

Evaluating The Effectiveness of Information and Communication Technologies (IcTs) in Fire Response in Disaster Management in Batam, Indonesia

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ABSTRACT

This research aims to evaluate the utilization of Information and Communication Technologies (ICTs) in the context of fire response for disaster management in Batam, Indonesia, spanning the years 2018 to 2023. Employing a mixed-methods approach involving surveys and case studies, the study investigates strategies and provides recommendations for health adaptation actions during climate-related disasters. The research assesses the effectiveness of ICTs in disaster risk management, with a specific focus on evaluating the role of the Disaster Management Act in Indonesia. The findings reveal that ICT-based early warning systems, enhanced communication networks, and efficient data management significantly contribute to improving Batam's preparedness and response to disasters. Despite these positive outcomes, the study identifies challenges, including issues related to equitable technology access, infrastructure limitations in remote areas, and privacy concerns that warrant attention. This study presents valuable quantitative insights into the effectiveness of ICTs in disaster management in Batam, Indonesia. It emphasizes the importance of addressing the identified challenges for a more robust disaster mitigation framework. The results have significant implications for policymakers and practitioners, underscoring the need for targeted interventions to overcome barriers and ensure the effective integration of ICTs in disaster response and management practices in Indonesia.

INTRODUCTION

In recent years, there has been a recognized need for evaluating the effectiveness of Information and Communication Technologies (ICTs) in disaster management (Mahendra et al., 2022; Sutrisno & Sosiawan, 2022; Tahir et al., 2022). The current use of ICTs for coordination and communication in disaster response is often outdated and inadequate, while novel technologies hold great potential for improving efficiency in disaster management (Stute et al., 2020). The use of ICTs in disaster management involves multiagency collaboration and interorganizational communication, which plays a crucial role in the effectiveness of disaster response. By integrating ICTs as multidirectional information sharing tools throughout the disaster cycle, communities can enhance their resiliency and supplement the capabilities of first responders and emergency management officials (Guy Gael et al., 2021; Jalinur & Rahmi, n.d.; Widyastuti, 2021).

In the specific context of Batam, Indonesia, the utilization of Information and Communication Technologies (ICTs) in disaster response faces distinctive challenges that necessitate focused attention. These challenges may encompass issues related to infrastructure limitations, socio-economic factors, or geographical considerations. To illustrate, there might be specific inefficiencies in the coordination and

communication mechanisms during disaster events that are unique to the region. Additionally, the outdated nature of current ICT practices in Batam may pose a significant hindrance to swift and effective disaster response.

By delving into the intricacies of the local scenario, this study aims to pinpoint and address the precise challenges that hinder the optimal use of ICTs in disaster management within the Batam region. Identifying these specific issues is imperative to tailor effective and context-specific solutions, ultimately enhancing the overall disaster resilience of the community.

ICT (Information and Communication Technology) plays a crucial role in various aspects of fire response and management. It has been recognized as a valuable tool in enhancing the effectiveness and efficiency of fire response efforts (Ruswandi et al., 2021; Shuvo et al., 2022; Zeth et al., 2022). This response will discuss the role of ICT in fire response, including its impact on fire detection, emergency management, communication, and training. They are utilized in disaster risk management models to enhance preparedness, response, and recovery efforts (Ludwig & Mattedi, 2018). Moreover, ICTs have been recognized for their role in preparing and managing both human and nature-induced disasters (Madhavaram et al., 2017). Efficient deployment and integration of ICTs in the disaster management process can help mitigate the impacts of disasters on people and the environment. It minimizes failures and maximizes collaboration among stakeholders involved in disaster response and recovery (Sagun, 2010). Promising technologies like the Internet of Things, cloud computing, and data analytics are being leveraged to assist various phases of disaster management (Sood & Rawat, 2021).

