CRITICAL FACTORS AND BARRIERS TO THE ADOPTION AND USE OF TECHNOLOGY FOR AN EARLY WARNING SYSTEM: THE CASE OF NICARAGUA

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ABSTRACT- In the last years, Nicaragua, located in a high seismic activity area, has experienced catastrophic events related to earthquakes. Several studies have shown the value in the implementation of earthquake early warning systems (EEWS). The correct implementation of EEWSs can represent a minimization in loss of human lives, reduction of economic and social impact during natural disasters. In the last few years, EEWS technologies have improved significantly, incorporating new technologies like Big Data, the Internet of Things (IoT), or Artificial Intelligence (AI). However, studies show that implementing technology as-is without the correct understanding of its components could fail. Therefore, a correct understanding of the technology and its components is needed. This paper reviews several case studies relative to early warning systems for disaster management in the Republic of Korea and Mexico to present critical factors that improve the implementation of EEWS in Nicaragua. This study's results can help improve the understanding of success factors to adopting EEWS technology locally, developing policies and strategies to improve the implementation of EEWS in Nicaragua.

Keywords: Early Warning System, Earthquake, Emergency Response, Nicaragua, critical factors.

1. INTRODUCTION

Natural disasters represent one of the biggest problems in the world. Globally natural disasters cause severe impacts on the socio-economic system of the countries. However, prediction, warning, and mitigation improvements help to decrease natural disaster impact (Alexander, 2018). Natural disasters can be defined as some spontaneous, fast, or deep impact of the natural environment on the socio-economic system of a country. Earthquakes rank first as the most lethal among natural disasters. A study conducted by Santos and Reyes found that in the past 20 years, earthquakes had caused 56% of the deaths by natural disasters (Santos-Reyes, 2019). This is a sign that the world is in a race against time to find ways to prevent, mitigate the damage, and reduce the loss of human life caused by natural disasters. The geographic distribution of the countries also influences the type of Natural disaster that they need to afront. In the world, the zone with the highest seismic activity is known as the Pacific Ring of Fire. A zone in the shape of a horseshoe-shaped belt of 40,000 km (25,000 miles) long and up to 500 km (310 miles) wide. In this zone, 90% of the world's earthquakes (NOAA, 2021).Among these vulnerable countries to earthquakes is Nicaragua. In previous years, Nicaragua had encountered massive destructive earthquakes. The strongest event was registered in 1972 in the capital city "Managua". Around 80% of the city was destroyed. This event also generated a collapse of the economy. All public services were interrupted by two weeks. Most of the hospitals in the city disappeared as a consequence of this event. Around 10,000 human lives were lost, and

21,000 were reported injured (Jr & Muñoz, 2016). Based on the examination of the successful cases, the second purpose of this article is to provide critical success factors and examine the possible barriers in the case of Nicaragua regarding the implementation of an EEWS. In section 2, we conduct a literature review regarding the technological advance in EEWS. In section 3, we provide a case study of the Republic of Korea and Mexico relative to EEWS. To them compare it with Nicaragua's current situation in EEWS. Section 4 provides the findings of this study. In section 5, a brief discussion with recommendations, limitations, and future work for implementing EEWS are provided, and in section 6 conclusion of the study. In the last section, the references used by this article can be found.

2. LITERATURE REVIEW

2.1. Earthquake Early Warning System

A critical component of the Earthquake early warning systems (EEWS) is early warning systems (EWS). EWS is vital to reduce disaster losses, alert disaster management departments, decision-making officials, and the general population affected by a natural disaster. It provides information and helps to ensure that people are aware and prepared for evacuation, hiding, or self-protecting themselves (Zschau & Küppers, 2013). EWS is mainly composed of four components: a network of sensors for observation of natural disasters, telecommunication systems for real-time data collection and transmission, a system for the data processing, analysis, diagnostics, and forecasting or warnings, and a system to transmit and disseminate warnings (Zschau & Küppers, 2013).In earthquakes, EWS allows the detection of events in real-time; sensors detect the primary waves (P waves) and secondary waves (S Waves). P waves are transmitted using radiofrequency waves that travel faster than S waves(Gemma & Carmine, 2020). This allows EWS to generate emergency alerts. The idea of implementing earthquake EWS is not new; for the first time in November 1868, JD Cooper proposed installing sensors in the area of Hollister, California, to detect earthquakes and suggested the delivery of alert notices through telegraphic signals (Gemma & Carmine, 2020)**.** Another important part of the EEWS is the Public Warning Systems (PWS). It provides information to people that can be at risk because of the Natural Disaster. However, it is important to consider that these advances have not been fully integrated into public warning systems. In earthquakes, there are no advanced methods that allow us to predict or anticipate it. Therefore, public warning systems allow us to send instant notifications at the moment of the earthquake (Sorensen, 2000). In the past 20 years, the most popular technology used in PWS has been outdoor sirens, digital mediums, and people walking through the streets with loudspeakers (known as route alerts). However, these technologies present several limitations depending on the case, for example, the area covered by route alert or attention that people have for outdoor sirens. (Sorensen, 2000). As a result, PWS has integrated cell phone message alerts as one of the options to deliver alerts. The current PWS uses a high level of mobile phone penetration to distribute alerts in emergency cases.

