JISS Journal of Indonesian Social Science

Vol. 5, No. 10, October 2024
E-ISSN:2723 – 6692
P-ISSN:2723– 6595
http://jiss.publikasiindonesia.id/

Edy App: Earthquake Mitigation Innovation Using GIS for Disaster Response in Pariaman, Indonesia

Ratih Fitria Putri, Najwa Nur Awalia
Universitas Gadjah Mada, Indonesia
Email: najwa.nur.a@mail.ugm.ac.id
Correspondence: najwa.nur.a@mail.ugm.ac.id*

KEYWORDS
EDY App; Earthquake; Pariaman City; disaster mitigation; Geographic Information System (GIS)

ABSTRACT
Pariaman City, located along the Semangko fault line and the subduction zone of the Indo-Australian and Eurasian plates, is highly vulnerable to earthquakes and tsunamis. The region's susceptibility to large earthquakes, followed by vertical deformations, highlights the need for effective disaster mitigation. In response, this study proposes the development of the Earthquake Buddy Application (EDY App), designed to assist with earthquake mitigation efforts. The EDY App leverages Geographic Information System (GIS) technology to map earthquake-prone areas, provide early warnings, suggest evacuation routes and Temporary Evacuation Sites (TES), and facilitate aid distribution. This Android-based mobile application focuses on four key aspects: education, mitigation, evacuation, and donation. Key features include an Earthquake Vulnerability Map, real-time early warnings, mitigation instructions, TES recommendations with distance and time estimations, emergency contact options, and donation channels. Built with React Native, PHP, and MySQL, and integrated with Google Maps API, the app is designed to be user-friendly and accessible to the public. The EDY App's contribution to earthquake mitigation lies in its ability to create a disaster-aware community. By offering comprehensive information and support during critical moments, the app can potentially reduce casualties and enhance community preparedness in earthquake-prone regions like Pariaman. Through this innovation, it is expected that residents will be better equipped to respond to natural disasters, promoting a culture of safety and resilience.

Introduction

An earthquake with magnitudes of 7.9 and 6.2 on the Richter Scale struck Pariaman City in 2009 (USGS, 2009). The disaster resulted in 1,117 deaths, 1,214 serious injuries, 1,688 minor injuries, and damage to 279,432 houses (Satkorlak, 2009). This devastating event was caused by two earthquakes occurring in nearby locations: the Mentawai fault area (under the sea) and the Semangko fault (BPBD, 2019).

This phenomenon is closely related to the earthquake theory, which is a subduction event that occurs due to the collision of two plates that are approaching each other (continental plates and oceanic plates) and cause bending of the oceanic plates that infiltrate the bottom of the continental

plate. The Padang region and around the west coast of Sumatra are lowlands that are prone to tsunami disasters caused by earthquakes from the Sunda Trench because in the area there is a seismic gap that can be a source of earthquakes in the future (Sieh, 2009). This is also strengthened by the location of Pariaman City which is close to the Semangko fault line and the subduction zone of the Indo-Australia Plate under the Eurasian Plate which can trigger earthquakes (Oktiari & Manurung, 2010).

Seeing the high seismicity in the Indo-Australia Plate with the West Sumatra fault system and the Mentawai fault, Pariaman City is very interesting to study in terms of seismicity as an effort to mitigate earthquake disasters. This area also has zones that are dynamic and complex because they can change in depth and shape quickly (Curey et al., 1989 in Akmam, 2011). Based on the earthquake that hit Padang Pariaman in 2009, it was stated that there were difficulties in collecting data from residents for assistance when the earthquake occurred. In addition, evacuation of victims is difficult due to ignorance of evacuation routes, gathering points, and difficulties in getting help when an earthquake occurs (Nadila & Ratri, 2020). Therefore, earthquake disaster mitigation efforts in Pariaman City are very necessary considering that the location is a coastal area close to the location of the source of the earthquake and tsunami.

Earthquake mitigation can be realized by creating an application that is integrated with each other to be able to solve these problems, such as mapping earthquake-prone areas, determining and proposing evacuation routes and temporary evacuation sites by utilizing geographic information systems (GIS), and can be a distributor of assistance in the form of donations. Remote sensing technology and GIS play an important role in disaster mapping as a reference for disaster mitigation and reducing the risks that occur (Sumari et al., 2016). The role of GIS can help estimate the number and area of disaster-prone areas and can map disaster vulnerability with spatial visualization results (Figure 1).

