Vulnerability Assessment and Damage Estimation: An Input for the Mitigation and Preparedness Plan for "The Big One" Earthquake in Barangay Cangatba, Porac, Pampanga

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Abstract: - The Barangay Cangatba, Porac, Pampanga is situated in an area prone to earthquakes, and several earthquake sources nearby might produce an earthquake of any magnitude at any moment. This study aimed to assess the vulnerability and estimate the possible damages by the Big One earthquake as an input for the mitigation and preparedness plan in Brgy. Cangatba. This study also aimed to generate several scenarios of the Big One; to determine the damage ratio of the buildings; and to estimate the human loss, human injury, and economic loss in Brgy. Cangatba; as well as to create a GIS evacuation map. The damage ratio in different types of buildings was calculated using fragility curves of buildings of the Philippines. Computed population data of each building in different occupancy times, damage ratios, mortality ratios, injury ratios, and building prices were used to compute the number of human losses, human injury, and economic loss due to the Big One. The results reveal that the worst event of an earthquake is from 7.2-7.7 Mw along the West Valley Fault. The buildings in Brgy. Cangatba are subject to intensity VII, which is destructive based on MMI (Modified Mercalli Intensity), which can cause 11.42-47.31% damage to buildings equivalent to an anticipated 58 fatalities and 29 injuries in a 2 PM event, 92 fatalities, and 34 injuries in a 5 PM event, and nine fatalities and five injuries at 2 AM. The community might suffer a projected ₱ 362,195,715.31. The feedback from the residents shows that an evacuation map would help the community once the worst earthquake event occurs.

Key Words: — *The Big One Earthquake, GIS, Human Loss, Human Injury, Economic Loss.*

I. INTRODUCTION

The Philippines is located along the Pacific Ring of Fire, which is frequently affected by seismic and volcanic activity (Prasetyo et al., 2020).

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According to Kahandawa et al. (2018), an earthquake is a periodic natural occurrence that causes significant harm to communities and the environment. Aside from active volcanoes, the Philippines is surrounded by five active faults: Western Philippine Fault, Eastern Philippine Fault, Southern Mindanao Fault, Central Philippine Fault, and Marikina/Valley Fault. The Philippine Institute of Volcanology and Seismology (PHIVOLCS) has recorded an average of 20 earthquakes per day, with 100–150 per year being felt.

On April 22, 2019, the Philippine Institute of Volcanology and Seismology (PHIVOLCS) reported that an earthquake with a magnitude of 6.1 occurred in Zambales. The epicenter of the earthquake is located on the mountain range between Zambales and Pampanga at a depth of 10 kilometers and 18 kilometers northeast of Castillejos, Zambales. The observed earthquake intensity varied by city or municipality, and Pampanga province saw a disproportionately high number of earthquake fatalities (Santos & Principe, 2021). Moreover, an earthquake of Intensity VI (very strong) struck the town of Porac, Pampanga.

Assessing vulnerability and damage estimation are fundamental factors necessary to determine whether a specific building or structure and its location are prone to seismic activities. Upon investigation and undergoing such processes, accumulated data, and information will enable people from nearby to at least be prepared to mitigate the effects that these occasions can contribute to affected places and their people.

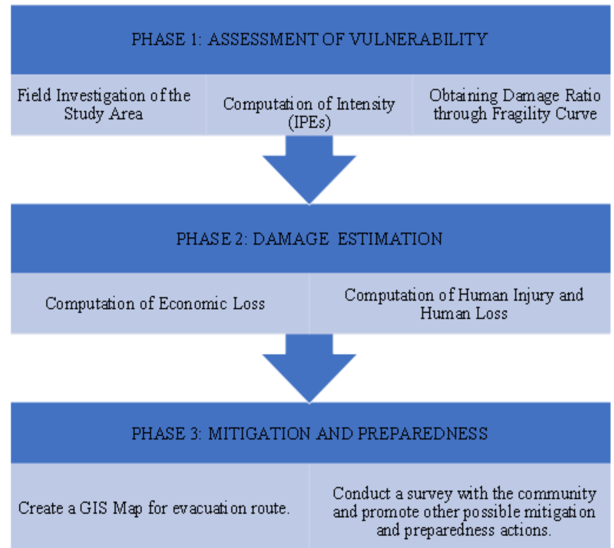
The term “big one” is used in many parts of the world. It is a term used to describe damaging and strong earthquake scenarios (Cansinas, 2021). The first earthquake that was considered the “Big One” was “The Great 1906 Earthquake” which happened in San Francisco, California. It was hit by a magnitude of 7.9 (Britannica, n.d.). In the Philippines, it is often equated to the worst-case earthquake scenario in the greater Metro Manila area.