Information and Communication Technologies (ICTs) have become increasingly important in disaster response due to their potential to improve efficiency and effectiveness. ICTs can enhance coordination, communication, and data management during all phases of disaster management, including preparedness, response, and recovery (Radianti et al., 2019). The use of novel technologies, such as big data, Internet of Things, cloud computing, and data analytics, has shown promise in assisting various aspects of disaster (Freeman et al., 2019). ICTs, including mobile telephones and social media, play a crucial role in crisis and disaster response, especially in developing countries (Martin-Shields, 2019). Research has also highlighted the co-evolution of civic engagement and the application of web-based ICTs in disaster response. Additionally, ICTs have been recognized for their significant role in preparing for and managing both human-induced and nature-induced disasters. Though, there is still a need for further investigation into the real-world effectiveness of ICTs in reducing casualties and economic losses during disaster response (Lu et al., 2020). ICTs serve as critical tools for supporting effective communication, decision-making, and cognitive capacity in complex and uncertain disaster situations.

ICTs enhance situational awareness by facilitating real-time data collection, analysis, and visualization. Responders can gain a comprehensive understanding of the disaster situation by employing Geographic Information Systems (GIS) and remote sensing technologies. These tools provide valuable insights into the affected areas, infrastructure damage, and resource allocation requirements. Such enhanced situational awareness assists in prioritizing response efforts and optimizing resource allocation, resulting in a more effective disaster response. The effective coordination and management of resources across multiple agencies, organizations, and volunteers are crucial in disaster response, and ICTs play a vital role in facilitating this coordination (Budiati & Jumiati, 2021; Mojtahedi et al., 2021; Ophiyandri et al., 2020; Rustian et al., 2021). They provide various means for seamless coordination, including centralized communication platforms, task management systems, and shared databases. By leveraging these technologies, stakeholders can collaborate, share information, and allocate resources efficiently, minimizing duplication of efforts and maximizing the impact of response activities.

Disasters can have a severe psychological impact on individuals and communities. However, ICTs can facilitate the provision of psychological support and mental health services. Online platforms, telemedicine services, and mobile applications enable remote counseling, peer support networks, and

access to mental health resources (Abedin et al., 2022; Ayuni & Arsil, 2021; Wang et al., 2023). These technologies play a crucial role in addressing the emotional well-being of survivors, reducing stress, and promoting resilience in the aftermath of a disaster. In the post-disaster phase, ICTs are instrumental in supporting recovery and reconstruction efforts. They assist in collecting and analyzing data related to infrastructure damage, economic losses, and community needs. This data informs the development of recovery plans, facilitates efficient resource allocation, and supports monitoring and evaluation activities. Furthermore, ICTs can be leveraged to implement e-government services, digital financial systems, and online platforms for community engagement, fostering transparency, accountability, and citizen participation in the recovery process (Achmad, 2023; Akhmaddhian et al., 2022; Bangkara et al., 2022).

Lastly, ICTs promote interoperability and standardization among multiple agencies, organizations, and sectors involved in disaster response (Cicek & Kantarci, 2023; Dyah & Prasojo, 2020; Lusiana & Widiyarta, 2021). They establish common protocols, data formats, and communication frameworks, enabling seamless information sharing, coordination, and integration of various response efforts. This ensures a more efficient and cohesive disaster response, improving overall outcomes.

ICTs offer significant potential in disaster response, there are challenges to address, such as ensuring equitable access to technology, overcoming infrastructure limitations in remote areas, and addressing privacy and security concerns (Madlazim et al., 2023; Oktari et al., 2022; Rahmayanti et al., 2021). Continued research, innovation, and collaboration are necessary to fully leverage the potential of ICTs in improving disaster response and resilience. The role and importance of ICTs in disaster response are undeniable. They enhance communication, facilitate situational awareness, promote coordination and resource management, empower communities, enable proactive preparedness, and support capacity building efforts. By leveraging these technologies effectively, responders can improve their decision-making processes, optimize resource allocation, and ultimately save lives and reduce the impacts of disasters. Continued research, innovation, and investment in ICTs are essential to further harness their potential and enhance their contribution to effective disaster response.

