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LLMs in the Generation of Seismic Alert Communiqués

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ABSTRACT: Peru is in the Ring of Fire, a zone of high seismic activity. Currently, alerts generated by technical-scientific entities are often bland and lack precise geographic context, resulting in alerts of limited usefulness for informing the public. In this paper, we present a conceptual model and architecture to explore the potential of Large Language Models (LLMs) to produce various forms of seismic warnings tailored to the particularities that would be required for different geographic areas of a given locality in Peru. The proposal was evaluated in a controlled environment with the participation of 47 users with diverse ethnographic characteristics. The context of the study was explained to them, and they were provided with a questionnaire designed to assess the ease of understanding, usefulness and quality of the content of the alert communications generated by an LLM. The results show that, according to the indicators assessed, seismic warnings generated by an LLM are 76% easy to understand, 81% useful and 71% acceptable quality.

Keywords: LLMs, ChatGPT, earthquake, alert, disasters, Peru.

I. INTRODUCTION

The effectiveness of seismic alerts is heavily reliant on both, their precision and relevance to affected regions. An appropriate alert saves lives, avoids injuries, and contains material damage by providing clear and detailed instructions based on the particularities of each locality [1]. In Peru, the effectiveness of seismic communication is notably limited; most alerts are too general, disregarding the singularity of the geographical regions [2]. This generalize often makes them less useful and can cause an undue level of chaos and panic in the public, as they offer a generic type of information that people in opportunities cannot understand and do not adjust to the particularities of their own context to make the right decisions [3, 4]. This research aims to fill this gap by proposing a seismic warning system that integrates region-specific data and leverages an LLM to generate clear and context-aware communications. The LLM will process information in real time and deliver messages that are not only accurate, but also easily understandable to the population, facilitating timely and informed decision making. The contribution of this study lies in the development of a more adaptable communication model that supports useful, understandable, localized and accessible messages for communities in high-risk areas, ultimately improving public safety and minimizing potential damage during seismic events.

Peru, being on the Pacific Ring of Fire, is particularly susceptible to seismic activity [5]. The different regions of the country reflect different geographic, demographic and structural characteristics of their communities, all of which can significantly influence how warnings are communicated. Since each region has its own set of risks and characteristics, a warning directed to a coastal area should not be the same as one directed to a mountainous town. The proposed system, powered by the LLM, will adapt the content of alerts according to these regional differences, ensuring that each community receives clear, relevant, and actionable information based on its unique context. By harnessing the capabilities of the LLM, this research aims to move beyond generic alert messages and offer a more localized, comprehensible, and effective communication strategy. In doing so, it seeks to contribute to the overall preparedness and resilience of Peruvian communities facing seismic threats.

The objective of this study is to explore how LLMs can be used to generate seismic warning communications adapted to different geographical contexts in Peru. To achieve this objective, we propose a conceptual model and a technological architecture. We focus on the use of the ChatGPT-4 service because of its higher degree of accuracy compared to ChatGPT-3.5 [6, 7]. In this way we produce seismic alerts that are relevant to the audience with respect to language, local context, and dissemination medium, tailoring messages to the needs and characteristics of various groups [8]. Based on this objective, the research seeks to answer the following question: How can LLMs be leveraged to generate effective and contextually relevant seismic warnings for diverse geographic regions of Peru? Consequently, we hypothesis that the use of a model based on LLMs, specifically ChatGPT-4, will improve the ease of understanding, usefulness and content quality of seismic warning messages for different audiences in Peru.

To measure the effectiveness of the solution, we will evaluate the proposal by means of a user-centered questionnaire, which will allow us to estimate the consistency of the information provided. Some relevant work is detailed in the following section. Section 3 presents the proposed conceptual model and Section 4 the technological architecture. In Section 5 we present the case study of seismology in Peru and in Section 6 we focus on the method of characterization and data extraction. Section 7 discusses data integration and prompt design. Section 8 is dedicated to validating the proposal, Section 9 to the discussion, and finally, the conclusions are presented.

II. RELATED WORK

Recently, LLMs have revolutionized automated text generation, demonstrating outstanding capabilities in complex natural language processing tasks. Models such as GPT-3/4 have proven to be highly effective in producing coherent and relevant textual content [9], making them valuable tools for various applications, including emergency communications [10, 11]. However, using LLMs to generate emergency communications poses unique challenges. Pan et al. [12] emphasize that while LLMs can generate text that sounds credible, they also carry a significant risk of producing incorrect information. This can be particularly hazardous in emergencies, where comprehension, accuracy, and clarity are critical. Comparing these findings with previous studies, Vinton [11] describes the great potential of LLMs in enhancing alert generation but also underscores the need for mechanisms that reduce the likelihood of errors. This gap in the existing literature highlights the necessity of developing more robust guidance and control techniques for LLM-generated content.

This study addresses these challenges by proposing a structured, guided text-generation approach designed to minimize misinformation. By incorporating real-time validation and context-aware algorithms, the research aims to improve the reliability of LLM-generated emergency communications. This aligns with the recommendations of Sun et al. [10], who advocate for stricter control mechanisms to ensure the accuracy and trustworthiness of information in critical scenarios. In the narrow field of seismic warnings, conventional systems have traditionally relied on algorithms and real-time seismic data. While these systems have proven effective for rapid earthquake detection, they often deliver generic messages that do not consider the regional context, potentially limiting the clarity and effectiveness of emergency communication [11]. As large language models (LLMs) continue to evolve, recent studies suggest their potential to generate more context-aware warnings, improving communication during emergencies [10]. However, despite promising findings, prior research has identified significant limitations related to the control and reliability of model outputs [12, 13]. For instance, Sun et al. [10] highlight the risk of inconsistent or overly generalized warnings, while Pan et al. [12] emphasize the need for enhanced mechanisms to guide LLM-generated content to ensure accuracy and relevance.

This paper aims to address these gaps by introducing an approach that combines the adaptive capabilities of LLMs with targeted content generation techniques. Specifically, the proposed method implements a guidance mechanism designed to control the output, ensuring that warnings are not only contextually relevant but also factually reliable. By building upon the insights from previous research and addressing their identified limitations, this work seeks to improve seismic warning communications, enhancing both their precision and their ability to reduce misinformation during critical moments [12, 13].

III. CONCEPTUAL MODEL

In this section, we describe the conceptual model of the proposal. Figure 1 illustrates how seismic communications can be structured by considering factors such as language, context, and dissemination. The characteristics of each of these factors are described below:

- Language: In multilingual regions, it is essential that communications be issued in the predominant languages of the local population. The model considers languages such as Spanish, English, Quechua, and Aimara, ensuring that alerts effectively reach all demographic groups [14, 15].
- Context: Seismic communications must be adjusted according to the context, which includes variables such as weather and the geography of the locality. Adapting the content to these factors ensures that the information provided is relevant and accurate for the audience [16].
- Dissemination: The distribution of communications can be carried out through different media. Written formats, such as social media and SMS messages, allow for rapid and widespread distribution of information [17]. On the other hand, audiovisual media, such as radio and television, offer an alternative to reach a wider and more diverse audience, especially people with disabilities and people located in areas where Internet access may be limited [18].

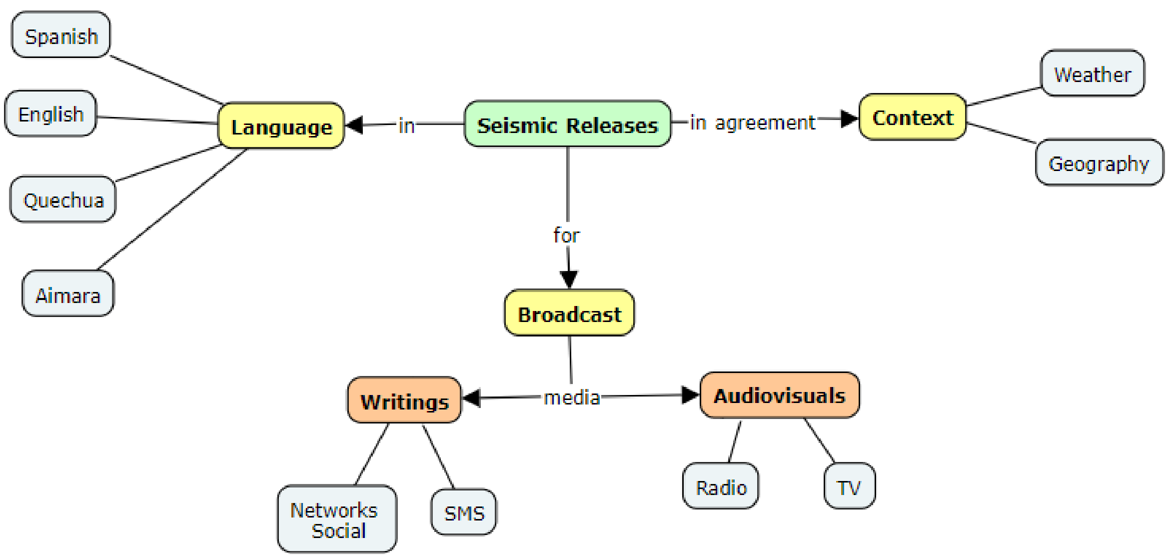

FIGURE 1. Conceptual model of the proposal.

