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"A Framework for a Mobile-Enabled Earthquake Early Warning System (EEWS) for Notre Dame of University"

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Abstract
This study developed a proposed Mobile-Enabled Earthquake Early Warning System (EEWS) framework for Notre Dame of Dadiangas University to strengthen campus earthquake preparedness, awareness, and readiness. Further, the study, recognizing that even short warning windows can reduce injuries and improve response coordination, the study aimed to assess the institutional practices and perceptions related to earthquake impacts and drills, and design a layered, feedback-driven EEWS framework that connects official seismic sources to rapid mobile alerts and measurable response actions. A descriptive correlation approach was used, utilizing multiple instruments such as a structured survey questionnaire to gather baseline information on earthquake drill frequency and perceived earthquake impact indicators. A total of 100 respondents participated across the departments of the university. The results show that earthquake drills are usually done. Most of the respondents who answered said they were done once a year or twice a year, while twelve (12) said they were done more than twice a year, and one (1) said they weren't done at all. The survey revealed that the magnitude of the earthquake had the biggest impact followed by other impacts of the earthquake and injuries caused by the earthquake Potential loss of life or death and physical or structural damage were rated as moderate. Based on these results and how EEWS is currently used, the study suggested a five-layer framework: (1) a detection layer that uses external seismic data providers like PHIVOLCS and the Japan Meteorological Agency; (2) a data processing layer with an event-processing and decision engine supported by a database and analytics module; (3) an alert dissemination layer that sends push and SMS notifications to mobile phones; (4) a response layer that combines campus protocols and user actions through the NDDU mobile EEWS app; and (5) a monitoring and evaluation layer that collects metrics and user feedback to keep the system tuned and better. Overall, the study gives a useful, campus-specific EEWS framework that connects detection to decision to action and makes sure that it is always getting better through tracking and user feedback. This helps universities be safer and more coordinated when they prepare for and respond to earthquakes.

Keywords:
Earthquake, Early Warning System, EEWS, Mobile Framework

1. Introduction

The Problem and Its Setting

Earthquakes are among the most devastating natural disasters, affecting communities worldwide. Countries such as Japan, the United States, and Mexico have developed advanced Earthquake Early Warning Systems (EEWS) to mitigate seismic risks (Chung et al., 2021). These systems leverage real-time seismic data and automated alerts to provide critical warnings before strong shaking occurs, enabling swift responses that can save lives and minimize damage (Minson et al., 2022). The integration of AI-driven seismic monitoring and cloud-based alert systems has further enhanced the reliability of EEWS, reducing false alarms and improving overall preparedness (Allen & Melgar, 2019). However, despite technological advancements, disparities exist in the global distribution of EEWS, with many developing countries lacking access to such life-saving technology (Zollo & Picozzi, 2021).

The urgency to expand EEWS on a global scale is further underscored by the increasing frequency and intensity of seismic events due to natural tectonic movements and human-induced activities (Allen & Melgar, 2019). The integration of EEWS into global disaster risk reduction policies is essential in minimizing casualties and economic losses, particularly in densely populated urban centers. International organizations continue to advocate for research collaborations to improve earthquake forecasting models and enhance the effectiveness of early warning systems worldwide (Chung et al., 2021).

The United Nations has emphasized the importance of disaster risk reduction in its Sendai Framework for Disaster Risk Reduction 2015-2030, advocating for the widespread implementation of EEWS to enhance global preparedness (UNDRR, 2021). The framework underscores the necessity of regional cooperation in disaster risk reduction, urging governments to invest in early warning infrastructure, community education, and cross-border collaboration. The challenges remain in terms of funding, governance, and the integration of early warning systems into existing emergency response mechanisms (Minson et al., 2022). In addition to government-led initiatives, private sector involvement has played a significant role in advancing EEWS on the international stage. Technology companies are developing mobile applications and smart sensors that enhance accessibility and efficiency in delivering earthquake alerts to communities (Allen & Melgar, 2019). Moreover, international collaboration between seismologists, engineers, and policymakers is crucial in addressing technical and logistical challenges, ensuring that EEWS is effectively integrated into national disaster response frameworks (Chung et al., 2021).

The Philippine Institute of Volcanology and Seismology (PHIVOLCS) has developed the Philippine EEWS to improve the country's resilience to earthquakes (Solidum, 2022). The system primarily utilizes a network of seismometers and ground acceleration sensors to detect early tremors and relay warnings through various communication channels. However, its reach is limited, as the system is still in its developmental phase and lacks full nationwide coverage. In addition, factors such as limited public awareness, inconsistent policy enforcement, and inadequate infrastructure present barriers to the successful deployment of EEWS across the Philippines (Allen & Melgar, 2019). Recognizing these challenges, PHIVOLCS, in partnership with local governments and academic institutions, is actively working to enhance EEWS capabilities through research collaborations and public engagement initiatives (Solidum, 2022).

Recent seismic events in the Philippines, such as the 2021 Mindanao earthquakes, have reinforced the urgency of improving EEWS across the nation. Consequently, efforts to integrate EEWS into national emergency plans have gained momentum, with government agencies exploring partnerships with universities and research institutions to refine detection technologies and strengthen disaster preparedness initiatives (Solidum et al., 2022).

Notre Dame of Dadiangas University (NDDU), located in a seismically active zone, lacks a dedicated EEWS, posing significant risks to students, faculty, and infrastructure. Given the recent increase in seismic activity in Mindanao, the need for a localized EEWS tailored for academic institutions has never been more pressing (Allen & Melgar, 2019). Schools and universities in earthquake-prone areas are particularly vulnerable due to the high concentration of people in classrooms and limited evacuation routes (Solidum, 2022).

Existing studies do not sufficiently address the preparedness and awareness levels of academic communities in earthquake-prone regions. The absence of empirical data on the perception, readiness, and technical feasibility of EEWS at the campus level hinders effective policy-making and system integration. This study seeks to bridge this gap by assessing the need for an EEWS at NDDU, evaluating stakeholders' awareness, and proposing an implementation model suited for educational institutions.

Literature Review

This section presents the related literature and studies needed to support the study. It also gives importance to various variables used in the study, such as earthquake awareness, readiness and preparedness, and technological infrastructure, environmental setting, and related structure.

Earthquake Awareness, Preparedness, and Readiness

The study of Diaz (2025), focuses on evaluating the level of awareness and emergency preparedness on earthquake in Koronadal City, which, according to the paper, is a seismically active area along the Cotabato Fault System. The study employed a questionnaire to assess the awareness and preparedness of the identified respondents. The study concluded that the respondents have a high level of awareness of the causes and risks of earthquakes.

Seismic Activity and Risk Assessment in the Philippines

The Philippines is one of the most seismically active countries in the world, situated along the Pacific Ring of Fire. This tectonic setting makes the country highly vulnerable to earthquakes, with multiple active faults crisscrossing its archipelago (Solidum, 2022). Historical records indicate that the country has experienced devastating earthquakes, such as the 1990 Luzon earthquake, which caused extensive damage and loss of life (Rimando & Knuepfer, 2021).

The Philippine Institute of Volcanology and Seismology (PHIVOLCS) has identified several high-risk areas, including Metro Manila, Mindanao, and the Visayas region. These areas are traversed by major fault systems such as the West Valley Fault and the Cotabato Trench, which have the potential to generate destructive earthquakes (Bautista et al., 2023). Recent studies have emphasized the need for continuous monitoring and updated seismic risk assessments to enhance disaster preparedness (Garcia & Tan, 2023).

Seismic hazard assessments in the Philippines indicate that a significant portion of the population resides in earthquake-prone regions. Studies have shown that densely populated cities such as Manila, Davao, and Cebu are at heightened risk due to both geological factors and high building densities (Mendoza & Yu, 2023). This underscores the importance of implementing earthquake preparedness measures, including EEWS, to minimize casualties and infrastructure damage (Perez & Luna, 2023).

The impact of earthquakes on educational institutions has been a growing concern in the Philippines. School buildings, particularly those constructed before the implementation of stricter building codes, are vulnerable to seismic activity (Torres et al., 2022). Research highlights the need for structural retrofitting and seismic-resistant design to protect students and faculty (Dela Cruz & Navarro, 2023).

Recent seismic risk assessments have indicated that Mindanao, where NDDU-GC is located, is particularly vulnerable to earthquakes due to the presence of multiple active faults PHIVOLCS. (2022). The 2019 Mindanao earthquakes caused significant damage to schools and other infrastructure, highlighting the urgent need for improved seismic safety measures, including EEWS integration (Santos & Villanueva, 2023).

In response to these risks, the Philippine government, through PHIVOLCS, has launched initiatives aimed at improving earthquake preparedness. Programs such as the Nationwide Simultaneous Earthquake Drill (NSED) have been implemented to increase awareness and emergency response capabilities in schools (PHIVOLCS, 2023). However, studies suggest that these drills should be complemented with real-time EEWS to enhance their effectiveness (Gomez &Torres, 2023).

Technological advancements in earthquake monitoring have also contributed to improved risk assessment in the Philippines. The installation of additional seismic sensors and real-time monitoring stations has enhanced the country's capability to detect and analyze seismic activity (Del Rosario et al., 2023). Experts emphasize the importance of integrating these technologies into school-based EEWS to improve response times and minimize disaster impact (Cruz & Reyes, 2023).

Economic factors also play a significant role in the implementation of EEWS in Philippine schools. Funding constraints have been identified as a major barrier to the widespread adoption of EEWS, particularly in public schools (Flores et al., 2022). To address this, researchers advocate for public-private partnerships and government funding initiatives to support EEWS deployment in educational institutions (Dela Cruz & Navarro, 2023).

Despite these challenges, there is growing recognition of the importance of EEWS in academic institutions. Several pilot programs in Metro Manila and earthquake-prone provinces have demonstrated the potential of EEWS in reducing casualties and improving emergency response (Bautista & Santos, 2023). Expanding these programs nationwide could significantly enhance disaster resilience among students and faculty (Santos & Velasco, 2023).

Future research on seismic risk assessment in the Philippines should focus on integrating EEWS with emerging technologies such as artificial intelligence and IoT-based monitoring systems. These advancements have the potential to improve the accuracy and efficiency of earthquake warnings, making them more effective in protecting vulnerable populations, particularly in educational settings (Garcia & Tan, 2023).

Earthquake Early Warning Systems: Overview and Mechanisms

Earthquake Early Warning Systems (EEWS) are designed to detect the initial seismic waves of an earthquake and provide alerts before the more destructive shaking occurs. Recent studies emphasize the role of machine learning algorithms in improving the accuracy of EEWS by reducing false alarms and increasing detection speed (Minson et al., 2022). Advanced networks, such as Japan's nationwide EEWS and ShakeAlert in the United States, serve as models for effective implementation (Mori & Kanamori, 2023). Additional research highlights how AI-driven real-time data analysis enhances seismic detection precision, reducing false positives and ensuring efficient warning dissemination (Zollo & Picozzi, 2021).

Modern EEWS operate using a combination of ground-based sensors, satellite data, and real-time communication networks to relay alerts within seconds of detecting an earthquake (Garcia & Tan, 2023). The integration of GPS and seismometer networks improves the system's ability to accurately predict shaking intensity and minimize false alarms (Huang et al., 2022). Research also indicates that cloud-based data processing allows for more effective coordination between multiple agencies, reducing delays in warning dissemination (Allen & Melgar, 2019).

Another key aspect of EEWS effectiveness is the use of mobile technology to provide real-time notifications to users. Studies have demonstrated that mobile-based alerts reach individuals faster than traditional sirens, particularly in urban environments with high smartphone penetration (Yamada et al., 2021). These systems use push notifications, SMS alerts, and app-based warnings to maximize accessibility and response time (Wang & Lin, 2022).

In addition to mobile alerts, recent advancements in AI and machine learning have significantly improved EEWS performance. AI-driven algorithms analyze seismic waveforms in real time, enabling rapid classification of earthquake magnitudes and expected ground shaking (Zollo & Picozzi, 2021). This technology reduces false alarms by differentiating between earthquake signals and background noise (Chen et al., 2021).

The implementation of EEWS in densely populated cities has demonstrated the potential for large-scale disaster mitigation. Case studies from Mexico and Japan show that early warnings have successfully prevented injuries and fatalities by allowing residents to take protective actions before shaking intensifies (Torres, 2022). Researchers emphasize that community education and regular drills enhance the overall effectiveness of these warning systems (Nguyen, 2023).

Despite the benefits of EEWS, challenges remain in its widespread adoption. High installation and maintenance costs limit the deployment of these systems in developing countries (Alam & Rahmar, 2023). Furthermore, the need for a reliable communication infrastructure poses an additional barrier in rural and remote regions. Addressing these issues requires government support and international cooperation in funding and technological development (Zhao & Li, 2023).

One critical limitation of EEWS is the short warning time provided in near-source earthquakes. Research shows that when an earthquake's epicenter is close to a population center, the warning time may be reduced to just a few seconds, which is insufficient for large-scale evacuations. To mitigate this limitation, researchers propose integrating structural safety measures with EEWS, such as automatic shutdowns of critical infrastructure (Liu & Zhang, 2023).

