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MORALITY BEFORE KNOWLEDGE

Authentic spatial vulnerability assessment for evacuation shelters in disaster planning: A case study of tubay, agusan del norte, Philippines

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ABSTRACT

Background: Authenticity plays a pivotal role in addressing the primary challenges encountered in disaster planning, particularly when it comes to assessing vulnerability and evaluating the spatial distribution of shelter demand and resources. Ensuring the accuracy and reliability of data is essential for effectively managing available resources at each evacuation center, as well as for accommodating evacuees and ensuring the safety of both staff and refugees. In real-life circumstances, the authenticity of the information gathered becomes even more critical, as an imbalance in shelter and population distribution often hinders access to evacuation shelters. **Method:** In this paper, the researchers introduce a spatial assessment technique that not only analyzes vulnerability but also authentically assesses the spatial distribution of shelter demand and supplies, thereby enhancing the overall effectiveness of disaster planning in Tubay, Agusan del Norte, Philippines. **Result:** The study focuses on Tubay, Agusan del Norte, Philippines, taking into account spatial accessibility. The researchers found that out of the 33 shelters assessed, 21 are feasible locations for evacuation centers, and approximately 51% of the total population points are vulnerable to flooding. **Conclussion:** Utilizing GIS maps, the results reveal a significant decrease in overall shelter capacity to 64.26%. The study's findings emphasize the critical need for evaluating the relationship between vulnerable shelters and the demand for resources at each location. This information serves as a practical tool, offering flexibility in terms of data availability for decision-makers, enabling them to investigate areas, and providing a valuable reference for developing and improving emergency management decisions and strategies

KEYWORDS: evacuation shelters; GIS; spatial accessibility; spatial distribution; vulnerability assessment

1. Introduction

The vulnerability of cities, with a focus on different aspects. Horváth (2012) highlight the need for a comprehensive approach to vulnerability assessment, considering a wide range of hazards and dimensions (Horváth & Csaba, 2012). Tapia (2017) specifically looks at the vulnerability of European cities to climate change (Tapia et al., 2017), while Tariq (2020) delves into the vulnerabilities of Ubiquitous cities, particularly in relation to information and communication technologies (Tariq et al., 2020). These studies collectively underscore the importance of understanding and addressing the vulnerabilities of cities to enhance their resilience and authenticity.

Disasters are expected to occur more often and with greater severity in the future due to climate change, unplanned urbanization, and the increasing accumulation of individuals

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and properties in dangerous environment (Davis et al., 2015; Rosselló et al., 2020). Every year, about 20 typhoons affect the Philippines. Flooding and landslides occur most frequently in different parts of the Philippines. The Philippines, which are located just above the equator, face the western Pacific with nothing else to withstand the impact of storms before they hit the land (Vergano, 2013). Many people live on low-lying coastal islands, with more than 60% of the population living in coastal areas (Vergano, 2013). Historically, the Caraga and Surigao regions have been subject to natural disasters such as earthquakes, typhoons, and heavy flooding. Most typhoons pass by Caraga Region where Tubay, Agusan del Norte is situated as they enter the country. January of 2014, the country's first typhoon of the year, "Agaton," has impacted over half a million people in 14 provinces throughout the Zamboanga Peninsula, Northern Mindanao, Davao, and Caraga (Lagsa et al., 2014). So, as Tubay is also a path of typhoon, it is necessary to come up with a plan for achieving the goal of creating new disaster risks plan. However, vulnerability is a difficult concept to grasp because it differs from person to person and by situation. We describe vulnerability in this analysis as the circumstances defined by physical, location and environmental factors or processes that increase a person's and population's susceptibility to the effects of hazards.

Evacuation shelter assignment and evacuation preparation are also important components of emergency preparedness (Bashawri et al., 2014). Evacuation centers play an important role when disasters occur. In order to ensure the safety of evacuees and aid residents in their recovery from the resulting trauma, it is crucial to establish a foundation that facilitates the process of coping with and adjusting to the stresses of the situation (Sritart et al., 2020; Yu & Wen, 2016). In times of emergency, the task of supplying and coordinating appropriate shelters has become an integral part of government emergency response. Several studies have found that when designing and evaluating shelters, it is often important to evaluate site suitability based on physical location. Geographical information system (GIS) is widely used nowadays to find good alternative shelters outside the hazardous area.

The spatial distribution of emergency shelters is a critical issue that warrants further discussion, particularly in relation to estimating demand and addressing the inadequacy of available shelters. Evaluation of population in various situations, especially in the case of disaster, helps in the estimation of the affected population for evacuation planning and response (Sritart et al., 2020). Studies show how GIS was utilized to evaluate emergency shelter demand by considering spatial population distribution through urban and community analyses (Small & Nicholls, 2013). In this study, we proposed a new approach for evaluating the vulnerability of disaster shelter preparation in Tubay, Agusan del Norte, Philippines by incorporating the spatial distribution of both population and evacuation shelters.

2. Methods

For effective shelter assignment and evacuation preparations, it is necessary to have a thorough comprehension of the shelter's suitability as well as the population's distribution. GIS technology is a valuable tool that aids researchers in comprehending vital data and visualizing it by modeling or mapping. The usability of a shelter, influenced by an imbalance in the allocation of shelter demand and services, stands out as a key problem that requires additional discussion. This is essential for a comprehensive analysis and measurement of the vulnerability of disaster shelter preparations.