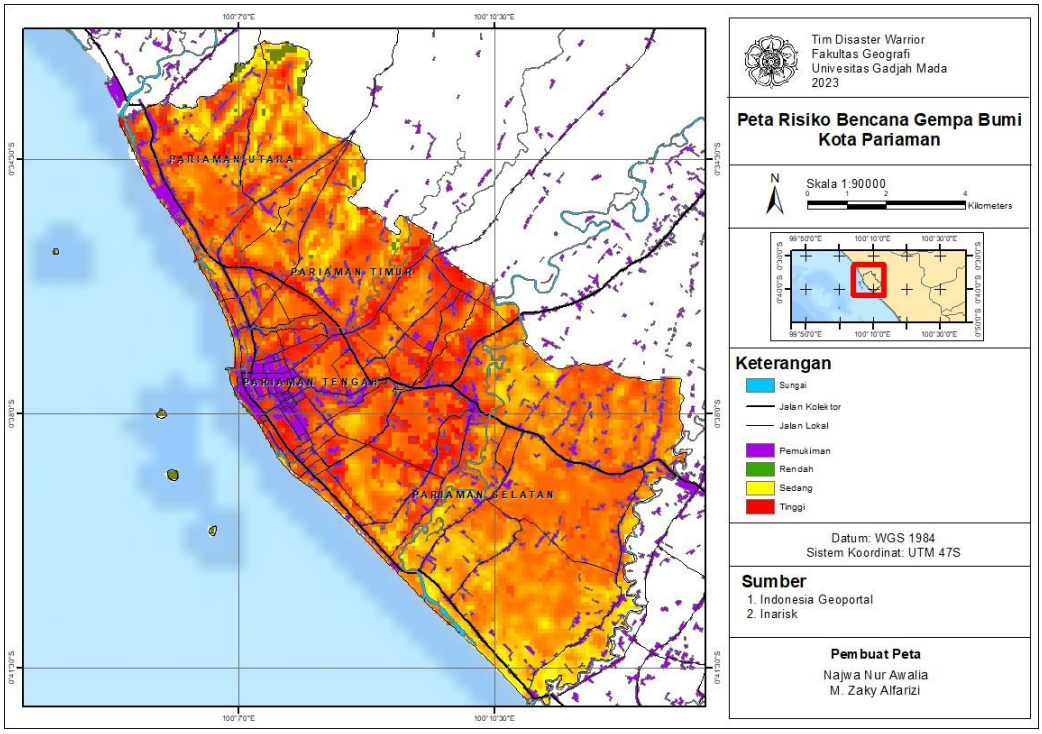

Figure 1. Pariaman City Earthquake Disaster Risk Map

Based on Figure 1, it is known that most of the residential areas in Pariaman City are still concentrated and grouped in areas that are classified as high to earthquake disasters. Even though the location is close to the subduction zone between the Indo-Australia plate and the Eurasian plate and is close to the Mentawai megathrust which is prone to tectonic plate movement.

Based on the urgency of the problem, the United Nations (UN) has the ambition to realize the Sustainable Development Goals (SDGs) (Hoelman, 2016). Innovation proposals will contribute to several sustainable development goals, including point 3 to reduce the number of deaths and illnesses due to natural disasters, point 9 to increase access to information and communication technology in an inclusive manner, point 11 to make cities and settlements inclusive, safe, resilient, and sustainable, and point 13 as a risk-based disaster management effort, identifying, and mapping areas prone and affected by disasters. Seeing the urgency of earthquake disasters that are prone to occur in Indonesia, it is necessary to innovate to minimize the loss of life due to the disaster (Hadiwijoyo & Anisa, 2020).

This research aims to design a Geographic Information System (GIS)-based application that can present information and map earthquake-prone areas, provide early warnings, and provide recommendations for evacuation routes and Temporary Evacuation Sites (TES) in Pariaman City. This application will also facilitate the distribution of aid as part of disaster mitigation. The benefits of this research include assisting the government in reducing the impact of earthquake disasters, providing mitigation information for the community, and being a reference for industry and academia in decision-making and disaster research.

