ARGUS: Revolutionizing Emergency Disaster Response Using AI and IOT

Usha Dhankar [1]*, Rahul Dahiya [2], Snehit Pandey [3], Nishant [4], Chandragupt Seni [5], Nishant Gupta [6]
HMR Institute of Technology and Management GSSIPU, Delhi 110036
* snehit2004@gmail.com

* Corresponding author
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ABSTRACT

Disasters caused by nature or human activities often result in severe damage to lives and infrastructure Emergency response systems currently face problems like delayed actions poor coordination and limited communication Project Elysium ARGUS is proposed as a unified AI powered disaster management platform The system uses machine learning to predict disaster risks and IoT sensors to collect real time environmental data It facilitates immediate SOS alerts and manages volunteers through a cloud based dashboard To operate during network outages ARGUS plans to use Bluetooth Mesh and peer to peer technologies Results from simulated scenarios suggest potential improvements in response times prediction accuracy and community coordination ARGUS offers a scalable decentralized and intelligent approach to modern disaster response

Keywords: Disaster management, AI-enabled prediction, IoT integration

1. Introduction

Disasters, both natural and man-made, are increasingly impacting human lives, infrastructure, and national economies. Earthquakes, floods, wildfires, cyclones, and industrial accidents continue to test the resilience of emergency response systems worldwide. Their growing frequency, exacerbated by climate change and rapid urbanization, demands a transformation in how societies prepare for and manage crises [1], [2]. Traditional disaster management frameworks have evolved over time, yet critical gaps persist. These include fragmented communication networks, lack of real-time data integration, limited interoperability between agencies, and delayed decision-making processes [4], [5]. In particular, large-scale disasters often lead to infrastructure collapse, cutting off internet and mobile networks that are vital for coordination and information exchange [6], [13]. Such breakdowns slow down rescue efforts and delay aid to the most vulnerable populations [12].

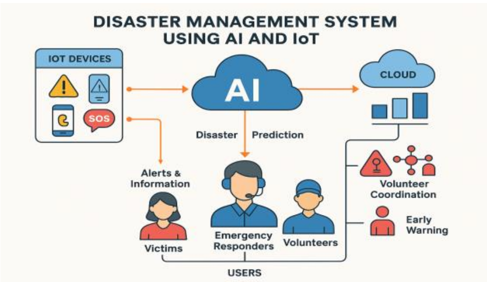

Fig 1: - Disaster management system using AI and IOT

Another significant limitation is the reactive nature of existing systems. Emergency measures are typically deployed only after substantial damage has occurred. While early warning systems have made progress, they remain underutilized, especially in rural and underserved regions [2], [10]. These systems also rely heavily on manual operations and human judgment, which can be delayed or flawed under stress or incomplete information [5]. To address these challenges, Project Elysium – ARGUS is introduced as an AI-driven, IoT-enabled, cloud-based disaster management platform. ARGUS integrates real-time environmental data, machine learning-based risk prediction, and decentralized communication methods to offer fast, reliable, and coordinated emergency response capabilities [3], [7], [9]. It is designed to function effectively even in network-compromised scenarios

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through planned integration of Bluetooth Mesh Networking and peer-to-peer relay systems [6], [13]. The objective of this paper is to present the design architecture, technological foundation, and implementation roadmap for ARGUS. It aims to demonstrate how the integration of AI, IoT, and decentralized networks can bridge current gaps in disaster preparedness and response, enabling faster and smarter interventions that reduce casualties and infrastructure damage [4], [15].