The spatial heterogeneity of the disparity between demand and power services, which can be hidden in summarized statistics and due to reduced connectivity, creates vulnerability during a catastrophe. For this, the researchers summarized the flow of method to achieve their goal:

1. To measure the geographic accessibility of shelters, a study of the spatial distribution of shelter planning services and population was taken;

2. Estimation of shelter demand in order to determine shelter shortage based on the spatial usability of the usual situation versus the critical situation;
3. Vulnerability review of emergency shelters in terms of vulnerability mitigation in disaster preparedness and management.

2.1. Study area

The Municipality of Tubay is a fourth-class municipality in the Philippines and is located in the province of Agusan del Norte. The municipal center is located on the island of Mindanao at about 9° 10' North, 125° 31' East. It has a population of 24,932 people according to 2015 census and the elevation is measured to be 10.1 meters or 33.0 feet above mean sea level. Tubay is a coastal municipality with a land area of 138.09 square kilometers or 53.32 square miles which constitutes 5.06% of Agusan del Norte's total area. It has a population density of 181 people per square kilometer, or 468 people per square mile.

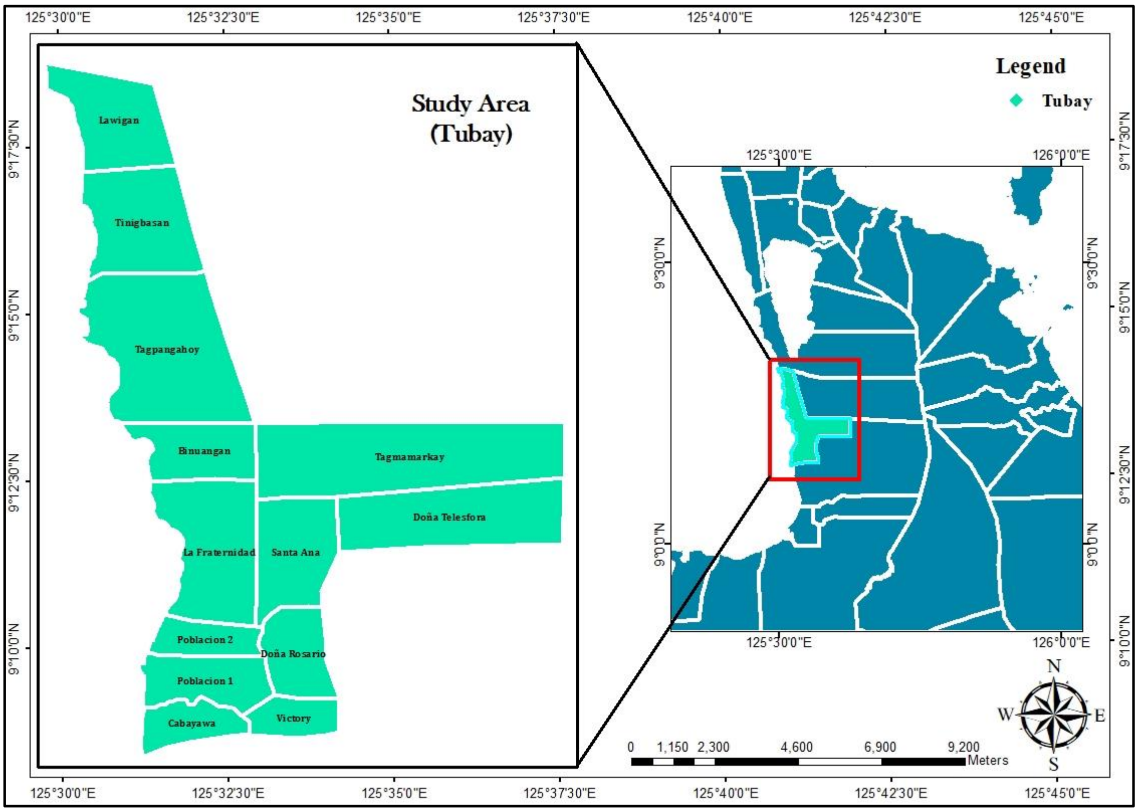

Fig 1. Map of the study area (Tubay, Agusan Del Norte, Philippines)

2.2. Datasets

The researchers collected the census data from an open-source website of Office of Civil Defense through its Electronics Freedom of Information EFOI and from Philippine Statistics Authority (PSA). The boundary data was downloaded from an opensource website of PhilGIS. Table 1 shows the summary of the various datasets used in this study.

Table 1. Data collected

Data Information	Source	Application

1.)	Boundary data	PhilGIS	Boundary of study area
2.)	Census data (with age)	Electronic Freedom of Information	Spatial Distribution Analysis
3.)	Census data (per barangay)	Philippine Statistics Authority	Spatial Distribution Analysis
4.)	Designated Evacuation Sites	Municipality of Tubay	Vulnerability Analysis
5.)	Road Network	LiDAR	Spatial Accessibility Analysis
6.)	Building footprints	LiDAR	Spatial Distribution Analysis
7.)	Evacuation Area	Municipality of Tubay	Spatial Accessibility Analysis
8.)	Flooding Data (Agaton 2014)	LiDAR	Reference for disaster events

2.3. Spatial distribution of shelter planning services and population

Census statistics is often used to cover specific geographic areas based on census tract scale units such as territory, city, or municipal-scale units. Tubay census data were gathered for this research. The researchers used these data at the national level to identify and establish administrative areas based on population.

2.4. Spatial accessibility analysis

In this research, the accessibility based on the spatial distribution of both shelter and population, including the evacuation distance and direction, was taken into account in the efficient estimate of the evacuation shelter demand. Several surveys, however, have projected that 25% of the total amount of census data will evacuate to emergency shelters, and have used this information as input data to predict shelter demand (Zhao et al., 2017).

