INCODING: Journal of Informatic and Computer Science Engineering

https://journal.mahesacenter.org/index.php/incoding/index || ISSN 2776-432X (Online)

6(1) 2026: 70-82

DOI: https://doi.org/10.34007/incoding.v6i1.948



Information and Communication Technology Management for Supporting Integrated Natural Disaster Operations in Regional BPBD Institutions

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Submited: 2025-07-11; Reviewed: 2026-03-11; Accepted: 2026-05-06

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Abstract

This study examines the management of Information and Communication Technology (ICT) in supporting natural disaster management operations. The study uses a descriptive qualitative approach by analyzing disaster management concepts, ICT management, BPBD institutional roles, and relevant literature. The findings show that ICT management needs to be integrated into the organizational structure of the Regional Disaster Management Agency (BPBD) to strengthen coordination, information accuracy, and emergency response effectiveness. ICT infrastructure such as radio communication, early warning systems, GIS, databases, servers, and emergency communication networks must be supported by competent human resources. The reliability of this model depends on the integration of technological assets, trained personnel, and institutional relationships. During safe periods, ICT supports preparedness, monitoring, and data management. During disasters, ICT strengthens warning distribution, evacuation coordination, and operational communication. After disasters, ICT supports damage assessment, aid distribution, and recovery planning. Therefore, ICT should be positioned as a strategic element of disaster governance rather than merely technical support.

Keywords: ICT Management; BPBD; Disaster Management; Early Warning System; Disaster Communication.

How To Cite: Ash-shidiqqi, E. A. (2026). Information and Communication Technology Management for Supporting Integrated Natural Disaster Operations in Regional BPBD Institutions. *INCODING: Journal of Informatic and Computer Science Engineering, 6(1) 2026: 70-82*

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INTRODUCTION

Natural disasters are complex events that may occur as a result of natural processes, human activities, or the interaction between both. Earthquakes, floods, landslides, volcanic eruptions, tsunamis, and fires are not only physical phenomena, but also social and administrative challenges because they affect human life, public infrastructure, economic activities, and the continuity of government services. In disaster-prone countries, disaster management cannot be understood merely as an emergency response after a hazard occurs. It must be treated as a continuous governance process involving risk reduction, preparedness, rapid response, recovery, and institutional coordination. This is particularly relevant for Indonesia, which is geographically and geologically located in an area highly exposed to various natural hazards [1], [2].

Indonesia's vulnerability to disasters is influenced by its position along active tectonic plates, volcanic zones, and hydrometeorological risk areas. Floods, landslides, earthquakes, volcanic eruptions, and tsunamis have repeatedly affected different regions and caused material losses, social disruption, and casualties. The previous manuscript notes that floods represent one of the most frequent disasters in Indonesia, followed by landslides, earthquakes, and tsunamis. It also emphasizes that Indonesia is among the countries with high flood risk. This condition shows that disaster management requires more than conventional administrative procedures. It requires a reliable system capable of producing accurate information, maintaining communication, supporting rapid decision-making, and coordinating multiple actors under emergency conditions [3]–[5].

Information and Communication Technology (ICT) has become an essential instrument in disaster management operations. ICT supports the collection, processing, distribution, storage, and visualization of disaster-related information. Through ICT, government institutions can conduct disaster risk mapping, operate early warning systems, manage databases, distribute emergency information, coordinate evacuation, and support logistics management. In the context of disaster response, information accuracy and communication speed are critical because delayed or inaccurate information may increase panic, weaken coordination, and reduce the effectiveness of rescue operations. Therefore, ICT must not be viewed only as a set of technical devices, but as a strategic component of disaster governance [6], [7].

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Several disaster experiences in Indonesia have shown that communication failure can worsen disaster impacts. During major disasters such as the Aceh tsunami in 2004, the Yogyakarta earthquake in 2006, and the West Sumatra earthquake in 2009, public communication services were disrupted, while official information was often delayed or difficult to access [8], [9]. When public communication infrastructure collapses, affected communities may rely on rumors, fragmented information, or individual initiatives. This situation can produce confusion and secondary panic. The Yogyakarta earthquake experience, for example, showed how the absence of immediate official information created uncertainty and fear regarding a possible tsunami threat. These cases demonstrate that disaster management requires communication systems that remain functional even when ordinary public infrastructure is damaged [10], [11].