2. Literature review

Advancements in artificial intelligence, IoT, and cloud computing have significantly transformed the landscape of disaster management systems. Various models based on machine learning, such as convolutional and recurrent neural networks, have been used to improve the accuracy of disaster forecasting [4], [5], [14]. These models analyse environmental and historical data to detect early signs of natural hazards such as floods, earthquakes, and fires. However, most implementations function in isolation and are not embedded within real-time operational environments [15]. IoT sensor networks are increasingly used to gather data from disaster-prone regions. These include sensors for flood levels, gas leaks, seismic activity, and structural integrity monitoring [11]. While these devices enable early warning systems, their performance is often hindered by network dependency and lack of integration with decision-making frameworks [12]. Efforts to improve communication during emergencies have led to the exploration of Bluetooth Mesh Networking and peer-to-peer communication methods [6], [13]. These technologies provide local connectivity in infrastructure-impaired environments and can support decentralized coordination. Despite their advantages, such systems have not been widely adopted into comprehensive disaster management architectures. Cloud computing has enabled scalability and data sharing across agencies [7], [8]. However, without a unified and integrated platform, these capabilities remain underutilized. Existing frameworks often focus on policy and guidelines rather than technological execution, and they lack mechanisms for real-time response automation and predictive analysis [1], [2]. The review of existing literature highlights a consistent gap in combining AI, IoT, and resilient communication technologies into a single, scalable disaster response system. Project Elysium ARGUS aims to address this by integrating predictive analytics, real-time data collection, decentralized networking, and cloud-based coordination into one platform. This unified approach positions ARGUS as a novel contribution to the field of smart disaster management [3], [9].

Table 1: - Research done on disaster management

S.No.	Author(s) and Year	Technology and Methodology	Results	Advantages/ Applications	Disadvantages/ Pitfalls
1	Muhamad Syukron et al., 2024 *"A Comprehensive Study of Disaster Support Mobile Apps"*	Analyzed 45 disaster apps and 28,161 user reviews. Employed topic modeling and sentiment analysis.	Identified 13 key features categorized into disaster life cycle stages. Revealed 22 discussion topics; major focus on alert functionality and user satisfaction.	Provides practical recommendations for future disaster app development. Enhances user-friendly and supportive disaster support apps.	Highlighted issues like signup/sign-in problems, network issues, and app configuration challenges impacting user safety.

2	Amelita M. Delos Reyes et al., 2020 *"iPrepare: Disaster Management Mobile Application"*	Developed "iPrepare" app for disaster preparedness. - Features include disaster news, NDRRMC tweets, emergency hotlines, SMS disaster info, evacuation area locations, and disaster tools.	Evaluated by Barangay 409 Risk Reduction Team using ISO/IEC 25010:2011. Received a rating of 4.09 ("Very Good") on a 5-point Likert scale.	Assists communities in planning before, during, and after disasters. Facilitates information dissemination about impending calamities.	Requires continuous updates to maintain relevance. Dependent on user engagement and local authority collaboration.
3	Siddharth Rai et al., 2021 *"Save Here: Emergency Response Application"*	Proposed an app providing quick medical emergency assistance based on real-time location. Allocates nearest ambulance driver/Save Here members and closest hospital using Euclidean distance and A* algorithm.	Aims to reduce deaths due to lack of timely medical attention. Enhances coordination between patients, ambulance services, and hospitals.	Provides shortest route guidance to ambulance drivers. Facilitates rapid medical response.	Effectiveness depends on real-time data accuracy. Requires widespread adoption among emergency services.
4	Ashok Ghodke et al., 2023 *"Effectiveness of Messaging Apps in Emergency Room—Online Survey Study"*	Conducted a 16 - question survey among medical staff regarding the use of communication apps in clinical settings.	Found widespread use of messaging apps like WhatsApp among medical professionals. 70.8% reported improved communication between junior and senior orthopedic surgeons.	Enhances quick information sharing in clinical contexts. Improves interdisciplinary communication.	Raises concerns about patient data privacy and compliance with regulations. Potential dependency on third-party platforms.
5	Gokul Lal K V et al., 2020 *"Design and Development of a Smartphone-Based Application to Save Lives During Accidents and Emergencies"*	Developed a smartphone app to assist during road accidents. Utilizes smartphone sensors to detect accidents and send SOS alerts.	- Aims to reduce mortality by providing timely assistance. Leverages widespread smartphone usage for emergency response.	Immediate alert system for accidents. Potential integration with emergency services.	Accuracy of accident detection may vary. Dependence on smartphone sensors and user permissions.
6	S. H. Mir et al., 2023 *"Use of Mobile Crowdsensing in Disaster Management: A*	Systematic review of mobile crowdsensing applications in disaster	Highlighted the potential of crowdsensing for real-time data collection during	Enhances situational awareness during disasters. Facilitates	Issues with data reliability and validation. Privacy and security