The characteristics that constitute the conceptual model can help ensure that information reaches all audiences appropriately, including those who speak indigenous languages or local dialects. LLMs can contribute to this process by enabling communications to dynamically adjust to changes in the environment and the specific needs of each situation. For the public, this would translate into greater confidence in seismic alerts and better preparedness to face emergencies [19].

IV. PROPOSED ARCHITECTURE

Following the presentation of the conceptual model, this section illustrates and characterizes the architecture designed to integrate seismic data and LLMs in the generation of seismic communications. Figure 2 presents an architecture that consists of three steps. This framework encompasses the entire process, from the monitoring system to the generation of seismic communication, incorporating all the characteristics described in Section 3.

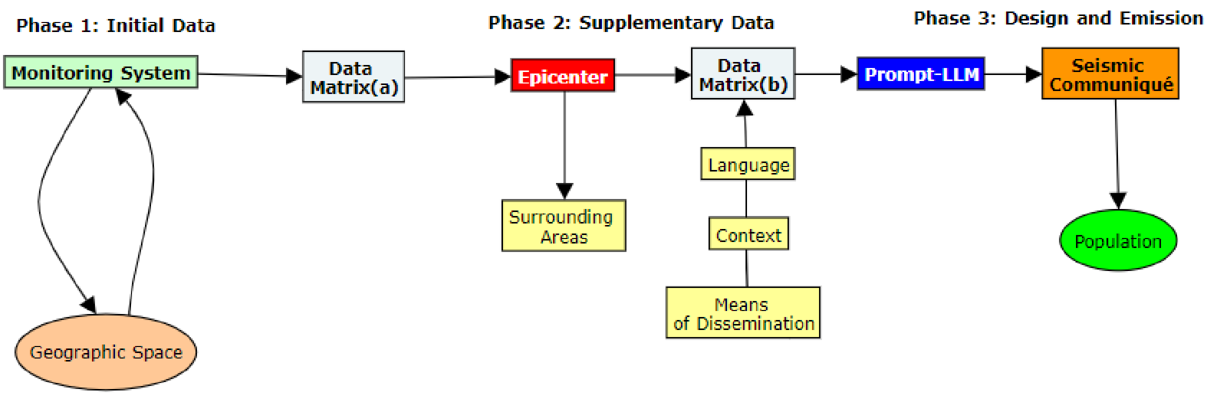

FIGURE 2. Proposed architecture.

4.1 MONITORING SYSTEM

The process begins with the monitoring of the geographic area, where data is collected and stored in a data matrix (a), as shown in Table 1. This module is responsible for the continuous surveillance of seismic activity, including data such as date, time, geographic position, epicenter, and magnitude of events in a specific region [20].

Table 1. Data matrix (a).

Data	Values	Description
Date	08/04/2024	The day on which the seismic event occurs.
Time	22:07:01	The exact time the seismic event was recorded.
Latitude	-3.96	The geographic position of the epicenter in terms of latitude.
Longitude	-81.24	The geographic position of the epicenter in terms of longitude.
Reference	28 km al NO de Máncora, Talara - Piura	Location of the epicenter.
Depth	32 KM	The depth at which the seismic event occurred, measured in kilometers.
Magnitude	4.8	The magnitude of the seismic event, measured on the Richter scale.
Intensity	III-IV Máncora	Intensity in Modified Mercalli Scale (MMI).

4.2 COMPLEMENTARY DATA

The data stored in the data matrix (a) is sent to the "Epicenter" module, which acts as the core for processing and analysis to determine the surrounding areas or zones adjacent to the epicenter. Once the surrounding areas are identified, this data is transferred to the "Context" module as part of the geographic characteristics. In data matrix (b), the user determines the language, context, and dissemination medium deemed appropriate for the communication, as shown in Table 2.

Table 2. Data matrix (b).

Data	Values	Type	Description
		Data from table 1 (...)	
Language	Spanish	--	Language in which the release will be generated according to the epicenter.
Context	Surrounding Areas	Km	Depending on the epicenter.
	Weather	Numeric	Meteorological Data (max and min temperature, humidity, rainfall and storm status)
Media Diffusion	Written Press	Social Networking	Means of dissemination for the expansion of the seismic release

4.3 PROMPT-LLM AND SEISMIC COMMUNIQUÉ GENERATION

Having detailed the subsections that address data collection, processing, and supplementation, the Prompt-LLM module functions to integrate all the aforementioned information and structure a prompt-sentence. The prompt would make a request to the ChatGPT-4 service to generate the communication based on the characteristics of data matrix (b). In this way, it would be possible to dynamically disseminate clear and timely communications to the public.

V. SCENARIO: EARTHQUAKES IN PERU

As a case study, Peru was selected due to its high seismic vulnerability and the diversity of its geographical regions [21]. In the following paragraphs, the relevance of choosing Peru as a case study will be detailed, as well as the current situation of the country regarding the manner and means by which seismic alerts are issued.

5.1 RELEVANCE OF THE GEOGRAPHICAL CONTEXT

Peru is a country with remarkable geographical diversity, and each of its regions faces unique seismic challenges that affect how seismic alerts should be issued and managed [22]. On the coast, the threat of tsunamis and the high population density require alerts that consider both the earthquake and the risk of flooding. In the highlands, the mountainous topography increases the risk of landslides, and warnings must reflect these additional hazards. In the jungle, the dispersed population and limited infrastructure pose different challenges to issuing effective warnings. The dispersed population and limited infrastructure make effective communication difficult [23]. Jungle communities mostly reside in remote locations where access to modern communication technologies, as in the rest of the country, is limited. Therefore, seismic warnings must consider other means of communication such as community radios and messaging networks that can operate without internet connection [24].

5.2 GENERALITY OF THE COMMUNIQUÉS

The generic nature of communications is one of the main challenges in issuing seismic warnings in Peru. In any case, many of their current messages are not timely and do not sufficiently consider the enormous cultural and geographic variations between different parts of the nation [25]. As a result, communication often fails to resonate with local communities, leading to a continued lack of engagement, understanding, and perpetuates user disconnection. This lack of detail towards the population can generate negative effects, since the inhabitants could respond inadequately to an alert that does not specify that it is adapted to their situation, either by not taking the necessary precautionary measures or by adopting countermeasures that do not correspond to the required response. For better illustration, Figure 3 shows how the responsible entity issues a first seismic report.

FIGURE 3. Seismic reporting.

VI. CHARACTERIZATION AND DATA EXTRACTION

In the previous sections we have addressed the key pieces to understand the big picture and the learnings that the solution provides. In this section, we will focus on data characterization and extraction. This section is then divided into the development of two phases. In the first phase we focus on the detection and characterization of data sources. This step involves an in-depth exploration of the characteristics of the data available such as its format, quality and relevance. The second phase is concerned with extracting and transforming complementary data. This requires the development of specific methods and techniques to collect additional data to complement and enrich the initial information. These methods include the use of APIs and the integration of external databases to ensure data integrity and quality.

6.1 CHARACTERIZATION OF THE DATASET

The agency in charge of detecting disasters of destructive magnitude is a decentralized public entity under the Ministry of Environment, called the Geophysical Institute of Peru (IGP). The IGP issues seismic reports through its web portal, "Último Sismo" (Last Earthquake). Among its features, it includes a section called "Seismic Data", where reported earthquakes are shared. The data published by the IGP follows the structure shown in Table 3 [26]. Due to the lack of direct access to the IGP's technological architecture, this data source has been utilized, as it not only provides reliable information but also allows for the development and experimentation with real data from recent seismic events.

Table 3. IGP dataset.