2.4.1 Using grid index in building footprints

This study used grid population data. High-resolution spatial grid cells data can give detailed spatial distribution, which are very useful for epidemiological studies, public resource allocation and disaster risk assessments (Ramsdale et al., 2017). Many gridded population resources can be found online, but it is not available in the Philippines. So, the researchers employed another method which is converting building footprints into grids. These building footprints were assumed to be the population within that area. Each grid contains 1 or more building footprints (Small & Nicholls, 2013).

2.4.2. Population points and evacuation sites

After converting the building footprints into grid index, the centroid point of grid index was generated and represented as population points within each area. To present an origin and calculate accessibility, at this point, a road network study was carried out, with the GIS platform used to produce evacuation routes and the average evacuation travel time for each population point. This study method used a closest-facility analysis to determine the travel path between evacuation sites and population points.

As a reference point, the population points were used as incident features in the GIS software by implementing the "closest-facility" analysis. The closest facility analysis approach was used to weigh in the location points of the identified evacuation shelters as facility features. In this research, it was assumed that walking would be the primary means of reaching the nearest shelters.

2.4.3. Buffer zone

As network analysis is not applicable due to a small area and lack of road network, the researchers used Buffer Analysis. The distance applied is 500 meters from the evacuation center. The buffer tool generates a polygon layer by creating circular buffer zones with a set diameter around the chosen objects or features. This approximates the nearest population point from the evacuation area without taking the road network into account (Parmenter, 2019). Every emergency shelter's service coverage was examined using buffer network analysis.

2.5. Shelter demand estimation

This step examined the travel expense along the evacuation path, which is the size and length of the route, to assess the usability of the evacuation shelters. The gap for each point on the road network, reflecting residential units and shelters, was measured, along with the approximate travel time. The overall access location for each shelter was calculated by summing the total projected population requirement. This was determined by adding the sizes of all accessed population points that could reach the evacuation shelter using this formula:

$$Di = \Sigma \cdot Pji \qquad (1)$$

Where, Di is the expected population demand for shelter i, and Pji is the population size of each area j, that can enter shelter i.
To assess each shelter's capacity, the ratio of accommodation capacity was calculated by dividing the designated capacity of each shelter by the projected population demand using this formula:

$$Ri = Ci/\Sigma P, I \qquad (2)$$

Where Ci is the designated capacity of shelter i, and Ri is the capacity ratio of shelter i.

2.6 Vulnerability analysis

To assess the vulnerability of the emergency shelters in the case study area, the location of prior dangerous areas was taken into account to avoid location from being an obstacle feature in the assessment of the shelter's functionality during an actual disaster situation in the case study area. This research investigated the physical vulnerability in terms of the location and capability impacted by the catastrophe to determine the vulnerability of each shelter, with consideration of a recent real disaster in the case study area. Previous flooding incident was taken into account to assess the vulnerability and susceptibility of shelter and demand of every barangay of Tubay. The researchers chose Typhoon Agaton 2014, for this caused a catastrophe in Agusan del Norte. In January 2014, the Philippines was hit by Tropical Cyclone Agaton, a small but devastating tropical storm (Lagsa et al., 2014).

3. Results and Discussion

3.1 Spatial distribution

Tubay primarily consists of coastal regions, and when considering the vulnerable population aged 50 and above, approximately 15% of the total population is deemed vulnerable. Gender distribution within this age range is evenly split between male and female, as indicated in Table 2. Numerous studies have highlighted the higher mortality rate among the elderly during disasters. The perception that elderly individuals are more susceptible to floods is not uncommon, particularly in the context of the Philippines (Ye & Aldrich, 2019).

Table 2. Summary of the overall population and vulnerable groups in comparison to the specific capacity of evacuation shelters within the Municipality of Tubay.

Information	Amount	Ratio (Total population)
Total Population	24,932	24,932
Male	13001	52.15
Female	11931	47.85
Shape Area (sq.km)	138.09	-
Total population of 50 years old and above	3660	14.68
Male	1820	7.30
Female	1840	7.38
Total Capacity of existing Evacuation Shelters	6450	25.87

There were 33 facilities identified as evacuation centers in Tubay. As shown in Table 2, these facilities have a combined evacuation capacity of 6,450, serving 25.87% of the total population. A recent study on emergency shelter design for disasters found that 25% of the overall population, including vulnerable residents, would utilize public shelters if evacuated. In the study area, the current shelter capacity ratio of 25.87% is insufficient to accommodate the entire population. Despite meeting the technical planning design of 25% for the vulnerable group (ages 50 and above), with a shelter capacity of 6,450, it surpasses 100%. However, a significant portion of residents faces challenges in accessing evacuation shelters due to the condition of evacuation routes and the uneven distribution of shelters. Figure 2 illustrates the spatial distribution of the population and existing evacuation shelters in Tubay. The design of the study was inspired by a grid population approach, chosen for its ease of assessment and allocation within grid cells, maintaining data fidelity. In the absence of gridded population data in the study area, the researchers employed a GIS tool called the grid index tool, assuming building footprints as the number of households and population.

The generated grid index, indicated by the color Malachite green, represents grids containing one or more building footprints. Grids without color denote areas without population, such as mountains, lakes, or rivers. Each shelter's capacity is distinguished from others using Mars red symbols with varying shapes based on their capacity. The grid index employed was set at 250 meters, chosen to strike a balance between avoiding map congestion (if lower than 250 meters) and preventing the map from appearing too spacious or vacant (if higher than 250 meters).