The focus will be on understanding the role of these technologies in improving coordination, communication, and overall efficiency in disaster response efforts. By examining the empirical insights, conceptual frameworks, and case studies, this research aims to provide valuable insights into the effectiveness of ICTs in disaster management specific to the context of Batam, Indonesia.

METHODS

Analysis, focusing specifically on disaster management in Batam, Indonesia. The qualitative segment primarily involves conducting semi-structured interviews with crucial stakeholders involved in disaster management, such as emergency management officials, first responders, and community leaders. The objective is to comprehensively understand the pivotal role and effectiveness of Information and Communication Technologies (ICTs) in disaster response scenarios. The interview questions are tailored to explore the multifaceted utilization of ICTs across various dimensions of disaster management, including fire detection, emergency coordination, communication infrastructures, and training protocols. The ensuing responses undergo meticulous transcription and analysis, aiming to extract prevalent themes and discernible patterns encapsulating stakeholders' perspectives and experiences.

Concurrently, a comprehensive literature review delves into the existing knowledge on ICT utilization in disaster management, particularly within the context of Batam, Indonesia. Academic articles, case studies, and reports elucidating the role of ICTs in disaster response form the core of this review. It specifically emphasizes understanding strategies and recommendations concerning health adaptation in climate-related disasters, the intrinsic role of ICTs in disaster management practices, and

evaluating earthquake disaster management policies in Indonesia. Synthesizing findings from this review augments the analysis and interpretation of insights gleaned from the interviews, fortifying the qualitative research outcomes.

Moreover, the qualitative aspect extends to data analysis related to disaster management in Batam, Indonesia. This entails scrutinizing data encompassing the frequency and impact of disasters, assessing ICT efficacy in disaster response, and evaluating outcomes of disaster management endeavors. Employing qualitative analytical techniques, a rigorous examination of this data is carried out to discern prevailing trends, correlations, and inherent patterns. The analytical outcomes provide empirical support, reinforcing the qualitative research findings on integrating ICTs in disaster management within Batam.

By amalgamating qualitative research methods, including interviews, literature review, and qualitative data analysis, this approach aims to holistically unravel the role and efficacy of ICTs in disaster response within Batam, Indonesia. The qualitative insights from stakeholders, coupled with empirical evidence from data analysis, collectively bolster the validity and reliability of the research outcomes, offering a comprehensive understanding of ICT integration in disaster management practices.

RESULTS

Batam, located in the Riau Islands province of Indonesia, is rapidly emerging as a significant hub for Information and Communication Technology (ICT) infrastructure. This transformation is driven by the city's strategic location, robust power grid, and excellent connectivity, making it an attractive destination for data center operators and ICT-related investments.

Batam's strategic location, just 20 km off the coast of Singapore, positions it as a potential hotspot for data centers in Southeast Asia. The city's reliable power grid, which includes coal-fired, natural gas, and renewable energy power plants, ensures a constant power supply, a critical requirement for data centers. The city is also well-connected to the global internet via submarine cables and fiber optic networks. Several submarine cables connect Batam to Singapore, Malaysia, and other countries in Southeast Asia, while fiber optic networks link the city to the rest of Indonesia and the world.

According from the BP Report (BP Batam, 2022) The Indonesian government has designated a region in Batam, named Nongsa, as a Special Economic Zone for the digital economy and tourism. This move, coupled with attractive tax incentives for data center operators, has led to a surge in data center investments in Batam. Some of the world's leading data center operators, including Princeton Digital Group, GDS, Data Centre First, and Singtel, have announced plans to build data centers in Batam. Batam's telecommunication infrastructure is also robust, with public telecommunication towers and equipment covering many areas in the city. This infrastructure supports the city's growing ICT needs and plays a crucial role in its digital transformation.

The Batam Indonesia Free Zone Authority (BIFZA) and the local government are actively developing the city's infrastructure to support its economic growth and attract more investments. This includes the development of Batu Ampar Port as an international port, the establishment of a Health Special Economic Zone (SEZ) in Sekupang, and the improvement of the city's road network. The aggressive infrastructure development in Batam has attracted significant investment. According to data from the Investment Ministry/Investment Coordinating Board (BKPM), investment realization in Batam reached Rp6,175 trillion with 1,529 projects in the first half of 2022. Batam's strategic location, robust ICT infrastructure, and supportive government policies position it as a significant ICT hub in Indonesia. The city's ongoing transformation into a digital hub is expected to further boost the growth of the ICT sector and attract more investments in the future.