Date UTC	Time UTC	Latitude (º)	Longitude (º)	Depth (km)	Magnitude (M)
01/01/2024	07:06:07	-10,69	-78,54	35	4.2

In this context, meteorological data, such as maximum and minimum temperature, humidity, rainfall, and storm conditions, are obtained from automatic weather stations installed in each locality. In some cases, this data may come from the National Meteorology and Hydrology Service of Peru (SENAMHI) and, in other instances, from private weather stations. Given this and with the aim of enriching the available data, the solution proposes the following:

- Latitude and Longitude: Regarding geographic labels, is it truly useful to provide information in the format "-10.69, -78.54" or would it be more effective to present the data in a way that is more understandable and useful to citizens? For this case, we consider that the information could be presented along with details such as "surrounding areas". This way, the information would not appear overly technical by being limited to just coordinates but would be more intuitive and empathetic to the public. For the development of this task, we involve the use of the Python programming language and the Google Maps API to access these complementary data [27].
- Depth: Sometimes, simply stating that the depth of the seismic event is "33 km" as shown in Figure 3, is not sufficient. To improve the presentation, it is proposed to include a brief and approximate depth analysis through the involvement of an LLM (ChatGPT-4). This would allow for the characterization of the event's impact and classification of the depth type. The classification is described in categories such as shallow (0-70 km), intermediate (70-300 km), or deep (>300 km) [28, 29]. This would strengthen the existing information and provide a completer and more detailed context for the public.
- Magnitude: Every seismic event can be classified into different alert levels. However, the seismic report presents this information in a way that is too technical, making it difficult to interpret. To enhance this informative content and taking the IGP web portal as a reference, we propose that, through the LLM, an alert level be determined in a more intuitive way, using a color-coded system, such as: green for magnitudes below 4.5, yellow for magnitudes between 4.5 and 6.0, and red for magnitudes above 6.0 [26].

By evaluating and optimizing the data provided by the IGP, it is possible to improve the accessibility and understanding of seismic reports. It is not enough to merely adjust the presentation of the data. We must consider that the information should be clear and understandable to citizens. Therefore, we propose that the generated seismic communications align geographic information with more intuitive details, classify the depth of seismic events into clear categories, and structure magnitude alert levels using a color-coded system. These improvements will make this type of information more accessible and useful to the population, facilitating better interpretation and a more effective response to seismic events.

6.2 DATA EXTRACTION AND TRANSFORMATION

This section describes the techniques and mechanisms employed for data extraction, focusing on ChatGPT and Python-based programming techniques. ChatGPT-4 is used for data transformation, as well as for analysis and classification according to the characteristics of the seismic event. Simultaneously, Python is employed along with the Google Maps API to extract information about locations or points of interest surrounding the earthquake's epicenter, obtaining updated geographic data that facilitates the identification of potentially affected areas and provides crucial spatial context for the analysis of the seismic event [30].

A. Surrounding Areas (Python)

To extract the surrounding zones, the epicenter coordinates (latitude and longitude) are used as a starting point. Table 4 presents a snippet of the code that identifies the surrounding areas. As an example, Figure 4 shows a list of these areas within a 5 km radius. The full code can be found at Githubi. This code also generates a visual representation, as shown in Figure 5, where the area within the radius is highlighted with a blue shading.

- Input Data: -16.53, -71.63

Table 4. Python code fragment for the extraction of circumstantial zones.

Code for identification of circumstantial zones

```
(…)
# Define the coordinates of the center point
latitude = -16.53
longitude = -71.63
central_point = (latitude, longitude)
# Search for locations within a 5 km radius
```

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```
places_result = gmaps.places_nearby(location=central_point, radius=5000)
(…)
# Show the places found
for place in places_within_radius:
print(f"Name: {place['name']}, Coordinates: {place['coords']}, Address: {place['address']}")
```

1 https://github.com/OSCARPC/chatgpt-earthquake/blob/main/googlemaps.py

- Result: The code presented in Table 4 has identified a total of 20 locations within a 5 km radius around the