Due to these unforeseen events, the Philippine Institute of Seismology and Volcanology (PHIVOLCS), as well as other Governmental organizations, keep bolstering the disaster management system to lessen the potential harm that "The Big One" is likely to cause by the West Valley Fault movement. As a result, research called MMEIRS, or the Manila Earthquake Effect Reduction Study, was conducted in 2004 and demonstrated the potential for "The Big One" to damage 40% of residential structures and approximately 35% of all public buildings. Additionally, it also revealed an estimated number of 34,000 possible outcomes of casualties, 114,000 people who have suffered severe injuries, and fire occurrences linked to the earthquake that could result in an additional 18,000 fatalities and will harm the country's infrastructure, such as water, roads, ports, and telecommunications.

II. Conceptual Framework

The study has projected each footprint of anticipated damage into a GIS to produce a vulnerability map utilizing the evaluated gathered data for better representation. In addition, the projected magnitude of "the Big One" earthquake will be utilized to assess the damage. The resulting maps are then used to highlight the situations in recommendations for mitigation and preparedness. Table 1 shows the course of action that have been undertaken to complete the study.

Table.1. Research Paradigm



III. Methodology

The study is conducted with a quantitative type of research. Data collection strategies such as assessment of existing resources from the Local Government Units (LGUs), reliable studies online, and data set from GIS program or through actual field investigation is applied to find the required data in the study. The researcher went to the Municipality of Porac, Pampanga and Barangay Cangatba to seek assistance. Figure 1 depicts the flow of concepts that were investigated.

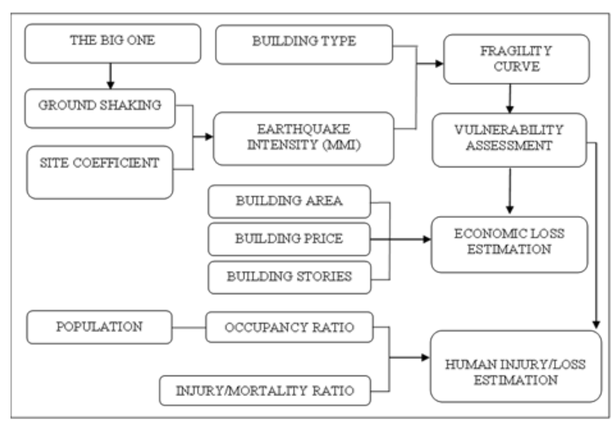


Fig.1. The Flowchart of The Big One Earthquake, vulnerability assessment, and damage estimation

IV. Assessment Of Vulnerability

Stage 1: Field Investigation of the Study Area

Barangay Cangatba is selected as an area of interest since it contains a relatively higher concentration of built-up structures than other barangays in the municipality. This area is also one of the most affected Barangay when the 6.1 Mw earthquake of 2019 occurred. The building stories and classification will mainly be the focus of the on-site investigation.

Fig.2. The study area in Porac

Stage 2: Computation of Intensity (IPEs)

Equation (1) by Allen and co-authors (2012) is used to estimate the intensity of the earthquake at a distance from the rupture zone. Equation (2) was used by Rusydy et al. (2018) to compute the site amplification effect.

$$(1) \quad I\left(M, R_{rup}\right) = c_0 + c_1 M + c_2 ln\sqrt{R_{rup}^2 + [1 + c_3 e^{(M-5)}]^2} + S$$

In the above equations, I stands for intensity in MMI, M stands for the magnitude of the earthquake in Mw, Rrup stands for the distance to the rupture zone in km, c is a coefficient number (c0 = 3.950, c1 = 0.913, c2 = −1.107, and c3 = 0.813), S is the site correction, and F is the site amplification (Fv for an extended period, Fa for a short period) representing the amplification capacity of the local soil.

$$(2) \quad S = 3.18\, log\ (F)$$

To get the value of F, it was classified first what type of soil needs to be examined, then it was checked on Table 2 to know what the value of F is, to be able to solve the site correction S.