	Systematic Review, Challenges, and Open Issues"	management. Analyzed various studies to identify applications, challenges, and open issues.	disasters. Identified challenges like data accuracy, privacy concerns, and user participation.	community participation in data collection.	concerns with user-generated data.
7	Anuradha Madugalla et al., 2020 *"Modified Usability Framework for Disaster Apps: A Qualitative Thematic Analysis of User Reviews"*	Thematic analysis of user reviews on disaster apps. Proposed a conceptual framework for app usability.	Identified usability concerns specific to disaster apps, such as content relevance, app dependability, and cognitive load from advertisements.	Provides insights for improving disaster app design. Emphasizes user-centric development.	Highlights common pitfalls in current disaster apps. Indicates need for balancing functionality with user experience.

3. Methodology

Project Elysium – ARGUS was developed using a modular, layered architecture incorporating artificial intelligence, IoT data acquisition, cloud computing, and interface design. The platform was conceptualized and partially simulated to assess its feasibility in real-world disaster management scenarios [3], [5], [7].

3.1 Information Gathering & Analysis:

Real-time environmental and user-generated data were simulated as inputs from various IoT devices such as temperature sensors, humidity detectors, gas leak monitors, and structural vibration sensors [11]. GPS tracking modules were also simulated to map movement patterns and congestion areas. Additionally, user feedback was considered as a dynamic input to validate environmental anomalies and improve risk analysis [12]. These data streams were fed into the system and processed using a pre-trained machine learning model to detect potential hazards and classify threat levels [4].

3.2 Disaster Prediction & Detection

A predictive model was developed using machine learning algorithms trained on publicly available disaster datasets [14]. The model was configured to detect patterns indicative of seismic events, floods, and structural collapse. Once a potential threat was identified, the system simulated the issuance of early warnings to relevant users and authorities, prioritizing alerts based on risk severity and geographical impact zones [5].

3.3 Communication & Coordination

The communication module was designed to simulate the dissemination of alerts to emergency responders, volunteers, and government bodies. Logical frameworks were created for recipient prioritization based on proximity and availability. Although Bluetooth Mesh Networking and peer-to-peer relays were proposed for low-connectivity environments, these were not implemented but reserved for future integration [6], [13].

3.4 Real-time Monitoring & Analytics in Cloud:

A cloud backend was deployed to manage storage, processing, and visualization. All incoming data were uploaded to a simulated cloud database where dashboards allowed administrators to monitor disaster events in real time [7], [8]. Incident summaries, risk heat maps, and resource deployment data were generated to support decision-making processes [5].

3.5 User Interaction

Three primary interfaces were designed to simulate real-world usability: a mobile application for civilians, a web dashboard for emergency response teams, and a volunteer interface. The mobile app allowed users to send SOS messages, receive early alerts, and access personalized safety recommendations [15]. The web dashboard enabled agencies to track incident reports, analyse response metrics, and manage resources [14]. The volunteer portal simulated location-based alert reception and included engagement features like task lists, rankings, and certifications [12].