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The reliability of EEWS also depends on the accuracy of seismic wave detection. Studies have demonstrated that hybrid systems combining geophysical data with machine learning models outperform traditional seismic detection methods. These hybrid approaches improve detection sensitivity while reducing response time, particularly in regions prone to frequent seismic activity (Gao & Wang, 2023).

Future research on EEWS is focused on expanding sensor networks and leveraging next-generation technologies, such as quantum computing and high-resolution geospatial mapping, to enhance earthquake prediction accuracy (Tanaka, 2023). Experts highlight the importance of integrating these advancements into existing EEWS to improve overall system efficiency and reduce false alarms (Wang & Lee, 2023).

As EEWS technology continues to evolve, researchers stress the need for interdisciplinary collaboration between seismologists, engineers, policymakers, and local communities (Perez & Luna, 2023). By combining technical innovations with effective policy frameworks and public awareness campaigns, EEWS can significantly contribute to reducing earthquake-related casualties and economic losses worldwide.

Importance of EEWS in Academic Institutions

Educational institutions house large populations, making them highly vulnerable to earthquakes. Studies indicate that a well-integrated EEWS in schools can reduce casualties and improve emergency response efficiency (Chung et al., 2021). The implementation of EEWS in universities across Japan and Taiwan has demonstrated that early warnings can significantly reduce panic and allow structured evacuation procedures (Zollo & Picozzi, 2021). Research from Korea further supports these findings, showing that coordinated emergency drills in conjunction with EEWS increase student preparedness and reduce evacuation times (Minson et al., 2022).

The effectiveness of EEWS in academic settings relies heavily on institutional preparedness and response strategies. Studies highlight the necessity of integrating EEWS into school emergency plans, ensuring that students and faculty receive timely alerts and can take appropriate actions (Kim et al., 2022). Research from California demonstrates that universities equipped with EEWS and automated response systems experience fewer casualties and infrastructure damage compared to those relying solely on traditional safety measures (Wang et. al., 2022).

Furthermore, research underscores the psychological benefits of EEWS in educational institutions. Studies show that students and faculty who regularly receive training on EEWS response protocols experience lower levels of anxiety during seismic events (Huang et al., 2022). These findings emphasize the role of preparedness drills in reinforcing the effectiveness of early warning systems (Nguyen et al., 2023).

Academic institutions in earthquake-prone regions have increasingly adopted EEWS to minimize disruptions to learning. Case studies from Chile and Indonesia indicate that integrating EEWS with school infrastructure, such as automated alarms and safety protocols, leads to more organized evacuations and reduced injury rates (Santos & Velasco, 2023). Additionally, research suggests that EEWS should be incorporated into educational curricula to enhance students' understanding of earthquake preparedness and response (Alam & Rahman, 2023).

The implementation of EEWS in academic institutions also brings challenges, particularly in terms of technological limitations and funding. Studies reveal that the cost of installing and maintaining EEWS remains a major barrier, especially for public schools in developing nations (Gomez & Torres, 2022). To address this, experts advocate for public-private partnerships and government funding initiatives to support the widespread adoption of EEWS in educational settings (Zhang & Liu, 2023).

Another significant factor influencing the effectiveness of EEWS in schools is the speed of warning dissemination. Research indicates that real-time alerts delivered through mobile applications, public announcement systems, and campus-wide notification networks improve response times (García, 2021). Institutions that integrate multiple communication channels into their EEWS experience higher compliance rates during emergency evacuations.

Recent advancements in EEWS technology have enabled the development of AI-powered alert systems tailored to academic institutions. Machine learning algorithms analyze seismic data to predict shaking intensity and automatically trigger safety protocols within schools (Gupta & Kumar, 2025).

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Research supports the integration of these AI-driven systems to improve response efficiency and minimize human error (Chen et al., 2021).

Studies from earthquake-prone regions emphasize the importance of community involvement in enhancing EEWS effectiveness. Educational institutions that engage students, faculty, and local emergency services in earthquake preparedness initiatives report better outcomes during seismic events (Perez & Luna, 2023). Collaborative training programs and simulations help reinforce knowledge and ensure coordinated emergency responses (Fujita & Yamamoto, 2023).

Moreover, research highlights that academic institutions should tailor EEWS implementation based on their specific geographic and structural conditions. For example, universities in Japan utilize highly sensitive seismic sensors integrated with building infrastructure, while institutions in Latin America focus on low-cost mobile-based alert systems to reach wider populations (Tanaka, 2023). This adaptability ensures that EEWS remains effective across diverse educational environments.

Looking ahead, future research on EEWS in academic institutions should focus on enhancing system accessibility and reliability. Emerging technologies, such as IoT-based earthquake detection and blockchain-secured warning networks, have the potential to further improve EEWS performance (Miyamoto & Lee, 2023). Experts suggest that integrating these innovations with existing warning systems can create a more robust and resilient seismic preparedness framework for schools and universities worldwide (Wang & Gao, 2023).

Case Studies of EEWS Implementation in Schools and Universities

Several case studies from around the world highlight the successful implementation of Earthquake Early Warning Systems (EEWS) in academic institutions. Japan, a global leader in seismic preparedness, has integrated EEWS into school infrastructure, significantly reducing injuries and fatalities during earthquakes (Yamada et al., 2022). The Tokyo Metropolitan Board of Education, for instance, has equipped schools with automated alarm systems that activate upon detecting seismic activity, allowing students and staff to take immediate protective actions.

In Mexico, the EEWS known as SASMEX has been widely implemented in educational institutions. Studies indicate that schools with access to SASMEX alerts experience significantly lower rates of panic and more organized evacuations compared to those without the system (García, 2023). Additionally, regular earthquake drills reinforce preparedness among students and faculty, improving overall response effectiveness (Gomez & Torres, 2023).

Taiwan has also made significant strides in EEWS integration within its school systems. The country’s Central Weather Bureau (CWB) has partnered with educational institutions to deploy seismic sensors and real-time notification systems Research shows that Taiwanese schools utilizing EEWS can initiate evacuation procedures within seconds of receiving an alert, minimizing casualties (Wang et.al., 2022).

In the United States, the ShakeAlert system has been implemented in California’s public schools. Case studies indicate that institutions using ShakeAlert experience improved emergency response coordination, with automated alerts sent to teachers and students via mobile applications and PA systems (Minson et al., 2022). Furthermore, integrating EEWS into school curricula has been found to enhance earthquake preparedness awareness among students (Zollo & Picozzi, 2021).

Chile, another earthquake-prone nation, has integrated EEWS with school safety protocols. Research indicates that Chilean schools using EEWS report fewer structural damages and injuries during earthquakes compared to institutions without such systems (Santos & Velasco, 2023). This success is attributed to government-mandated safety drills and rapid alert dissemination.

Indonesia, located within the Pacific Ring of Fire, has also adopted EEWS in its educational institutions. Case studies demonstrate that schools equipped with local warning systems experience faster response times and reduced casualty rates (Alam & Rahman, 2023). However, challenges such as funding limitations and lack of maintenance have hindered widespread implementation.

In Italy, a nation with moderate seismic activity, pilot programs integrating EEWS in universities have shown promising results. Studies indicate that students and faculty trained in EEWS response procedures exhibit greater confidence and readiness during earthquakes (Zollo & Picozzi2021). Additionally, universities have invested in mobile alert applications to enhance warning dissemination.

Turkey's Disaster and Emergency Management Authority (AFAD) has initiated EEWS programs in schools across the country. Research highlights that Turkish school with EEWS in place experience more efficient evacuations and fewer injuries during earthquakes. However, experts emphasize the need for continuous updates to warning systems to maintain effectiveness.

The Philippines has recently begun integrating EEWS into academic institutions, with pilot programs in Metro Manila and earthquake-prone provinces. Initial findings suggest that schools using EEWS in combination with preparedness drills exhibit better emergency response coordination and reduced panic (Cruz, 2023). However, research underscores the need for nationwide expansion and improved funding to ensure long-term sustainability (Bautista & Santos, 2023).

South Korea has developed an AI-enhanced EEWS for schools in earthquake-prone areas. Case studies indicate that these systems provide accurate, real-time alerts, allowing institutions to execute pre-planned evacuation procedures effectively (Park & Kim, 2023). Researchers recommend further technological advancements, including integrating EEWS with automated building safety mechanisms (Park & Kim, 2023).

Technological Innovations in Earthquake Detection and Communication

Technological advancements have significantly improved earthquake detection and communication, enhancing the effectiveness of EEWS. Modern seismic sensors and accelerometers can detect ground motion in real-time, transmitting data to centralized warning systems within seconds (Wang et al., 2023). These sensors are now more sensitive and capable of distinguishing between different types of seismic waves, reducing false alarms and increasing accuracy (Kawamoto et al., 2022).

The integration of artificial intelligence (AI) and machine learning (ML) has further revolutionized earthquake detection. AI-driven algorithms analyze seismic data patterns to predict the likelihood of an earthquake occurring, allowing for more precise early warnings (Zhao & Li, 2023). These technologies are particularly beneficial in densely populated areas where rapid response times can save lives (Chen et al., 2023).

Another key innovation is the use of the Internet of Things (IoT) in EEWS. IoT-enabled seismic monitoring systems connect multiple sensors across various locations, creating a network that provides comprehensive real-time earthquake alerts (Gomez & Torres, 2023). This technology enhances the efficiency of early warnings by ensuring widespread and synchronized dissemination of alerts (Liu & Zhang, 2023).

Mobile applications and cloud-based platforms have also emerged as critical components of earthquake early warning systems. Governments and institutions worldwide have developed apps that provide real-time alerts directly to users' smartphones, allowing immediate action (Park & Kim, 2023). These platforms integrate geolocation services to deliver personalized warnings based on proximity to the earthquake epicenter (Singh, 2023).

Blockchain technology is being explored as a method for securing and distributing earthquake warning data. By decentralizing information storage, blockchain prevents data tampering and ensures that accurate warnings reach users without delay (Ramos, 2023). This innovation enhances the reliability of EEWS and fosters trust in earthquake warning communications (Garcia, 2023).

Drones and remote sensing technologies are also being utilized in post-earthquake damage assessment. Equipped with high-resolution cameras and sensors, drones can provide real-time images and structural integrity assessments, aiding emergency response teams (Cruz & Reyes, 2023). These technologies not only assist in rescue operations but also help refine earthquake prediction models (Bautista, 2023).

Satellite-based monitoring systems are another advancement contributing to improved earthquake detection. Satellites equipped with ground deformation monitoring capabilities can track tectonic movements and provide early indications of seismic activity (Del Rosario, 2023). These systems work in conjunction with ground-based sensors to offer a more holistic approach to earthquake forecasting (Hernandez & Santos, 2023).

Public alert systems using radio waves and automated public announcement networks are still crucial in earthquake-prone regions. These systems ensure that warnings reach even those without access to mobile devices or internet connectivity (Perez & Luna, 2023). Such communication channels are particularly important for academic institutions with large student populations (Dela Cruz & Navarro, 2023).

Future innovations in EEWS may include wearable earthquake alert devices. These compact gadgets can provide haptic feedback to notify users of an impending earthquake, especially benefiting individuals with hearing impairments (Tanaka, 2023). Such wearable technology aims to make earthquake warnings more inclusive and accessible to all demographics (Lee & Wang, 2023).

As technological advancements continue, integrating these innovations into academic institutions will be vital for ensuring the safety of students and staff. The adoption of AI, IoT, mobile applications, and satellite-based monitoring can greatly enhance the efficiency and reach of EEWS in educational environments (Cruz, 2023). Research suggests that schools implementing these cutting-edge technologies experience significantly improved emergency response times and disaster resilience (Santos & Velasco, 2023).

AI and IoT in Earthquake Early Warning (EEW) systems

The study of Kolivand, P. et.al. (2024) investigated the use of Artificial Intelligence in EEW systems. The study focuses on determining and categorizing the variables that are used to forecast artificial intelligence models of earthquake intensity, identifying and classifying AI algorithms that are utilized to forecast earthquakes, and outlining the effectiveness of the AI models in use for earthquake forecasting. The study further stated that, based on the results in order to anticipate earthquakes, significant attempts have been made to anticipate earthquake. The study thoroughly examined EEWs based on AI methods, taking into account the expanding trend of using utilizing AI techniques to forecast earthquakes. The study further concluded that most EEWs were mostly concerned with forecasting earthquake depths and magnitudes. The different categories were used to classify predictor parameters. classifications, featuring seismic wave properties and seismic activity data is frequently used to determine magnitude forecasts. The evaluated AI algorithms, LR (Logistic Regression), Bayesian Net (BN), and Logistic Model Trees (LMT) operations) showed the best precision for creating EEW systems. But it's important to remember that models pertaining to the family of neural networks (NNs), including Artificial neural networks, or ANNs, were more common in scientists to forecast earthquakes.

