



International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Survey on Digital Disaster Management: Preparing for the Worst with Smart IT Tools

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ABSTRACT:

Disasters can occur at any time, causing serious damage and loss. In today's world, digital technologies play a major role in improving disaster management and response. Using tools such as early warning systems, mobile apps, satellite monitoring, and cloud-based platforms will help to deliver alerts, implement rescue operations, and support real-time decision-making. However, a major challenge is how to alert people when there is no electricity or network connection during disasters. This is especially critical in areas which are affected more. To overcome this, we can use battery-powered radios, SMS-based alerts, satellite phones, solar-powered devices, and public announcement systems. Offline-enabled apps and mesh networks also ensure communication even without regular connectivity. By making disaster response systems more flexible and less dependent on power or internet, digital technologies can help save lives and reduce the impact of emergencies.

KEYWORDS: *Disaster Management, Digital technologies, early warning systems, satellite phones, mesh networks, solar power devices*

INTRODUCTION:

Disaster management involves recovering from natural or man-made disasters like floods, earthquakes, and fires. Various digital technologies such as mobile apps, satellite monitoring, and cloud systems help to send alerts quickly during emergencies. These technologies provide early warnings, faster updates, and better communication between rescue teams, government, and the public. Rescue teams use digital maps to find affected areas more efficiently. Sensors and drones are used to monitor damage in real time. People can report problems using mobile apps, which helps the rescue teams take action quickly. Social media is also used to spread emergency information to a large number of people. Cloud systems store important data so that it can be accessed anytime, even during disasters.

In addition, artificial intelligence (AI) and machine learning algorithms are now being applied to predict disaster risks more accurately. Big data analytics helps in identifying vulnerable regions and populations before a disaster occurs. Internet of Things (IoT) devices, such as smart weather stations, can continuously collect environmental data for early forecasting. Geographic Information Systems (GIS) allow authorities to visualize affected zones and plan resource distribution effectively. Mobile-based communication ensures that even rural or remote populations receive timely alerts. Virtual reality simulations are also being used to train rescue teams for better preparedness. Blockchain technology ensures that relief funds and resources are distributed transparently and securely. Cloud computing ensures scalability during massive data surges in disaster situations. These advancements together improve disaster readiness, reduce response time, and enhance recovery efforts. Ultimately, integrating technology into disaster management strengthens community resilience and saves countless lives.

ADVANTAGES OF DIGITAL DISASTER MANAGEMENT:

- Early warning systems give people time to prepare before disasters strike.
- Faster communication spreads emergency alerts quickly to everyone.
- Real-time monitoring tracks disaster impact instantly.
- Better coordination improves teamwork between rescue agencies.
- Efficient resource management ensures help reaches the right places.
- Accessibility of information keeps important data safe and available.
- Public participation allows citizens to report issues directly.

- Cost-effectiveness reduces expenses in managing disasters.
- Transparency ensures fair distribution of relief and funds.
- Training and preparedness improve response through simulations.

LITERATURE REVIEW:

Recent research draws attention to the increasing contribution of digital technologies in disaster preparedness, response, and recovery. Mobile applications, satellite systems, drones, and cloud platforms are mentioned extensively as instruments that enhance resilience towards natural and man-made disasters (Reference 1, 2, 3). Research points out that these technologies facilitate quicker communication, real-time monitoring, and more effective coordination among government officials, rescue workers, and the public (Reference 4, 5, 8). Sophisticated methods like artificial intelligence (AI), the Internet of Things (IoT), and big data analysis are increasingly being utilized for predictive disaster management (Reference 5, 9, 11). But, the literature further reports that concerns such as accessibility, data privacy, and infrastructure lacks also continue to limit large-scale uptake and equitable access (Reference 6, 10, 12).