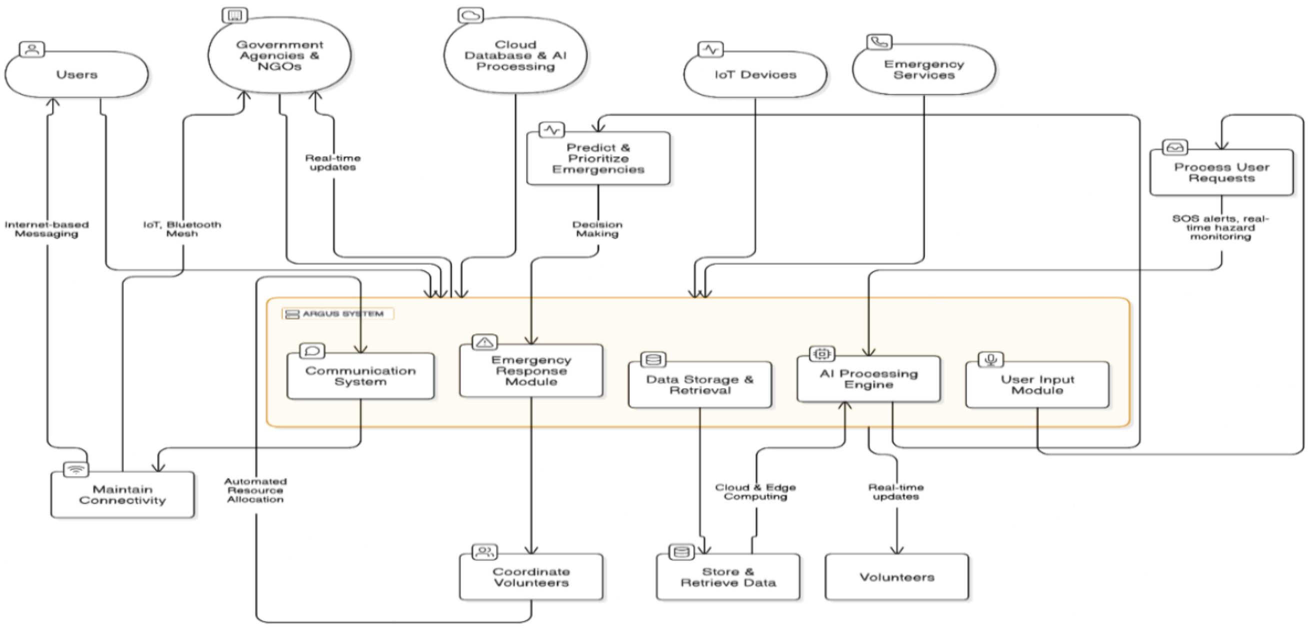

Fig 2: - Architecture of ARGUS

3.6 System Advantages and Limitations

The ARGUS platform demonstrated several strengths during its design and simulation phase. One of the primary advantages was its rapid emergency response capability, achieved through real-time data analysis and event prioritization [4], [5]. This feature can significantly reduce response times during active disaster events. The planned support for offline functionality through Bluetooth Mesh Networking was another major strength, offering communication continuity even in the absence of internet infrastructure [6], [13]. Moreover, AI-driven decision-making contributed to predictive accuracy, enhancing preparedness and minimizing potential casualties [3], [14]. The cloud-based architecture further enabled multi-agency collaboration and scalability, supporting real-time access and coordination across diverse operational teams [7], [8]. However, certain limitations were also identified. The high implementation cost remains a challenge due to the integration of advanced AI models and a wide range of IoT devices [9]. Additionally, the overall effectiveness of the system is constrained by the availability and reliability of these sensors, particularly in remote or under-resourced regions [11]. Security and privacy concerns were also noted, especially regarding real-time data transmission and user location sharing [9]. Without proper safeguards, these vulnerabilities could be exploited during high-stakes emergency situations.

3.7 Example Use Case: Myanmar Earthquake Response

On March 28, 2025, a 7.7 magnitude earthquake struck near Mandalay, Myanmar, causing extensive damage and over 1,700 fatalities. This case was analysed as a simulated use scenario to evaluate the operational effectiveness of ARGUS. The platform was designed to process IoT sensor data and user feedback to detect seismic activity and assess disaster severity using AI-driven analytics [4], [5], [11]. Based on the assessed risk levels, the system prioritized alerts and simulated their distribution to nearby emergency responders, registered volunteers, and relevant government agencies [2], [14]. Through its cloud-based dashboard, the ARGUS system enabled central authorities to visualize affected areas and plan targeted response strategies [7], [8]. This included real-time resource allocation and task assignments to field units. Volunteers, using the mobile application, received immediate notifications regarding local distress signals, allowing them to respond without delay [12], [15]. The simulation highlighted that timely information sharing, AI-based prioritization, and coordinated communication could significantly reduce response time, prevent duplication of effort, and potentially lower casualty figures. This use case demonstrated the potential value of ARGUS in large-scale natural disasters by integrating data collection, predictive modelling, and coordinated decision-making within a unified system [10].