Materials and Methods

The data and information in writing this scientific paper are secondary data obtained through the literature study method. The steps of the literature study method in writing this scientific paper are as follows:

1. Collecting data and information through literature studies from books, journals, and the internet;
2. Analyze data and information to achieve the purpose of writing from the results of problem identification;
3. Determining alternative solutions presented in the form of prototype designs for applications using Geographic Information Systems in efforts to mitigate earthquake disasters in Indonesia, especially Pariaman City, West Sumatra;
4. Examine the data from the results of the analysis and manage it so that a writing conclusion is obtained.

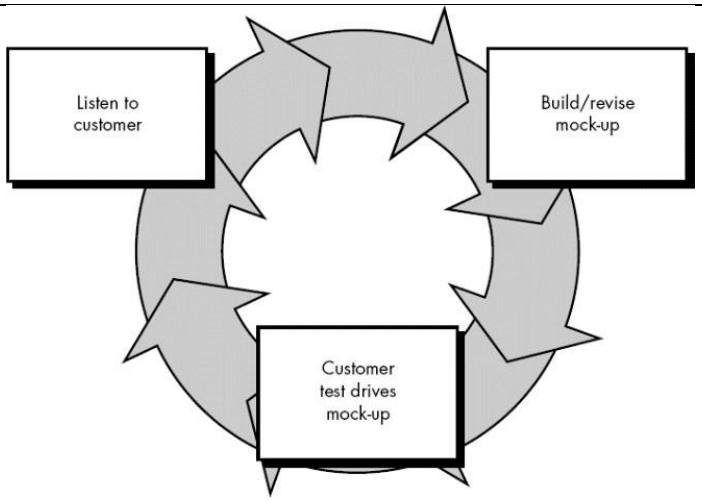

Figure 2. Prototype Model

source: Khosrow-Pour, 2005

Disaster vulnerability analysis can be carried out using the principles of Geographic Information Systems (GIS) through mapping that is included in the hazard class when a disaster occurs (Putra et al., 2019). The method used in the development of this system is to use prototypes to get a representation of the application modeling that will be created with a mockup as the initial application design, then it will be evaluated by the user. After the mockup is evaluated by users, the next stage of the mockup will be a reference material for software developers to design applications that are suitable for application on a certain regional scale (city/regency/national).