3. CASE RESEARCH METHODOLOGY

To explore the critical success factors and barriers. In this study, we propose to explore the current situation of the Republic of Korea and Mexico regarding EEWS.

3.1. EEWS in The Republic of Korea

The Korean Earthquake Early Warning System (KEEWS) began operations in 2015, with the main objective of detecting earthquakes of magnitude 5.0 or greater. The country presents a very robust seismic network based on the ElarmS-2 developed at the University of California, Berkeley, United States. In its first two years of implementation, the system efficiently detected earthquakes with magnitude 3.0. It detected 2016's earthquakes with a magnitude of 5.1 and 5.8. The system's goal is to send alerts within the 50s of detecting an earthquake over 5.0 (Dong-Hoon, 2017). The Korean Meteorological Administration (KMA) currently has 95 broadband seismometers, 27 short-period seismometers, and 142 accelerometers in its seismic observation network. This network was created to provide a fully automated seismic event response in the event of tsunamis or earthquakes. The network records seismic wave velocities and accelerations. It runs on its own and provides real-time data. With the help of a program called ANTELOPE, seismic waveforms are analyzed, and a report is generated automatically (Korea Meteorological Administration, n.d.). When a P wave is detected by six or more of the 150 seismometers installed in Korea, the EEWS device automatically analyzes and forecasts the estimated area of the earthquake epicenter and the magnitude of the occurrence. If strong shocks are predicted, KMA uses these projected forecasts to alert people in affected areas through television and radio. If a magnitude is greater than 5.0, an EEWS warning is given to the general public. Currently, the National Disaster Warning System in Korea is composed of 6 different modules and can alert 37.5 million users. The Government of Korea, through the Ministry of Public Safety and Security, is in charge of requesting the transmission of CBS messages in the disaster area (Jeong, 2009).

3.2. Critical success factors (CSFs)

John F. Rockart developed the concept of critical success factors in 1979. The main objective was to help area managers find key information needed for decision-makers (Rockart, 1979). Critical success factors are used to develop strategic plans, monitor activities, implement certain technology, and help to achieve high performance. In the case of Nicaragua, to determine the critical success factors needed for implementing an EEWS, and following the approach proposed by a PEST analysis, we propose critical success factors taken from successful cases of implementation of EEWS.

Table 1. Critical Success Factors for Nicaragua EEWS

DIMENSION	CRITICAL FACTOR	SOURCE
Politics	1. New policy and strategies.	(Westhead, 2012)
	2. Articulation of the legal framework.	(Westhead, 2012)
Environmental	3. Identification of the areas with the highest seismic activity.	(Santos-Reyes, 2019)
	4. Study of the soil and use of natural resources.	(Fancy et al., 2009)
	5. Geographic location and its implications	(Strauch et al., 2018)
Social	6. Training of the people who will benefit from the project.	(Santos-Reyes, 2019)
	7. Identify the cultural, educational, and characteristics of the population involved.	(Sutton et al., 2020)
Technologies	8. Identify the technology and its flaws or limitations.	(Cremen & Galasso, 2020)
	9. Accurate selection of the technology to implement	(Cuéllar et al., 2017)
	10. Adequate seismic network	(Santos-Reyes, 2019)

4. EXPECTED RESULTS

As mention in the critical success factors of section 3. It is important to consider several processes and components to develop a correct EEWS. As a result of our analysis, this study will proposed a model for

Nicaragua EEWS. This system will take into consideration the critical factors and good practices from Mexico and the Republic of Korea.

5. DISCUSSION

The correct implementation of earthquake early warning systems represents an important difference between life and death. In Nicaragua, the country only possesses a system that can monitor and store seismic activity data. As a result of this study, after seeing the benefits, barriers, limitations, and critical success factors provided by EEWS systems implemented by the Republic of Korea and Mexico, we will like to discuss the key findings that can help Nicaragua in the successful implementation of an EEWS. For a successful implementation, the country needs to have national policies that coordinate the different institutions involved in the emergency alert and response process. An Earthquake classification criteria must be established to identify which events represent a risk to the population and must be communicated to the public. It is also crucial for the permanent emergency response training of the population to determine the factor of the effectiveness of the EEWS.

6. CONCLUSION

EEWS can help reduce the number of fatalities from high-magnitude earthquakes. It has been possible to identify the ability of countries to reuse existing technology to develop systems with a high degree of efficiency. In the case of Nicaragua, the earthquake detection system is in an elementary stage. It is essential that the country focus efforts on developing an EEWS that considers the use of CBS. This needs to be considered a priority considering that the country is located in high seismic activity. In conclusion, Nicaragua presents the optimal conditions for implementing an earthquake early warning and public emergency alert system, which could positively impact the way the population responds to these emergencies.

AUTHOR CONTRIBUTIONS

This section presents the contributions made by the authors: Ms. Alina Rivas and Mr. Ronny Estrella conceived and designed the analysis utilized in this paper. Ms. Alina Rivas performed the data collection. Mr. Ronny Estrella performed the analysis of the results. Both authors work to write the paper.

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