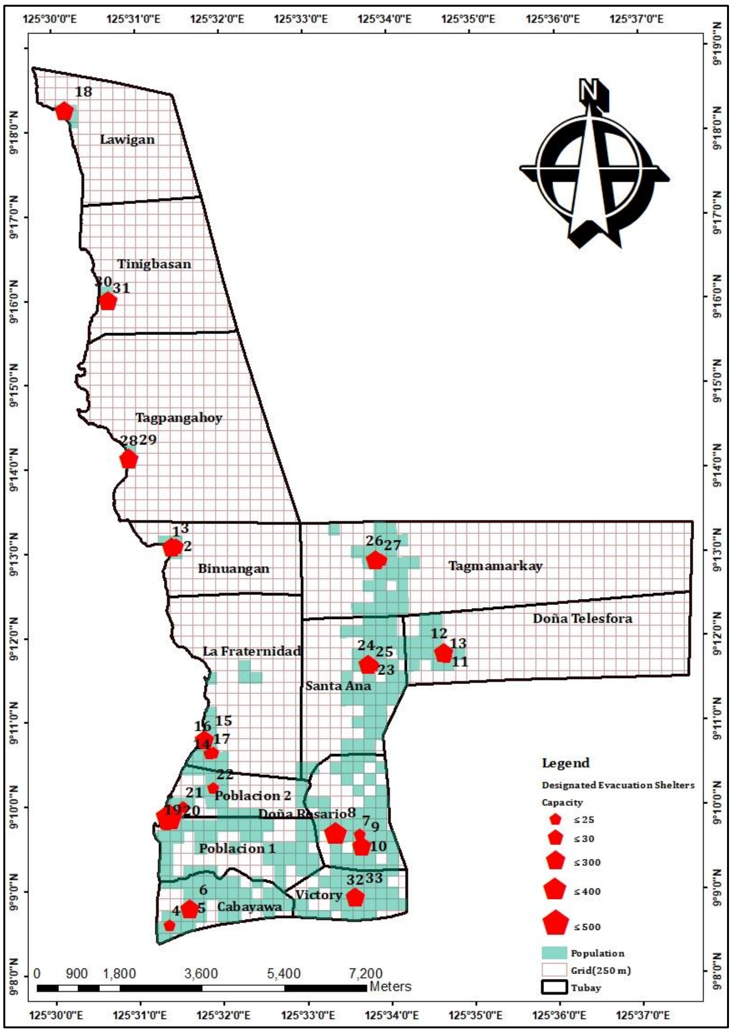

Fig 2. Spatial distribution of the population and the designated evacuation shelters of Tubay

3.2 Assessment of accessibility

During Typhoon Agaton in 2014, local authorities in the case study area advised people to seek refuge in the nearest evacuation centers. The study focused on assessing the availability and scarcity of evacuation shelters concerning evacuation resources, demand, and the distance to evacuation routes. Areas without flooding incidents were also considered to evaluate shelter accessibility during and after the flood. Given the lack of a comprehensive road network in some barangays within the study area, the researchers employed the buffer tool to generate a 500-meter buffer zone. This zone was used to estimate the coverage area of evacuation shelters, considering that walking is the primary mode of transport in this study. Figure 3 depicts the evacuation route to shelters, alongside the actual road network, from population points in each grid area.

Out of 276 population points, 112, or 40.58%, are located within the 500-meter buffer zone around evacuation areas, as depicted in the chrysoprase buffer zone. The fire red evacuation lines in Figure 3 represent routes beyond the buffer zone, illustrating the remaining 164 population points located outside the buffer distance from evacuation centers. The unclear and invisible fire red evacuation routes indicate areas lacking a road network and are in close proximity to evacuation shelters. Notably, residents in coastal areas such as Lawigan, Tagpangahoy, Tinigbasan, and Binuangan can access shelters within a short time, developing their own roads that may not be included in the road network derived from the data source. Some points lack designated evacuation routes, primarily due to network analyst limitations, which requires available road networks for route analysis in a given area.