Table 2. Site Coefficient (Fa) for Five Different Soil Classifications Based on ASCE/SEI 7-10 for PGA Map 0.4 g.

Site Class	S_A	S_B	S_C	S_D	S_E
N-SPT	NA	NA	>50	15 to 50	<15
Fa	0.80	1.00	1.20	1.40	1.72

Damage ratio has been one of the fundamental factors in order to succeed in the study. In this study, vulnerability curves, assumed to be lognormal cumulative distribution function of damage ratio versus the Modified Mercalli Intensity (MMI) scale, were utilized using the computational, empirical, and heuristic approaches. A seismic vulnerability curve is a standard lognormal cumulative probability distribution function (Giovinazzi et.al. 2002, Saidi et.al. 2009, and Pacheco et.al. 2012) of the form:

$$(3) \quad DR[MMI] = \Phi[\frac{1}{\beta} ln\left(\frac{MMI}{\mu}\right)]$$

where DR[MMI] is the damage ratio of a building for the given Intensity in MMI; Φ is the standard lognormal cumulative distribution function; β is the standard deviation of the natural logarithm of MMI; μ as the median value of MMI. The controlling parameters namely the median μ and the uncertainty β, of the vulnerability curves for the key building types identified were estimated.

V. Damage Estimation

Stage 1: Computation of Economic Loss

The research considered four (4) variables to determine the value of economic loss (Equation 4).

(4) Economic Loss = DR x BA x NS x PB

The damage ratio for each building results in different casualties among those trapped in a collapsed or seriously damaged structure (Rusydy et al., 2017; Rusydy et al., 2018). The damage ratio (DR), building area (BA), number of stories (NS), and price of the building (PB) are the parameters.

Stage 2: Computation of Human Injury and Loss

Building vulnerability of each building results in a different number of casualties because the individuals are assumed to be trapped in collapsed or seriously damaged buildings. The human injury estimation (Equation 5) and human loss estimation (Equation 6) can be calculated using a variety of equations.

(5) Human Injury = OR x P x DR x IR

(6) Human Loss = OR x P x DR x MR

In this study, Equations (5) and (6), which was proposed by Hashemi & Alesheikh, were utilized to attain the estimated number of populations that might possibly be injured or worse could result in human loss. The following equation can be determined based on the injury ratio (IR) and mortality ratio (MR), respectively, wherein both equations were computed using the occupancy ratio (OR) of the structures at the time of the earthquake, the population (P) (Equation 7), and the damage ratio (DR) of each building present in the locale.

Table 3. Injury Ratio and Mortality Ratio for Worst-case Damage Scenarios in Different Types of Buildings Used in the Study of Hashemi & Alesheikh as cited by Rusydy (2018).

No.	Type of Building	Injury Ratio	Mortality Ratio
1	Low-rise Light Wood Frame (W1-L)	0.4	0.3
2	Low-rise Concrete Frame (C1-L)	0.2	0.8
3	Low-rise Steel Frame (S1-L)	0.4	0.4
4	Low-rise Masonry (CHB-L)	0.5	0.5

The data of the population gathered were divided into two categories namely Residential and Commercial/Institutional type of buildings. The population (P) of the residential structures was accumulated using the formula stated on the Equation (7) through multiplying the quotient of the total population of Barangay Cangatba and the total estimated area of the structures by its individual areas. The population of the Institutional and Commercial buildings, on the other hand, was attained by limiting the number of populations into 10 considering it is a small store that is commonly for customers who are not staying longer in the said building. This includes *Sari-Sari* stores, drug stores, car repair shops, etc. While one person per square meter was followed according to the Municipal Engineer of Porac.

$$(7) \quad P_{residential} = \frac{Population\ based\ to\ statistic}{Total\ Area\ of\ the\ Houses}\ x\ Area\ of\ House$$

FEMA suggested three distinct periods of the day (2 AM, 2 PM, 5 PM) as cited in the study of Rusydy (2018). The occupancy ratio is anticipated to be 1 for residential buildings and houses and 0 for institutional and commercial buildings such as schools, malls, offices, and other commercial buildings at 2AM. The occupancy ratio for the classification of the institutional and commercial buildings during the daylight scenario at 2PM is 0.75, whereas the occupancy ratio for the other classification is 0.25. Since the majority of both groups have been dismissed by 5PM and have already departed, an occupancy ratio of 0.5 is anticipated for this time period for both types of building.