METHODOLOGICAL LANDSCAPE:

The research methods employed in digital disaster management studies are diverse. Many studies are review papers that document existing technologies and their efficacy (Reference 2, 7, 10). Pilot projects and case studies are frequently carried out to validate mobile applications, early warning mechanisms, and information dissemination tools in disaster-hit locations (Reference 3, 6, 8). Empirical studies investigate AI- and IoT-based frameworks for prediction, monitoring, and damage estimation of disasters based on historical and current datasets (Reference 5, 9, 11). Simulation methods and virtual reality (VR) models are also utilized to train response teams and enhance readiness (Reference 6, 12). Big data analytics is also increasingly being utilized to measure risk, predict the impact of disasters, and facilitate decision-making in real time (Reference 4, 5, 9).

KEY RESEARCH THRUSTS AND OBJECTIVES:

The main research goal in this field is to create good early warning systems and rapid alert dissemination (Reference 5, 8). Timely communication among governments, rescue forces, and impacted communities is a common thrust (Reference 1, 6, 9). Geographic Information Systems (GIS) and computerized maps are also extensively researched for finding disaster-affected areas and organizing relief activities optimally (Reference 4, 7). Most works also stress the use of AI and IoT models for damage assessment, optimization of resources, and predictive analysis (Reference 2, 5, 11). Cloud-based systems are investigated as secure repositories for storing data and making it available in times of crises (Reference 1, 9, 11). Another prime focus is on public engagement, where mobile applications and social media platforms enable people to report incidents and obtain timely notifications, which in turn enhances community-driven disaster management (Reference 3, 6, 12).

IDENTIFIED GAPS AND PERSISTENT CHALLENGES:

In spite of its promise, digital disaster management is plagued with various challenges. The digital divide continues to be a huge problem, especially in rural and remote regions where there is poor internet connectivity, low digital literacy, and the technology is prohibitively expensive (Reference 3, 7, 10). Most disaster management solutions do not have offline capacity, robust security aspects, and interoperability, which undermines their use during times of necessity (Reference 1, 2, 6). Data privacy and trust are also major issues, as people can be reluctant to provide individual or geolocation data (Reference 5, 9, 12). Technical limitations, such as sensor, drone, and other equipment dependability, reduce real-time tracking and AI incorporation (Reference 8, 11). Additionally, slow public awareness and uptake hamper the effectiveness of these technologies (Reference 6, 8).

OBJECTIVES OF THE STUDY:

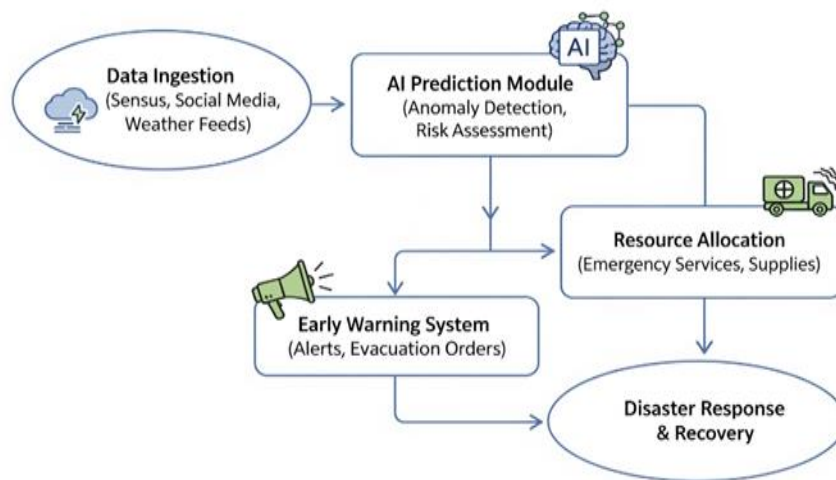
Following are the objectives of research paper:

1. To send alerts for people even without electricity or internet.
2. To explore and use offline communication methods like SMS, radios, and mesh networks.
3. To improve public safety by keeping communication alive in critical situations.
4. To enhance coordination between rescue teams, government, and the public.
5. To integrate AI, IoT, and cloud platforms for better disaster prediction and management.
6. To ensure reliable data storage and accessibility during emergencies.