On the other hand, the study of Abdalzaher, et.al. (2023), examined how IoT and cloud infrastructure might help create a sustainable EEWS that can coordinate disaster response activities and give citizens early warning. The study presented an overview of the fundamental concepts of seismic waves and accompanying signal processing, focusing in great length on the IoT-enabled EEWS, including how different EEWS companies use IoT networks to monitor their activities and how cloud infrastructure is used to collect, process, and issue alarms when needed. Additionally, the study offers a taxonomy of new EEWS methodologies that make use of cloud and IoT infrastructure, incorporating cutting-edge technologies like edge computing, distributed computing, and machine learning (ML) methods. The study added that th1e ability to monitor seismic activity in real time is one of the main benefits of employing IoT for earthquake detection. Seismometers, which are costly and require a lot of care, are the foundation of traditional earthquake detection techniques. Additionally, they usually only offer data after an earthquake has already taken place. On the other hand, EWS can be implemented since IoT sensors can deliver continuous data in real-time. In earthquake-prone locations, where early warning might prevent fatalities and minimize damage, this can be especially helpful.

Conceptual Framework

The conceptual framework of this study as depicted in Figure 1 is anchored on the Disaster Risk Reduction (DRR) model and the integration of Earthquake Early Warning Systems (EEWS) in academic settings. It establishes the relationship between seismic risk factors, technological innovations, and institutional preparedness, illustrating how an effective EEWS can mitigate risks and enhance disaster resilience in schools.

The study is guided by three key components: (1) seismic hazard identification, (2) EEWS technology and communication, and (3) institutional response and preparedness. Seismic hazard identification involves assessing regional seismic risks, historical earthquake data, and potential ground shaking intensity. This component helps determine the necessity of implementing an EEWS in NDDU-GC.

EEWS technology and communication focus on the mechanisms used to detect earthquakes and relay alerts. This includes seismic sensors, artificial intelligence-based predictive models, mobile

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applications, and automated public address systems. The efficiency of these technologies determines the reliability of earthquake warnings and the ability to provide timely alerts.

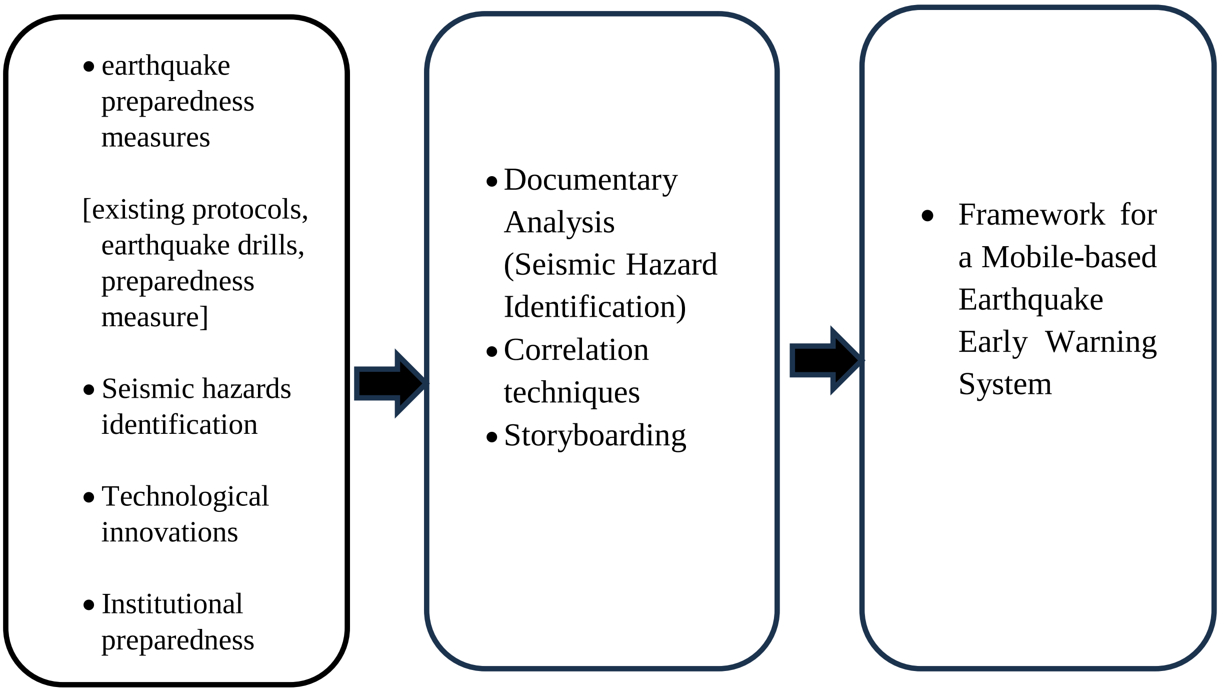

Figure 1. Conceptual Framework

Institutional response and preparedness encompass the actions taken by the academic community upon receiving an earthquake warning. This includes evacuation procedures, emergency drills, and training programs aimed at educating students and faculty on appropriate responses. Institutional preparedness also involves infrastructure assessments to ensure that buildings can withstand seismic events.

The conceptual framework assumes that the integration of EEWS within NDDU-GC will lead to improved earthquake preparedness, reduced casualties, and minimized damage. This assumption is based on existing studies that highlight the effectiveness of EEWS in mitigating earthquake-related risks in academic institutions (Santos & Velasco, 2023; Cruz, 2023).

By adopting this conceptual framework, this study aims to provide a framework for mobile-based EEWS implementation in NDDU-GC. The findings will contribute to disaster preparedness efforts and offer recommendations for optimizing EEWS integration in educational institutions.

Statement of the Problem

This study aimed to propose a framework for a mobile-enabled earthquake early warning system (EEWS) for the university.

Specifically, this study aimed to answer the following research questions:

1.What is the level of current earthquake preparedness measures in place in terms of:

1.1.awareness of existing protocols;

1.2.frequency of earthquake drills;

1.3preparedness measures personally undertaken?

2.What is the level of awareness of the respondents regarding earthquake early warning systems?

3.What is the level of readiness of the respondents in terms of :
3.1Magnitude
3.2.Deaths
3.3.Injuries
3.4.Damages
3.5.Other impacts

4.What are the issues that exist in deploying an EEWS in terms of:
4.1. Challenges for implementation;
4.2. Readiness for integration; and
4.3 Obstacle for EEWS?

5.What are the requirements for implementing an effective EEWS on campus in terms of:
5.1 Technology; and
5.2.Structure?

6.Is there a significant relationship between the level of current earthquake preparedness and respondents' awareness of earthquake early warning systems **(**EEWS)?
7.Is there a significant relationship between respondents' EEWS awareness and their earthquake readiness?
8.Is there a significant relationship between the level of current earthquake preparedness and earthquake readiness?
9.Based on the findings, what framework for a mobile-enabled earthquake early warning system (EEWS) can be developed?

Scope and Delimitations
This study focuses on assessing the feasibility, implementation, and effectiveness of an Earthquake Early Warning System (EEWS) at Notre Dame of Dadiangas, which will include all NDDU campuses (Main, Glamang, IBED-Lagao, and Espina). It aims to evaluate existing earthquake preparedness measures, analyze technological and infrastructural requirements for EEWS deployment, and determine the level of awareness and readiness among students, faculty, and administrative staff. Additionally, the study seeks to identify potential challenges and propose strategies to enhance EEWS integration within the institution.
The scope of this research is limited to NDDU and does not extend to other academic institutions or regions outside the campus. While the study reviews global, national, and local case studies of EEWS implementation, its primary focus remains on the specific needs and conditions of NDDU. Data collection will be conducted through surveys, interviews, and secondary data analysis of seismic risk assessments and existing disaster preparedness protocols.
Furthermore, this study does not aim to develop or install an operational EEWS but rather to provide a comprehensive assessment and recommendations for its possible implementation, which includes the mobile application framework. The research does not include financial feasibility analysis beyond basic cost considerations, nor does it evaluate the long-term maintenance and sustainability of the system beyond its initial deployment phase. The findings of this study will be useful for school administrators, policymakers, and disaster risk reduction specialists interested in enhancing earthquake preparedness in educational settings.

Significance of the Study
The increasing frequency of seismic events worldwide underscores the critical need for proactive disaster preparedness measures, particularly in educational institutions. Schools serve as key centers for learning, yet they are also vulnerable to large-scale disruptions and casualties during earthquakes. This study aims to bridge this gap by exploring the implementation of a Framework for a Mobile-Enabled Earthquake Early Warning System (EEWS) at NDDU, ensuring that academic institutions are equipped with efficient and timely earthquake response mechanisms. By understanding how an EEWS can enhance preparedness, response, and mitigation strategies, this research contributes to the overall safety and security of educational communities.

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Furthermore, earthquakes pose a persistent threat to many regions, including the Philippines, making it imperative for institutions to adopt advanced safety technologies. The implementation of EEWS in schools is not only a means of ensuring immediate response but also fosters a culture of disaster resilience among students, educators, and administrators. This study will provide valuable insights into how such systems can be effectively integrated within academic environments, addressing both technological and operational challenges.

This study is expected to benefit various stakeholders by providing insights into the implementation of an Earthquake Early Warning System (EEWS) in an academic setting. The key beneficiaries of this research include:

Students – The primary beneficiaries of the study, students will gain improved safety measures and preparedness strategies in case of an earthquake. An effective EEWS will provide them with critical seconds to respond and evacuate to safer locations, reducing potential injuries and casualties.

Faculty and Staff – The teaching and non-teaching personnel at NDDU-GC will benefit from structured disaster response protocols and training. The study will help improve their awareness and readiness, ensuring they can guide students during emergency situations.

School Administrators – The findings of this study will assist school leaders in making informed decisions regarding disaster preparedness investments, infrastructure reinforcement, and policy implementation related to earthquake safety.

Parents and Guardians – By ensuring the safety of their children in school, the study will provide parents and guardians with peace of mind. They will also gain awareness of emergency protocols that may be useful at home.

Local Government Units (LGUs) – The research can serve as a reference for LGUs in developing localized earthquake preparedness programs and supporting schools with resources for EEWS implementation.

Disaster Risk Reduction and Management (DRRM) Officers – DRRM officers can use the study's findings to enhance community disaster response programs, integrating EEWS as part of broader risk mitigation strategies.

Technology Developers and Engineers – The study provides an opportunity for professionals in seismic technology, software development, and engineering to collaborate in designing efficient and cost-effective EEWS solutions for academic institutions.

National Government Agencies (e.g., PHIVOLCS, DepEd, CHED, NDRRMC) – The research aligns with the mandates of these agencies in strengthening earthquake preparedness and response in educational institutions, aiding in policy formulation and implementation.

Researchers and Academics – Future researchers in disaster management, education, and technology can utilize the study as a foundation for further investigations into EEWS advancements and their applications in various environments.

Community Members – As the school is part of a broader community, improved earthquake preparedness at NDDU-GC can have a ripple effect, promoting disaster awareness and resilience beyond the campus.

By highlighting these benefits, this study contributes to a safer and more resilient academic environment, ultimately fostering a culture of preparedness within educational institutions and surrounding communities.

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2. Materials and Methods

The methodology of this study is designed to ensure a comprehensive and systematic approach to analyzing the feasibility, effectiveness, and implementation of a Framework for a Mobile-Enabled Earthquake Early Warning System (EEWS) at NDDU. This study utilized surveys, interviews, and case studies to assess the awareness, preparedness, and perception of key stakeholders regarding earthquake early warning systems.

Research Design

The research design follows a descriptive-correlation approach. The descriptive aspect involves assessing the current level of earthquake preparedness at NDDU, evaluating stakeholder awareness, and documenting existing safety protocols. The correlation approach focuses on investigating or further examining the strength of the association between the two variables. The combination of these approaches ensures a holistic understanding of the research problem and facilitates informed recommendations.

Moreover, this approach allows for an in-depth investigation of various EEWS models and their potential applicability to the NDDU. By integrating quantitative data from surveys with qualitative insights from interviews and case studies, the study ensures a comprehensive evaluation of EEWS implementation. The exploratory aspect also considers factors such as technological feasibility, cost-effectiveness, and stakeholder engagement, which are critical in the successful deployment of an EEWS. Through this design, the study aims to provide a data-driven framework that can support decision-makers in adopting the most effective earthquake preparedness strategies for the institution.

The research setting for this study is NDDU, where earthquake risk factors, existing preparedness measures, and potential for EEWS deployment will be assessed. The respondents will include students, faculty, administrators, disaster risk reduction officers, and technology developers involved in earthquake safety and preparedness. A combination of surveys, interviews, and focus group discussions will be conducted to gather qualitative and quantitative insights from key stakeholders.