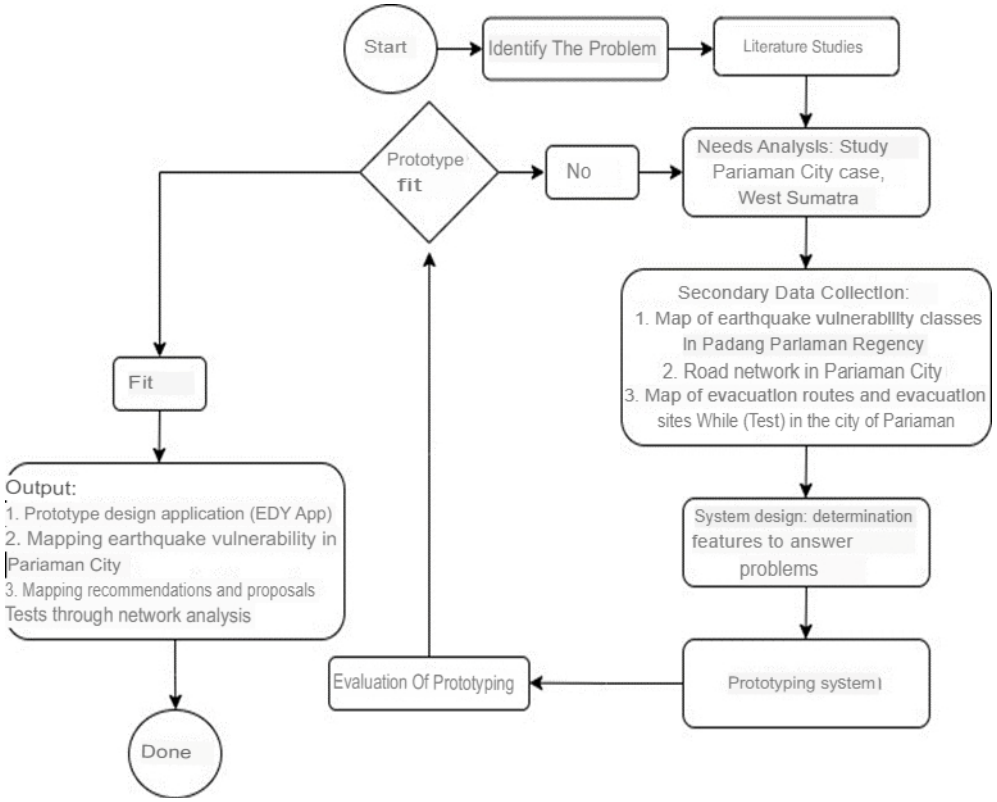

Figure 3. Flow diagram of scientific papers

Results and Discussions

App View

Earthquake Buddy Application (EDY App) is an innovation in the use of Geographic Information Systems (GIS) in efforts to mitigate earthquake disasters in Indonesia. This application emphasizes on four main aspects, namely education, mitigation, evacuation, and donations, especially for earthquake disasters. The EDY App has six main features, namely Earthquake Vulnerability Map, Early Warning Notifications, Earthquake Mitigation Action Information, Proposed Temporary Evacuation Routes and Sites (TES), Emergency Calls, and Donations. The educational function is found in the "Earthquake Vulnerability Map" feature which functions to display spatial data in the form of an Earthquake Vulnerability Class Map in a certain area and an Earthquake Prone Map (Estimated Value Distribution from Ground Surface Vibration) as shown in Figure 4.

Figure 4. EDY App Display

The next function is as an early warning. EDY App is equipped with a Global Positioning System (GPS) which functions as a navigation satellite system and positioning a person. In addition, this application is also equipped with a notification system that is directly connected to each user's mobile phone. Users can turn on the notification bell to get the latest information regarding earthquake conditions and warnings in the form of emergency messages if there is an indication of a potential earthquake in the area where the user lives. So that users can find out early as an effort to evacuate to a safer place. The mitigation function is also found in the Earthquake Mitigation Action Information feature which can be accessed to increase community preparedness in dealing with earthquakes.

An equally important function of the EDY App is the evacuation function by providing recommendations in the form of proposed evacuation routes and Temporary Evacuation Sites (TES) around earthquake-prone areas (Figure 4.1). So that through this application, it is hoped that the public can obtain information about safe location points for evacuation in the event of an earthquake in the area. As an effort to evacuate, this application is equipped with an "Emergency Call" menu consisting of phone numbers of several agencies, such as the police, the National Disaster Management Agency (BNPB) and the Regional Disaster Management Agency (BPBD. So that if users

need emergency assistance, they can contact these numbers which are directly connected to government agencies.

How the App Works

EDY App (Earthquake Buddy Application) is an innovation in the form of an application that aims to inform earthquake-prone locations by presenting spatial data in the form of maps, providing early warnings, and recommendations in the form of actions that need to be taken in the event of an earthquake and alternative evacuation routes or Temporary Evacuation Sites (TES) at the user's location. When entering the application, users are directed to create an account first on the Profile feature by completing personal data and verifying the account. After the user has an account, the user can log in and take advantage of the main feature, namely the display of spatial data information in the form of an Earthquake Vulnerability Class Map at the user's location. This application is equipped with a Global Positioning System (GPS) as a satellite system for navigation and positioning of a person, so that when entering the application automatically the GPS system will also activate and detect the user's location.

The case study in this paper is in Pariaman City, Padang Pariaman Regency, West Sumatra. So that when the user enters the EDY App and selects the Vulnerability Map feature, this application will automatically display the Earthquake Vulnerability Map in Pariaman City along with a description that contains information on the interpretation of the map. If the user's location is an earthquake-prone area, then this application will warn the user that the location occupied is an earthquake-prone area for reasons that cause the level of vulnerability. So it is hoped that through this application, users can also become more vigilant and ready to be on standby by knowing the vulnerable conditions of their residence.

In addition to displaying spatial data in the form of maps, the EDY App also functions in providing recommendations for earthquake mitigation actions. There is a special feature that will display information in the form of actions that users need to take as an effort to mitigate earthquakes, both indoors and outdoors. In addition, the EDY App is equipped with an Emergency Call feature with several emergency numbers that users can contact in the event of an emergency or during an earthquake. This feature is equipped with a phone number that is directly connected to several government agencies, both regional and national scale. So that apart from being a victim, users can also act as informants related to earthquake emergencies that occur in certain areas to related agencies.