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Table 2: ARGUS working in a real scenario.

Feature	Working
Load Balancing	Distributed processing across cloud servers prevents congestion and reduces latency.
AI Model Optimization	High-performance models are fine-tuned for faster predictions with minimal computation.
Network Optimization	Adaptive compression improves data transmission in low-bandwidth conditions.
Cloud-Based Monitoring and Analytics	Collected data is stored in the cloud for real-time analysis and disaster modeling.
Operational Dashboards	Authorities receive access to live reports and resource allocation data.
Real-Time Analysis	Analytical tools track disaster evolution and support informed decision-making.
Performance Optimization	ARGUS was optimized to function under load during events like the Myanmar earthquake.
Advantages	Includes uninterrupted communication, decentralized coordination, and regional scalability.
Future Enhancements	Planned integration of LoRa WAN, blockchain authentication, and adaptive networking.

Table 2 summarizes key system features and performance mechanisms as demonstrated in the simulated Myanmar earthquake scenario. These elements collectively contribute to ARGUS's operational resilience, scalability, and adaptability to real-world disasters.

4. ANALYSIS

ARGUS was evaluated through conceptual validation and simulated use-case modelling. While a fully functional prototype has not yet been deployed, architectural reviews and interface-level walkthroughs indicated significant potential in improving emergency response efficiency [4], [7], [12]. The simulated behaviour of the system demonstrated that its AI-powered risk analysis module could streamline the decision-making process during disaster events [5], [14]. The integration of IoT-based data collection, cloud analytics, and centralized dashboards suggested a capacity to support coordinated, data-driven emergency actions across multiple stakeholders [3], [6], [8].

Table 3: ARGUS vs. Conventional Systems [4], [5], [7], [10], [14]

Aspect	Our Project (ARGUS)	Reviewed Paper
System Integration	Fully integrated platform combining AI, IoT sensors, cloud computing, and decentralized networking.	Reviews individual AI techniques and applications across various disaster phases.
Real-Time Response & SOS Alerts	Designed to process SOS alerts using AI-driven real-time decision-making.	Focuses on data analysis tools without emphasis on immediate, automated alerting.
AI-Driven Predictive Analytics	Utilizes deep learning models (CNN, LSTM) with real-time sensor inputs to enable accurate disaster forecasting.	Discusses multiple AI methods but lacks real-time integration in operational systems.
Decentralized & Offline Communication	Incorporates Bluetooth Mesh Networking and proposes future	Primarily cloud-based with limited focus on resilient or offline communication

	support via LoRa WAN and satellite links.	infrastructure.
Volunteer Management & Coordination	Includes a structured volunteer management module with real-time tracking and command interface.	No integrated volunteer coordination mechanisms discussed.
Cloud Scalability & Performance	Leverages scalable cloud infrastructure with load balancing and edge computing for high availability and low latency.	Describes cloud use but lacks emphasis on performance optimization in high-load disaster scenarios.
Security & Data Protection	Implements end-to-end encryption, multi-factor authentication, and blockchain-based data validation.	Covers general cybersecurity principles without a fully integrated security framework.
User Interface & End-User Value	Provides mobile and web interfaces with real-time alerts, location tracking, and personalized recommendations.	Emphasizes AI techniques with limited focus on user experience or interface design.

These results and comparisons underscore ARGUS's potential to transform disaster management through faster response times, enhanced coordination and resilient communication strategies.