Previous studies have discussed disaster management from different perspectives. Toha explains disaster management as a set of strategies and adaptations to reduce disaster risk, emphasizing the importance of preparedness and institutional response [12]. Purnomo and Sugiantoro discuss disaster management as a process that includes mitigation, preparedness, emergency response, and recovery, showing that disaster governance must be organized before, during, and after disasters [13]. Sudaryono highlights the role of schools in disaster mitigation learning, indicating that disaster preparedness also depends on public education and community capacity [14]. Haifani, through the case of the Yogyakarta earthquake, discusses earthquake disaster risk management and shows the importance of organized institutional response in reducing disaster impacts [15]. Meanwhile, Schipper and Pelling argue that disaster risk reduction should be integrated with climate change adaptation and development planning, meaning that disaster management must be embedded in broader governance and development systems [16].

Although these studies are relevant, they tend to emphasize disaster preparedness, institutional response, community education, and risk reduction in general. They have not sufficiently explained how ICT should be institutionally managed within regional disaster management agencies, particularly in relation to operational coordination, technological reliability, human resource readiness, and information flow during disaster conditions. In many cases, ICT is discussed as a supporting tool, but not as a management system that requires organizational structure, clear division of tasks, maintenance mechanisms,

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trained personnel, and integration with disaster operations. This creates an important research gap. Disaster management studies need to move beyond the question of whether technology is useful, and begin to examine how technology should be managed, who should control it, and how it should be integrated into institutional disaster response mechanisms.

The problem becomes more significant because disaster management involves many actors, including local governments, BPBD, technical agencies, security institutions, volunteers, communities, and non-governmental organizations. Each actor may have different data, communication devices, reporting mechanisms, and operational procedures. Without integrated ICT management, coordination may become inefficient, information may be duplicated, and decision-making may be delayed. This problem shows that the availability of technology alone is not sufficient. What is required is a management model that connects technological assets, human resources, and institutional relationships into one reliable disaster operation system.

The Regional Disaster Management Agency, or Badan Penanggulangan Bencana Daerah (BPBD), has a strategic position in this context. BPBD is responsible for coordinating disaster management at the regional level, including mitigation, preparedness, emergency response, and post-disaster recovery. Because BPBD functions as the main regional coordinator, ICT management should be integrated into its organizational structure. An ICT unit or Technology Affairs Section within BPBD can support administrative operations and field operations. Administrative operations include data management, reporting systems, documentation, internal communication, and coordination among agencies. Field operations include early warning systems, radio communication, mapping, evacuation support, emergency communication, and real-time information distribution.

This study focuses on the management of Information and Communication Technology in supporting natural disaster management operations, particularly through the integration of ICT into the BPBD organizational structure. The focus is not merely on the use of ICT devices, but on the development of an institutional model that enables ICT to function reliably before, during, and after disasters. The model emphasizes three important elements: technological assets, human resource capacity, and institutional relationships. These elements are important because ICT reliability depends not only on

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hardware and software, but also on trained operators, clear authority, coordination procedures, and sustainable maintenance.

Based on this focus, the purpose of this study is to analyze the role of ICT management in supporting natural disaster management operations and to formulate an integrated ICT management model within BPBD. This study aims to show that disaster communication and information systems can be more reliable when ICT is managed as part of the institutional structure of disaster management. Through this model, BPBD is expected to improve disaster preparedness, strengthen emergency response, reduce coordination failures, and support post-disaster recovery through accurate information, effective communication, and sustainable technological management.

RESEARCH METHODOLOGY

This study uses a descriptive qualitative approach to examine the management of Information and Communication Technology (ICT) in supporting natural disaster management operations. The qualitative approach is used because the study focuses on understanding institutional models, coordination patterns, technological support, and the role of human resources in disaster management. The object of this study is the ICT management model within the Regional Disaster Management Agency or Badan Penanggulangan Bencana Daerah (BPBD), particularly in relation to administrative operations and field operations before, during, and after disasters.