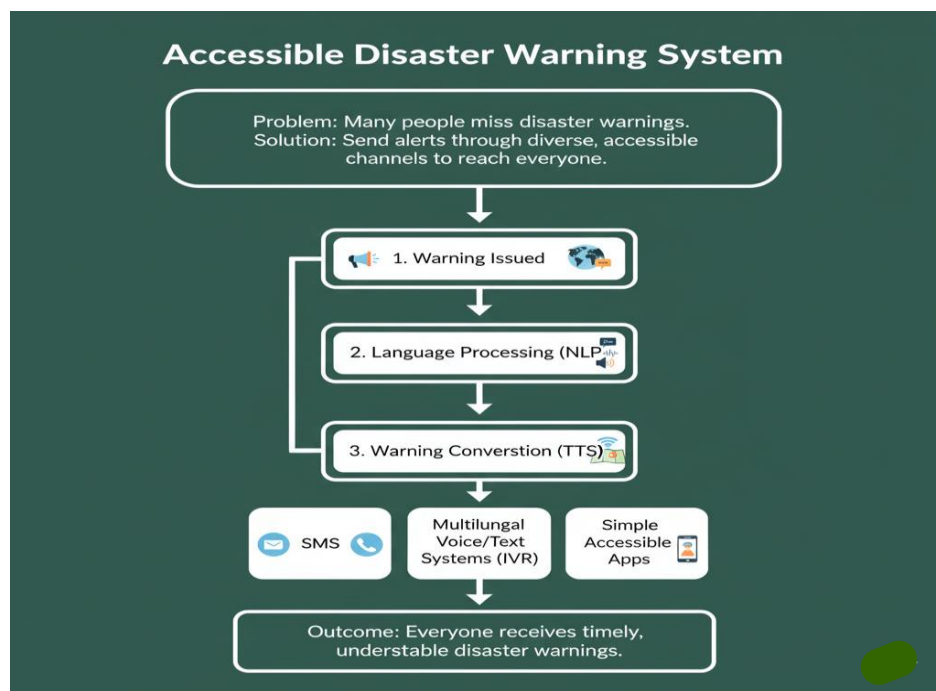
NEW METHODS USED:

1. IoT Mesh Networks – for reliable communication even when infrastructure is damaged.
2. AI Chatbots & Virtual Assistants – to provide real-time safety tips and guidance.
3. Multilingual Voice/Text Systems – to overcome language barriers in warnings.
4. Digital Twin Smart Cities – for disaster planning, monitoring, and simulation.
5. Deep Learning with Satellite Images (CNNs) – for automatic disaster area and damage detection.
6. Time-Series Forecasting (LSTM Models) – to predict disaster timing and intensity.