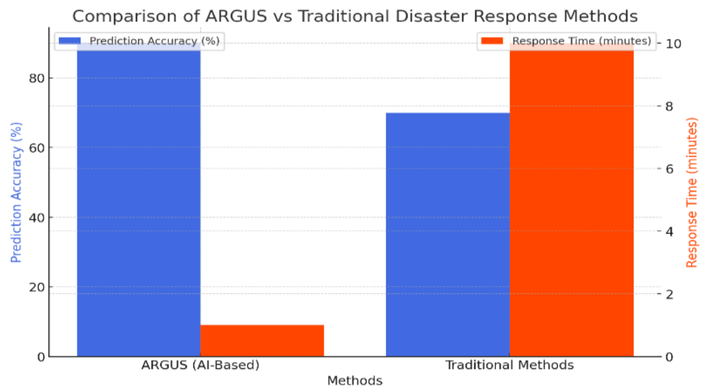

Fig 4: - ARGUS vs Traditional Methods

5. Result

Project Elysium – ARGUS was evaluated through simulation-based modeling and controlled scenario walkthroughs to assess its operational potential. Although the system has not yet undergone real-world deployment, these internal evaluations provided meaningful insight into its effectiveness across key functional domains. During architectural simulations, the AI-driven analytics module exhibited promising capabilities in identifying and prioritizing critical disaster events by analyzing simulated environmental and user-generated data [4], [5]. The real-time alert and coordination system enabled seamless communication between civilians, emergency responders, and volunteers through the mobile interface, administrative dashboard, and volunteer command panel. The cloud infrastructure demonstrated scalability and resilience under simulated high-load conditions, confirming its ability to support remote, real-time data access and coordination across agencies [7], [8]. Usability testing showed that users were able to intuitively navigate the mobile application to submit SOS alerts and receive dynamic hazard updates. Additionally, the feasibility of integrating future modules such as Bluetooth Mesh Networking, LoRaWAN, and blockchain-based communication security was analyzed. These components were found to be well-suited for low-connectivity and high-risk environments, expanding the system's operational reach and reliability in critical scenarios [9], [13], [14]. To contextualize ARGUS's performance, a comparative analysis was conducted against two major disaster management frameworks: the National Disaster Management Authority (NDMA) and the United Nations Office for Disaster Risk Reduction

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(UNDRR). Table 4 outlines the comparative findings, emphasizing ARGUS's edge in real-time responsiveness, predictive analytics, and decentralized communication capabilities.

Table 4: -Comparison of ARGUS with NDMA and UNDRR [1], [2], [10]

Feature	ARGUS (Proposed System)	NDMA (National Disaster Management Authority)	UNDRR (United Nations Disaster Risk Reduction)
Response Time	AI-driven system designed for rapid SOS alert processing and decision-making.	Manual coordination; time varies.	Strategic guidance only; lacks operational mechanisms.
Predictive Analytics	Uses machine learning for forecasting based on real-time and historical data.	Limited to historical trend analysis.	Focus on high-level policy; no predictive engine.
Volunteer Mobilization	Provides automated, trackable volunteer coordination features.	Primarily manual mobilization.	Promotes resilience but lacks operational volunteer systems.
Decision-Making & Resource Allocation	Intelligent dispatch with AI-based decision support.	Governed by manual protocols.	Policy-focused; not dispatch-enabled.
Data Security & Reliability	End-to-end encryption with blockchain support for data integrity.	Conventional databases; lower data redundancy and resilience.	Recommends security best practices; lacks implementation.
Disaster Impact Reduction	Real-time alerts, IoT monitoring, and automation minimize delays and casualties.	Focused on post-disaster relief.	Emphasizes awareness and mitigation; not real-time responsive.
User Accessibility & Personalization	Offers personalized alerts, maps, and interfaces for multiple users (citizens, agencies).	Limited engagement tools; mostly passive systems.	Policy-level engagement only; no direct user interface.

These findings demonstrate ARGUS's potential to enhance disaster response through predictive intelligence, real-time coordination, and improved scalability. Continued development and real-world validation will be necessary to fully establish the system's impact.