The mitigation efforts carried out by EDY App are complemented by providing proposals in the form of evacuation routes and Temporary Evacuation Sites (TES) in earthquake-prone locations as an alternative to prevention and rescue. When the user gets a notification that the area where they live is an earthquake-prone area, this application will immediately direct the user to the next page which includes recommendations for earthquake mitigation measures and proposed evacuation routes and TES at the user's location. So that before or during an earthquake, the proposed TES feature provided by the EDY App can be used as a reference for users to save themselves to a safer place. This feature has been integrated with Google Maps, so that the distance and travel time to the evacuation site can be known. The app will display several test suggestions, but will only recommend the test that is closest to the user's location so that it will be easier to reach in a shorter time as an effective and efficient mitigation effort.

Application System Design

The design of the EDY App system is explained by using an activity diagram which is used to determine the flow of activities between the user and the system of the application created, as in Figure 4.2 attached.

Usefulness and Level of Urgency of Application

The EDY App (Earthquake Buddy Application) emphasizes the benefits for the community as an effort to mitigate earthquakes and realize a society that is responsive to earthquake disasters. Considering Indonesia's location on tectonic plates and included in the ring of fire area, this indicates that Indonesia is prone to earthquakes and has the potential to cause a tsunami. Based on these facts, it shows that the EDY App has a high level of urgency to be applied in the community, especially in areas with a high level of earthquake vulnerability, such as Pariaman City, West Sumatra. The EDY App can be used as a bridge between the government and stakeholders and the community in overcoming earthquakes that occur, so synergy from various parties is needed.

Advantages of EDY App

Edy App (Earthquake Buddy Application) has an advantage over other disaster mitigation applications because this application not only provides information, but also provides proposals in the form of evacuation routes and Temporary Evacuation Sites (TES) around the user's location that take into account accessibility, distance, and travel time. This application emphasizes four main functions, namely education, mitigation, evacuation, and donation. The educational aspect is carried out by providing information in the form of spatial data (Earthquake Vulnerability Map) and increasing public awareness. The mitigation aspect is carried out by providing information in the form of mitigation actions before and during an earthquake. In addition, there is an early warning feature that is directly connected to each user's mobile phone, in the form of the latest notifications to emergency SMS if there is an area with the potential for an earthquake, so that the public can evacuate immediately. The evacuation aspect is carried out by providing proposals for evacuation routes and Temporary Evacuation Sites. Meanwhile, the donation function is carried out as an effort to distribute assistance to affected victims, both in the form of money and goods. The use of mobile phones is considered quite effective considering the high percentage of mobile phone users in Indonesia which reaches 65.87% BPS, (2021) and in the midst of an all-digital digitalization era.

Determination of Temporary Evacuation Site (TES)

GIS attribute processing uses Arcview software that has a network analysis extension to determine the service area of a point from a distance based on the availability of the road/accessibility network. In this study, the network analysis function is used to determine settlements that are affordable or unreachable by existing TES. After that, this extension function is also used to determine the location of the proposed TES that is strategic for settlements that are not reached by the existing TES. So that the road network plays an important role because it aims to know the direction of evacuation to a safer place. The workflow is shown in Figure 5.