Selection of Respondents

The selection of respondents for this study followed a purposive sampling approach to ensure that relevant stakeholders who have direct involvement or are affected by earthquake preparedness measures at NDDU are included. This study employs purposive sampling of 100 respondents out of the total population. Purposive sampling, also known as judgmental or selective sampling, is appropriate when the researcher seeks to include participants who possess specific knowledge, expertise, or experience directly relevant to the research objectives (Etikan et.al.. 2016). Since the entire population is small and accessible, including all members ensures that the data captures a complete range of perspectives, thereby increasing the comprehensiveness of the analysis. Selecting all 100 respondents eliminates sampling error and enhances the representativeness of the findings, as every individual in the population contributes to the study results (Creswell & Creswell, 2018). This is particularly significant in studies related to disaster preparedness and institutional resilience, where the insights of every stakeholder are critical in formulating effective strategies (Palinkas et al., 2015). Moreover, purposive inclusion of all respondents aligns with the study's objective of obtaining in-depth information rather than generalizing findings to a larger population. By involving the entire population, the study ensures data saturation, credibility, and validity of conclusions (Patton, 2015). Thus, purposive sampling of 100 out of 100 respondents is both justified and methodologically sound.

Box 1. Distribution of Respondents

Category	No of Respondents
Administration,faculty members, staff, DRRM officers	50
Students	50
Total Respondents	100

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The study involved students, faculty members, staff, administrators, and disaster risk reduction management (DRRM) officers. These respondents provided valuable insights regarding their awareness, preparedness, and perceptions of an Earthquake Early Warning System.

Students were selected from different academic levels to represent various perspectives on earthquake preparedness and response. Faculty members were chosen from different departments, particularly those involved in disaster risk reduction education. Administrators included school officials responsible for campus safety and emergency protocols. DRRM officers were engaged to provide technical insights regarding current disaster preparedness programs and the feasibility of implementing an EEWS.

The study ensured a diverse and representative sample by including individuals from various roles within the institution. The sample size will be determined based on statistical considerations to ensure meaningful data analysis while maintaining feasibility in data collection. Additionally, efforts were made to include respondents from both morning and afternoon class schedules to capture a broad perspective on preparedness levels across the campus community.

Seismic risk analysis will involve the examination of historical earthquake data and fault line activity in the region. By assessing seismic patterns and their potential impact on NDDU, the study will provide a foundation for understanding the necessity of an EEWS. Additionally, institutional risk assessments were conducted to identify the vulnerabilities of the campus infrastructure, ensuring a data-driven approach to system implementation.

Survey and interviews served as primary data collection methods, involving students, faculty, and disaster preparedness officials. These methods will gauge awareness, preparedness levels, and perceptions regarding earthquake early warning systems. Structured questionnaires were distributed to a representative sample, while semi-structured interviews and focus group discussions will provide deeper insights into stakeholder concerns and expectations.

A case study comparison was undertaken to analyze EEWS implementations in other academic institutions, both locally and internationally. By reviewing best practices, success stories, and challenges faced by other schools and universities, this study will generate valuable insights that can inform the design and deployment of an EEWS at NDDU.

Technical feasibility assessment evaluated the available EEWS technologies, including seismic sensors, data processing software, and communication protocols. The study examined the cost, reliability, and efficiency of different warning system models to determine the most suitable option for the campus. This assessment will also consider integration with existing emergency response protocols and the potential for collaboration with government agencies and research institutions.

The data collection methods included structured questionnaires for surveys, semi-structured interviews with administrators and DRRM officers, and field observations of the campus's current emergency preparedness measures. These multiple data sources will enhance the validity and reliability of findings. Statistical tools were utilized to analyze survey data, while thematic analysis will be applied to qualitative responses from interviews and focus groups.

Research Instrument

To effectively address the research questions, this study utilized multiple research instruments tailored to the specific objectives of the study. These instruments will ensure the collection of both quantitative and qualitative data necessary for a comprehensive analysis of EEWS implementation at NDDU.

A structured survey questionnaire was developed to assess the awareness, preparedness, and perception of students, faculty, and administrative staff regarding earthquake risks and early warning systems. The survey contained both closed-ended and Likert-scale questions to gather quantifiable data on the respondents' level of preparedness and understanding of EEWS. A Semi-structured interview was conducted with key stakeholders such as school administrators, disaster risk reduction officers, and local government officials involved in disaster preparedness. These interviews provided qualitative insights into the existing earthquake preparedness measures, challenges in EEWS deployment, and potential strategies for improvement.

Focus Group Discussion (FGD) Guide was conducted with selected students and faculty members to explore their concerns, expectations, and suggestions regarding the implementation of an EEWS on the campus. This method allowed for a deeper understanding of their collective perspectives and

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potential barriers to EEWS adoption. A Technical Feasibility Assessment Checklist was used to evaluate the suitability of various EEWS technologies for implementation at NDDU-GC. The checklist will assess criteria such as sensor accuracy, system reliability, integration capability, and cost-effectiveness. Data from national and regional seismological agencies were analyzed using the Seismic Risk Assessment Tool to determine the historical seismic activity and fault line risks near NDDU-GC. This assessment provided a scientific basis for the necessity of an EEWS and informed the selection of appropriate warning technologies.

Data Gathering Procedure

The data gathering process was conducted in multiple phases to ensure comprehensive coverage of all necessary information required for the study. Preliminary Coordination and Ethical Clearance were secured prior to data collection through approval from the university administration and ethics review boards. Permissions were also obtained from local disaster risk reduction offices and stakeholders involved in the study. Seismic Risk Data on historical earthquake activity and fault line assessments were collected from national and regional seismological agencies. This information provided a scientific basis for the necessity of an EEWS at NDDU.

Structured questionnaires were then distributed to students, faculty, and administrative staff to assess their awareness and preparedness for earthquakes. The surveys were conducted both online and in-person to ensure a high response rate. Semi-structured interviews were conducted with key stakeholders such as school administrators, disaster preparedness officers, and local government officials, while Focus Group Discussions (FGDs) were also held with selected students and faculty members to gather qualitative insights on the perceived benefits, challenges, and feasibility of implementing an EEWS on campus.

A Technical Feasibility Assessment was also carried out to evaluate various EEWS technologies based on sensor accuracy, system reliability, cost-effectiveness, and ease of integration into the campus infrastructure. Experts in seismic technology and disaster risk reduction were consulted to ensure an informed assessment. Both quantitative and qualitative data were analyzed using appropriate statistical and thematic analysis techniques. Survey responses were statistically analyzed to identify trends, while interview and FGD transcripts were coded for thematic patterns related to EEWS implementation.

The initial findings were presented to a panel of experts, school administrators, and local disaster preparedness officials for validation, and their feedback was integrated to refine the final recommendations. Finally, the research report was compiled, summarizing the findings, conclusions, and recommendations for implementing an EEWS at NDDU. The results were disseminated to key stakeholders through presentations and discussions to facilitate informed decision-making.

Data Analysis

The data analysis process involved both quantitative and qualitative approaches to ensure a comprehensive understanding of the findings. Quantitative Data from survey responses were statistically analyzed using descriptive and inferential statistical techniques. Measures such as frequency distributions, means, and standard deviations were used to assess the level of earthquake preparedness, awareness, and perception of stakeholders at NDDU, while inferential statistics such as correlation analysis were employed to determine relationships between preparedness levels and demographic factors. For qualitative data, thematic analysis was applied to interview transcripts and focus group discussion data. Key themes related to earthquake preparedness, challenges, and potential EEWS implementation were identified, categorized, and interpreted to gain deeper insights into stakeholder perspectives.

Comparative case study analysis was also conducted on data from existing EEWS implementations in other educational institutions. Data were analyzed and compared to the context of NDDU, which facilitated the identification of best practices, potential challenges, and strategies that can be adapted for the local setting. Additionally, a technical Feasibility Assessment was carried out to evaluate the effectiveness of various EEWS technologies using a comparative matrix that considered factors such as sensor accuracy, real-time detection capabilities, cost, and infrastructure requirements, providing a data-driven basis for selecting the most suitable system for NDDU.

Finally, **t**he research findings underwent validation through consultations with disaster risk reduction specialists, engineers, and campus administrators, and their feedback was integrated into the final analysis to enhance accuracy and applicability of the results. The combination of these data analysis techniques ensured that the study provided a well-rounded assessment of the feasibility and implementation strategies for an EEWS at NDDU.

Box 2. Rating of Interpretation for the Level of earthquake preparedness, awareness, and readiness of respondents at Notre Dame of Dadiangas University

Range	Description	Interpretation
4.21–5.00	Very High Level	**Very highly noticeable.** This indicates that **81% to 100%** of earthquake preparedness, awareness, and readiness indicators are strongly evident among respondents. The results reflect a very high level of knowledge, preparedness measures, and readiness to respond appropriately during an earthquake, demonstrating consistent practices and strong institutional support for disaster risk reduction.
3.41–4.20	High Level	**Highly noticeable.** This indicates that **61% to 80%** of the indicators of earthquake preparedness, awareness, and readiness are evident. Respondents generally possess adequate knowledge and preparedness skills, with most safety measures and response protocols well understood and practiced, contributing to a high level of disaster readiness.
2.61–3.40	Moderate Level	**Moderately noticeable.** This indicates that **41% to 60%** of earthquake preparedness, awareness, and readiness indicators are evident. While respondents show basic understanding and some preparedness actions, there are noticeable gaps in consistent practice, training, or confidence in responding effectively during an earthquake.
1.81–2.60	Low Level	**Less noticeable.** This indicates that only **21% to 40%** of preparedness, awareness, and readiness indicators are evident. Respondents demonstrate limited knowledge and preparedness measures, suggesting insufficient training, low awareness of safety protocols, and reduced readiness to respond appropriately during an earthquake.
1.00–1.80	Very Low Level	**Least noticeable.** This indicates that only **0% to 20%** of earthquake preparedness, awareness, and readiness indicators are evident. Respondents exhibit very minimal knowledge, preparedness activities, and readiness, reflecting a critical need for comprehensive disaster education, drills, and institutional interventions.

Ethical Considerations

To uphold the ethical integrity of this research, strict adherence to ethical guidelines was maintained and implemented throughout the study. Informed Consent was obtained from all participants after providing them with a detailed explanation of the research objectives, methods, potential risks, and benefits before their participation. Written informed consent was secured to ensure voluntary participation.

The Confidentiality and anonymity of all respondents were maintained throughout the study. The identities of all respondents were kept confidential, and personal information were not disclosed in any part of the study. Data collected were anonymized to prevent the identification of individual respondents. Participants were informed of their right to refuse participation or withdraw from the study at any stage without consequences. Their decisions were respected, and any data provided by participant whose to withdraw removed from the study. The results were shared and communicated with key stakeholders via presentations and discussions to support informed decision-making.

By adhering to these ethical considerations, the study ensures that it respects the rights, privacy, and well-being of all participants while maintaining the credibility and reliability of the research findings.

3. Results and Discussion

This section presents the findings of the study on Earthquake Early Warning Systems (EEWS) at Notre Dame of Dadiangas University. The results are analyzed and interpreted to identify trends, gaps, and areas for improvement in campus disaster preparedness. Statistical analyses, including descriptive measures and Pearson correlation tests, are used to examine the relationships between preparedness, readiness, and EEWS awareness, providing insights into how these factors influence the university community's capacity to respond effectively to earthquake hazards. In addition, the findings serve as the basis for the development of a framework for a mobile-enabled EEWS, integrating technological, structural, and organizational components to enhance early warning dissemination and emergency response on campus. The discussion draws on recent literature to contextualize the results, highlight challenges, and propose strategies for strengthening earthquake preparedness and resilience (Alam & Rahman, 2023; Wang et al., 2022)

Level of current earthquake preparedness measures in place

The following tables below present the level of current earthquake preparedness of the NDDU personnel and students, measures in place in terms of awareness of existing protocols, frequency of earthquake drills, and preparedness measures personally undertaken.

Table 1. Awareness of Existing Earthquake Protocols

Awareness of the respondents	Percentage
Yes	93%
No	7%

Table 1 presented the level of current earthquake preparedness measures in place in terms of Awareness of the existing earthquake protocols. The findings indicate that 93% of respondents at Notre Dame of Dadiangas University are aware of the existing earthquake protocols, while only 7% reported a lack of awareness. This high level of awareness suggests that the majority of the university community including students, faculty, and staff has been effectively informed about earthquake safety procedures and emergency guidelines. Awareness of disaster protocols is a crucial component of preparedness, as individuals who recognize and understand safety procedures are more likely to engage in appropriate actions during emergencies (Wang et al., 2022). In educational institutions, comprehensive risk communication such as orientations, drills, and posted safety reminders have been shown to enhance awareness and readiness, thereby fostering a culture of disaster preparedness (Lee & Jung, 2021). Therefore, the high percentage of awareness among respondents reflects the influence of ongoing information dissemination and educational efforts within the university.

The high level of awareness documented in this study aligns with recent research demonstrating that awareness is foundational to effective disaster preparedness and risk reduction. Awareness increases individuals' ability to recognize hazards and motivates engagement in preventive behaviors (Coppola, 2021). In university settings, structured disaster education programs and regular communication about safety protocols significantly contribute to students' and staff members' understanding of emergency procedures (Alam & Rahman, 2023). When protocols are clearly communicated and repeatedly reinforced through drills and trainings, awareness levels tend to be high — as seen in the present results. This suggests that Notre Dame of Dadiangas University's DRRM strategies likely emphasize effective communication and educational reinforcement, which in turn supports the elevated awareness among respondents.