Data in this study are obtained through document analysis and review of relevant literature related to disaster management, ICT management, early warning systems, and regional disaster governance. The documents analyzed include regulations on disaster management, institutional descriptions of BPBD, previous studies on disaster risk reduction, and references related to management information systems. These sources are used to identify how ICT can support disaster mitigation, preparedness, emergency response, and post-disaster recovery.

The analysis is conducted by examining three main aspects of ICT management: technological assets, human resources, and institutional relationships. Technological assets include communication networks, radio systems, databases, early warning systems, GIS/maps, servers, and other supporting equipment. Human resources refer to operators, disaster volunteers, ICT staff, early warning system personnel, and emergency response

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teams. Institutional relationships refer to coordination between BPBD, local government agencies, SAR, TNI/POLRI, volunteers, communities, and other related stakeholders.

The data are analyzed descriptively by comparing the needs of disaster management operations with the ICT management model proposed in the BPBD structure. The analysis aims to explain how ICT can be integrated into disaster management institutions and how this integration can improve information accuracy, communication reliability, coordination effectiveness, and operational readiness. Through this method, the study formulates an ICT management model that can support disaster operations during safe periods, emergency situations, and post-disaster recovery.

RESULTS AND DISCUSSION

1. Integration of ICT Management within BPBD Institutions

The management of Information and Communication Technology (ICT) in disaster operations requires a clear institutional position because disaster response involves rapid coordination, accurate information flow, and direct operational control. In the context of regional disaster governance, the Regional Disaster Management Agency or Badan Penanggulangan Bencana Daerah (BPBD) has a strategic role as the main coordinating institution responsible for disaster mitigation, preparedness, emergency response, and post-disaster recovery. Therefore, ICT management should not be separated from the BPBD structure, because disaster-related information and communication systems must be directly connected to the institution that controls disaster operations.

The findings of this study indicate that the integration of ICT management into BPBD institutions can strengthen the effectiveness of disaster management operations. The establishment of a Technology Affairs Section within BPBD becomes important because ICT functions are not limited to technical support, but also include administrative coordination, information processing, reporting, early warning distribution, and field communication. In this model, ICT management is divided into two operational orientations: administrative operations and field operations. Administrative operations support internal management, documentation, database management, report preparation, and coordination among government agencies. Meanwhile, field operations support early warning systems, radio communication, evacuation coordination, disaster mapping, and emergency information distribution.

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This institutional integration is relevant because disaster management often involves multiple actors, such as local governments, technical agencies, SAR teams, TNI/POLRI, volunteers, non-governmental organizations, and affected communities. Without a centralized ICT management structure, communication may become fragmented and information may be distributed through different channels without clear verification. This condition can create delays, duplication of data, and different interpretations during emergency response. By placing ICT management within BPBD, the flow of disaster information can be coordinated through one institutional center, making communication more accountable and operational decisions more effective.

The integration of ICT into BPBD also supports the implementation of disaster management regulations. The original manuscript refers to Law Number 24 of 2007 concerning Disaster Management and regional government responsibilities in reducing disaster risk. This means that disaster management is not only a technical activity, but also a legal and institutional obligation of local governments. BPBD, as a regional disaster management institution, requires ICT support to carry out this obligation effectively. ICT helps BPBD manage disaster data, distribute warnings, coordinate stakeholders, and monitor disaster-prone areas.

In this model, the Technology Affairs Section has several core functions. First, it prepares ICT work plans to support disaster management activities. Second, it formulates technical policies regarding the use of ICT in disaster mitigation and emergency response. Third, it coordinates the use of ICT equipment and systems during disaster operations. Fourth, it evaluates and reports the implementation of ICT-based disaster support. These functions show that ICT management is not merely about providing devices, but about organizing technology as part of disaster governance.

The institutional placement of ICT within BPBD also improves command and coordination during emergencies. When disasters occur, BPBD acts as the center of evacuation and emergency response operations. If ICT management is located inside BPBD, information triggers, emergency reports, and data distribution can be managed from the same operational center. This arrangement reduces the possibility of conflicting information and strengthens the reliability of official communication. It also allows BPBD to coordinate more directly with other institutions and communities involved in disaster response.