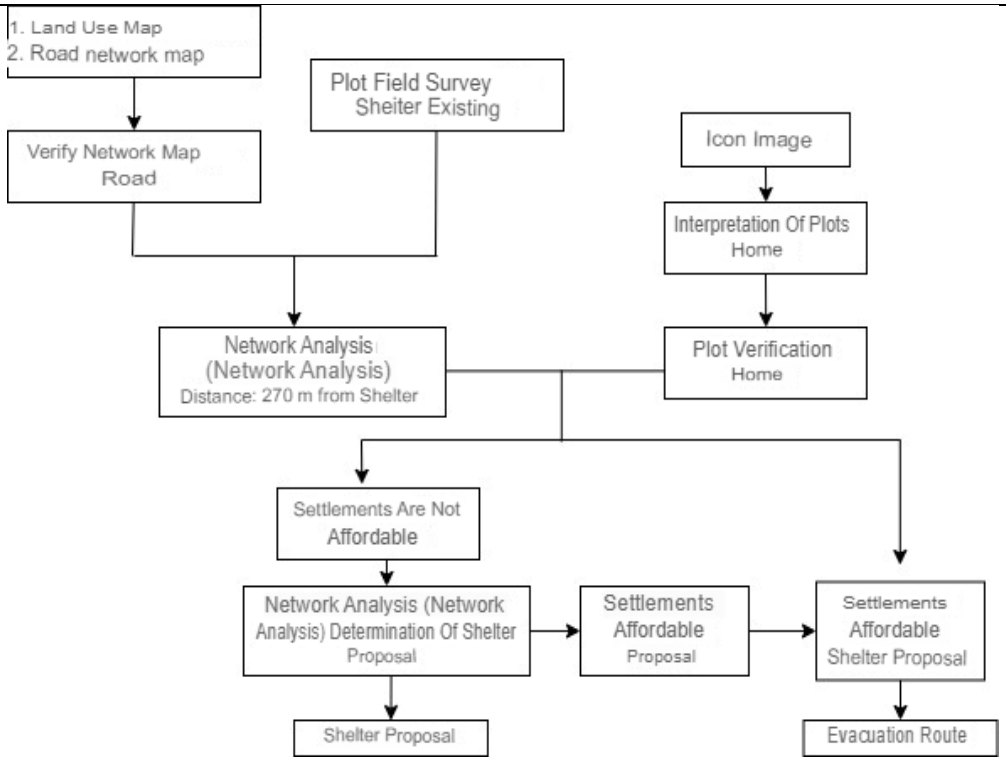

Figure 5. Flow diagram of the process of determining the Evacuation Route of the Temporary Evacuation Site (TES)

Source: Dewi et al., (2014)

Efforts are made to reduce disasters by evacuating residents to safer places as soon as possible. Therefore, a TES proposal was made in the form of a vertical building that has a minimum height of the TES floor is the maximum tsunami wave elevation at the TES location, plus 30%, plus 3 meters, and minus the ground height at the TES location (Applied Technology Council et al., 2008). The method for determining the safe distance to achieve TES refers to the Institute of Fire Safety and Disaster Preparedness Japan in Budiarjo (2006) explained that the evacuation speed = 0.751 m/s (walking speed of Elderly Humans) with the time used < 10 minutes. In this analysis, 6 minutes is used because it is assumed that the time can be reached by residents to the nearest TES. So based on this, the following calculations are obtained: Evacuation process time = 6 minutes = 6 x 60 seconds = 360 seconds, Distance from the TES

= 360 seconds x 0.751 m/s = 270.36 m = 270 m.

One of the analysis tools used in this EDY App study is network analysis. Network analysis is an analysis based on distance that refers to the network. The network used in this network analysis is road data. In addition to being an infrastructure to support community mobility, in the context of emergency response, the road network is also used as an evacuation access. The road network is used to determine whether a community group can be reached by a TES with a maximum distance of 270 m. The process of determining the coverage of existing TES is by using the Service Area analysis contained in the ArcGIS software tools. The data used is the location of the existing TES and the road network with the determination of the coverage distance of 270 m from the TES. The result is a polygon with a range of 270 m from the center where the TES is located (Figure 6)

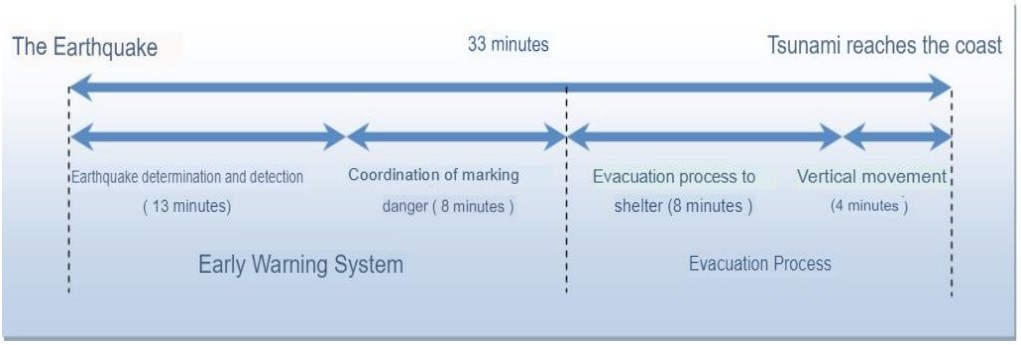

Figure 6. Time of the earthquake until the tsunami arrives on the coast

Source: Budiarjo, (2006)