Table.4. Occupancy Ratio Using Three Different Time Scenarios.

Occupancy Ratio	Three Different Times		
	2PM	5PM	2AM
Residential	0.25	0.5	1
Institutional and Commercial	0.75	0.5	0

VI. MITIGATION AND PREPAREDNESS

Stage 1: Geographic Information System (GIS) Evacuation Map

The software for geographic information systems will require numerous shape file data. The map of the Philippines using OpenStreet map was manipulated with ArcGIS software. ArcGIS is a geographical information system (GIS) software that allows handling and analyzing geographic information by visualizing geographical statistics through layer building maps like climate data or trade flows. ESRI (2018), through Map Viewer, Map Viewer Classic, and 3D Scene Viewer, it can access a gallery of basemaps and smart styles for exploring and visualizing the data.

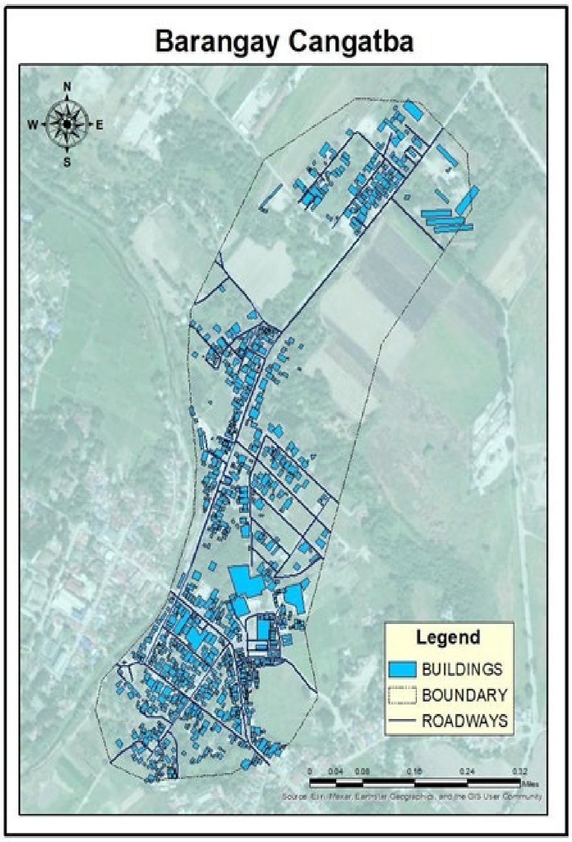


Fig.3. Sample template for GIS Map of Barangay Cangatba using ArcGIS 10.7

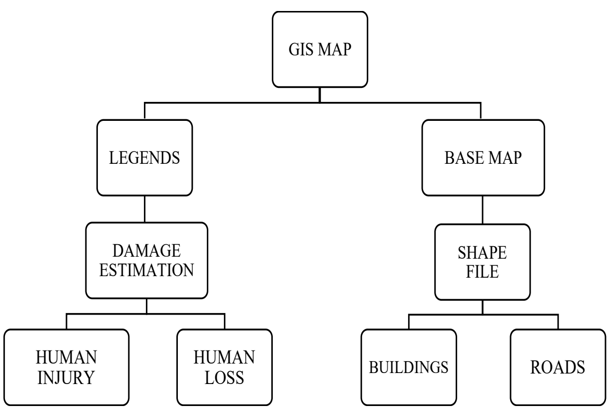


Fig.4. GIS map flowchart

This study has required a map for the specific area which ArcGIS offers. This app has played an essential role in the study by providing a base map of Brgy. Cangatba, Porac, Pampanga, where there are shape files of the different buildings and roads. This study used only one map of the given area, consisting of different colors of buildings, which was indicated in the legend.

The map was also based on the numerical data of damage estimation for The Big One earthquake that was done at three different times (2 PM, 5 PM, and 2 AM), as suggested by FEMA (2010), cited by Rusydy (2018). The legends have used three (3) categories of Damage Estimation: Human Injury and Human Mortality (See Figure 3).

Stage 2: Survey Feedback

The research was conducted a survey with the community and local officials along with the GIS evacuation map. This activity was done by coordinating the research with the local government unit. Additionally, it comprised of discussion about the following: The Big One discussion, GIS Map, and raising awareness about possible damage of such an earthquake. A survey questionnaire was used to get feedback from the community.