DIFFERENT WORKFLOWS



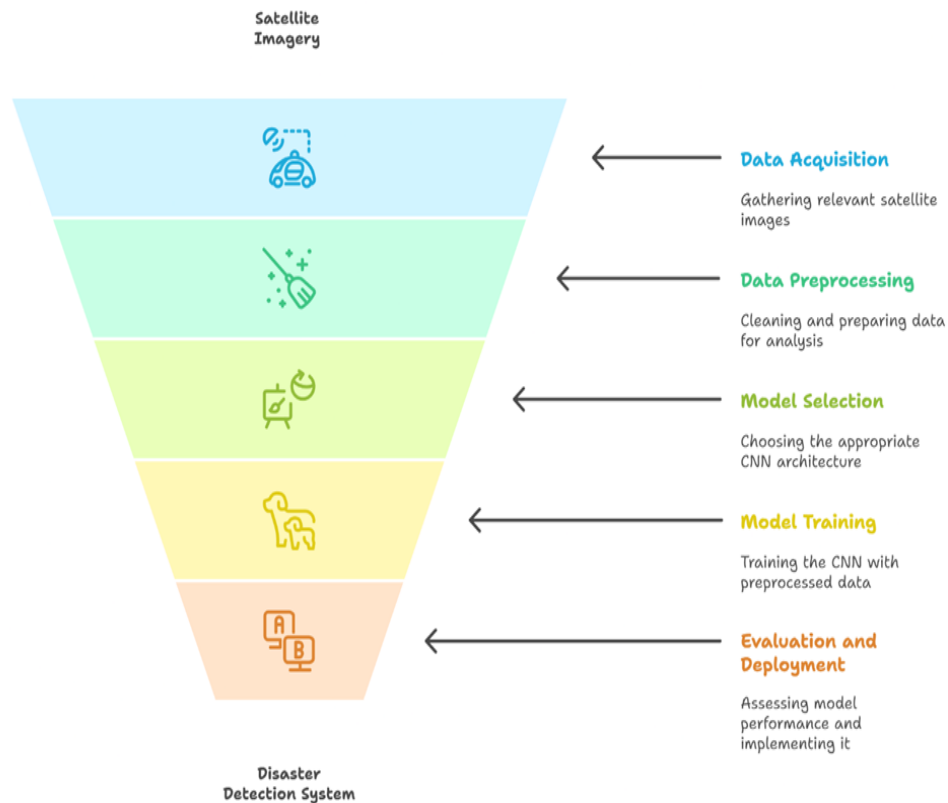
Early Warning Systems



AI Disaster Response System

It takes different data from social media, weather feeds and etc. and then AI detects the Risk based on that data. By predicting it allocates resources and emergency services to the Risky areas. It gives Early Warnings and alerts.

Disaster Detection Workflow Funnel



Made with Napkin

The image above illustrates the pipeline for the Disaster Detection Workflow Funnel, highlighting how to develop a deep-learning-based disaster detection system based on satellite images. The initiation of the pipeline starts with Data Acquisition, which is the gathering of satellite images that are about an event affected by disaster, or at risk of disaster. After Data Acquisition, the next step in the workflow is Data Preprocessing, which is when the satellite image data is cleaned, organized and prepped for AI analysis to ensure that the quality of data is sufficient for training. Flowing through the Model Selection portion of the pipeline, we have our selected Convolutional Neural Network (CNN) model architecture which we believe will best classify the detected disaster patterns for our application. Following Model Selection, we have the Model Training portion of the workflow where we will train our thoroughly prepped and cleaned CNN model to detect each type of potential disaster, based on the information learned from the data. Finally, we arrive at the Evaluation and Deployment stage where we will test the potential prediction nature of the model on (our) eventual selected disaster-detection satellite image data, make any modifications required, and finally deploy our practical disaster detection model into the real-world systems for operational analysis purposes. Collectively, this workflow funnel tracks each process step/database for getting an AI-based robust disaster detection system built, from Data Acquisition to deployment

Comparison Table:

	Title	Year	Performance Metrics	Research Objectives	Gaps
Reference 1	Cloud system for disaster communication with mesh networks	2024	Latency, throughput	Real time data sharing, reliable communication	Security and Data integrity
Reference 2	Disruptive technologies in disaster management	2025	Response time+Data latency	Preparedness, Recovery	Limited real world applications, Cyber security risks
Reference 3	2024 Noto Peninsula Earthquake: Need for digital transformation	2025	Recovery speed, Public satisfaction	Urgent need for digital transformation	Limited real time health monitoring, delay in adaptive AI
Reference 4	A Data-Driven Risk Assessment Approach Based on Geographical Risk	2024	Flood Risk Score, Response coverage	To integrate geographical data, To develop a data-driven framework	Most flood risk models are city-specific , Limited use of open and public datasets
Reference 5	Revolutionizing Early Warning Systems for Natural Disasters: Integrating AI and ML-Driven Models, Tools, and Platforms	2024	Prediction accuracy, Alert timeliness	To enhance early warning systems using AI and ML	Data quality issues, lack of unified platforms
Reference 6	Multilingual Standalone Voice-Based Social Network for Disaster Situations	2024	Message Delivery Rate, Latency, Speech Recognition Accuracy	To build a communication system that works without the internet	Limited support for multilingual voice communication
Reference 7	Digital Twin Smart Cities for Disaster Risk Management	2023	Simulation realism, System responsiveness	To explore digital twin applications in urban disaster risk management	Limited implementation, High cost of deployment
Reference 8	Addressing Early Warning Challenges Using Satellites	2023	Coverage area, Response time improvement	To use satellite tech for better evacuation planning	Data latency, dependence on weather conditions
Reference 9	Artificial Intelligence and Cloud-based Collaborative Platforms for Managing Disaster	2022	Collaboration effectiveness, Decision speed	To improve disaster operations with AI and cloud collaboration	Privacy concerns, Integration with legacy systems
Reference 10	Disaster-Resilient Smart Cities: A Review of Current Approaches, Challenges, and Opportunities for Future Research	2021	City resilience index, Technology readiness	To assess smart city frameworks for disaster resilience	Scalability issues, Need for real-time adaptability
Reference 11	An AI-Based Framework for Urban Disaster Resilience Using IoT and Cloud Computing	2021	System uptime, Detection accuracy	To develop a resilient framework for urban areas using AI and IoT	High energy consumption, Limited rural applicability

Reference 12	Evaluation Framework for Smart Disaster Response Systems in Uncertainty Environment	2020	System reliability, Flexibility under uncertainty	To evaluate disaster systems performance under uncertain scenarios	Complexity in implementation, Low real-world testing
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METHODOLOGY:

The study looks at filling those big holes in how disaster management works right now. It pushes for mixing in digital stuff and smart tech to make things run better. One main problem stands out. Poor internet and power cuts keep messing up talks during bad times. So they suggest tough setups like IoT mesh networks. Solar-powered tools for chatting. And apps that work without being online. That way operations keep going no matter what. Another issue hits hard. Not enough people know how to use fancy digital gear. Training in AI, GIS, and IoT monitoring seems key. It builds up teams for better responses. You know, they need that edge. Data stays safe too in this plan. Privacy matters a lot. Misinfo and hacks can kill trust when things go wrong. Cloud computing helps. Encryption too. Agencies share important info without worries. Data gets messy sometimes. Fragmented, not matching up. Standard formats fix that. Interoperable platforms make coordination smooth. For watching in real time, IoT sensors do the job. Satellite images help out. Drones check damage fast. They guide rescues right. Machine learning steps in next. Predictive analytics spots warnings early. Teams act before hits land. Proactive, you see. Public stuff wraps it up. Awareness campaigns keep going. Drills with simulations build readiness. Communities get tougher. Responses turn quicker, sharper, more dependable overall.

CONCLUSION:

Digital disaster management plays a vital role in strengthening preparedness and response during emergencies. The integration of technologies such as AI, IoT, GIS, and cloud computing enables faster prediction, efficient coordination, and transparent communication. Tools like drones, mobile apps, and satellite monitoring ensure that rescue operations are more accurate and timely. Offline-enabled solutions and solar-powered devices make communication possible even when networks fail. Data analytics helps authorities make better decisions and allocate resources effectively. Public participation through mobile and social platforms improves awareness and engagement. Despite challenges like connectivity issues and data privacy, innovative technologies continue to reduce these barriers. With continuous training and digital literacy, communities can become more resilient. Ultimately, technology-driven disaster management minimizes loss, saves lives, and ensures a faster recovery. Building smarter systems today will lead to safer and more prepared societies tomorrow.

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