```
Name: Cerro Verde, Coordinates: (-16.5429075, -71.6162786), Address: F94M+RFQ, Arequipa
Name: Culvert 03 SMCV, Coordinates: (-16.5299245, -71.6207086), Address: Unnamed Road, 04330
Name: Culvert 04 SMCV, Coordinates: (-16.5211062, -71.6199367), Address: Unnamed Road, 04400
Name: Torre 235, Coordinates: (-16.5392355, -71.6199565), Address: Via Cerro Verde 48
Name: CAMPAMENTO CJM - CV, Coordinates: (-16.5365582, -71.6177122), Address: F97J+9WF, Yarabamba
Name: Campamento de Geodrill, Coordinates: (-16.5371893, -71.6175009), Address: F97J+4XH, Yarabamba
Name: New Site D SMCV, Coordinates: (-16.5327102, -71.61551709999999), Address: F98M+WQ9, Unnamed Road, Jacobo Hunter
Name: Plataforma Entrenamiento Equipo Semipesado, Coordinates: (-16.5375388, -71.6154554), Address: Unnamed Road, 04330
Name: Ex. Pract. Cerr Verde, Coordinates: (-16.53810349999999, -71.6140791), Address: F96P+Q9, Jacobo Hunter
Name: Garita Tinajones SMCV, Coordinates: (-16.5426173, -71.616531), Address: F94M+X95, Via Cerro Verde, Arequipa
Name: Plta de Agregados, Coordinates: (-16.5429458, -71.6167099), Address: F94M+R8F, Yarabamba
Name: Chancado primario, Coordinates: (-16.5314744, -71.6107388), Address: F99Q+CP6, Yarabamba
Name: Ovalo China Cero, Coordinates: (-16.5150548, -71.61761299999999), Address: F9MJ+XX, Jacobo Hunter
Name: Plataforma de Chancado Tinajones, Coordinates: (-16.5444695, -71.6147051), Address: F94P+64, Jacobo Hunter
Name: Urbanización Cerro Verde, Coordinates: (-16.5269542, -71.6523749), Address: F8FX+636, Via Cerro Verde, Uchumayo
Name: CAMPAMENTO CELICON OPERACIONES MINA, Coordinates: (-16.5433465, -71.6119743), Address: F94Q+M66, Yarabamba
Name: CAMPAMENTO VYT CONTRATISTAS - SMCV, Coordinates: (-16.543478, -71.6119418), Address: F94Q+J6, Jacobo Hunter
Name: Garita ALCON Bravo 2, Coordinates: (-16.5509631, -71.6377704), Address: Via Cerro Verde 848
Name: Taller Electrico, Coordinates: (-16.54402019999999, -71.6115981), Address: F94Q+99R, Yarabamba
Name: Garita China, Coordinates: (-16.5077642, -71.6245398), Address: F9RG+V5W, Arequipa
```

FIGURE 4. List of surrounding areas within a 5 km radius.

Complementing the previously stated information, Figure 5 provides a visual representation. The epicenter is marked with a red pin at the center of the map. The blue shaded area indicates the region within a 5 km radius from the epicenter, highlighting the zones that could be affected by the earthquake. The additional red points on the map represent places of interest or specific points within this 5 km radius. This visualization helps to quickly identify the areas that are potentially influenced by the seismic event [31].

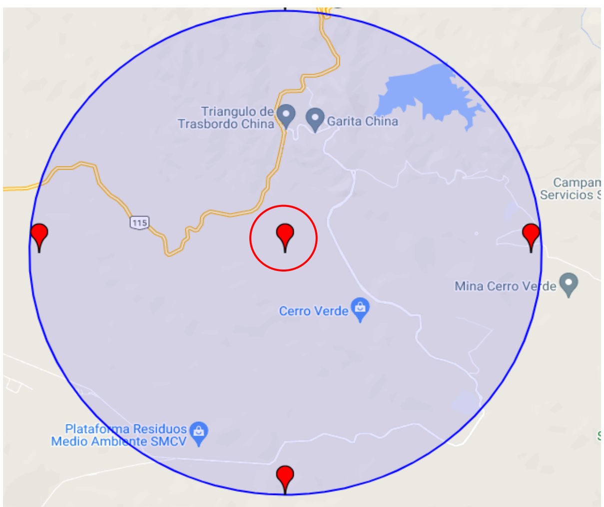


FIGURE 5. Visual representation of surrounding areas within a 5 km radius.

B. Depth

Based on the depth of the seismic event, ChatGPT 4.0 is tasked with analyzing and classifying the depth as shallow, intermediate, or deep. This classification will serve as an input when integrating the data for generating seismic communication.

- Data Input and Instruction: 30 km (depth)

An earthquake has occurred with a depth of {depth} km. Determine only the "depth grade" without additional content, based on the following data:

Shallow (0-70 km) / Intermediate (70-300 km) / Deep (>300 km)

- Result: Shallow

C. Magnitude

The alert status is determined based on the magnitude of the event. ChatGPT 4.0 acts as an interpreter according to the input value.

- Data Input and Instruction: 4.2 (magnitude)

An earthquake of {magnitude} M has occurred. Determine the "alert status" without additional content, based on the following data:

< M4.5 (Green) / M4.5 to M6.0 (Yellow) / > M6.0 (Red)

- Result (Alert Status): Green

VII. CHATGPT IN THE GENERATION OF SEISMIC RELEASES

In the previous section, data characterization and extraction were addressed. This section has been key as it allowed for the description of the methods of extraction and structuring of the necessary data to construct the prompt that will lead to the generation of the seismic report. In the next subsection, the general parameters of the prompt will be described, which will later be outlined in the design of the prompt and its results.

7.1 PROMPT PARAMETERS

This subsection focuses on the key parameters for constructing the prompt that will guide the generation of the seismic report. These parameters are divided into four categories. Table 5 contains the essential data of the seismic event that must be considered. Table 6 highlights the weather conditions in the affected area. Table 7 details the surrounding areas, while Table 8 covers aspects such as language, context, and the medium of dissemination. Regarding the initial configuration of the LLM, it is important to clarify that it was not specifically preset to the context of seismic warnings. This decision was made because the information provided in the warning inherently provides the necessary contextual details. The message begins with the following instruction "Instructions: Use the following information to create a seismic warning release directed to the public." This directive ensures that the LLM understands the context and generates the appropriate content without additional pre-training. This approach simplifies the use of the model and its applicability to different LLMs. On the other hand, it aligns with the principle of instruction engineering. Considering the above-mentioned forecasts, it is essential to clearly specify all the described parameters, as this will facilitate the elaboration of the seismic warning statement.

Table 5. Seismic event information.

Seismic Data
Date and Time: [Date and time of the seismic event]
Location: [Specific location of the epicenter]
Magnitude: [Magnitude of the earthquake]
Depth: [Depth of the earthquake]
Latitude: [Epicenter latitude]
Longitude: [Epicenter longitude]
Intensity: [Intensity in affected areas]

Table 6 outlines the parameters framed under meteorological conditions that are relevant for generating seismic alert notice. On some occasions, various weather factors can influence emergency operations or the public's response during a seismic event. Among the most important data are the maximum and minimum temperatures, which provide information about extreme thermal conditions that could affect infrastructure or the well-being of individuals in the event of evacuations or disruptions to basic services. Relative humidity also plays a significant role, as high levels of humidity could complicate rescue efforts or increase the discomfort of the affected population.

Table 6. Weather information to consider.

Weather Conditions
Maximum Temperature: [Maximum temperature]
Minimum Temperature: [Minimum temperature]
Relative Humidity: [Relative humidity]
Rainfall: [Recorded precipitation]
Thunderstorm: [Yes/No]

Table 7 provides information on the areas surrounding the seismic event, a necessary component for assessing the impact and response to an earthquake. This table should include a list of relevant zones and establishments located near the epicenter or in areas affected by the earthquake.

Table 7. Information on areas surrounding the seismic event.

Surrounding Areas
[List of nearby relevant areas and establishments]

Table 8 describes the dissemination parameters that must be included in the prompt. For this case, the language, context, and medium for broadcasting the seismic alert. This ensures better communication in emergency situations. First, the languages in which the information will be disseminated are specified, including Spanish, English, Quechua, or Aymara, ensuring the alert effectively reaches various communities in a language they understand. The context is also considered, including both the surrounding areas and the weather conditions, providing a comprehensive overview of the situation in the earthquake-affected areas. Finally, the possible dissemination channels for spreading the alert are mentioned, such as social media, text messages, radio, or television.

Table 8. Seismic alert dissemination parameters.

Language, Context, and Medium of Dissemination
Language: [Spanish, English, Quechua, or Aimara]
Context: [Surrounding Areas and Weather Conditions]
Medium of Dissemination: [social media, SMS, Radio, or TV]

7.2 DESIGN OF THE PROMPT

In this section, the prompt will be designed using the information presented in section 6.0 and considering the parameters established in section 7.1. It is essential that the user properly evaluates the seismic data so that the ChatGPT service can generate an appropriate seismic alert notice. In this context, our experimentation focuses on the data provided in Table 9, which describes a seismic event that occurred on April 8, 2024, at 22:07:01. The epicenter of the earthquake was located 28 km northwest of Máncora, in the province of Talara, Piura region. The event had a magnitude of 4.8 on the Richter scale and occurred at a depth of 32 km. The coordinates of the epicenter were latitude -3.96 and longitude -81.24. The recorded intensity was level III-IV on the Modified Mercalli scale, primarily affecting the Máncora area.

Instructions: Use the following information to create a seismic report directed at the public.

Table 9: Seismic event information.

Seismic Data	Values
Date and Time	08/04/2024 - 22:07:01
Location	28 km NW of Máncora, Talara – Piura
Magnitude	4.8
Depth	32 KM
Latitude	-3.96
Longitude	-81.24
Intensity	III-IV in Máncora

Complementing the information for generating the seismic alert notice, Table 10 provides details on the weather conditions. The maximum temperature reached 29.8°C, while the minimum temperature was 22.9°C, reflecting warm weather. The relative humidity, at 84.9%, indicates a rather humid environment, which could affect outdoor activities or emergency response capabilities. Additionally, 15.0 mm of precipitation was recorded, indicating significant rainfall, and the presence of a thunderstorm was confirmed. These weather conditions are crucial as they provide precise data that enhance the prompt, allowing for more detailed and relevant information to be communicated to the public. In this way, alerts and notices become more effective and tailored to the situation, facilitating better decision-making during emergencies.