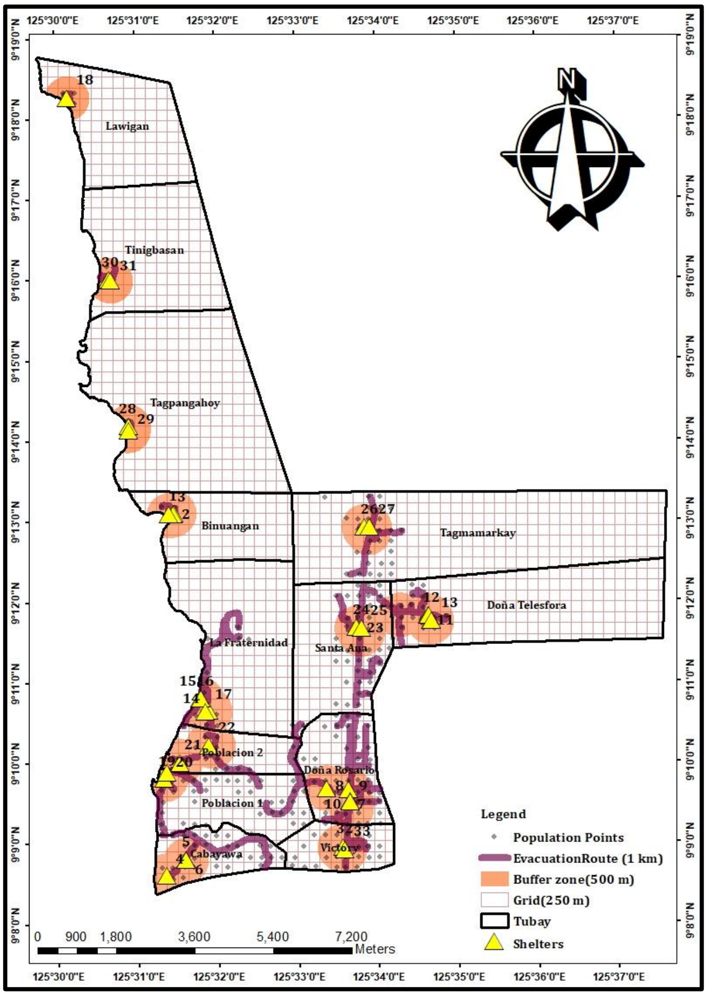

Fig 3. Spatial distribution of the designated evacuation shelters, population points and the evacuation route in Tubay

Table 3 provides an overview of shelter accessibility using network analysis, detailing the areas within walking distance of the nearest shelter, locations farthest from a shelter, and the slowest and fastest times to reach each shelter. Shelter 25 stands out with the highest number of accessed areas, covering 32 locations, while Shelters 1, 6, and 16 have the lowest number, with only one population point covered each.

The closest emergency centers can be reached within less than 10 minutes from the population points. Shelter 5, however, requires the longest time, almost 35 minutes to reach. It is noteworthy that each existing evacuation shelter is accessible within a timeframe of less than 10 minutes from the population points.

Table 3. The accessibility of each designated evacuation shelter, depicted by the reachable area within a 1 km walking distance and a 500 m buffer zone.

Shelter Number	No. of accessed area (Network analyst)	Closest Distance(km)	Fastest Duration(min.)	Longest Distance (km)	Longest Duration(min.)	No. of accessed area (Buffer zone)
1	1	0.122	1.455	0.122	1.455	3
2	-	-	-	-	-	3
3	2	0.048	0.575	0.424	5.052	3
4	5	0.006	0.069	0.255	3.04	11

5	27	0.063	0.754	2.883	34.342	11
6	1	0.135	1.607	0.135	1.607	11
7	23	0.279	3.319	2.46	29.303	24
8	26	0.007	0.08	2.236	26.64	24
9	2	0.769	9.156	0.947	11.282	24
10	10	0.032	0.377	0.672	8.01	24
11	19	0.171	2.039	1.456	17.343	15
12	-	-	-	-	-	12
13	3	0.059	0.707	0.497	5.915	13
14	4	0.369	4.394	0.409	4.868	14
15	10	0.326	3.888	2.816	33.543	15
16	1	0.16	1.907	0.16	1.907	16
17	-	-	-	-	-	17
18	3	0.108	1.281	0.175	2.089	3
19	7	0.202	2.41	1.437	17.117	7
20	8	0.195	2.32	0.964	11.484	7
21	3	0.067	0.792	0.408	4.864	7
22	17	0.122	1.452	1.682	20.038	7
23	4	0.446	5.31	0.985	11.731	13
24	2	0.237	2.828	0.237	2.828	13
25	32	0.205	2.445	1.78	21.021	13
26	3	0.097	1.161	0.144	1.72	12
27	24	0.17	2.024	1.32	15.719	12
28	-	-	-	-	-	2
29	2	0.095	1.14	0.373	4.445	2
30	2	0.059	0.706	0.804	9.578	2
31	-	-	-	-	-	2
32	21	0.009	0.106	1.095	13.042	15
33	5	0.169	2.009	0.412	4.902	15

3.3 Evaluation of capacity

Table 4 displays the estimated capacity of each evacuation shelter in Tubay, Agusan del Norte. Utilizing network analysis and the buffer tool, the results for the expected shelter demand (Di) for the nearest facilities reveal that the expected Di at some shelters significantly exceeds their capacity.

Shelters 18, 30, and 33 stand out with the highest capacity ratios, accommodating only 3, 2, and 5 population points, respectively, yet with capacity ratios (Ri) of 309%, 103%, and 109%. In contrast, the capacity ratios of other shelters are notably low, especially for shelters 7, 27, and 32, which were designed for 23, 24, and 21 accommodations, respectively. However, the anticipated demand from the closest examination of these shelters was 1003, 1333, and 1091 people, respectively.

Table 4. The accessibility of every certain evacuation shelter, as prominent through the total estimated population demand (Di), the potential ratio of every shelter (Ri).

Shelter Number	Shelter Capacity	No. of Accessed Area (Network analyst)	Di	Ri	No. of Accessed area (Buffer zone)
1	25	1	233	11%	3
2	30	-	-	-	3
3	300	2	519	58%	3
4	25	5	242	10%	11

5	500	27	981	51%	11
6	25	1	44	57%	11
7	25	23	1003	2%	24
8	25	26	506	5%	24
9	30	2	242	12%	24
10	300	10	713	42%	24
11	300	19	1619	18%	15
12	25	-	-	-	15
13	30	3	282	11%	15
14	300	4	458	66%	9
15	25	10	911	3%	9
16	25	1	598	4%	9
17	400	-	-	-	9
18	300	3	97	309%	3
19	300	7	682	44%	7
20	25	8	97	26%	7
21	300	3	339	88%	7
22	30	17	224	13%	7
23	300	4	717	42%	13
24	25	2	280	9%	13
25	300	32	1645	18%	13
26	25	3	224	11%	12
27	25	24	1333	2%	12
28	25	-	-	-	2
29	25	2	145	17%	2
30	300	2	290	103%	2
31	300	-	-	-	2
32	25	21	1091	2%	15
33	300	5	273	110%	15

The result shows that there are still evacuation shelters per barangay on the Tubay boundary with low population density, which is not accessible due to the inadequacy of their capacity.