VII. RESULTS AND DISCUSSION

7.1 Damage Ratio

The IPEs equation revealed that magnitudes of 7.7 Mw, based on the study of Rusydy, (2017), and 7.2 Mw based on PHIVOLCS, have shown that both of these parameters have fallen in the Intensity VII category. Considerations such as 69.6 km rupture distance, obtained from fault finder, and soil profile type Sd were used since there were no soil profile tests conducted in Barangay Cangatba as per the Municipal Engineer.

Table 5. Computed Damage Ratio of Different Types of Buildings in Intensity VII

Intensity	W1-L	C1- L	S1-L	CHB-L
VII	0.2714508	0.1962502	0.1142118	0.4730736

The calculated intensity through the use of the IPEs equation is intensity VII, it was then classified as Destructive intensity category based on PHIVOLCS Earthquake Intensity Scale. Damage ratios ranging from 0.11 to 0.47 were then computed through the use of seismic vulnerability curves (Equation 3), considering Intensity VII, as shown in Table 3.2. Damage values of 47.31% influences masonry (CHB-L) buildings, 27.15% to light wood frame (W1-L), 19.6% to low-rise concrete moment frame (C1-L) buildings, and 11.4% to low-rise steel moment frame (S1-L) buildings. Figure 4 shows the different damage ratio of intensity 3 to 11.

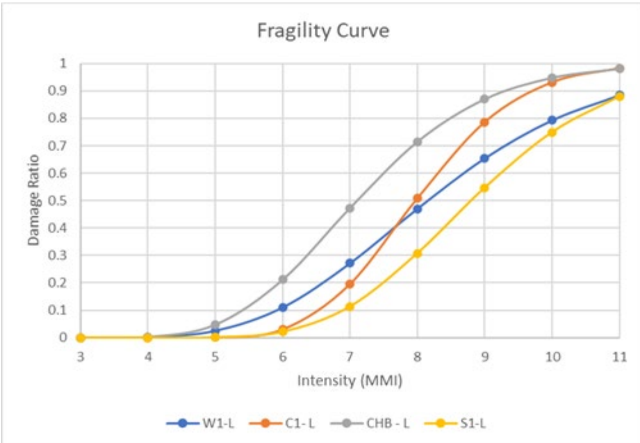


Fig.5. Fragility curve of three types of buildings in the study area as a function of intensity

7.2 Economic Loss

According to the Municipal Engineering office of Barangay Cangatba, for reinforced concrete structures (C1-L), the cost of residential and institutional and commercial building was estimated per square meter and varies from ₱15,000 to ₱20,000. For both building types using wood light frames, an estimated price of ₱5,000 was anticipated. It is estimated that a low-rise steel frame and a masonry (CHB) building cost approximately ₱10,000 per square meter and can be used for both types.

The table below shows that the highest financial loss in residential buildings is ₱265,722,258.32, while the institutional and commercial buildings posted a loss of ₱96,473,456.99, resulting in a total amount of ₱362,195,715.31 loss in Brgy. Cangatba.

Table.6. The Economic Loss in Different Types of Buildings in the Big One Earthquake Event.

ECONOMIC LOSS	
Type	PRICE
Residential	₱ 265,722,258.32
Institutional and Commercial	₱ 96,473,456.99
Total	₱ 362,195,715.31

7.3 Human Injury

The recorded human injury at three different times and is presented in Figure 6. Using the Equation (5), the researchers were able to calculate the number of injuries. A day is at its busiest at 2 PM in the afternoon. The above table shows that one person would be injured inside a W1-L, 10 in C1-L, 17 in S1-L, and one in CHB-L buildings with a total of 29 possible injuries. Most of the people, such as regular citizens and workers go home at 5 PM. Hence, residential and institutional and commercial buildings are both occupied. When the Big One earthquake occurred, it is shown that there were two injuries in W1-L, 20 in C1-L, 11 in S1-L, and one in CHB-L buildings summing up to 34 possible injuries being the highest. At 2AM, most people are inside their homes, thus, institutional and commercial buildings are finally vacated. For W1-L, there were no injuries recorded, while there is one in C1-L buildings, and two in both S1-L and CHB-L buildings with the least total number of four possible injuries.