Table 10. Weather information to consider.

Weather Conditions	Values
Maximum Temperature	29.8 °C
Minimum Temperature	22.9 °C
Relative Humidity	84.9%
Rainfall	15.0 mm
Thunderstorm	Yes

Table 11 provides a list of areas and establishments surrounding the seismic event zone, highlighting several accommodations and tourist spots near Máncora. The mentioned locations include hotels, bungalows, and beach houses, indicating a highly active tourist area. This information is important for establishing strategic communication points, ensuring that both the public and authorities are informed about areas that could be affected. By identifying key locations, the coordination of response efforts and the dissemination of alerts can be carried out more effectively, contributing to better management in case of an emergency or disaster.

Table 11. Information on areas surrounding the seismic event.

Surrounding Areas	
Máncora	Aquarena Vichayito Mancora Playa
Aranwa Vichayito Bungalows & Carpas	El Destino Casas y Bungalows Vichayito
Casa de Playa	Kimbas Bungalows
Los Corales	Villas del Mar Máncora
Hotel Grandmare & Bungalows	Suites del Mar Mancora
Peña Linda Bungalows	Makani Vichayito
Máncora Beach Bungalows	An'Anasha Hotel
DCO	Samana Chakra
Hotel Don Giovanni Máncora Perú	Kon Tiki Bungalows

Las Olas	Cercado de los Órganos

Table 12 presents the proposed structure for drafting a seismic alert report. It specifies that the report title, Seismic Alert Report should appear centered and in bold to ensure visibility and clarity within the document. The alert status is classified according to the earthquake's magnitude, using a color code that facilitates interpretation of the risk level. For magnitudes below 4.5, green is assigned, indicating a low-level alert. When the magnitude ranges between 4.5 and 6.0, yellow indicates a moderate alert. For magnitudes above 6.0, red is used, denoting a high alert and significant risk.

Table 12. Style structure for seismic warning report.

Reporting parameters
Title: Seismic Alert Report (centered and bold). Alert Status: Determine the alert status based on the magnitude: • Magnitude < 4.5: Green • Magnitude 4.5 to 6.0: Yellow • Magnitude > 6.0: Red

To properly structure the content of a seismic alert notice, it is important to consider two key elements: the description of the event and its classification based on depth. In this context, information such as the date, time, magnitude, location, and depth of the earthquake should be included, as shown in Table 13. Additionally, the earthquake is classified into three levels according to its depth.

Table 13. Main content.

Earthquake Description	Classification of the Earthquake by Depth
Include the date, time, magnitude, location, and depth of the seismic event.	Shallow (0-70 km) Intermediate (70-300 km) Deep (>300 km)

The recommendations that should be included in the seismic alert notice are based on several factors. First, they must be adapted to the time, magnitude, location, and epicenter of the event. Specific guidance should also be provided for the population in the affected surrounding areas. It is important to consider the current weather conditions when issuing any recommendations, as detailed in Table 14.

Table 14. Recommendations to be included in the report.

Recommendations
Tailored based on the time, magnitude, location, and epicenter.
Specific guidance for the population in the surrounding areas listed.
Consider current weather conditions.
Advise the public to stay informed through official sources and follow local authorities' instructions.

Table 15 provides additional precautions to include in the seismic alert notice. It is recommended to be prepared for possible aftershocks and to secure any objects that may fall. Furthermore, if the epicenter is in a coastal area, specific recommendations for residents in those areas should be provided. These complementary precautions should be incorporated by the specialist who conducted the analysis of the seismic event.

Table 15. Additional reporting precautions.

Additional Precautions
Be prepared for possible aftershocks and secure any objects that could fall.
If the epicenter is in a coastal area, provide specific recommendations for residents in those regions.

On the other hand, Table 16 presents the closing information that should be included in the seismic alert notice. For example, gratitude is expressed to the public for their cooperation and understanding, and the date, time, and signatures of regional and national authorities are added, formatted to align to the right of the document.

Table 16. Closing information to be included in the report.

Closing Characteristics
Thank you for your cooperation and understanding.
Date, time, and signature of regional and national authorities (aligned to the right).

Finally, Table 17 establishes the formatting requirements for generating the seismic alert notice using the prompt. In this case, the notice must be written in Spanish and in prose, without the use of bullet points. A legible font with an appropriate size is required, including line breaks between paragraphs. Titles and highlighted elements should be in bold. It is mandatory for the notice to be kept to a single page without exceptions. The notice will be shared on social media platforms such as Facebook and X (formerly known as Twitter). It should be generated in PDF format and then converted to JPG to provide both download options.

Table 17. Report generation format requirements.

Formatting Requirements
In Spanish.
No bullet points. Everything in prose.
Use a legible font and an appropriate font size.
Include line breaks between paragraphs.
The title and highlighted elements must be in bold.
The final document must be on a single page. This condition must be met without exception.
The announcement will be shared on social media platforms such as Facebook and X (formerly known as Twitter).
Generate a PDF file of the announcement and then convert it to JPG format to provide both download options.

All the data presented in the tables are relevant for designing the prompt and generating an effective seismic alert notice. The information contained in each table, from the weather conditions and affected areas to the details of the seismic event, provides an accurate framework for personalizing the alert message. Additionally, the formatting parameters and recommendations ensure that the notice is clear, accessible, and suitable for dissemination across various media, ensuring that both the public and authorities can take the necessary actions quickly and accurately.

For experimentation cases, the entire prompt, including the seismic alert parameters and detailed recommendations, is available in the GitHubii repository in both Spanish and English. This resource is shared with the intent that researchers and developers can conduct tests, modifications, and adjustments according to the specific scenarios of each region or situation. We believe that by having access to all the structured and updated information, it is possible to conduct simulations and optimize the alert issuance process, ensuring a more accurate and effective response to potential seismic events. The next section describes the result generated by the prompt, detailing how the collected information and established parameters are integrated to produce a seismic alert notice.

7.3 RESULTS OF THE PROMPT

The result of the prompt described in section 7.2 is shown in Figure 6. ChatGPT has generated the announcement in PDF format and converted it to JPG, enabling dynamic dissemination of information to users. It is important to note that for this case ChatGPT has generated the Seismic Alert Communiqué in Spanish language according to the parameters established in the format (Table 17).

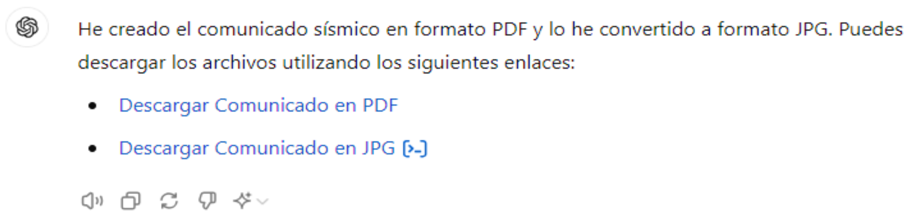
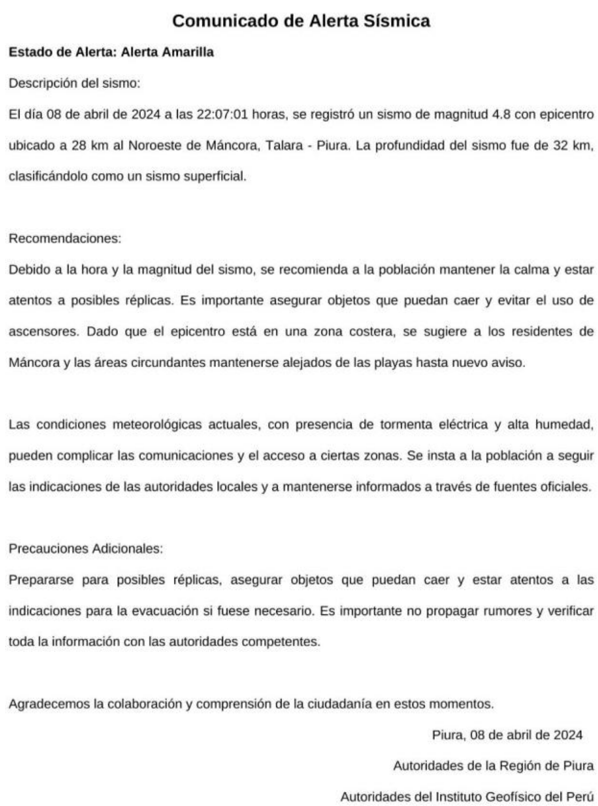


FIGURE 6. ChatGPTo's answer.

To access a complete view of the result, Figure 7 presents the seismic alert announcement. This figure clearly and legibly details each of the sections established in the notice. It can be observed how the announcement is



Comunicado de Alerta Sísmica

Estado de Alerta: Alerta Amarilla

Descripción del sismo:

El día 08 de abril de 2024 a las 22:07:01 horas, se registró un sismo de magnitud 4.8 con epicentro ubicado a 28 km al Noroeste de Máncora, Talara - Piura. La profundidad del sismo fue de 32 km, clasificándolo como un sismo superficial.

Recomendaciones:

Debido a la hora y la magnitud del sismo, se recomienda a la población mantener la calma y estar atentos a posibles réplicas. Es importante asegurar objetos que puedan caer y evitar el uso de ascensores. Dado que el epicentro está en una zona costera, se sugiere a los residentes de Máncora y las áreas circundantes mantenerse alejados de las playas hasta nuevo aviso.

Las condiciones meteorológicas actuales, con presencia de tormenta eléctrica y alta humedad, pueden complicar las comunicaciones y el acceso a ciertas zonas. Se insta a la población a seguir las indicaciones de las autoridades locales y a mantenerse informados a través de fuentes oficiales.

Precauciones Adicionales:

Prepararse para posibles réplicas, asegurar objetos que puedan caer y estar atentos a las indicaciones para la evacuación si fuese necesario. Es importante no propagar rumores y verificar toda la información con las autoridades competentes.

Agradecemos la colaboración y comprensión de la ciudadanía en estos momentos.

Piura, 08 de abril de 2024

Autoridades de la Región de Piura

Autoridades del Instituto Geofísico del Perú

FIGURE 7. Result of seismic report through ChatGPT.

structured to provide essential information about the seismic event, including the magnitude of the earthquake, the location of the epicenter, and recommendations for the public. Each part of the notice is designed to ensure that the information is understandable and accessible, thus facilitating a quick and effective response in the event of a seismic emergency.