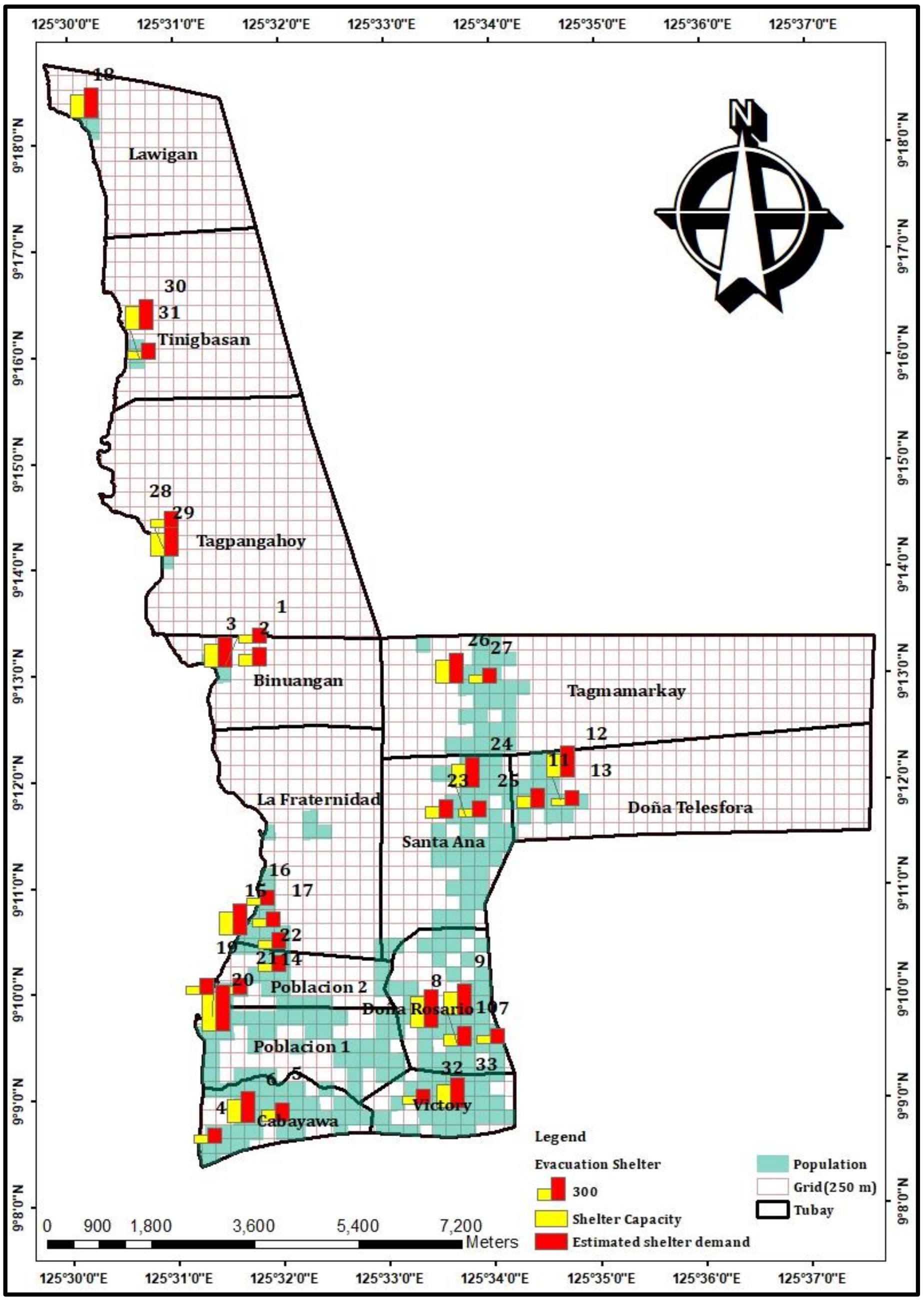

Fig 4. Comparison between the designated capacity and the expected shelter demand

3.4 Vulnerability of the shelters

To assess the physical vulnerability of the emergency shelters of every barangay in Tubay, we applied the flood that occurred in year 2014. During this year, tropical storm Agaton has caused a great damage in most parts of Agusan, del Norte. Figure 5 shows the established route generated through network analysis with a 1 km distance (purple heart) and a 500 m buffer zone (fire red) together with the existing evacuation shelter and the population points in Tubay, Agusan del Norte. The map also shows that there are 33 designated emergency shelters in the study area, and only 21 along the road network are still passable after the flood. It is estimated that there are only 26 shelters left. The results show that by generating the previous flood disaster in Tubay, Agusan del Norte, population points that are vulnerable to flood can access to their respective shelters since they can go through along the road network when they evacuate and most of them live near to the existing shelters of each barangay which is not reached by flood. Therefore, generating a new route is not necessary.

Since the purpose of this study is to assess the study area's physical vulnerability in terms of the distance, location and shelter's accessibility, a GIS model was used, showing that 12 out of 33

(36.36%) emergency shelters are vulnerable to flood. Due to the lack of a road network, these emergency shelters are inaccessible and isolated from the rest of the network.