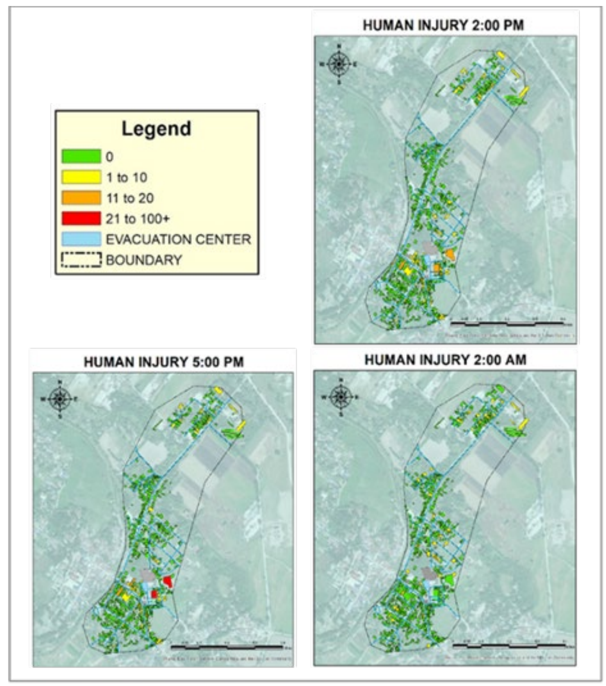


Fig.6. The number of injuries in each building; (a) 2 PM, (b) 5 PM, and (c) 2 AM. Digitally modeled using ArcGIS.

7.4 Human Loss

The recorded human loss at three different times and is presented in Figure 7 using the Equation (6). The busiest time of the day is at 2 PM, when most of the residents are at work and only a few people stay in their houses. The outcome shown in the table indicates that around 39 casualties were recorded in C1-L, 17 in S1-L, and one for both W1-L and CHB-L buildings with a total of 58 possible fatalities. At 5 PM, half of the population is about to leave the workplace and half of the population is already in their houses. Consequently, the occupancy ratio is 0.5. The estimated number of fatalities at this time would be 79 in the C1-L, 11 in the S1-L, and one for both W1-L and CHB-L buildings concluding a total of 92 possible fatalities. If an earthquake occurred at 2 AM, most of the people are expected to be at their homes. The occupancy ratio at 2 AM is one for all residential and zero for commercial buildings. At this time scenario, the highest recorded casualties would be four in C1-L, two for both S1-L and CHB-L, while there were no casualties recorded in W1-L buildings with a total of eight possible fatalities.

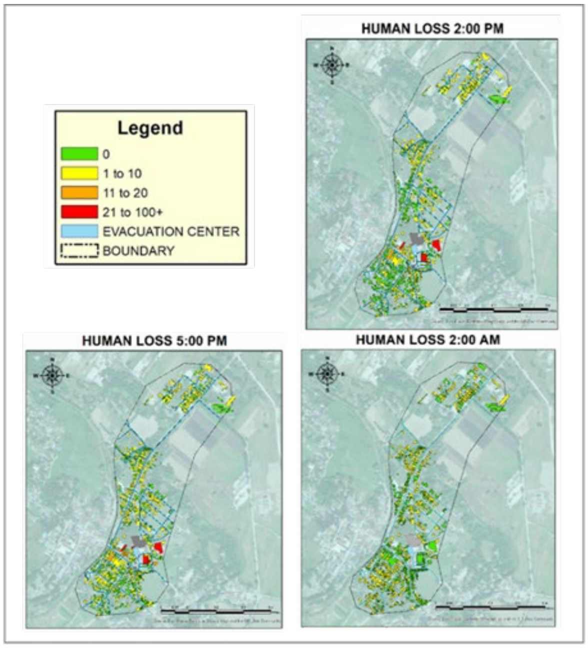


Fig.7. The number of fatalities in each building; (a) 2 PM, (b) 5 PM, and (c) 2 AM. Digitally modeled using ArcGIS.

7.5 Mitigation and Preparedness

The economic value of total or partial destruction of physical assets existing in the affected locale is greatly affected when a disaster occurs. Direct economic loss is closely equivalent to physical damage. This loss can either directly or indirectly lead to financial losses. The economic effects of an earthquake are significant because these may help the public and the government understand potential areas for building improvement and provide people time to prepare for the worst financial effects that could occur.

In this study, Figure 8 was generated from the combination of worst earthquake scenarios of human injury and human loss produced from Mw 7.2 and Mw 7.7 from the Big One earthquake. Using GIS analysis, the Evacuation Map of Barangay Cangatba is composed of building polygon data and routes that have the corresponding meaning as shown in the legend.