App Implementation Strategy

1. Parties Involved in Implementing EDY App

Synergy and collaboration between parties are needed to be able to realize the EDY App. The parties that will be involved in implementing this application are:

a. Geospatial Information Agency (BIG), which functions to provide basic geospatial information, such as Indonesia's terrain map, topographic map, and other maps in the form of spatial data.
b. The Meteorology, Climatology, and Geophysics Agency (BMKG), which functions in observing, analyzing and providing services in the fields of weather, climate, and earthquakes. BMKG will record meteorological, climatology, and geophysical conditions to identify if there are areas with the potential for earthquakes. This information will be integrated into the EDY App, so that EDY App will immediately warn and notify all its users through the SMS and notification features to immediately evacuate to a safer place based on the recommendations of the Temporary Evacuation Site (TES) feature.
c. The government needs cooperation with the government, both at the regional level, and the central government to be able to make regulations and socialization related to digital disaster mitigation efforts.
d. The Regional Disaster Management Agency (BPBD) is needed as the front line in carrying out disaster management in a coordinated and integrated manner with other Regional Apparatus Work Units in the region. BPBD is needed to socialize and coordinate with the community regarding the implementation of the EDY App in a region.
e. Academics, cooperation with academics and researchers is needed to develop applications in terms of theory and primary data that are needed. So that the information displayed can be more accurate thanks to the role of academics who conduct field surveys to obtain more comprehensive primary data.
f. Cooperation with the community is needed in the form of socialization related to the importance of disaster mitigation to minimize casualties. The form of socialization and counseling is part of efforts to educate the community, especially those located in earthquake-prone areas to be more prepared if an earthquake strikes.
g. Application developer (App developer), to be able to realize this application, someone who is an expert in the field of technology and programming languages is needed to be able to make prototypes into applications that can be used by the wider community in Indonesia.

2. EDY App Funding Source

Based on the attached Table 4.1, it is known that funds of IDR 101,750,000 are needed for the creation of the EDY App with 3-12 months of ongoing projects. This considerable cost certainly requires support from various parties, both the government and the private sector. EDY App can obtain funding from the government as an effort to realize a disaster response community by mitigating earthquake disasters.

3. Strategic steps to implement EDY App

a. Preparation: the preparation stage is carried out to prepare all the features contained in the EDY App, from the prototype design to the finished application on Android ready to use. Then simulate and test the application to ensure that the system in the application can run as it should.
b. Approach and socialization to the community in earthquake-prone areas: the approach and socialization to the community starts from the stage of introducing earthquake-prone areas and mitigation efforts, introducing the EDY App (the features contained in it), explaining how to use the application, and the advantages of the application. The socialization process is carried out in collaboration with local governments, BPBP, youth, regional organizations, Non-Governmental Organizations, and community leaders to be able to help disseminate this application and its benefits.
c. Application implementation: at this stage, the operation of the EDY App and its implementation in the event of an earthquake occurs. Later, EDY App will also synergize with Disaster Preparedness Groups in their respective regions for coordination in the field.
d. Implementation and follow-up actions: at this stage, implementation, evaluation, and follow-up actions from the local government or agencies are carried out in evacuating earthquake victims from the Temporary Evacuation Site.

4. EDY App Innovation Implementation Timeline

EDY App is projected to be implemented on a regional scale in May 2024 and on a national scale in 2026 as shown in table 1.

Table 1. Edy App Implementation Timeline

Number	Month and year	Activity description
1	March-August 2023	Preparation and Collection data: Manufacture prototype and design programming languages, as well as collect secondary data from various topics.
2	September-December 2023	Cooperate with various parties, such as the government (BNPB, BPBD, PMI, BASARNAS, Police, and Fire Department).
3	January-February 2024	Conducting socialization to the relevant community earthquake mitigation and application use.
4	March-May 2024	Conduct a regional trial of the application in Pariaman City, West Sumatra.
5	June-December 2024	Evaluation Use application and do improvements for national scale implementation.
6	2025-2026s	EDY App success and implementation projections on a national scale.

Conclusion

The conclusion of this study states that the EDY App (Earthquake Buddy Application) is designed to provide education, early warning, proposals for Temporary Evacuation Sites (TES), and distribute aid as part of earthquake disaster mitigation. The application integrates the Geographic Information System (GIS) with the Google Maps API to present Earthquake Vulnerability Maps and map evacuation routes and tests through network analysis. Suggestions for the development of this application include collaboration with various parties, further regulatory studies, and development of technology infrastructure using React Native

References

Applied Technology Council, (US), N. E. H. R. P., & (US), N. T. H. M. P. (2008). Guidelines for Design of Structures for Vertical Evacuation from Tsunamis. US Department of Homeland Security, Federal Emergency Management Agency.