In addition, Table 5 shows the remaining capacity of the 21 evacuation shelters after the flood, showing that the capacity has been reduced to 3,210 (64.26% of the total capacity of Tubay). The demand ratio for accessibility to the shelters that cannot be accessed are added to the remaining shelter which is closer to each barangay. Most of the existing shelters in this study area are located near the flood zone, but still accessible for accommodations (see Figure 6). Figure 6 shows a comparison between estimated pre-flood demand and post-flood demand.

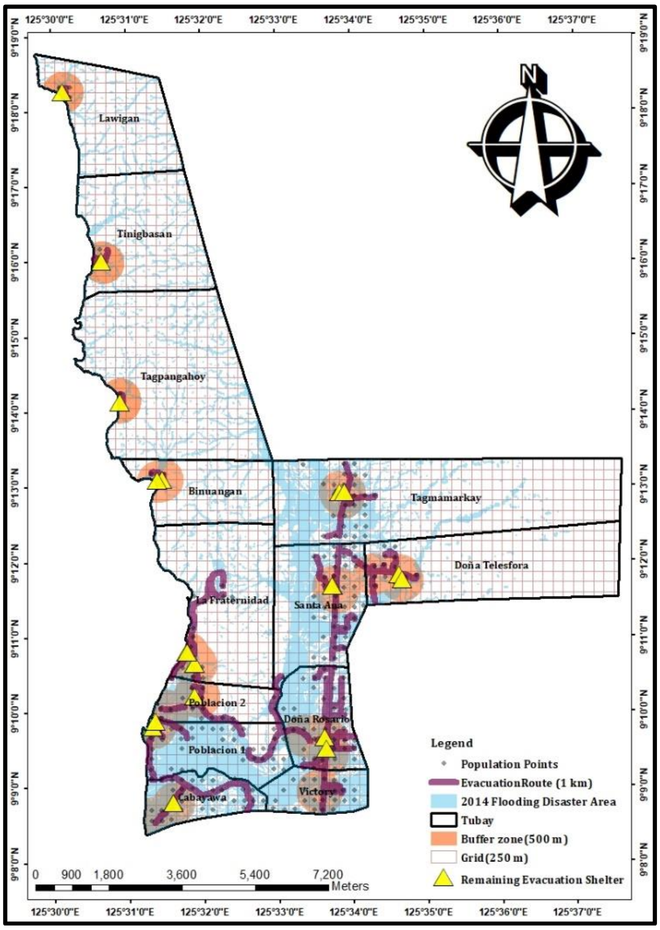

Fig 5. Evacuation route during the Agaton (2014) flood disaster from the population points to the designated evacuation shelters in Tubay for accessibility assessmen

Table 5. The vulnerability of the evacuation shelters

Shelter Number	Shelter Capacity	Before Flood	After Flood	No. of accessed are (Buffer zone)
		No. of accessed area (Network analyst) / Di	No. of accessed area (Network analyst) / Di	
1	25	1	233	1
2	30	_	_	_
3	300	2	519	2
4	25	5	242	0
5	300	27	981	32

6	25	1	44	1
7	25	23	1003	49
8	25	26	506	0
9	30	2	242	0
10	300	10	713	12
11	300	19	1619	2
12	25	–		–
13	30	3	282	3
14	300	4	458	4
15	25	10	911	10
16	25	1	598	1
17	400	–	–	–
18	300	3	97	3
19	300	7	682	7
20	500	8	97	8
21	25	3	339	0
22	30	17	224	20
23	300	4	717	20
24	25	2	280	18
25	300	32	1645	0
26	25	3	224	3
27	25	24	1333	24
28	25	–	–	–
29	25	2	145	2
30	300	2	290	2
31	300	–	–	–
32	25	21	1091	0
33	300	5	273	0

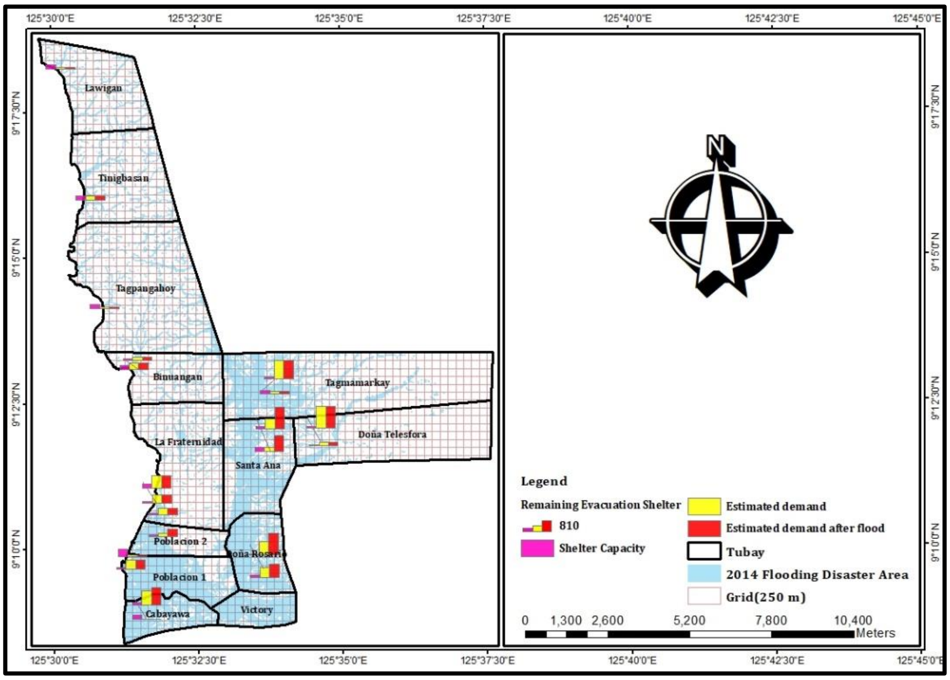

Fig 6. Comparison of the planning shelter capacity (ginger pink), estimated shelter demand (solar yellow), and estimated shelter demand after the flood disaster (mars red) in Tubay.