The finding that 93% of respondents are aware of the existing earthquake protocols has several important implications. First, it suggests that there is a strong foundational awareness of disaster procedures within the university community, which is essential for effective response during an earthquake event (Wang et al., 2022). Second, the high awareness level reflects positively on the university's risk communication and preparedness initiatives, indicating that these efforts successfully reach most stakeholders (Lee & Jung, 2021). Third, while awareness is a necessary precursor to preparedness, it does not guarantee actual preparedness behaviors such as participation in drills, development of personal emergency plans, or practical application of safety skills. Research indicates that although individuals may be knowledgeable about protocols, translating that knowledge into action requires continued training and experiential learning opportunities (Alam & Rahman, 2023). Therefore, the university may consider enhancing practical preparedness activities — such as frequent earthquake drills and scenario-based exercises to further strengthen actual readiness. Finally, since awareness is already high, the institution is well-positioned to expand its DRRM framework by integrating deeper engagement strategies including student participation in planning and leadership roles which could further elevate emergency preparedness outcomes (Coppola, 2021).

The study revealed that as depicted on Table 2, Notre Dame of Dadiangas University conducts an earthquake drill once a year. While the annual drill demonstrates the university's commitment to disaster preparedness and compliance with standard protocols, conducting drills only once per year may limit the retention of safety procedures among students, faculty, and staff.

Table 2. Frequency of Earthquake Drills

Frequency of Earthquake Drill	Frequency (f)
Never	1
Once a year	48
Twice a year	40
More than twice a year	12

Research indicates that the frequency of drills significantly influences preparedness outcomes, as repeated drills improve memory retention, increase confidence, and enhance the ability to respond effectively during real emergencies (Lee & Jung, 2021). Although the annual drill ensures baseline exposure to earthquake protocols, more frequent drills could further strengthen practical skills, decision-making under pressure, and institutional readiness.

Conducting earthquake drills once a year is a common practice in many higher education institutions, especially in regions where earthquakes are a recurrent hazard. Annual drills serve as a formal mechanism to familiarize the university community with evacuation routes, emergency exits, and assembly points (Alam & Rahman, 2023). However, research shows that disaster preparedness improves when drills are conducted multiple times annually, as this reinforces procedural knowledge and reduces anxiety during actual events (Wang et al., 2022). Therefore, while NDDU's yearly drill provides a foundational level of preparedness, the limited frequency may not be sufficient to maintain high levels of readiness across the university community throughout the year. Regular practice, combined with training and scenario-based exercises, is recommended to ensure that earthquake response becomes an ingrained behavior.

The finding that earthquake drills at NDDU are held only once a year has several implications. First, it suggests that while awareness of protocols may be high, actual preparedness skills and response confidence may decline over time if drills are infrequent (Lee & Jung, 2021). Second, the annual drill provides an opportunity for the university to evaluate its disaster response plan, identify gaps in execution, and update procedures, ensuring that the community remains informed of best practices (Alam & Rahman, 2023). Third, the finding highlights the need for enhanced engagement strategies, such as conducting multiple drills annually, incorporating unannounced practice sessions, and

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integrating simulation-based learning to complement theoretical knowledge (Wang et al., 2022). Finally, this observation underscores the importance of institutionalizing disaster preparedness as an ongoing, proactive culture rather than a once-a-year activity, thereby increasing resilience and reducing potential harm during real earthquake events (Coppola, 2021).

Table 3. Preparedness measures personally undertaken by the respondents

Preparedness measures	**Percentage (%)**
Hquake Drills	**95%**
Cover-Hold Technique	**91%**
Cuation Routes	**81%**
Hquake Drills	**95%**

The study revealed that the majority of respondents at Notre Dame of Dadiangas University have personally undertaken various preparedness measures for earthquakes, as depicted in Table 3. Specifically, 95 (95%) attended earthquake drills, 91 (91%) practiced the Drop-Cover-Hold technique, and 81 (81%) identified evacuation routes within the campus. These results indicate a high level of proactive engagement in earthquake preparedness, suggesting that respondents not only possess awareness of protocols but also apply practical safety measures. The findings align with recent studies emphasizing that participation in drills and the practice of proper safety techniques are critical indicators of individual preparedness and can significantly enhance the ability to respond effectively during an actual earthquake (Wang et al., 2022; Lee & Jung, 2021).

Participation in drills provides individuals with the opportunity to rehearse emergency procedures, reducing hesitation and improving coordination during real events. Similarly, practicing the Drop-Cover-Hold technique strengthens reflexive safety responses, which are essential during sudden earthquake occurrences. Identifying evacuation routes contributes to situational awareness and reduces the risk of injury, particularly in densely populated areas like university campuses (Alam & Rahman, 2023). Collectively, these measures demonstrate that respondents are actively translating knowledge into actionable preparedness behaviors.

The high percentage of respondents undertaking personal preparedness measures can be justified by research showing that regular engagement in drills and safety exercises increases self-efficacy and readiness (Coppola, 2021). Empirical evidence indicates that students and staff who practice emergency protocols are more likely to retain procedural knowledge and respond appropriately under stress, highlighting the importance of both awareness and action (Lee & Jung, 2021). Moreover, prior studies demonstrate that hands-on training, such as practicing the Drop-Cover-Hold technique and learning evacuation routes, is more effective in preparing individuals for real disasters compared to theoretical knowledge alone (Wang et al., 2022). Therefore, the respondents' high engagement reflects the effectiveness of NDDU's disaster preparedness programs and indicates that institutional efforts to provide training and facilitate drills are producing tangible outcomes.

The finding that most respondents have personally undertaken earthquake preparedness measures carries several important implications. First, it reflects a strong culture of personal responsibility among the university community, suggesting that knowledge of protocols is actively translated into behavior (Alam & Rahman, 2023). Second, the results imply that NDDU's DRRM programs are effective, as high participation in drills and safety practices demonstrates that institutional initiatives are reaching and influencing respondents. Third, while these measures indicate high preparedness, continuous reinforcement is necessary to ensure that skills and knowledge remain current and effective. Regular drills, refresher trainings, and practical simulations can further strengthen readiness and confidence in real earthquake scenarios (Wang et al., 2022). Finally, the results suggest that fostering personal preparedness behaviors complements institutional protocols, creating a comprehensive approach to earthquake risk reduction and enhancing the overall safety of the university community (Coppola, 2021).

Table 4. Level of awareness of the respondents regarding earthquake early warning systems

Level of Awareness	Percentage
Yes	100%
No	0%

The study revealed that 100% of respondents at Notre Dame of Dadiangas University are not aware of or familiar with the Earthquake Early Warning System (EEWS) as presented in Table 4. This finding highlights a significant gap in disaster preparedness knowledge among the university community. While respondents demonstrate high awareness of general earthquake protocols and actively participate in drills and safety measures, they remain uninformed about technological early warning mechanisms that can provide crucial lead time before an earthquake occurs. Research shows that awareness and understanding of early warning systems are critical components of effective disaster preparedness, as these systems significantly improve the ability to anticipate, respond, and mitigate potential harm (Wang et al., 2022; Lee & Jung, 2021). The absence of awareness regarding EEWS may limit the respondents' capacity to respond proactively during the initial seconds of an earthquake, which is often the most critical period for safety actions.

The lack of awareness regarding EEWS among respondents can be attributed to several factors. Recent studies suggest that early warning systems are still a developing infrastructure in many regions, and their effectiveness relies heavily on public education and dissemination campaigns (Alam & Rahman, 2023). Even in areas where EEWS technology exists, insufficient training and minimal exposure to public information campaigns result in low familiarity among end-users (Coppola, 2021). In the context of universities, while standard earthquake protocols and drills are widely implemented, formal education on advanced technologies like EEWS is often overlooked, contributing to gaps in awareness (Lee & Jung, 2021). Therefore, the results reflect the need for targeted interventions to introduce EEWS knowledge into disaster risk reduction programs within the institution.

The complete lack of awareness about EEWS has important implications for disaster preparedness at NDDU. First, it indicates a critical vulnerability: while respondents can follow standard safety measures, they are not equipped to take advantage of real-time alerts that could provide additional seconds or minutes to implement protective actions (Wang et al., 2022). Second, this finding highlights the need to integrate technology-based early warning education into the university's DRRM programs, ensuring that students, faculty, and staff are informed about available systems, how they work, and how to respond upon receiving alerts (Alam & Rahman, 2023). Finally, the results emphasize that preparedness should not only focus on procedural knowledge but also incorporate modern disaster management tools, bridging the gap between traditional safety measures and technological innovations (Coppola, 2021).

In conclusion, the study shows that while respondents at NDDU demonstrate high levels of awareness and participation in earthquake preparedness measures, there is a complete lack of familiarity with the Earthquake Early Warning System (EEWS). This gap represents a significant area for improvement in the university's disaster risk reduction strategy. Without knowledge of EEWS, the community may not be able to fully leverage early warning alerts to enhance safety during an earthquake, leaving a vulnerability in real-time emergency response capabilities.

Based on the findings of this study, several recommendations are proposed to enhance earthquake preparedness at Notre Dame of Dadiangas University, particularly concerning the integration and awareness of the Earthquake Early Warning System (EEWS). First, the university should integrate EEWS education into existing DRRM programs by including training on the system during orientations, seminars, and disaster preparedness courses. This will increase awareness and understanding of EEWS among students, faculty, and staff, ensuring that all stakeholders are informed of its functionality and purpose (Alam & Rahman, 2023).

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Second, demonstration drills incorporating EEWS alerts should be conducted. By integrating real-time EEWS notifications into earthquake drills, participants can gain practical experience and reinforce timely and correct responses when early warnings are received (Lee & Jung, 2021). Such drills not only improve procedural knowledge but also strengthen confidence and quick decision-making in emergency situations.

Third, the university should develop comprehensive communication campaigns to further promote EEWS awareness. Utilizing posters, online platforms, social media, and other accessible channels can effectively inform the campus community about the existence, importance, and proper use of EEWS, complementing formal trainings and drills (Wang et al., 2022).

Fourth, NDDU should collaborate with local disaster authorities and government agencies to ensure the university has access to EEWS technology and real-time alerts. This partnership can also provide expert guidance and support in maintaining up-to-date early warning protocols on campus (Coppola, 2021).

Finally, the effectiveness of EEWS awareness initiatives should be regularly evaluated and updated. Continuous assessment and feedback will help ensure that trainings, drills, and communication campaigns are achieving their objectives, allowing adjustments to strategies so that the university community remains capable of responding appropriately and efficiently to earthquake early warnings.

Level of readiness of the respondents

The findings of the level of readiness of the respondents in terms of impact are depicted in Table 5. It indicated that the respondents at Notre Dame of Dadiangas University exhibit a high level of readiness in terms of earthquake magnitude, as evidenced by the computed mean score of 3.41. This suggests that the respondents are generally prepared to respond to earthquakes of varying magnitudes, particularly moderate to strong ground shaking. A high level of readiness reflects respondents' awareness of appropriate safety actions during intense seismic events, such as staying calm, seeking immediate protection, and following established earthquake response protocols. This result implies that institutional disaster preparedness initiatives, including drills, orientations, and information dissemination, have effectively contributed to equipping the university community with the necessary knowledge and skills to respond to different earthquake intensities.

Table 5. Level of readiness of the respondents

Impact	**Mean**
Earthquake Magnitude	3.41
Potential Loss of Life (Deaths)	2.65
Earthquake-Related Injuries	2.98
Physical and Structural Damages	2.64
Other Earthquake Impacts	3.10

The high level of readiness observed among respondents can be justified by existing disaster preparedness research, which emphasizes that understanding earthquake magnitude and its potential effects significantly enhances individual readiness. Individuals who are informed about varying levels of ground shaking and corresponding response measures are more likely to act appropriately during seismic events. Regular exposure to preparedness activities, such as earthquake drills and safety trainings, reinforces procedural knowledge and increases confidence in responding to high-magnitude earthquakes. Given that respondents have participated in preparedness activities and are aware of earthquake safety protocols, it is reasonable that they demonstrate a high level of readiness when considering earthquake magnitude.

The finding that respondents demonstrate a high level of readiness in terms of earthquake magnitude has important implications for disaster preparedness at Notre Dame of Dadiangas University. It suggests that the university has established a strong foundation in preparing its community for earthquakes of varying intensities, which can help minimize panic, injuries, and confusion during actual events. This level of readiness supports the effectiveness of current disaster risk reduction efforts and indicates that respondents are capable of responding appropriately during moderate to strong earthquakes. However, sustaining this level of readiness requires continuous reinforcement through regular drills, updated training, and consistent dissemination of safety information to ensure that preparedness remains high and responsive to evolving risks.