BPBD. (2019, February 4). Mengenang Gempa 2009 di Kota Padang. Badan Penanggulangan Bencana Daerah Kota Padang. https://bpbd.padang.go.id/konten/mengenang-gempa-2009-di-kota-padang

BPS. (2021). Statistik Telekomunikasi Indonesia 2021. Jakarta: Badan Pusat Statistik.

Budiarjo, A. (2006). Evacuation Shelter Building Planning for Tsunami-prone Area; a Case Study of Meulaboh City Indonesia [Master thesis, International Institute for Geo-Information Science and Earth Observation]. https://purl.utwente.nl/essays/101910

Hadiwijoyo, S. S., & Anisa, F. D. (2020). Tujuan Pembangunan Berkelanjutan (Sustainable Development Goals). Rajawali Pers.

Hoelman, M. B. (2016). Sustainable development goals, SDGs: panduan untuk pemerintah daerah (kota dan kabupaten) dan pemangku kepentingan daerah. Infid.

Ismi, T. (2021, January 27). React Native Framework yang Jadi Topik Hangat di Kalangan Developer. Glints. https://glints.com/id/lowongan/react-native-adalah/

Juwairiah, Arahman, I., & Santosa, B. (2013). Aplikasi Mobile GIS Layanan Informasi Lokasi Penting Kota Surakarta Berbasis Android. Jurusan Teknik Informatika UPN "Veteran" Yogyakarta.

Khosrow-Pour, M. (2005). Encyclopedia of Information Science and Technology. IGI Global Publishing.

Mustafa, B. (2010). Lokasi Potensi Sumber Tsunami di Sumatera Barat. Jurnal Ilmu Fisika, 2(2), 94–100.

Nadila, S. M., & Ratri, A. M. (2020). Partisipasi Masyarakat dalam Adaptasi Bencana di Kabupaten Padang Pariaman. Share: Social Work Journal, 10(1), 11. https://doi.org/10.24198/share.v10i1.23707

Oktiari, D., & Manurung, S. (2010). Model Geospasial Potensi Kerentanan Tsunami Kota Padang. Jurnal Meteorologi Dan Geofisika, 11(2). https://doi.org/10.31172/jmg.v11i2.73

Putra, D. B., Suprayogi, A., & Sudarsono, B. (2019). Analisis Kerawanan Banjir Pada Kawasan Terbangun Berdasarkan Klasifikasi Indeks EBBI (Enhanced Built-Up and Bareness Index) Menggunakan Sig (Studi Kasus Di Kabupaten Demak). Jurnal Geodesi Undip, 8(1), 93–102.

Satkorlak. (2009). Recapitulation of West Sumatra EQ Impacts Friday October 23. UN OCHA Sumatra.

Sieh, K. (2009). Padang Earthquake Struck at Edge of Zone Where Much Bigger Quake. Expected. http://www.earthobservatory.sg/news/2009/

Suci, R. (2019). EWAS Pendeteksi Gempa Karya Ilmuwan UI. Jurnal Jabar. https://www.jurnaljabar.id/nasional/ewas-pendeteksi-gempa-karya-ilmuwan-ui-b1Xlm9b7E

Suhardiman. (2012). Zonasi Tingkat Kerentanan Banjir dengan Sistem Informasi Geografis (SIG) Pada Sub DAS Walanae Hilir [Unpublished undergraduate thesis]. Universitas Hasanudin, Makassar.

Sukamto, & Shalahuddin. (2015). Rekayasa Perangkat Lunak: Terstruktur dan Berorientasi Objek. Informatika.

Sumari, A. D. W., Nugroho, S. P., & Addin, T. N. (2016). Pengurangan Risiko Bencana Gempa Bumi-Tsunami di Pangkalan TNI AU Padang Akibat Megathrust Mentawai. Jurnal Pertahanan, 6(1), 119–149.

USGS. (2009). Magnitude 7.6 Southern Sumatera Indonesia. United Geological Survey. http://earthquake.usgs.gov/earthquakes/recenteqsww/Quakes/us2009mebz.php/

Yasien, N. F., Yustika, F., Permatasari, I., & Sari, M. (2021). Aplikasi Geospasial Untuk Analisis Potensi Bahaya Longsor Menggunakan Metode Weighted Overlay (Studi Kasus Kabupaten Kudus, Jawa Tengah). Jurnal Geosains Dan Remote Sensing, 2(1), 33–40. https://doi.org/10.23960/jgrs.2021.v2i1.47