By generating seismic announcements of this type, the aim is to strengthen interoperability among technical-scientific institutions, local governments, and citizens. Having an effective solution for generating seismic alert announcements, adapted to different geographic areas and temporal characteristics, will contribute to more effective communication. Although the results presented so far have focused on dissemination through social media, this methodology is equally applicable to other formats, such as instant messaging and radio press. In the next section, this proposal will be validated through the design of a questionnaire.

VIII. VALIDATION

To validate the proposal, we rely on the UEQ (User Experience Questionnaire) developed by Schrepp and Thomaschewski [32], which is designed to evaluate user experience. However, we have selected only specific sections of the questionnaire, focused on assessing the ease of understanding, usefulness, and quality of the content of the seismic alert announcement presented in Figure 7. In the following subsections, we detail the design of the instrument, describe the population and the selected sample, and present the results obtained from the questionnaire.

8.1 INSTRUMENT

Table 18 shows a simplified version of the questionnaire, which employs a Likert scale from 1 to 5. Values close to 1 indicate negative perceptions, while those close to 5 indicate positive responses. Values of 3 are considered neutral [33]. The complete questionnaire is available in a public repositoryiii. The application of this instrument will allow us to identify areas for improvement in the proposal, and based on these results, we will refine the process in future research.

Table 18. Questionnaire to evaluate seismic alert communication.

	1	2	3	4	5	
			Ease of understanding			
			The handling of the product seems to me to be			
incomprehensible	◎	◎	◎	◎	◎	understandable
			Utility			
			As far as usability is concerned, the product seems to me to be			
useless	◎	◎	◎	◎	◎	useful
			Quality of content			
			The information and data provided by the product is as follows			
old-fashioned	◎	◎	◎	◎	◎	current

8.2 POPULATION AND SAMPLE

An invitation was made through social media, encouraging citizens to participate in the validation of this study. As a result, 47 people participated, of which 19 were women and 28 were men. Among the participants, 5 had technical-scientific knowledge, while the remaining 42 had no training in seismic topics. The decision to include 47 participants was based on the principle of obtaining a diverse sample of individuals with varying levels of familiarity with seismic information. Although not a probability sample, this size was considered appropriate for the exploration nature of the study, following similar research practices in early-stage system validation. According to Johanson & Brooks [41], the sample size selected is appropriate for this pilot study, especially considering that the objective is to collect information about the usefulness, quality of content and level of understanding of the messages in the alerts generated. Furthermore, the sample included participants from different demographic and educational backgrounds, ensuring a variety of perspectives that enrich the evaluation process. The statistical significance of this sample size lies in its ability to identify trends and potential communication problems in seismic warnings, rather than to generalize the results to the entire population. We believe that larger and more representative samples will be used in future phases of the research to validate the observed results.

The questionnaire was administered anonymously and developed as follows:

- Participants were gathered in a Zoom room, where they were informed about the purpose and benefits of the study.
- One participant was invited to read the seismic announcement.
- The team provided instructions on how to respond to the questionnaire and shared the access link to the form, which was designed in Google Forms. To complement this process, a simulation was conducted with a different type of questionnaire.
- Participants had 15 minutes to complete the questionnaire.
- At the end of the allotted time, participants were asked if they had any questions or concerns. It was verified that responses from all 47 participants were obtained.
- Some feedback was received, which we will describe in the discussion section, and finally, the team expressed gratitude to each of the participants.

To complement the information previously presented during the Zoom meeting, participants were briefed on the context of their participation. They were instructed to simulate a scenario in which an earthquake had occurred in the town of Mancora, Peru. Based on this scenario, they received the seismic warning communication shown in Fig. 7, which was generated using our proposed approach. During the interaction, participants read the communication generated by the LLM. A few minutes later, they were presented with the standard warning message usually issued by technical-scientific entities (Fig. 3) in the event of an earthquake. The purpose of this was to make them aware of the differences between what is usually broadcast and what the solution provides.

The questionnaire took approximately 15 minutes to complete. After completing the questionnaire, participants were asked to provide feedback on the usefulness, ease, and quality of content of the seismic warning communication. Some participants found it novel to receive messages of this nature that can be adapted to their context. Other participants suggested that future tests could incorporate immersive environments that simulate an earthquake warning scenario to determine if their responses vary emotionally. This type of input would help to better assess the impact of the system under realistic conditions.

The data collected during this process were handled with strict adherence to ethical guidelines. Participants were informed of the purpose of the study, the voluntary nature of their participation, and the confidentiality of their responses. Their written consent was obtained prior to their participation, which guaranteed the protection of their privacy throughout the study. All data were anonymized prior to analysis to maintain the integrity and ethical standards of the research.

IX. RESULTS

Figure 8 presents an evaluation of the ease of understanding of a seismic announcement generated by ChatGPT. This evaluation is conducted through four questions that explore comprehensibility, ease, simplicity, and clarity. The first question, "Incomprehensible or understandable?", reveals that many users consider the seismic warning statement to be understandable. Specifically, 42% of respondents rate it as understandable, while 38% consider it very understandable. This indicates that, overall, the announcement meets the objective of being understandable to the public. The combined positive perception of 80% suggests that the message successfully conveys its content, although the remaining 20% may indicate areas where clarity could still be improved, possibly due to the technical nature of some terms.

The second question, "Difficult or easy to understand?", shows that the seismic warning statement is perceived as easy to understand by a significant portion of the respondents. Both the 38% who considered it easy to understand and the 38% who perceived it as very easy to understand constitute a large majority, with a total of 76%. On the other hand, 22% considered it somewhat neutral; this could be related to users not being very familiar with the context or requiring additional support to understand the purpose of the seismic warning statement. This mostly occurred in users between 18 and 21 years old who show a low level of experience in knowledge of reality and seismic events. This distribution evidences that, although the seismic warning statement is accessible to most, simplification of certain elements could improve general understanding.

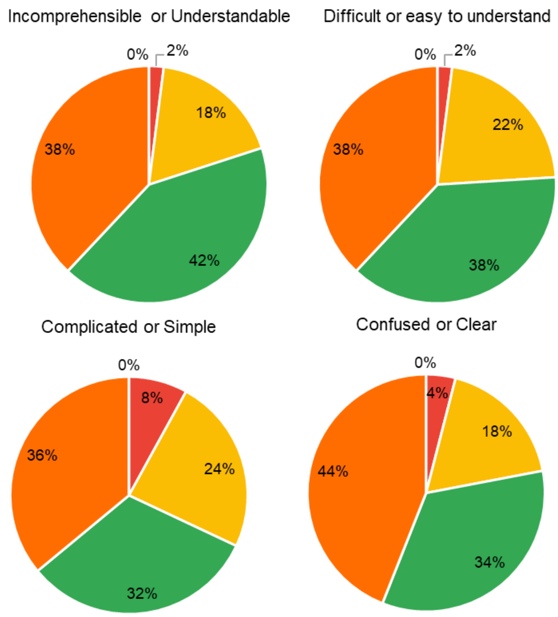


FIGURE 8. Indicator results: ease of understanding.

The third question, "Complicated or simple?" shows that the seismic warning statement is largely considered simple, with 36% of respondents rating it very simple and 32% rating it simple, giving a combined positive evaluation of 68%. The 24% neutral responses might suggest that some participants were unsure of the simplicity due to unfamiliar terminology or structure. Another factor that we believe may have influenced these results is the users' expectation of receiving shorter communication. However, reducing the length of the message could limit the clarity of actions or measures to be taken in this type of context. It is worth noting that no respondent rated the announcement as very complicated, which reflects the clarity of the communication generated by LLM.

The fourth question, "Confusing or clear?", reaffirms the clarity of the seismic warning statement: 44% of respondents rated it as very clear and 34% as clear, for a total of 78%. The small fraction of respondents who considered it neutral (18%) or confusing (4%) may indicate that the clarity of the message was effective overall, but could still benefit from adjustments, such as rewording or restructuring, to further minimize confusion among a small subset of the audience. On the other hand, we believe that the 18% of users who responded neutrally did so because they are unsure whether, in a real scenario, the system would help them make a decision, given that this time the experimentation was conducted in a simulated environment.

Complementing the above Fig. 9 presents the results for the usefulness indicator. The findings indicate a positive trend, with a significant majority of responses considering the solution as useful or very useful, while negative perceptions are minimal.

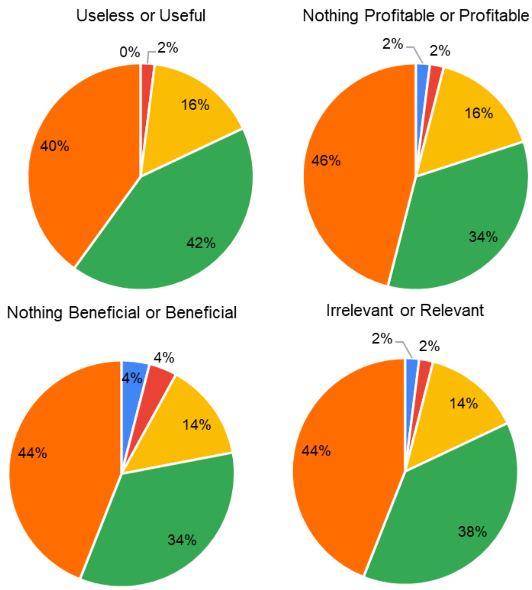


FIGURE 9. Indicator results: usefulness.

The results of the usefulness indicator are described below:

- Useful vs. Useless: The results show that 42% of respondents consider the seismic warning statement "useful", while 40% rate it as "very useful", for a combined positive perception of 82%. This strong majority says that the tool effectively communicates its purpose and in a potential way. However, the 16% who hold a neutral opinion may reflect uncertainty about the effectiveness of the tool in real-world situations, probably due to the simulated nature of the experiment. The 2% negative perception, although minimal, could indicate the need for minor adjustments to the content or delivery of the message to address skepticism.