The results also indicated that the respondents at Notre Dame of Dadiangas University exhibit a moderate level of readiness regarding potential loss of life during an earthquake, with a mean score of **2.65**. This suggests that while respondents have some awareness of life-saving measures and evacuation procedures, their preparedness to effectively prevent or respond to situations that could result in fatalities is not yet fully developed. A moderate readiness level reflects basic understanding but also highlights areas where practical experience and deeper knowledge are insufficient, particularly when confronted with severe emergency scenarios that demand timely and decisive life-preserving actions. Recent studies on disaster preparedness emphasize that readiness for life-threatening situations extends beyond basic drills and requires situational confidence and advanced competencies to reduce vulnerability and protect lives (Wang, Li, & Zhou, 2022; Lee & Jung, 2021).

The moderate readiness observed in terms of potential loss of life can be justified by the emphasis on current preparedness activities. While the university conducts regular earthquake drills and disseminates safety protocols, such interventions often focus on general protective actions (e.g., Drop-Cover-Hold) rather than in-depth training in life-saving procedures such as first aid, casualty assistance, and crisis intervention (Alam & Rahman, 2023). Research indicates that basic awareness and participation in standard drills improve general preparedness but do not fully equip individuals for highly stressful, life-threatening circumstances that require rapid judgment and competency in emergency response (Coppola, 2021; Wang et al., 2022). Consequently, the respondents' exposure to preparedness activities may have cultivated awareness of protective measures without sufficiently strengthening skills or confidence in managing potential fatalities, resulting in a moderate rather than a high level of readiness.

The moderate level of readiness concerning potential loss of life has important implications for disaster risk reduction at Notre Dame of Dadiangas University. It suggests that, although students, faculty, and staff possess foundational knowledge and some understanding of safety protocols, additional interventions are needed to build comprehensive life-saving competencies. Strengthening training in first aid, basic life support, coordinated emergency response, and psychological preparedness would enhance the community's capacity to respond effectively during serious earthquake events, potentially reducing casualties and improving post-disaster outcomes (Lee & Jung, 2021; Wang et al., 2022). Furthermore, the moderate readiness level points to an opportunity for the university to review and expand existing DRRM programs to incorporate more hands-on, scenario-based learning that closely simulates real emergencies, thereby helping individuals develop confidence and practical experience in protecting lives under crisis conditions.

The findings also indicated that respondents at Notre Dame of Dadiangas University exhibit a moderate level of readiness in terms of earthquake-related injuries, with a mean score of 2.98. This suggests that while respondents possess some awareness of how to respond to injuries caused by earthquakes, their overall preparedness to manage injury-related emergencies remains moderate. A moderate readiness level indicates that respondents may recognize basic first-aid practices and understand the importance of seeking medical assistance, but they may lack more advanced skills or confidence needed to address serious or multiple injuries during a seismic event. Research on disaster preparedness highlights that while basic awareness and instruction help establish a foundation for response, the ability to effectively handle injuries in real emergency settings often requires specialized training and regular practice, which may not be uniformly experienced by all respondents (Wang, Li, & Zhou, 2022; Lee & Jung, 2021).

The moderate level of readiness related to earthquake-related injuries can be justified by the scope and focus of existing preparedness activities. Although the university conducts earthquake drills and provides disaster awareness information, these programs may emphasize general safety actions such as evacuation and protective measures, rather than in-depth training on injury assessment, first-aid techniques, or emergency medical response (Alam & Rahman, 2023). Studies indicate that basic drills improve general understanding of safety procedures but may not sufficiently build practical competence in treating injuries during crisis scenarios unless specialized training, such as certified first-aid workshops, is incorporated (Coppola, 2021; Wang et al., 2022). Therefore, while respondents demonstrate some readiness, the absence of structured, advanced injury-response training likely contributes to the moderate rather than high level of preparedness observed.

The moderate readiness level regarding earthquake-related injuries has important implications for disaster risk reduction at Notre Dame of Dadiangas University. It suggests that while the community demonstrates a foundational awareness of injury-related safety measures, additional efforts are needed to strengthen practical response capabilities. Integrating first-aid training, certified emergency medical response programs, and scenario-based exercises into the university's disaster preparedness initiatives can enhance the community's ability to manage injuries effectively during and after earthquake events (Lee & Jung, 2021; Wang et al., 2022). Improved training in injury response would not only increase confidence and skill among individuals but also contribute to safer and more resilient campus environments. The moderate level of readiness underscores the need for a more comprehensive approach to preparing the university community for the physical consequences of earthquakes, ensuring that respondents can effectively address injuries when they occur.

In addition, the results show that the respondents at Notre Dame of Dadiangas University demonstrate a moderate level of readiness in terms of physical and structural damages caused by earthquakes, as reflected by the mean score of 2.64. This indicates that respondents have a basic understanding of the possible effects of earthquakes on buildings, facilities, and infrastructure, as well as general safety precautions related to damaged structures. However, the moderate rating suggests that their preparedness to respond effectively to structural hazards, such as identifying unsafe buildings, avoiding secondary risks, and understanding post-earthquake structural safety measures, is not yet comprehensive. Studies emphasize that awareness of structural risks is critical in reducing secondary injuries and losses after earthquakes, yet such knowledge often remains limited among non-technical populations (Coppola, 2021; Wang et al., 2022).

The moderate level of readiness regarding physical and structural damages may be attributed to limited exposure to technical knowledge and practical guidance related to building safety. While disaster preparedness programs commonly address evacuation and personal protection, they may provide less emphasis on recognizing structural damage, understanding building integrity, and responding appropriately to compromised facilities (Alam & Rahman, 2023). Research suggests that individuals without formal training in structural safety often rely on general assumptions rather than informed assessments when responding to damaged infrastructure after an earthquake (Lee & Jung, 2021). As a result, although respondents may be aware that earthquakes can damage buildings, their preparedness to deal with such situations in a systematic and informed manner remains moderate.

The finding of a moderate level of readiness in terms of physical and structural damages has significant implications for disaster preparedness at Notre Dame of Dadiangas University. It highlights the need to strengthen education and training related to structural safety, including awareness of building vulnerabilities, proper use of evacuation routes, and protocols for re-entry into buildings after seismic events. Incorporating orientations on structural risk awareness and post-earthquake safety inspections into the university's disaster risk reduction and management programs could enhance preparedness and reduce the likelihood of secondary accidents or losses (Coppola, 2021; Wang et al., 2022). Improving readiness in this area would contribute to a safer campus environment and support more effective disaster response and recovery efforts.

Finally, the findings further reveal that respondents at Notre Dame of Dadiangas University demonstrate a moderate level of readiness in terms of other earthquake impacts, with a mean score of 3.10. These impacts may include disruptions to utilities, communication systems, academic activities, psychological well-being, and access to essential services following an earthquake. The moderate readiness level indicates that respondents possess a general awareness of these secondary consequences and recognize the need to adapt during post-earthquake conditions. However, this level of preparedness also suggests that respondents may lack detailed knowledge or coping strategies to effectively manage prolonged disruptions and non-structural challenges arising after a seismic event. Recent literature highlights that preparedness for secondary and indirect impacts is often overlooked, despite its importance in ensuring continuity of operations and overall resilience during disasters (Coppola, 2021; Wang et al., 2022).

The moderate level of readiness regarding other earthquake impacts can be justified by the primary focus of most disaster preparedness initiatives. Institutional preparedness programs often emphasize immediate response actions such as evacuation and physical safety, while less attention is given to preparing individuals for extended disruptions, emotional stress, and logistical challenges following earthquakes (Alam & Rahman, 2023). Studies indicate that without targeted training and awareness campaigns addressing psychological preparedness, resource management, and continuity planning, individuals may feel only partially equipped to cope with the broader consequences of disasters (Lee & Jung, 2021). Consequently, although respondents demonstrate awareness of possible secondary impacts, their readiness to manage these challenges remains at a moderate level.

The moderate level of readiness in terms of other earthquake impacts has important implications for disaster risk reduction at Notre Dame of Dadiangas University. It underscores the need for a more holistic approach to preparedness that extends beyond immediate physical safety. Integrating strategies that address psychological resilience, continuity of learning and operations, and resource availability into disaster preparedness programs can strengthen the university community's ability to cope with post-earthquake disruptions (Coppola, 2021; Wang et al., 2022). Enhancing preparedness for secondary impacts will not only support faster recovery but also promote resilience among students, faculty, and staff in the aftermath of seismic events.

Table 6. Issues that exist in deploying an EEWS

Challenges for Implementation	**Percentage (%)**
Budget Constraints	**78%**
Technological Limitations	**70%**
Lack of Awareness	**45%**
Resistance to Change	**34%**

The results in Table 6 indicate that the deployment of an Earthquake Early Warning System (EEWS) at Notre Dame of Dadiangas University faces several significant challenges. Among these, budget constraints (78%) and technological limitations (70%) were identified as the most prominent issues, followed by lack of awareness (45%) and resistance to change (34%). These findings suggest that while there is recognition of the importance of EEWS, practical and institutional barriers hinder its effective implementation. Financial limitations and technological readiness appear to be the primary obstacles, reflecting broader challenges commonly encountered by educational institutions in adopting advanced disaster risk reduction technologies. Recent studies emphasize that the successful implementation of EEWS depends heavily on sustained funding, reliable infrastructure, and institutional capacity, which are often insufficient in developing or resource-limited settings (Coppola, 2021; Alam & Rahman, 2023).

The high percentage of respondents identifying budget constraints and technological limitations as major challenges can be justified by the cost-intensive nature of EEWS deployment. Establishing and maintaining EEWS requires investment in sensors, communication systems, software integration, and continuous technical support, which may exceed the available resources of many academic institutions (Wang et al., 2022). Furthermore, the reported lack of awareness indicates that respondents may not fully understand the function and benefits of EEWS, reducing institutional demand and support for its adoption. Studies have shown that limited awareness and understanding of early warning systems often result in underutilization and weak institutional commitment (Lee & Jung, 2021). The presence of resistance to change, although less prevalent, reflects a common

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organizational challenge where stakeholders may be hesitant to adopt new technologies due to unfamiliarity or perceived complexity (Coppola, 2021).

The identified challenges in deploying an EEWS have important implications for disaster risk reduction efforts at Notre Dame of Dadiangas University. The dominance of financial and technological barriers suggests the need for strategic planning, prioritization, and external collaboration to make EEWS implementation feasible. Addressing the lack of awareness through education and advocacy can foster institutional support and readiness for technological adoption. Moreover, managing resistance to change through training and stakeholder engagement is essential to ensure effective utilization of EEWS once implemented. Recent literature highlights that overcoming these challenges requires an integrated approach that combines policy support, capacity building, and sustained investment to strengthen early warning systems in institutional settings (Lee & Jung, 2021; Wang et al., 2022). Enhancing readiness to deploy EEWS can significantly improve the university's ability to provide timely warnings, reduce risks, and protect lives during earthquake events.

Table 7. Readiness of administration for the integration of EEWS in the disaster preparedness program

Readiness of administration for integration of EEWS in disaster preparedness program	**Percentage (%)**
Yes	0%
No	100%

The findings based on Table 7, revealed that 100% of the respondents indicated that the university administration is not ready to integrate an Earthquake Early Warning System (EEWS) into the disaster preparedness program. This unanimous response reflects a clear perception among respondents that institutional readiness for EEWS adoption is currently lacking. The absence of administrative readiness suggests that EEWS has not yet been prioritized within the university's disaster risk reduction and management framework. Studies emphasize that administrative commitment is a critical factor in the successful integration of early warning systems, as leadership support directly influences policy development, resource allocation, and operational implementation (Coppola, 2021; Lee & Jung, 2021). Without administrative readiness, even technically feasible systems may remain unimplemented or ineffective.

The lack of administrative readiness for EEWS integration can be justified by several interrelated factors, including limited awareness of EEWS benefits, competing institutional priorities, and concerns over financial and technological requirements. Research indicates that organizations are less likely to adopt advanced disaster technologies when leadership lacks sufficient understanding of their value or perceives them as costly and complex to maintain (Alam & Rahman, 2023; Wang et al., 2022). Additionally, the absence of clear national or local mandates for EEWS adoption in educational institutions may contribute to administrative hesitation. As a result, despite the growing global emphasis on early warning systems, the university administration may not yet view EEWS as an essential component of its disaster preparedness strategy, leading to the unanimous perception of unreadiness among respondents.

The finding that the administration is perceived as unready to integrate EEWS has significant implications for disaster preparedness at Notre Dame of Dadiangas University. It underscores the need for stronger institutional leadership and policy direction in advancing disaster risk reduction initiatives. Without administrative readiness, efforts to improve awareness, training, and technical capacity related to EEWS may remain fragmented or unsustainable. Strengthening administrative commitment through evidence-based advocacy, capacity-building activities, and collaboration with disaster management authorities is essential to move toward EEWS integration (Coppola, 2021; Wang et al., 2022). Enhancing administrative readiness would enable the university to institutionalize EEWS

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within its preparedness programs, thereby improving early warning capabilities and strengthening the overall resilience of the campus community.