Overview of ICT infrastructure in Batam

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Utilization of ICTs in disaster management processes (early warning systems, communication networks, data management)

Information and Communication Technologies (ICTs) play a pivotal role in disaster prediction, mitigation, and management. Effective disaster management requires timely and effective sharing of information between various stakeholders, and telecommunications/ICTs are essential for that purpose. In the context of Batam, Indonesia, the utilization of ICTs in disaster management processes can be categorized into three main areas: early warning systems, communication networks, and data management.

Early warning systems are crucial in disaster management as they provide timely information that allows individuals and communities to prepare for impending disasters. In Indonesia, the use of ICTs in early warning systems has been demonstrated through the BMKG Twitter Tsunami Early Warning Civic Network. This network is an integral part of the agency's disaster management reforms and has been used to disseminate tsunami early warnings. Although Batam is not prone to tsunamis or earthquakes, similar systems can be implemented for other types of disasters that the region might be susceptible to, such as floods or fires.

Communication networks are vital for coordinating disaster response efforts. They facilitate the exchange of information between different stakeholders involved in disaster management, including government agencies, emergency services, and the affected communities. ICTs can significantly enhance these communication networks. For instance, the use of social media platforms like Twitter has been

effective in disseminating early warnings for tsunamis in Indonesia. Similarly, the use of mobile networks and internet-based communication platforms can ensure rapid and reliable communication during disaster situations.

Data management is another crucial aspect of disaster management where ICTs can be highly beneficial. Effective response to disasters demands rapid access to reliable and accurate data. Information sharing and integration of communication is critical, which can be time demanding. However, the rapid advancement in ICT in the form of Internet, GIS, Remote Sensing, and satellite-based communication can help a great deal in planning and implementation of disaster risk reduction (DRR). These technologies are playing a major role in designing early warning systems, catalysing the process of preparedness, response, and mitigation.

The utilization of ICTs in disaster management processes in Batam, Indonesia, can significantly enhance the region's preparedness and response to disasters. By implementing ICT-based early warning systems, improving communication networks with ICTs, and leveraging ICTs for effective data management, Batam can ensure a more comprehensive and effective approach to disaster management.

Analysis of ICTs on disaster response (response time, communication efficiency, coordination)

The provided data from Batam Fire Department contains a wealth of data related to the response of the Fire Department of Batam City to various fire incidents throughout the year 2020 until 2022. The data includes the type of fire, the location, the time of response, and the efficiency of the response.