The color green was designated as safe, which means fewer, or no possible nearby buildings could cause potential casualties or damages after an earthquake. Yellow was designated as average, concluding that a casualty of 1 to 10 people could possibly occur, and few nearby buildings might have been damaged. Orange represents poor, which means that 11 to 20 casualties are projected to happen, and nearby buildings might have been greatly damaged. Lastly, red is defined as critical, which means more than 21 casualties have possibly occurred and nearby buildings were expected to suffer from damages or worst, could collapse.

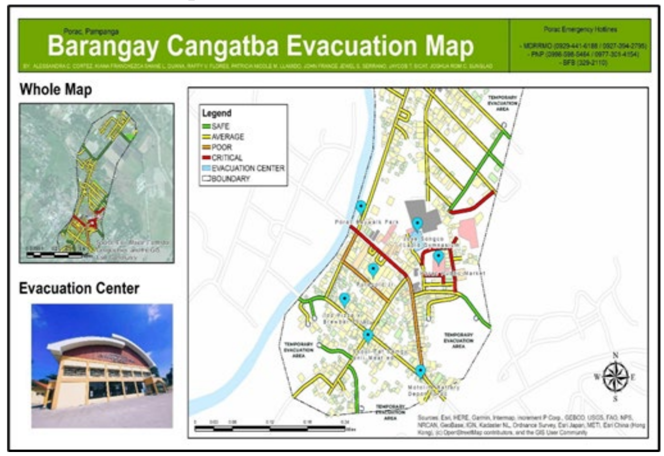


Fig. 8. GIS based Evacuation Map of Brgy. Cangatba shows the possible route to temporary evacuation areas and evacuation center after an earthquake using ArcGIS 10.7.

7.6 Survey Result

Table.7. Background of the Community about Evacuation Map

BACKGROUND ABOUT EVACUATION MAP	YES	NO	YES%	NO%
Q1: Are you aware of the evacuation routes and evacuation center in your barangay?	49	65	43%	57%
Q2: Are you familiar with using and reading an evacuation map?	79	35	69%	31%

Table 7 shows the background of the residents of Barangay Cangatba about evacuation map. Fifty-seven percent of the residents were not aware of the routes and evacuation center of their Barangay, while 43% were aware. On the other hand, 69% of the residents were familiar with the use of an evacuation map and only 31% were not. This result shows that this study is necessary in order to raise awareness about the routes and evacuation center of the Barangay, and that the GIS map of this study would be helpful since the majority of the population knew how to use and read an evacuation map.

Table.8. Understanding of the Community About the GIS Evacuation Map

UNDERSTANDING ABOUT THE GIS EVACUATION MAP	YES	NO	YES%	NO%
Q3: Do you find the map easy to use/understand?	100	14	88%	12%
Q4: Does the map clearly show evacuation routes and evacuation centers?	108	6	95%	5%
Q5: Do you require the emergency evacuation routes to be on a map?	98	16	86%	14%

Table 8 shows how the community understands the GIS Evacuation Map. Eighty-eight percent of the respondents were able to understand the map clearly and found it easy to use, while the remaining 12% had a bit of difficulty understanding it, since most of them aren't really residing in Brgy. Cangatba. When it comes to the clarity of the routes and the location of the evacuation center, most of the respondents or 95% recognized the routes easier and only 5% of them need a little time to assimilate it. Lastly, 86% of the respondents agreed that emergency evacuation routes would be helpful if it were to be on the map, while the other 14% disagreed.

Table.9. Visual Aspect of the GIS Evacuation Map

VISUAL ASPECT OF THE GIS EVACUATION MAP	YES	NO	YES%	NO%
Q6: Do you think the map provides detailed information?	100	14	88%	12%
Q7: Do you understand the figures shown on this map?	114	0	100%	0%
Q8: Are the assigned colors and meanings along the routes clear enough?	114	0	100%	0%
Q9: Does the map accurately represent its legends?	112	2	98%	2%
Q10: Do you find the map visually pleasing?	114	0	100%	0%

Table 9 shows the feedback of the respondents about the visual aspect of the GIS Evacuation Map. Eighty-eight percent of the respondents said the map provides the detailed information needed to understand it easily, while 14% of respondents were looking for other details to be provided in the map. Representation of the legends shown that most of the respondents or 98% validated the accuracy of the information on the map, but the other 2% had seen a little inaccuracy or had difficulty identifying the difference of the legends. At last, the map was pleasing, and all respondents agreed that they understood all the information portrayed on it, including the colors and meanings along the routes.