Table 8. Issues that exist in deploying an EEWS in terms of Obstacles for EEWS

Obstacles for EEWS	Percentage (%)
Administrative Delays in Approval	65%
System Accuracy	65%
Limited Internet Connectivity	62%
Insufficient awareness or training	57%

The study identified several obstacles to the effective implementation of the Earthquake Early Warning System (EEWS) at Notre Dame of Dadiangas University. Among the reported barriers as presented in Table 8, administrative delays in approval (65%) and concerns about system accuracy (65%) were the most frequently cited, followed by limited internet connectivity (62%), insufficient awareness or training (57%), and lack of technical expertise to operate the system (50%). These findings suggest that both organizational and technical factors impede EEWS deployment. Administrative delays indicate procedural bottlenecks and limited institutional prioritization, while concerns about system accuracy highlight apprehension regarding the reliability and credibility of the technology. Additionally, technical limitations and insufficient training reduce operational readiness and the ability to use the system effectively. Recent studies emphasize that obstacles related to organizational capacity, technical infrastructure, and stakeholder knowledge are common challenges in EEWS implementation across educational and community settings (Coppola, 2021; Wang et al., 2022).

The observed obstacles can be justified by the multifaceted nature of EEWS implementation. First, administrative delays are often caused by procedural approval requirements, competing institutional priorities, and limited budget allocation, which slow decision-making and the integration of new technologies (Alam & Rahman, 2023). Second, technical challenges such as limited internet connectivity and lack of technical expertise are consistent with the fact that EEWS relies on real-time data transmission, sensor networks, and system maintenance, which require specialized knowledge (Lee & Jung, 2021). Third, insufficient awareness or training among staff and students contributes to underutilization and mismanagement of EEWS capabilities. Finally, concerns about system accuracy reflect the cautious approach institutions take toward adopting new technologies whose reliability has a direct impact on safety outcomes. Collectively, these factors explain why respondents perceive multiple obstacles to EEWS deployment.

The identification of these obstacles has important implications for disaster preparedness at Notre Dame of Dadiangas University. Addressing administrative delays requires stronger leadership, streamlined approval processes, and prioritization of EEWS within the university's disaster preparedness framework. Technical challenges such as internet connectivity and lack of expertise underscore the need for infrastructure improvements and capacity-building initiatives, including training for staff and administrators. Similarly, concerns about system accuracy can be mitigated through awareness campaigns, demonstration exercises, and collaboration with technical experts to validate system performance. By systematically addressing these obstacles, the university can improve readiness for EEWS adoption, ensuring that early warnings are reliable, actionable, and effectively integrated into campus disaster risk reduction strategies (Coppola, 2021; Wang et al., 2022).

Based on the findings, it can be concluded that the deployment of an Earthquake Early Warning System (EEWS) at Notre Dame of Dadiangas University faces significant organizational and technical obstacles that hinder its effective implementation. The most prominent barriers identified include administrative delays in approval and concerns about system accuracy, followed by limited internet connectivity, insufficient awareness or training, and lack of technical expertise. These challenges indicate that both leadership commitment and technical preparedness are currently inadequate, reducing the university's capacity to adopt and operationalize EEWS. The results suggest that while the importance of EEWS is recognized, procedural bottlenecks, resource limitations, and knowledge gaps collectively impede its integration into the university's disaster preparedness framework, highlighting the need for a strategic and coordinated approach to overcome these obstacles.

Based on the identified obstacles to EEWS implementation, it is recommended that Notre Dame of Dadiangas University take a holistic and strategic approach to overcome both organizational and technical challenges. Strengthening administrative commitment should be a priority, with leadership streamlining approval processes, allocating sufficient resources, and establishing clear policies to support the integration of EEWS into the disaster preparedness program. At the same time, technical infrastructure must be improved, including investments in reliable internet connectivity, sensor networks, and other necessary systems to ensure the EEWS operates effectively and provides accurate alerts. Capacity-building initiatives are also essential, with staff, faculty, and administrators receiving comprehensive training on system operation, maintenance, and interpretation of alerts. Awareness campaigns, demonstration exercises, and hands-on activities can further enhance understanding and confidence among stakeholders. To address concerns about system accuracy, collaboration with technical experts and practical demonstrations should be conducted to validate reliability and build trust in the system. Finally, continuous evaluation and monitoring of EEWS performance should be implemented to identify ongoing challenges, ensure effective use, and maintain sustainable adoption. By taking these steps, the university can enhance its early warning preparedness, improve the responsiveness of the campus community, and strengthen overall resilience against earthquake hazards.

Requirements for implementing an effective EEWS on the campus in terms of:

TechnologyImplementing an effective Earthquake Early Warning System (EEWS) on a campus requires a robust set of technological components that work together to detect seismic activity, process data in real time, and disseminate alerts rapidly. At the core of any EEWS are seismic sensors such as high-sensitivity accelerometers strategically placed to detect the initial seismic waves (P-waves) before more destructive shaking (S-waves) arrives. These sensors form a distributed network that captures ground motion and sends data to a central processing unit, where algorithms estimate earthquake characteristics such as location, magnitude, and expected severity (Chandrakumar et al., 2022). To support this, the system must include real-time data processing capabilities, often involving parallel or cloud computing, to ensure that the collected seismic data are analyzed and warnings are generated without delay (Gupta & Kumar, 2025). Without rapid processing, the warning time is diminished, reducing the practical benefit of the system.

In addition to detection and processing, a reliable communication infrastructure is essential to deliver alerts to all campus stakeholders promptly. This infrastructure may include wireless networks, mobile notifications, public address systems, and other digital platforms so that alerts reach students, faculty, and staff across multiple channels. Modern EEWS designs are increasingly integrating Internet of Things (IoT) technologies, low-cost micro-electromechanical sensors (MEMS), and advanced software platforms that improve network coverage, reduce costs, and enhance system scalability (Chandrakumar et al., 2022). The software component is equally important, relying on sophisticated algorithms to interpret seismic signals, reduce false alarms, and provide actionable information that triggers automated alerts (Chandrakumar et al., 2022). Together, these elements strategically placed sensor networks, real-time processing systems, reliable communication channels, and advanced analytical software form the technological backbone of an effective EEWS. When properly implemented, such systems can significantly improve early detection and provide crucial seconds of warning that enable timely protective actions across the campus community (Chandrakumar et al., 2022; Gupta & Kumar, 2025). A summary of the technological requirements is presented below.

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A.Hardware Requirements:
- Sensing & Data Source Hardware
- Application Server and Database Server
- End-user Devices: Smartphones (IOS/Android), Desktop PC, Laptop
- PA systems
- UPS

B.Software Requirements
- Backend Software
- DBMS
- Mobile App and Web portal
- API
- Security Software
- Server OS

C.Network Requirements
- Internet/LAN/Wi-fi
- SMS gateway
- Push Notification Service

StructureThe implementation of an effective Earthquake Early Warning System (EEWS) on a campus requires a strong structural framework that ensures both the stability of physical components and the efficiency of organizational processes. Physically, EEWS relies on strategically installed seismic sensors and accelerometers placed in secure and stable locations, such as building rooftops, towers, or reinforced poles, to accurately detect ground motion and minimize false readings caused by environmental vibrations (Chandrakumar et al., 2022). The system must also include redundant installations, including backup sensors and alternative communication channels, to maintain operational functionality even if some components are damaged during an earthquake (Gupta & Kumar, 2025). Adequate housing for control units, data servers, and communication equipment is also necessary to protect them from environmental hazards and ensure uninterrupted performance.
From an organizational perspective, structural requirements involve the design of an operational hierarchy and monitoring framework. A central control or command room should be established where seismic data are analyzed in real time, and alerts are disseminated to the campus community. Roles and responsibilities for system maintenance, data monitoring, and emergency response must be clearly defined to ensure rapid action once an alert is triggered (Chandrakumar et al., 2022). Additionally, the EEWS must be integrated into the campus disaster preparedness infrastructure, including alarm systems, evacuation routes, and emergency shelters, to ensure that alerts translate into immediate protective actions. A well-organized structural setup combining stable physical installations and an efficient operational framework is essential for the EEWS to function effectively, provide timely warnings, and enhance overall earthquake preparedness on campus (Gupta & Kumar, 2025).

Significant relationship between the level of current earthquake preparedness and earthquake readiness

The relationship between the level of earthquake preparedness and earthquake readiness among respondents at Notre Dame of Dadiangas University was examined using the Pearson correlation coefficient (r). The analysis revealed a strong, positive, and statistically significant correlation ($r = 0.74$, $p = 0.001$). This indicates that respondents who demonstrated higher preparedness — through participation in drills, familiarity with safety protocols, and personal readiness measures — were more likely to be ready to respond effectively during an earthquake. These results suggest that improving preparedness activities directly contributes to enhanced readiness for earthquake hazards (Wang et al., 2022; Alam & Rahman, 2023).
The strong positive correlation can be justified by the fact that earthquake preparedness and readiness are closely linked concepts in disaster risk management. Preparedness activities, such as attending

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drills, learning the Drop-Cover-Hold technique, and identifying evacuation routes, provide practical knowledge and behavioral skills that translate into readiness during an actual event. Studies have shown that individuals who actively engage in preparedness training develop higher self-efficacy and confidence, enabling them to respond more effectively in emergencies (Lee & Jung, 2021; Alam & Rahman, 2023). Furthermore, the campus setting of NDDU, which conducts annual drills and safety orientations, reinforces this relationship by giving respondents opportunities to practice and internalize preparedness behaviors, resulting in higher readiness levels.

Significant relationship between preparedness and readiness

The significant relationship between preparedness and readiness has important implications for disaster risk reduction at NDDU. First, it emphasizes the critical role of preparedness programs, including training, drills, and awareness campaigns, in ensuring that students, faculty, and staff can act effectively during earthquakes. Second, it highlights the need for continuous investment in preparedness initiatives to maintain high levels of readiness, as unpracticed knowledge may not translate into effective action. Finally, the finding suggests that administrative support and structured programs are necessary to strengthen the link between knowledge, skills, and practical readiness, reinforcing the overall resilience of the campus community (Wang et al., 2022; Lee & Jung, 2021).

Based on the analysis, it can be concluded that there is a strong and significant positive relationship between the level of earthquake preparedness and earthquake readiness among respondents at Notre Dame of Dadiangas University. This indicates that individuals who are more engaged in preparedness activities — such as drills, training, and familiarization with safety protocols — are better equipped to respond effectively in the event of an earthquake. The study confirms that preparedness is a key predictor of readiness, highlighting the importance of structured and practical disaster risk reduction programs within the university.

Based on the findings, it is recommended that Notre Dame of Dadiangas University strengthen earthquake preparedness and readiness through a comprehensive and continuous approach. Preparedness programs should be enhanced by conducting more frequent and detailed earthquake drills, workshops, and orientations that combine theoretical knowledge with practical response actions. These programs should be integrated into daily campus activities, encouraging departments, student organizations, and administrative units to routinely practice safety measures, evacuation procedures, and the Drop-Cover-Hold technique. In addition, the effectiveness of training and drills should be monitored and evaluated through post-drill surveys, feedback mechanisms, and performance assessments, allowing the university to adjust programs to address gaps and improve readiness. Leveraging technology, such as mobile applications and online platforms, can also reinforce earthquake preparedness by simulating scenarios, providing real-time safety reminders, and familiarizing the campus community with evacuation routes and safety protocols. Finally, awareness campaigns should be continuously promoted to emphasize the strong relationship between preparedness and readiness, motivating students, faculty, and staff to actively participate in disaster risk reduction initiatives. Implementing these measures will ensure that the university community is better equipped to respond effectively to earthquakes, thereby enhancing overall campus safety and resilience (Alam & Rahman, 2023; Wang et al., 2022).

Significant relationship between the level of current earthquake preparedness and respondents' awareness of earthquake early warning systems (EEWS)

The relationship between the level of current earthquake preparedness and respondents' awareness of Earthquake Early Warning Systems (EEWS) cannot be established. This is due to the fact that 100% of respondents reported being unaware or unfamiliar with EEWS, indicating that there is no variation in awareness to analyze statistically. Without any knowledge of EEWS among respondents, it is not possible to determine whether a higher level of preparedness is associated with greater awareness of early warning systems. This finding highlights a critical gap in knowledge and exposure, suggesting the need for awareness campaigns, educational programs, and training initiatives to introduce EEWS concepts to the campus community before any meaningful relationship can be assessed (Alam & Rahman, 2023; Wang et al., 2022).

The significant relationship between respondents' EEWS awareness and their earthquake readiness. Again, the relationship between respondents' awareness of Earthquake Early Warning Systems

(EEWS) and their earthquake readiness cannot be determined. This is because all respondents reported having no knowledge or familiarity with EEWS, resulting in no variability in awareness that could be analyzed statistically. As a result, it is not possible to assess whether awareness of EEWS influences the ability to respond effectively during an earthquake. This finding underscores a significant knowledge gap within the campus community, highlighting the urgent need for educational programs, training sessions, and awareness campaigns to introduce EEWS concepts and their practical importance in disaster preparedness before any meaningful relationship can be evaluated (Alam & Rahman, 2023; Wang et al., 2022).