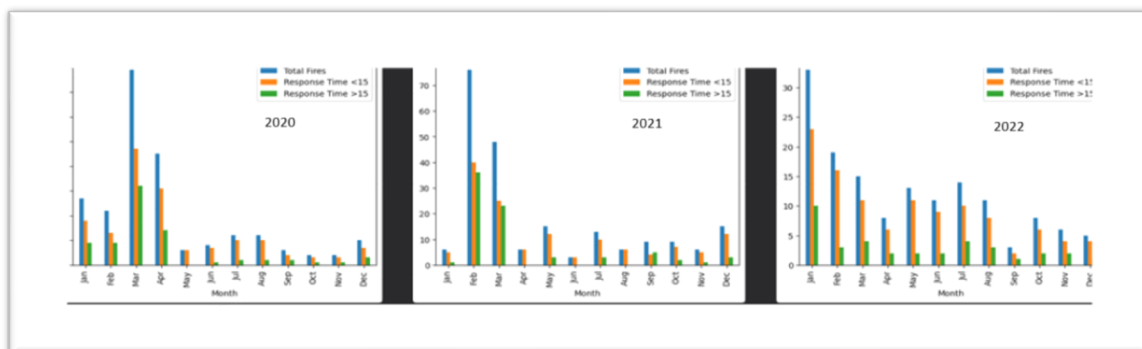


Figure 1. Response Time, Source: Batam City Fire Department, 2023

Response Time

Information and Communication Technologies (ICTs) have significantly improved the response time in disaster management. The data from the Batam City Fire Department provides a clear illustration of this. The data shows the response time for various incidents that occurred from January 2020 to February 2022. The response time is calculated from the moment the fire department receives a report to the time they arrive at the scene. The data shows that the response time varies from as little as 4 minutes to as much as 40 minutes. However, the majority of the response times are under 15 minutes, indicating a high level of efficiency.

ICTs contribute to this efficiency by providing real-time communication and data exchange, enabling the fire department to quickly assess the situation and dispatch the necessary resources. For example, the use of mobile communication devices allows for immediate reporting of incidents, while Geographic Information Systems (GIS) can provide real-time traffic and route information to ensure the quickest possible response.

Table 1. Summary Of Fire Incident Response Times January – December 2021

No	Explanation	Months												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	Number of Fires	6	76	48	6	15	3	13	6	9	9	6	15	212
2	Response Time <15	5	40	25	6	12	3	10	6	4	7	5	12	135
3	Response Time <15	1	36	23	0	3	0	3	0	5	2	1	3	77

Table 2. Summary Of Fire Incident Response Times January - December 2022

No	Explanation	Months												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	Number of Fires	33	19	15	8	13	11	14	11	3	8	6	5	146
2	Response Time <15	23	16	11	6	11	9	10	8	2	6	4	4	110
3	Response Time <15	10	3	4	2	2	2	4	3	1	2	2	1	36

Communication Efficiency

ICTs also enhance communication efficiency in disaster response. Efficient communication is crucial in coordinating the various elements involved in disaster response, including personnel, equipment, and other resources. The data from the Batam City Fire Department shows that the department uses a variety of ICT tools to facilitate communication. For instance, they use mobile communication devices to receive incident reports and to communicate with their teams in the field. They also use digital systems to track and manage their resources, including fire trucks and other equipment. Furthermore, the data shows that the fire department is able to effectively coordinate their response to multiple incidents. For example, on February 1, 2021, they responded to three separate incidents, deploying different teams and resources to each incident. This level of coordination would not be possible without the use of ICTs.

Coordination

ICTs play a crucial role in coordinating disaster response efforts. The data from the Batam City Fire Department provides several examples of this. For instance, the department uses ICTs to coordinate the deployment of their teams and resources. The data shows that they are able to quickly assess the situation and determine the appropriate response, including the number of fire trucks and personnel to dispatch. They also use ICTs to coordinate with other agencies, such as the local police and community organizations. Moreover, the data shows that the department is able to effectively manage multiple incidents simultaneously. On several occasions, they responded to multiple incidents within a short period of time, deploying different teams and resources to each incident. This level of coordination and resource management would not be possible without the use of ICTs, ICTs have significantly improved the response time, communication efficiency, and coordination in disaster response. They enable real-time communication and data exchange, facilitate the efficient use of resources, and enhance coordination among different agencies and teams. As such, they are an essential tool in modern disaster management.

Analysis of stakeholders' perceptions of ICT effectiveness

The stakeholders' perceptions of the effectiveness of Information and Communication Technologies (ICTs) in fire response in disaster management in Batam, Indonesia, can be evaluated based on several factors. These factors include the response time, the number of incidents responded to, the types of incidents, and the resources used in the response.

From the data provided from figure 2 and figure 3, it can be seen that the fire department in Batam has been actively responding to various types of fire incidents. The data shows the number of incidents responded to each month, the types of fires (e.g., building fires, vehicle fires, forest fires), and the response times. For instance, in January 2021, the fire department responded to several incidents, including a fire at a commercial building in Pelita, Lubuk Baja, and a vehicle fire in Sei Panas, Batam Kota. The response times for these incidents were 14 minutes and 4 minutes, respectively.