VIII. Conclusion

This study successfully created several earthquake scenarios and determined the worst-case scenario affecting the residents in Brgy. Cangatba. In this study, two different types of building occupancy were classified, and these are made up of 582 residential buildings, and 169 institutional and commercial buildings. The locale of Brgy. Cangatba is composed of 751 building structures. Moreover, these types of building structures are still classified according to their typology, having 11 W1-L as low-rise wood buildings, 713 C1-L as low-rise reinforced concrete buildings, 19 S1-L as low-rise steel buildings, and 8 CHB-L as low-rise masonry made from concrete hollow blocks.

IPEs resulting from the magnitude of 7.2 Mw, from PHILVOLCS, and 7.7 Mw, from nearest WVF, fall under intensity VII. The intensity is acquired in terms of the distance based on the location and its description is rooted in Modified Mercalli Intensity Scale. The different types of buildings would react differently to earth tremors, thus, a variation in damage ratios was calculated, such that 47.31% influences masonry (CHB-L) buildings, 27.15% to light wood frame (W1-L) buildings, 19.63% to low-rise reinforced concrete frame (C1-L) buildings, and 11.42% to low-rise steel frame (S1-L) buildings.

In the worst-case scenario, C1-L has the highest number of possible earthquake casualties during 5 PM having 92 human losses and 34 human injuries. While, during the daytime (2 PM); it is expected that there are earthquake casualties of 58 human losses and 29 human injuries. As for nighttime (2 AM), at this time the lowest number of casualties are expected having 8 human losses and 4 human injuries. Aside from human loss and injury, the Brgy. Cangatba might also suffer a calculated economic loss of ₱362,195,715.31. Residential structures can expect a gross damage of ₱265,722,258.32, while commercial buildings will result in an amount of ₱96,473,456.99. These projected losses can directly influence the economic stability of the community.

Obtained data produced evacuation maps, which show the vulnerable area, the evacuation routes, and temporary evacuation areas and evacuation center. Based on the survey result about their background; the majority of the residents are not aware of the evacuation routes and evacuation center of their barangay, and creating an evacuation map would help since most of them are familiar with its usage. On their understanding about the GIS evacuation map; majority of the residents agreed that they find the created map easy to use and understand, clearly show the routes and evacuation center, and they all require the evacuation routes to be on the map. Likewise, to the visual aspect, most of the respondents answered yes that the map provides detailed information, they understand the figures shown, the assigned colors and meanings are clear enough, and they find the map visually pleasing.

IX. Recommendation

Based on the study, the recommendation was utilized to improve the Mitigation and Preparedness plan for 'The Big One' Earthquake in the barangay. The administration of Barangay Cangatba should set up an evacuation sign boards and routes, particularly the area where many people go or stay. Aside from that, all institutional and commercial buildings, including schools, public markets, and municipal buildings, must also be equipped with an earthquake early warning system, subsequently, all buildings, including residential ones, must also have a copy of the evacuation map for an easy access to the routes and evacuation centers. The barangay may also conduct forums/seminars for community engagement and other possible ways to disseminate information and plan about earthquakes for the awareness and preparedness of its people.

Future researchers may provide the exact numbers of data needed and find another formula for the computations for better and more accurate results in the future. Conducting of an actual house-to-house survey, will be helpful, for the population in order to measure the exact area of the building at the same time a face-to-face consultation to the Municipal LGU in order to determine the individual prices of the building. Loss-estimation models would be improved if they could project direct losses to structures other than buildings, contents of buildings, possible fires following earthquakes, and the factors used in econometric models to describe economic change.

The proposed method is applicable anywhere in any earthquake-prone areas with the potential for future earthquakes. This study could be enhanced by first expanding the model to include other influential factors on losses such as secondary hazards. Additionally, the proposed model could be expanded to simulate different reactions to earthquake scenarios and provide relief and instructional programs.

The emergency situation potentially generated by such an earthquake could put disaster emergency response agencies under huge pressure. The researchers suggest the Disaster Management Agency of the city increase their capacity in order to give punctual and effective measures to respond to such emergency situations. In buildings held by people or organizations other than the government, quality control and building codes should be enforced.

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