6. Discussion

Project Elysium – ARGUS was evaluated in simulated disaster scenarios to assess its feasibility and effectiveness in emergency response. The results demonstrated that the integration of AI-driven decision-making [4][5], IoT-based environmental sensing [11][15], and cloud-based coordination [7][8] significantly improved operational readiness compared to traditional systems. ARGUS addressed key challenges such as delayed responses [2], fragmented data flow, and reliance on damaged infrastructure by implementing real-time monitoring, predictive analytics, and modular data pipelines. The inclusion of AI risk analysis enabled faster identification of high-threat areas [5][14], while cloud dashboards supported centralized visualization and decision support [7]. Although features such as Bluetooth Mesh Networking [6][13] and satellite-based communication remain under development, their design integration strengthens ARGUS's potential to function in low-connectivity environments. Unlike existing AI tools that operate in isolation, ARGUS brings together prediction, coordination, and communication into a unified platform [1][4]. This integration enables real-time alert dispatch, automated volunteer coordination, and user-specific hazard awareness [12]. User interfaces were structured to address distinct needs: civilians receive localized alerts and guidance, volunteers access assignment tools, and emergency agencies monitor incidents via a centralized dashboard [10][15]. The system architecture is designed to scale through edge computing and resilient cloud services [3][8]. While ARGUS performed well in simulated conditions, real-world deployment challenges remain. These include managing inconsistent sensor input, aligning with national disaster infrastructure [2], and ensuring system security under stress [9]. To overcome these limitations, ARGUS requires further development in model robustness, multi-stakeholder integration, and cybersecurity infrastructure. Its future effectiveness depends on partnerships with government agencies, NGOs, and international bodies for policy alignment and real-world trials [1][2]. Overall, ARGUS demonstrates strong potential to serve as a next-generation disaster response platform with practical applications in diverse emergency environments.

6.1 Future Scope

The future roadmap of ARGUS includes several enhancements to improve its performance, adaptability, and global usability. Planned developments involve deeper integration of advanced deep learning techniques to improve forecasting accuracy and reduce false positives [4][14]. To enhance connectivity in infrastructure-compromised zones, future versions will incorporate Bluetooth Mesh Networking, peer-to-peer communication, and satellite-based links [6][13]. Data integrity and security will be improved through blockchain-enabled emergency data validation [9], enabling trusted collaboration across agencies. The platform is expected to support multilingual interfaces and international disaster response protocols, allowing global scalability and interoperability [1]. AI-powered chatbots will provide real-time assistance to users, while advanced alert systems will deliver personalized, context-aware safety recommendations [10][12]. Additional improvements in edge computing will allow faster local data processing [3], reducing reliance on central servers and improving performance in remote or high-risk areas. These planned upgrades will support ARGUS's evolution into a comprehensive, intelligent, and reliable system capable of adapting to emerging disaster scenarios and technological advancements.

7. Conclusion

The implementation of the ARGUS model demonstrated a promising advancement in the field of disaster management by integrating artificial intelligence, IoT, and decentralized communication technologies into a unified platform. Designed to generate real-time SOS alerts, prioritize risks through AI-driven analytics, and coordinate volunteer efforts via a centralized cloud dashboard, ARGUS showcased its potential in simulated environments. The system improved data flow, situational awareness, and emergency coordination, even under disrupted connectivity conditions, through features such as edge computing and planned offline mesh networking. Its modular and scalable architecture allowed flexible adaptation across a variety of disaster scenarios and operational landscapes. By streamlining decision-making and enabling rapid mobilization of resources, ARGUS aimed to reduce disaster severity, infrastructure damage, and response delays. Its inclusive interface design empowered stakeholders across all levels—including government agencies, NGOs, volunteers, and affected civilians—positioning ARGUS as a collaborative and community-focused solution. However, as the platform remains in its developmental phase, real-world deployment has not yet occurred. The current version relies on simulated datasets and conceptual models, with features such as blockchain security, peer-to-peer communication, and satellite integration still pending implementation. Future development will focus on enhancing offline capabilities, improving prediction accuracy through advanced AI algorithms, and aligning the system with national and international emergency protocols. In summary, ARGUS presents a forward-looking and technologically driven approach to disaster response. By uniting predictive analytics, real-time communication, and decentralized decision-making, the system offers a viable, intelligent solution for modern crisis management in disaster-prone regions.

8. Declaration

We, the authors, declare that there are no conflicts of interest related to this research. We have no financial, personal, or institutional influences that could affect the study's integrity. All affiliations and contributions have been transparently disclosed.

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