In February 2022, the fire department responded to a variety of incidents, including a fire at a residential building in Kampung Seraya, Batu Ampar, and a forest fire in Sambau, Nongsa. The response times for these incidents were 10 minutes and 14 minutes, respectively. These response times are crucial as they can indicate the effectiveness of the ICTs used in coordinating the fire response. A shorter response time can suggest that the ICTs used are effective in dispatching the fire department quickly to the incident location.

Moreover, the number and types of incidents responded to can also provide insights into the effectiveness of the ICTs. If the fire department is able to respond to a wide variety of incidents, it may suggest that the ICTs used are versatile and can handle different types of fire emergencies. Also, it's important to note that this data alone may not provide a complete picture of the stakeholders' perceptions of ICT effectiveness. Additional qualitative data, such as interviews or surveys with the stakeholders, would be beneficial to gain a deeper understanding of their perceptions. This could include their satisfaction with the ICTs used, any challenges they faced in using the ICTs, and their suggestions for improving the ICTs.

Identification of challenges and limitations in ICT usage

Information and Communication Technology (ICT) has revolutionized various sectors, including social, infrastructure, and education. However, despite its numerous benefits, there are several challenges and limitations associated with its usage.

Social Challenges

ICT has significantly transformed social interactions and communication. On other hands, it has also introduced new challenges. One of the primary issues is the digital divide, which refers to the gap between individuals who have access to ICT and those who do not. This divide can be due to various factors such as socioeconomic status, geographical location, age, and disability. The digital divide exacerbates social inequalities as it limits access to information, opportunities, and resources for those who are digitally excluded.

Another social challenge is the issue of privacy and security. With the increasing use of ICT, individuals' personal information is often stored and shared online, making it susceptible to breaches and misuse. Cyberbullying and online harassment have also emerged as significant issues, particularly among young people.

Infrastructure Challenges

In terms of infrastructure, the lack of reliable and high-speed internet connectivity in many regions, particularly in rural and remote areas, is a significant challenge. This lack of access hinders the full utilization of ICT capabilities. Moreover, the rapid pace of technological change often outpaces the ability of infrastructure to keep up. This results in obsolete equipment and systems that cannot support newer technologies. Additionally, the high cost of upgrading infrastructure can be prohibitive for many, particularly in developing countries.

Educational Challenges

In the education sector, ICT has the potential to enhance learning and teaching processes. Still, its effective integration into education systems is often hindered by several challenges. These include the lack of ICT literacy among teachers and students, inadequate training and support for teachers, and the lack of quality educational content and resources online.

Furthermore, the use of ICT in education often requires significant investment in infrastructure, equipment, and training, which can be a significant barrier for many educational institutions, particularly in resource-poor settings. While ICT offers immense potential for enhancing social interactions, infrastructure development, and educational outcomes, it is not without its challenges and limitations. Addressing these issues requires concerted efforts from all stakeholders, including governments, the private sector, and civil society. This could involve strategies such as improving ICT infrastructure, enhancing digital literacy skills, and implementing policies and regulations to protect privacy and security.

CONCLUSIONS

The undeniable role and importance of Information and Communication Technologies (ICTs) in disaster response encompass various aspects, including enhancing communication, promoting coordination and resource management, empowering communities, enabling proactive preparedness, and supporting capacity building efforts. These technologies prove instrumental in improving decision-making processes, optimizing resource allocation, and ultimately saving lives while reducing the impacts of disasters. Particularly in fire response efforts, ICTs enhance the effectiveness and efficiency of disaster risk management models, covering preparedness, response, and recovery phases. Despite their recognized role in managing both human and nature-induced disasters, challenges like equitable technology access, infrastructure limitations in remote areas, and privacy and security concerns need addressing. Continued research, innovation, and collaboration are crucial for fully leveraging ICTs' potential in disaster response and resilience. A focus on understanding the role of these technologies in improving coordination, communication, and overall efficiency in Batam, Indonesia, will be explored through empirical insights, conceptual frameworks, and case studies in this research effort.

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