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Thus, the integration of ICT management within BPBD institutions provides an important foundation for reliable disaster operations. This model ensures that technology, information, human resources, and institutional authority are connected in one management structure. The effectiveness of disaster response depends not only on the availability of communication tools, but also on the clarity of institutional responsibility in managing those tools. Therefore, ICT integration within BPBD can be understood as a strategic effort to strengthen regional disaster governance before, during, and after disasters.

2. ICT Infrastructure and Human Resource Readiness in Disaster Management

ICT infrastructure is one of the main elements that determines the effectiveness of disaster management operations. Disaster response requires communication systems that remain functional even when public infrastructure is damaged. The findings show that BPBD needs various technological assets, including telephone networks, satellite phones, VoIP, GSM, fax networks, internet connection, radio communication, Handy Talky, GIS, databases, early warning systems, SMS gateway, backup servers, CCTV, GPS, and supporting computer equipment. These technologies are needed to support information collection, disaster monitoring, warning distribution, field coordination, and emergency decision-making.

The use of radio communication has a particularly important role because it can continue to function when ordinary communication infrastructure is disrupted. During major disasters, cellular networks and internet access may become unstable or completely unavailable. In this situation, radio communication, including UHF, VHF, HF radio, rig/base station, and dual-band Handy Talky, becomes an alternative communication channel for coordination between BPBD, field officers, volunteers, and related agencies. This confirms that disaster communication systems must be designed with redundancy, meaning that BPBD should not depend on only one communication technology.

In addition to communication devices, ICT infrastructure also includes data and mapping systems. GIS, disaster risk maps, hazard maps, geomedical maps, and regional capability databases are important for identifying vulnerable areas, determining evacuation routes, and supporting logistical planning. Early warning systems also require reliable hardware and software, such as earthquake monitoring systems, ocean wave and

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weather monitoring systems, accelerometers, coastal CCTV, and disaster analysis systems. These instruments allow BPBD to monitor potential hazards and distribute warnings more quickly to communities in disaster-prone areas.

However, technological infrastructure alone is not sufficient. The reliability of ICT in disaster management also depends on human resource readiness. BPBD requires personnel who are able to operate, maintain, and interpret ICT systems. These human resources include early warning system operators, network analysts, database managers, logistics managers, rapid response teams, and disaster volunteers. The original manuscript also mentions the involvement of several volunteer and community-based organizations such as TAGANA, PMI, ORARI, RAPI, Menwa, and Scouts in supporting disaster communication and response activities.

Human resource readiness must be developed through regular training and capacity building. ICT-based disaster management requires personnel who understand both disaster operations and technological procedures. For example, an early warning system operator must not only operate equipment, but also understand warning protocols, information verification, and communication procedures. Similarly, a database manager must be able to process disaster data accurately so that it can support decision-making. Without trained personnel, sophisticated ICT equipment may not function optimally during emergencies.

Therefore, BPBD needs to organize routine training involving internal staff, technical agencies, volunteers, and related institutions. Training should include the use of radio communication, emergency reporting procedures, GIS-based disaster mapping, early warning system operation, database management, and coordination simulation. Such training strengthens operational readiness during safe periods, so that when disasters occur, personnel already understand their roles and communication channels. The original article emphasizes that training can be conducted in cooperation with institutions such as BASARNAS, BNPB, provincial BPBD, TNI, and POLRI.

The combination of adequate ICT infrastructure and prepared human resources forms the operational foundation of disaster management. Technology provides the tools, while human resources ensure that those tools are used correctly, quickly, and responsibly. In disaster situations, the failure of either element can weaken response effectiveness. Advanced equipment without competent operators will not produce reliable

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information. On the other hand, competent personnel without proper technological support will face limitations in communication, monitoring, and coordination. Therefore, ICT infrastructure and human resource readiness must be developed together as an integrated part of BPBD disaster management operations.