- Not Useful vs. Useful: In this dimension, 80% of the respondents give a positive evaluation, with 46% rating the tool as "very useful" and 34% as "useful". This high level of approval shows that most participants recognize the practical advantages of the seismic warning release. However, the 18% who adopt a neutral stance may represent individuals who, despite understanding the message, are not sure how useful the information can be in the face of a possible earthquake, perhaps for middle-aged citizens they do not consider it a big problem, however, more adult citizens who have already experienced situations of similar natures boast to have a greater attention in this type of contexts. On the other hand, the 2% who perceive the seismic warning communiqué generated by LLM as "not useful", this could be influenced by isolated cases in which the message did not fit the expectations or experiences of the users. Perhaps they prefer shorter texts that only communicate the event and not its depth.
- Not Beneficial vs. Beneficial: Not beneficial vs. beneficial: A significant 78% of respondents consider the solution "beneficial" (34%) or "very beneficial" (44%), indicating a high perception of value. The 14% with a neutral perception could be attributed to participants who were not able to foresee the benefits of the tool in practice. It is necessary to keep in mind that for this case the experimentation has been executed in a controlled environment and perhaps in the next evaluation under a real scenario the answers will tend to change. 8% consider the seismic warning statement "not beneficial". This could be attributed to the fact that there are doubts about its capacity to inform, since on occasions the technical-scientific entities have issued communiqués that are poorly adjusted to reality, and it is probable that these users are dragging a perception from the past that is aligned with the proposal. We also consider that another factor is linked to

the lack of familiarity with solutions of this type and that as their interaction in the future becomes more continuous, they will be able to respond in a more critical and focused manner to this type of alert.

- Irrelevant vs. Relevant: The data reveal that 82% of respondents rated the tool as “relevant” (38%) or “very relevant” (44%), underlining its perceived importance in the context being evaluated. 14% of neutral responses could indicate that respondents were unsure of the relevance of the message in different situational contexts. Another factor influencing this type of response is that being in a simulated environment, they do not perceive fear of the event and therefore it does not tend to affect their emotions directly. On the other hand, the 4% who consider the tool irrelevant could reflect a minority with specific expectations not satisfied by the current design, possibly due to the length, tone or content of the message.

The results consistently reflect a positive perception of the seismic warning statement in all the elements evaluated. However, the presence of neutral responses ranging from 14% to 18% show some uncertainty, probably influenced by experimental conditions and lack of real-world interaction. To solve this problem, future evaluations in real environments and possible adjustments in the structure or content of the message could improve the perceived usefulness and relevance of the proposal. After reviewing the findings of the usefulness indicator Fig. 10 illustrates the results corresponding to the content quality indicator. This indicator assesses respondents' perceptions of the quality of the content generated by ChatGPT, considering aspects such as relevance, interest, development, and coherence of the content. The results predominantly reflect a positive evaluation, indicating that the content is perceived as well-developed, interesting, and coherent, with only a minority expressing negative or neutral perceptions.

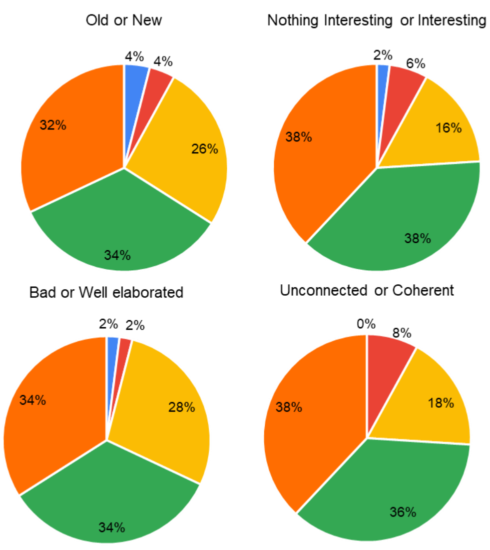


FIGURE 10. Indicator Results: Quality of Content

- Outdated vs. Current: The results show that 34% of respondents consider the content to be “current”, while 26% rate it as “very current”, which adds up to a positive perception of 60%. This suggests that many participants recognize the information as temporarily relevant. However, 32% of respondents who take a neutral stance indicate a notable level of uncertainty, which may be due to a lack of context about the timeliness of the content or the absence of specific temporal markers in the message. The 8% who perceive the content as “outdated” could reflect concerns about the applicability of the information to current conditions, evidencing the need for periodic updates or clearer references to the date of publication of the content to reinforce the perception of its relevance. However, in this first experimentation, only one seismic warning announcement was shared which was linked to a particular context. In future studies to mitigate this weakness, longitudinal evaluations could be conducted to help improve the perception of users regarding the timeliness of the content generated by LLM.

- Not Interesting vs. Interesting: 76% of participants rate the content as "interesting" (38%) or "very interesting" (38%), highlighting the overall good reception of the message. The 16% of neutral responses could be due to content that, while clear, may lack elements that resonate with all audience segments. Meanwhile, the 10% who expressed a negative perception of 8% as "not at all interesting" and 2% as "somewhat interesting." This type of response points to the need to improve content presentation strategies, perhaps with greater diversity or the incorporation of a map that establishes the georeferenced point of the epicenter. Thus, we consider that the incorporation of visual aids or closer examples could increase the attractiveness of the content of the seismic warning communications, especially in areas where the citizenry is much younger.
- Poorly Developed vs. Well Developed: The data indicate that 68% of respondents considered the content to be well developed, with 34% rating it as "well developed" and another 34% rating it as "very well developed". The 28% neutral responses could reflect individuals who found the structure adequate but not particularly noteworthy, potentially due to the absence of additional contextual elements or more detailed explanations. The 4% who rated the content as poorly developed likely perceived gaps in structure or clarity, evidence that a more systematic organization of information could address these concerns. On the other hand, we value the neutral responses as a factor for improvement, since during the experimentation we received contributions to improve the content. Among the contributions, it was mentioned that communication could be generated in a shorter way and perhaps in different formats that could be adjusted to quick reading, especially on mobile devices.
- Incoherent vs. Coherent: Inconsistent versus consistent: The results show that 74% of respondents consider the content to be coherent, with 38% rating it as "coherent" and 36% as "very coherent." This indicates that, in general, the content maintains logical consistency. The neutral group of 18% could represent respondents who experienced minor difficulties in connecting the ideas presented, possibly due to the complexity of certain terms or the structure of the narrative. As mentioned above, a fragment of the users is very young, so they are not fully familiar with this type of context compared to the more adult users who have been able to perceive this type of situation more frequently. On the other hand, the 8% who consider the content to be incoherent could indicate the need to revise and simplify the technical sections or to ensure smoother transitions between ideas. Another factor that could have influenced this type of responses is due to the fact that the experimentation was carried out in a simulated environment and several of the participating users expressed the interest that a next experimentation be carried out in a more real environment and contrast it with the information of the technical-scientific entities and be able to determine with greater precision the coherence of the information provided by the seismic warning communiqué.

The findings of the above elements show a predominantly positive perception in all dimensions, with positive responses ranging from 60% to 76%. However, the presence of mostly neutral perceptions of 32% in the "Outdated vs. current" category and 28% in the "Poorly developed vs. well developed" dimension shows that certain aspects of the content could benefit from adjustment. Specifically, providing more context regarding the time relevance of information, improving engagement with content through more dynamic formats, and refining structural and visual elements to improve clarity and further reinforce audience perception of content.

Fig. 11 reflects the perceptions of users with respect to three categories: ease of understanding, usefulness and quality of content. In the first category, it can be seen that the majority of users, specifically 76%, consider the information presented to be clear and understandable, while 24% have difficulties in this regard. In terms of usefulness, 81% of respondents evaluate the information positively, suggesting that they find the content applicable to their needs, although 19% do not share this perception. Finally, with regard to the quality of the content, 71% rate this aspect favorably, while 29% express some dissatisfaction. In this sense, there is a predominantly positive trend in the three elements evaluated, with a better perception of usefulness and a lower perception of content quality, which reflects specific areas for improvement to increase overall satisfaction. We also believe that the negative results are due to the fact that the experimentation to validate our proposal was conducted in a cabinet environment, which limited direct interaction with the system. Some participants stated that they would like to see the application carried out in a real scenario in the future, where citizens can interact directly with the system and evaluate its performance in conditions closer to reality.