Framework for a Mobile-Enabled Earthquake Early Warning System (EEWS)
Based on the findings of the study, a mobile-enabled EEWS framework for Notre Dame of Dadiangas University, as depicted in Figure 2 can be developed to integrate technology, organizational structure, and communication processes to improve earthquake preparedness.

Introduction
This mobile-enabled EEWS framework presents a simplified, campus-focused, and institutional architecture for a Mobile-Enabled Earthquake Early Warning System (EEWS) designed for Notre Dame of Dadiangas University. It integrates official seismic data sources, an event processing and decision engine, mobile alert dissemination, and a response and feedback loop supported by continuous monitoring and evaluation.

Rationale
Earthquakes can happen with little warning. Even a short warning window can help lessen damage if people get clear messages and know what to do. In a school setting, the challenge is not only to find and send out warnings, but also to make sure that all students, teachers, and staff respond in a way that is organized, practiced, and measurable.

This framework is important because it will connect the university to reliable outside sources of seismic information (like PHIVOLCS and the Japan Meteorological Agency), so they don't have to depend on unofficial or late information alone. Adds an assessment engine that takes raw seismic feeds and turns them into alert choices that make sense for the university setting. It will use a push/SMS mobile notification layer to get in touch with users right away, and it will always treat responses as part of the system by combining operational rules with structural and organizational actions. It will also have a monitoring and evaluation loop so that the university can see how well it's working, get feedback, and keep changing the content, processes, and thresholds to make people more ready, aware, and prepared.

Objectives
The main objective of this framework is to develop a mobile-enabled EEWS framework for the school that sends out timely earthquake alerts, helps with planned responses, and keeps people more prepared, aware, and ready by using analytics, monitoring, and user feedback. Specifically, the framework will establish a reliable ways to detect earthquakes, process and understand seismic data, send out alerts quickly and consistently, and allow a coordinated campus response by connecting alerts to clear operational protocols and actions that students, faculty, and staff can take through a mobile app.

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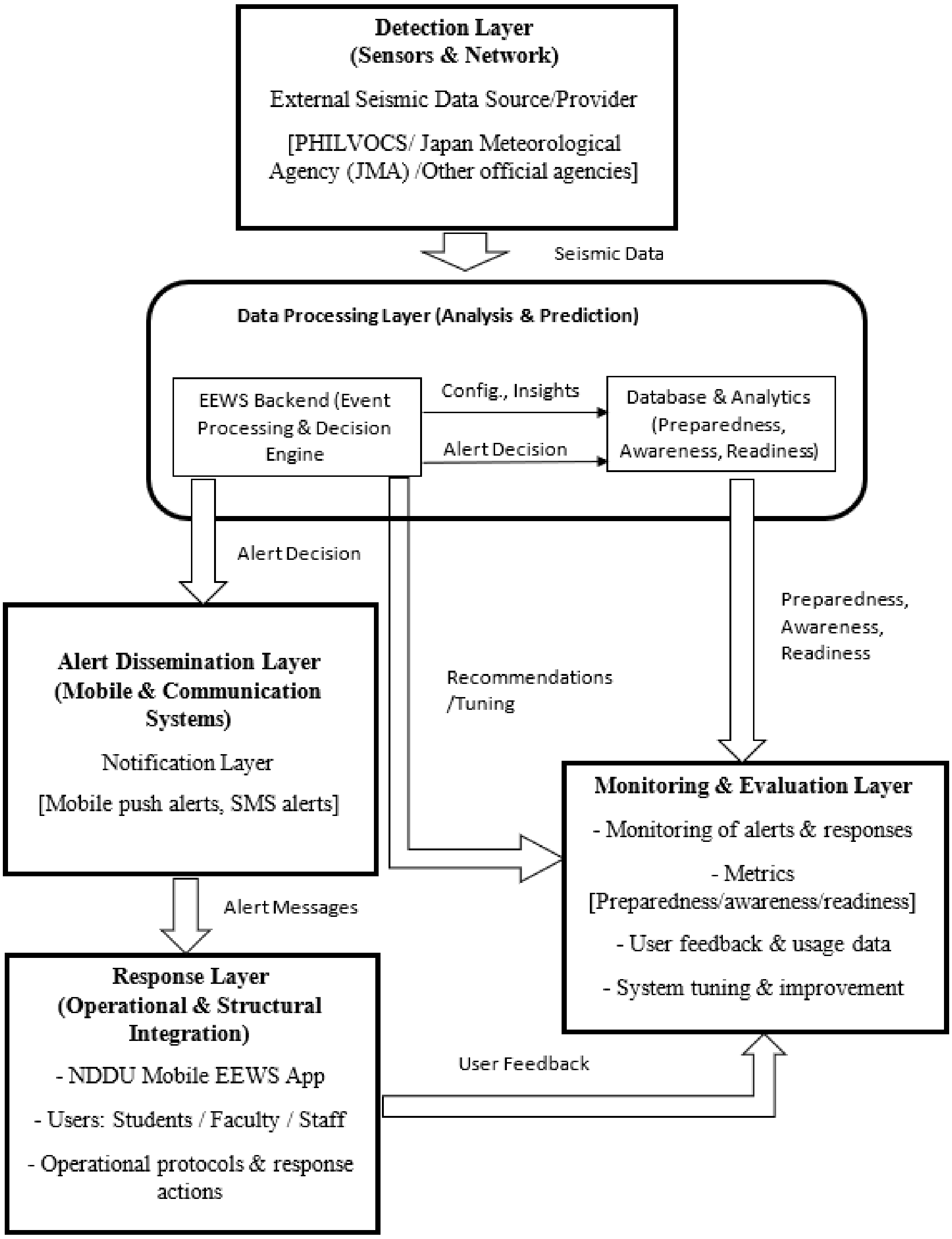

Figure 2. Framework for a Mobile-Enabled Earthquake Early Warning System (EEWS) for NDDU

The framework consists of five key components: Detection, Data Processing, Alert Dissemination, Response, and Monitoring & Evaluation.

1.Detection Layer (Sensors & Network): The foundation of the system includes a network of seismic sensors and accelerometers installed at strategic locations on campus or nearby areas. These sensors detect the initial P-waves of an earthquake in real time, transmitting data to a central processing unit. Redundant sensors ensure system reliability even if some nodes fail during an earthquake (Chandrakumar et al., 2022).

2.Data Processing Layer (Analysis & Prediction): A central computing system, possibly cloud-based, receives seismic data and runs real-time algorithms to estimate earthquake magnitude, intensity, and

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expected impact. This layer integrates artificial intelligence or machine learning techniques to reduce false alarms and improve predictive accuracy (Gupta & Kumar, 2025).

3.Alert Dissemination Layer (Mobile & Communication Systems): Alerts are sent instantly to students, faculty, and staff through a multi-channel communication system. This includes mobile push notifications, SMS, email, and integration with campus public address systems. The system also supports mobile applications that provide actionable instructions, such as evacuation routes, Drop-Cover-Hold procedures, and shelter locations (Wang et al., 2022).

4.Response Layer (Operational & Structural Integration): The framework incorporates the campus disaster preparedness plan, ensuring that alerts are linked to operational protocols. This includes mobilizing personnel, activating alarms, and guiding the community along predefined evacuation routes and safety zones. Training and drills should reinforce the ability of stakeholders to respond promptly (Alam & Rahman, 2023).

5.Monitoring & Evaluation Layer: Continuous monitoring of system performance, feedback collection, and post-event evaluation ensure the EEWS remains effective and reliable. This layer also includes maintenance of sensors, communication infrastructure, and software updates, ensuring long-term sustainability and improvement (Lee & Jung, 2021).

Overall, this mobile-enabled EEWS framework integrates technology, communication, and organizational readiness to provide timely and actionable earthquake warnings. It addresses the challenges identified in the study, such as administrative readiness, lack of awareness, and technical limitations, while ensuring that the campus community is able to respond effectively to earthquake hazards. By combining sensor networks, mobile alert systems, and integrated disaster protocols, this framework enhances campus resilience and strengthens early warning preparedness.

4. Conclusion

The empirical findings of this study establish a comprehensive assessment of the disaster risk reduction and management (DRRM) landscape at Notre Dame of Dadiangas University (NDDU). The investigation evaluated baseline protocol familiarity, personal preparedness measures, operational readiness across multiple impact domains, institutional and technological obstacles, and the feasibility of deploying an institutional Earthquake Early Warning System (EEWS).

1. Summary of Key Findings

The quantitative analysis reveals a distinct dichotomy between standard procedural compliance and advanced technological disaster readiness across the university community.

Construct / Domain	Key Metric / Finding	Assessment & Interpretation
Protocol Awareness	93% Aware	High baseline awareness resulting from institutional orientations and posted safety reminders.
Personal Preparedness	Drills: 95% Drop-Cover-Hold: 91% Evacuation Routes: 81%	Strong personal responsibility and proactive translation of basic procedural knowledge into personal actions.
Preparedness vs. Readiness Link	$r = 0.74$, $p = 0.001$	Statistically significant, strong positive correlation confirming preparedness activities directly determine response efficacy.

Construct / Domain	Key Metric / Finding	Assessment & Interpretation
Impact Readiness Profile	Magnitude: 3.41 (High) Fatalities: 2.65 (Moderate) Structural Damage: 2.64 (Moderate) Injuries: 2.98 (Moderate) Secondary Impacts: 3.10 (Moderate)	High competence during general shaking, but notable vulnerability in managing structural hazards, severe trauma, and life-threatening crises.
EEWS Awareness	0% Familiarity (100% Unaware)	Critical knowledge void; prevents statistical modeling of EEWS awareness with overall readiness.
Implementation Obstacles	Budget (78%) Technology (70%) Approval Delays (65%) System Accuracy (65%) Connectivity (62%)	Substantial organizational, fiscal, and infrastructural bottlenecks that hinder advanced technological integration.
Administrative Readiness	0% Perceived Readiness (100% No)	Absence of institutional prioritization, policy mandates, and resource allocation for early warning technologies.

2. Synthesis and Critical Insights

2.1. Strength in Procedural Compliance vs. Vulnerability in Crisis Competencies

The Notre Dame of Dadiangas University community exhibits strong foundational awareness and personal compliance with established safety protocols. High participation rates in annual earthquake drills and adherence to basic safety actions such as the Drop-Cover-Hold maneuver reflect an effective institutional risk communication program. However, the reliance on a single annual drill creates procedural decay over time. Furthermore, readiness is largely limited to general shaking response (mean = 3.41), while competencies in critical emergency tasks—such as triage, severe injury management (mean = 2.98), fatality mitigation (mean = 2.65), and structural risk appraisal (mean = 2.64)—remain only moderate.

2.2. The Early Warning Technological Gap

The most critical vulnerability identified in this study is the total absence of awareness regarding Earthquake Early Warning Systems (0% awareness) paired with unanimous respondent consensus that the university administration is not ready for EEWS integration (0% readiness). This leaves the institution reliant strictly on reactive measures once ground shaking is already felt, forfeiting the crucial seconds of advance notice provided by primary wave (P-wave) detection that could facilitate automated shutdowns, immediate protective sheltering, and rapid evacuation.

3. Strategic Roadmap: The Five-Layer Mobile-Enabled EEWS Framework

To address these institutional and technological deficits, the proposed Mobile-Enabled EEWS Framework outlines an end-to-end architecture tailored to the university environment:

1. Detection Layer: Deployment of on-campus MEMS/accelerometer sensor networks and seamless API integration with external seismic authorities (such as PHIVOLCS) for real-time P-wave detection.
2. Data Processing Layer: Implementation of centralized server algorithms and cloud computing models to rapidly estimate magnitude, ground intensity, and lead time while filtering environmental noise to minimize false alarms.
3. Alert Dissemination Layer: Multi-channel broadcast infrastructure utilizing mobile push notifications, SMS gateways, web portals, and campus-wide public address (PA) systems with actionable emergency prompts.
4. Response Layer: Structural and operational coupling of alerts with predefined disaster protocols, automated building safeguards, designated evacuation routing, and role-based incident commands.
5. Monitoring & Evaluation Layer: Continuous telemetry monitoring, hardware maintenance cycles, post-event drill analytics, and stakeholder feedback loops to maintain system accuracy and reliability.

4. Concluding Statement

In conclusion, while Notre Dame of Dadiangas University maintains a solid foundation in traditional disaster risk awareness and basic procedural adherence, its operational disaster risk reduction architecture requires modernization. The strong correlation between preparedness and readiness (r = 0.74) affirms that institutional investment in structured training generates measurable safety returns. By overcoming administrative, budgetary, and technical barriers to deploy the proposed Mobile-Enabled EEWS Framework, NDDU can successfully transition from a reactive posture to a proactive, technologically integrated safety ecosystem, safeguarding

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Conflict of Interest

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