3. Reliability of the ICT Management Model in Disaster Operations

The reliability of the ICT management model can be seen from its ability to support disaster management operations during safe periods, emergency situations, and post-disaster recovery. In a safe period, ICT management functions to prepare disaster data, maintain communication infrastructure, update hazard maps, train personnel, and ensure that early warning systems are ready to operate. This stage is important because disaster response cannot be prepared only after a disaster occurs. The readiness of technology, information systems, and human resources must be built before an emergency situation emerges.

During disaster events, the ICT management model becomes more critical because BPBD must distribute accurate information, coordinate evacuation, manage emergency reports, and connect field officers with decision-makers. When ICT is integrated into the BPBD structure, information can be processed and distributed through one official operational center. This reduces the risk of contradictory information, delayed instructions, and unverified reports. In disaster conditions, communication reliability is not only a technical matter, but also a matter of public safety because inaccurate information may cause panic and ineffective evacuation.

The model also strengthens coordination among institutions involved in disaster response. BPBD does not work alone; it must coordinate with local government agencies, SAR, TNI/POLRI, health services, volunteers, community organizations, and other stakeholders. ICT integration allows these actors to exchange data, receive instructions, report field conditions, and coordinate logistical needs more effectively. The original manuscript emphasizes that BPBD becomes the focal point for evacuation and emergency response operations, while the ICT field supports the distribution of information and data in a more secure and accurate manner.

Reliability is also shown through the model's ability to maintain communication when ordinary public infrastructure is disrupted. Natural disasters often damage

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electricity, cellular networks, roads, and public communication systems. Therefore, BPBD requires alternative and backup communication channels, such as radio communication, satellite phones, VoIP, GSM, internet-radio integration, and other emergency communication devices. The existence of multiple communication channels makes the disaster management system more resilient because operational coordination can continue even when one communication system fails.

In post-disaster recovery, ICT supports damage assessment, aid distribution, data documentation, and recovery planning. BPBD can use databases, GIS, maps, reports, and communication systems to identify affected areas, calculate losses, prioritize assistance, and monitor rehabilitation activities. This shows that ICT management is not only relevant during emergency response, but also during the normalization phase after a disaster. Accurate data and well-managed communication help ensure that recovery programs are based on actual field conditions rather than assumptions.

The reliability of this model depends on three interconnected elements: technology, human resources, and institutional relationships. Technology provides the infrastructure for communication and data processing. Human resources ensure that the technology can be operated, maintained, and interpreted correctly. Institutional relationships ensure that information can move across agencies and communities through clear coordination channels. If one of these elements is weak, the overall disaster management operation may become ineffective. Therefore, the ICT management model within BPBD must be developed as an integrated system, not as a collection of separate devices or isolated technical functions.

Overall, the ICT management model integrated into BPBD can improve the effectiveness of disaster operations because it provides a clearer structure for information management, communication coordination, and emergency decision-making. The model enables BPBD to prepare before disasters, respond during emergencies, and support recovery after disasters. This confirms that ICT should be positioned as a strategic component of disaster management governance. Its reliability is determined not only by the sophistication of technological equipment, but also by the strength of institutional coordination and the readiness of human resources involved in disaster operations.

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CONCLUSION

The integration of ICT management within BPBD institutions is necessary to strengthen disaster management operations. BPBD requires a clear ICT structure because disaster response depends on accurate information, reliable communication, and coordinated decision-making. By placing ICT management inside BPBD, disaster-related data, warning systems, reports, and communication channels can be managed through one institutional center.

ICT infrastructure and human resource readiness are essential components of this model. Communication tools, early warning systems, GIS, databases, servers, and radio networks must be supported by trained personnel who understand both technological procedures and disaster operations. Without competent human resources, technological equipment cannot function effectively during emergencies.

The ICT management model integrated into BPBD is reliable because it supports disaster operations before, during, and after disasters. In safe periods, ICT supports preparedness and monitoring. During disasters, it strengthens emergency communication and evacuation coordination. After disasters, it supports data collection, recovery planning, and aid distribution. Therefore, ICT should be positioned as a strategic element of regional disaster governance, not merely as technical support.

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