, accuracy of incident reporting, and transparency in resource allocation compared to existing systems.

Usability Findings

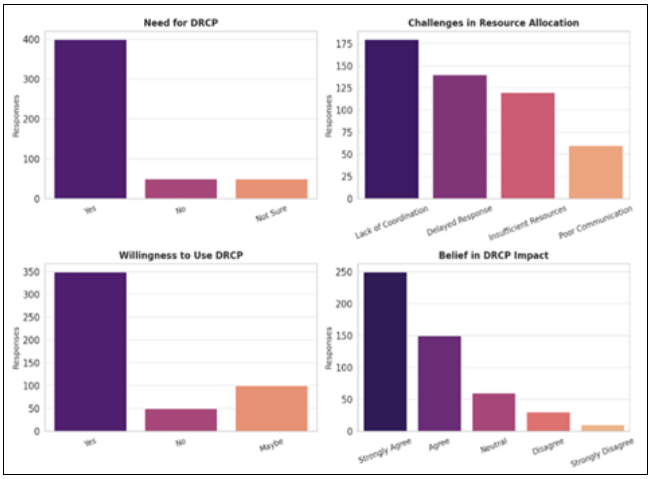
Participants reported improvements in:

- Communication speed
- Accuracy of incident location data
- Transparency in resource tracking
- Ease of coordinating multiple agencies.

A. Survey Results

- 87% found the platform easy to use
- 92% agreed real-time messaging improved response coordination
- 81% believed DRCP would reduce delays during crises
- 76% supported nationwide adoption.

DRCP Results:



Result
Source: Author: 2025

Fig 8: Survey Results

These results show strong acceptance and indicate that DRCP meets key user needs.

4. Discussion

The DRCP tackles a number of critical issues in Zambia's disaster management framework. The existing systems are characterized by fragmentation, communication delays, and limited coordination among the various government agencies (Chitondo *et al*., 2024) [6]. The DRCP addresses these problems through a combination of the three measures: it provides a centralized platform, which integrates the communication channels, allows reporting in real time and resource tracking to be done in an efficient manner (Ocal & Torun, 2025) [22].

The DRCP not only existing tools but also introduces the following advantages:

- Better Communication: The real-time chat system enables the sharing of instant updates among responders, coordinators, and local authorities and thus lessens the delays that might have been caused by manual reporting and fragmented messaging (Aravindis, 2023) [2].
- Unified Resource Management: The platform displays the entire staff, equipment, and supply available at any time, which helps in ensuring that the most critical areas receive the proper allocation during emergencies (Chen & Zhang, 2014; ASC, 2019) [5, 3].
- Higher Situational Awareness: The combination of geotagged incident reports and a centralized dashboard gives the decision-makers the ability to monitor the emergencies in real time, select the areas that need to be prioritized, and provide the necessary support (Kim & Hastak, 2018; Zhang *et al*., 2025) [17, 20].
- Encouragement of Multi-Agency Collaboration: The DRCP, by allowing the different agencies to access and

update the information in a structured manner, brings about coordinated response efforts and, at the same time, cuts down the overlap of work (ICRC, 2021; IASC, 2020) [16, 15].

- Flexibility and Availability: The platform's modular structure guarantees that it can incorporate additional capabilities, such as mobile apps, AI-based predictive analytics, or offline reporting tools for rural areas (Wibowo *et al*., 2025; Yadav & Yadav, 2025) [19, 21].

Compared to existing tools, the DRCP:

- Consolidates communication channels
- Offers real-time reporting and location tracking
- Enables centralized resource allocation
- Enhances collaboration between different agencies

Its modular and scalable design also aligns with the Incident Command System (ICS), improving operational efficiency.

The communication speed was improved by DRCP, as well as the accuracy of the incident location and the transparency in resource tracking, the pilot testing confirmed these improvements. Users were positive in their feedback and expressed their conviction that the system could indeed minimize the time lost in emergency response during disasters (Chitondo *et al*., 2024; Ocal & Torun, 2025) [6, 22]. These results are consistent with the general trend in research all over the world, which points out that the digital platforms when integrated still prove to be very useful in improving disaster preparedness and response (Hassan *et al*., 2017; Zhang *et al*., 2025) [14, 20].

There is a lot of promise with regards to DRCP, but the challenges have not been eliminated yet. To reach a broader engagement, training for emergency get personnel ready, the integration with the existing national systems would be required, and the rural areas must be provided with a reliable internet connection (Banda *et al*., 2025; DMMU, 2015) [7, 10]. Future developments may include the use of predictive analytics to determine areas at high risk of disasters, next to the automated alerting for early warning and mobile-friendly interfaces for accessing populations using only mobile rather than desktop platforms (Wibowo *et al*., 2025; Yadav & Yadav, 2025) [19, 21].

To sum up, DRCP has shown that web-based coordination platforms can be a powerful tool to greatly assist and improve the disaster response operations in Zambia by eliminating the communication barriers, controlling the allocation of resources in one place, and through the cooperation of many stakeholders that already were working within the same area (Ocal & Torun, 2025; Aravindis, 2023) [22, 2].

The findings support the argument that digital platforms can significantly improve disaster response capacity when appropriately designed.

5. Conclusion and Future Work

This study presents the design and development of a web-based Disaster Response Coordination Platform for Zambia. The platform improves communication, enhances resource tracking, and provides a centralized command environment for emergency responders. Pilot tests confirm its potential to strengthen national disaster response.

Future work will include:

- Development of a mobile app version
- Integration with SMS/offline reporting for rural areas
- Use of AI for predictive disaster analytics
- Full integration with Zambia's national early warning system (ZNEWS)
- Scaling to national deployment through government agencies

The DRCP offers a practical, scalable, and user-centered solution for enhancing disaster resilience in Zambia.

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