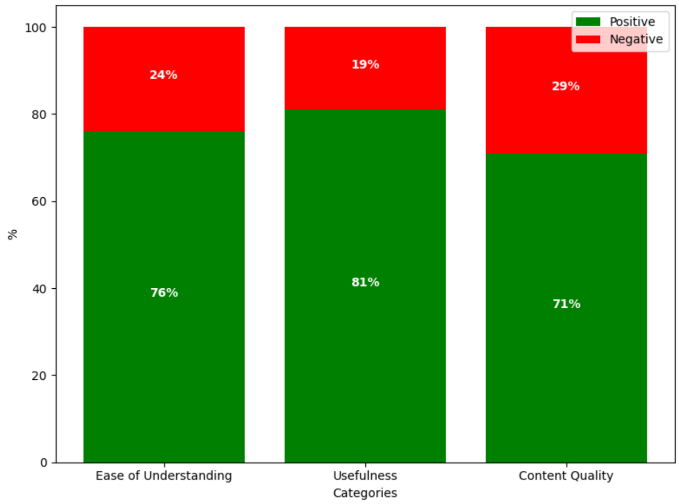


FIGURE 11. Average values of evaluator indicators.

The results obtained across the different indicators evaluated in the study reflect a predominantly positive assessment of the proposed solution. The seismic announcement generated by ChatGPT is perceived as comprehensible, easy to understand, useful, and relevant in the context of seismic alerts. The quality of the content is highlighted for its timeliness, coherence, and interest, although some areas for improvement in the perception of certain specific aspects have been identified. It is important to note that negative perceptions, although minority, may be related to distrust in the generated information, given that the seismic alert announcement is produced using ChatGPT [34].

To improve these perceptions and strengthen user confidence, it would be advisable to consider deeper training of the model in the future. This would allow for adjustments to the accuracy and relevance of the announcements, responding more effectively to the expectations and needs of the public. Together, these findings indicate that the generation of seismic alert announcements through this proposal is well received by users, who appreciate its potential, solidifying it as an option in the field of disaster risk management.

X. DISCUSSION

The involvement of novel technologies in emergency or disaster contexts, such as the generation of seismic alerts, must always be accompanied by a strict assessment not only of their technical effectiveness, but also of user perception and trust. In this research, ChatGPT was used to generate seismic alert announcements. The results obtained indicate that the proposed solution has largely achieved the goal of providing understandable and easy-to-understand warnings for most users. This finding is also like the result of Sarangi et al [35] who emphasized the clarity and simplicity of content generated by a large linguistic model [36]. That is, the use of LLMs such as ChatGPT could improve the transmission of critical information in emergency situations, where speed and accuracy are key.

While the model has been generally well received, a group of participants was identified as expressing neutral or negative views. These perceptions could be linked to a general distrust of AI-based technologies, especially in contexts where information accuracy is relevant. On the other hand, one of the main limitations of this study is the small sample size of 47 participants, which restricts the generalizability of the results and increases the risk of sampling bias. With a small sample, individual perceptions may in some cases disproportionately influence the overall findings, reducing the representativeness of the conclusions.

Studies such as those by Kim Dam-yul [37] and Ayoub et al. have also evidenced [38] that it is problematic to rely on automated systems, especially when making critical decisions affecting public safety. They may simply not be aware, even if models such as ChatGPT are very advanced, they may not be able to handle the variance and time pressure of a sudden phenomenon, such as an earthquake.

To address these concerns, it would be advisable to consider deeper and more specialized training of the model, using more consistent and domain-specific data related to disaster risk management. Literature suggests that the continuous improvement of artificial intelligence models through the incorporation of updated and contextualized data can increase their accuracy and relevance, which in turn can enhance public perception and trust. By doing so, not only would the quality of the generated content be optimized, but the perception that these systems are reliable for such tasks could also be reinforced.

The use of ChatGPT for generating seismic alert announcements demonstrates great potential for improving communication in emergency situations [39]. Yet, optimization of the model based on this mix of objective technicality and user subjectivity is necessary for its validation up to its adoption and from there to its full application potential. The need to constantly improve and adapt this model to risk management contexts will be important to turn this technology into a useful and reliable tool for population protection in case of disasters [40]. By working on technical refinement and closer communication focused on user needs, this approach will not only improve the accuracy of the messages generated but will also help build the trust necessary for these technologies to be effectively integrated into risk management. With the continued evolution of models such as ChatGPT, their ability to transform communication at critical times will continue to be a critical topic that deserves attention and research.

In this way, we believe that LLMs enhance existing seismic warning systems by improving the interpretation, dissemination and personalization of warnings through advanced processing of large volumes of data in real time. Their ability to simultaneously analyze multiple sources of information, such as seismic sensors, social networks and messaging platforms, allows identifying relevant patterns and filtering out false or inaccurate information, ensuring more reliable communication during emergencies [43]. LLMs can therefore generate alerts tailored to different audiences, adjusting the language, tone and urgency of the message according to the profile of the recipients, whether they are citizens, authorities or the media [42]. This customization helps to make warnings more understandable and promote a faster and more appropriate response to risk. Another relevant improvement is the ability of LLMs to provide automatic and accurate recommendations in real time, guiding the population with clear indications on the actions to follow according to their location and the magnitude of the event. Likewise, their integration with virtual assistants or mobile applications could resolve doubts instantly, reducing misinformation and collective panic. We believe that LLMs facilitate the continuous learning of this type of systems, through the analysis of historical data and user feedback, which would allow in the future to identify areas for improvement and adjust both the response times and the quality of the warnings. In this way, LLMs not only complement but also transform seismic warning systems, making them more efficient, accessible and adaptive to the needs of the population.

In future research, it is recommended to expand the sample size and ensure its diversity in order to obtain more representative and robust results. Also, it would be relevant to conduct comparative analyses between different participant profiles and to employ mixed methodologies, combining quantitative and qualitative approaches to explore users' perceptions and experiences in greater depth. Ideally, it is suggested to have a control group and an experimental group, which would allow for more accurate comparisons and richer findings. On the other hand, it is important that future studies evaluate similar proposals using specific metrics to measure the satisfaction and accuracy of the model from the perspective of the participants, thus contributing to a more complete assessment of its performance. In the context of implementing LLM-generated seismic warnings, it is recommended that future studies priorities the development of algorithms capable of processing large volumes of seismic data in real time, in order to optimize the speed and accuracy of warnings. Similarly, it would be desirable to integrate LLMs with seismological sensor systems and digital platforms, such as social networks, to identify patterns of behavior during emergencies and streamline the communication of warnings. To ensure the effectiveness of the system, it is suggested that simulations and pilot tests be carried out in different regions of Peru, considering different geographical and population scenarios, which will allow its performance to be evaluated in different contexts. Finally, it is important to implement feedback protocols that facilitate the continuous improvement of the model, allowing for its adjustment based on interaction with users and civil protection authorities, thus ensuring a more efficient response adapted to the needs of the population.

XI. CONCLUSION

The study has demonstrated that ChatGPT has the capability to generate clear and useful seismic alert announcements, positioning itself as a competent tool for emergency situations. Most users perceived the announcements as comprehensible and relevant. However, areas for improvement were identified, particularly concerning public trust in automated systems. In terms of content quality, although the reception was predominantly positive, challenges persist regarding the perception of the timeliness and coherence of the information, highlighting the need for continuous refinement of the model.

To improve these aspects, future work should focus on developing advanced training techniques for the model that integrate real-time data and domain-specific risk management information. Additionally, it would be valuable to conduct simulations of seismic events that allow for experiencing the behavior of the proposal in controlled situations and gathering user feedback after the simulated event. This would facilitate the exploration of long-term public perception, with the goal of assessing and strengthening trust in the tool.

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Author Contributions

All authors made an equal contribution to the development and planning of the study.

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

Data Availability Statement

The data used in this paper can be requested from the corresponding author upon request.

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