3.5 Discussion

This study introduces the use of GIS techniques for evaluation and estimation of spatial accessibility of evacuation shelters and demands for the purpose of disaster risk reduction in Tubay. The spatial heterogeneity of an imbalance among population demand and shelter ability resources increases vulnerability during a disaster, our approach factored in both the spatial distribution of shelter demand and resource availability when estimating spatial accessibility and assessing shelter deficiency. The foregoing analysis and findings show that the suggested approach in this study may be utilized to map the geographic distribution of shelter demand as well as offer a statistical assessment of shelter vulnerability and population vulnerability. The method used helped in analyzing the possible demand and the availability of evacuation centers before and after a disaster. This shows the imbalance between the existing shelters and the population value in every barangay of Tubay. Some parts of Tubay are densely populated and situated in coastal regions. It is difficult to access the parts of those barangays for they are located in between the sea and mountains. So, this will help the government of Tubay to evaluate the situation especially in the coastal areas, and other parts of Tubay during flood. Furthermore, GIS-based mapping was used to help with shelter designation and evacuation planning by establishing the spatial distribution of evacuation shelters.

In addition, the availability and distance of evacuation routes were taken into consideration when selecting this method. Because withinside the actual world, travel routes might be covered, collapsed, or disconnected while catastrophe strikes, reducing efficiency and affecting evacuation and shelter accessibility, the study used the distance-based function of the actual road network to estimate facility accessibility rather than the Euclidean distance (Sritart et al., 2020). According to our study, the shelter demand surrounding the flooding area soared substantially and considerably exceeded the allocated shelter capacity as a result of the fragmented road network, as seen in the 2014 flooding scenario. However, building a new evacuation shelter is not easy to construct considering the place and land cover. Based on statistical data for the study area, our findings highlighted the need for shelter and the remaining sites' location because of the flood, particularly in places like Doña Rosario, Victory, Cabayawa, Poblacion 2, and Sta. Ana, where demand exceeds capacity. The results presented in this paper provide information to local government officials, who may use this information to plan and manage critical supplies, such as food, sanitary services like toiletries, and bathroom supplies, in order to meet the demand.

Since we do not have the geographical location of the vulnerable people in each barangay, we assumed that all numbers of vulnerable individuals stated in Table 1 are affected by the flood.

Individuals identified as vulnerable in this study and those who have been affected by the crisis scenario should be provided emergency healthcare or medical support. Depression and anxiety levels rise with age in disaster-affected areas (Jia et al., 2010). As a result, for long-term catastrophe management, this study provides critical data for policymakers. Additionally, the approach indicated that residents living in the study area had trouble evacuating due to the steep terrain and long evacuation distance to the bigger evacuation shelters. The findings for these specific locations provide helpful evidence that the local government should manage and plan for evacuations in these areas, especially for the elderly, who are unwilling to escape if evacuation distances are great (Sritart et al., 2020). The results above provide insight into how the local government will facilitate and establish convenient evacuation centers that are easily accessible, particularly for adults and elderly individuals.

Vulnerability assessment in urban areas is crucial for understanding the impact of urbanization and globalization on cities. Urban vulnerability is a result of high pressure due to urbanization and globalization (Ernawati, 2013). This pressure can lead to contested marketplaces, where retail spaces are branded as authentic consumption experiences for tourists and residents (González, 2019). However, there are conflicting views on the impact of tourism and consumption on city authenticity. Some studies suggest that tourism consumption may de-authenticate the culture of the visited city, resulting in the loss of place distinctiveness and subsequent loss of authenticity (Wickens, 2016). On the other hand, certain aspects of local context, heritage, and identity contribute to customers' in-store authentic experience in international gastronomy retailing, highlighting the role of the city context in shaping authenticity (Pasquinelli et al., 2021). Additionally, townships, favelas, and slums are often considered places of authenticity, representing the true life of the visited city or country (Meschkank, 2010).

The notion of authenticity is also intertwined with the changing landscapes of power in cities, particularly in the context of gentrification and neoliberalism. Aesthetic ideas of authenticity are proposed to support the right to a diverse city, reflecting the evolving socio-spatial changes in urban areas (Zukin, 2014). Moreover, the perception of self-government among Aboriginal women living in cities is based on kinship ties, challenging traditional hierarchical models and highlighting the diverse urban Aboriginal identities in Canada (Peters, 2011).

4. Conclusions

In conclusion, vulnerability assessment in urban areas is closely linked to the multifaceted concept of city authenticity, encompassing tourism, consumption, urban identities, and socio-spatial changes. The interplay between urbanization, globalization, and local context shapes the authenticity of cities, highlighting the need for comprehensive assessments that consider the diverse factors influencing urban vulnerability and authenticity.

4.1 Conclusions

This study focuses on assessing the vulnerability and evaluate the spatial distribution of both shelter demand and resources in Tubay, Agusan del Norte. According to GIS technology findings, the generated evacuation route by applying the closest facility tool in the network analyst is the only road that people can go through with their respective shelters. Shelters 4,8,9,21,25,32 and 33 was found out to be ineffective for emergency evacuation for the following reasons: (1) these shelters are susceptible to flood, (2) the insufficiency of the capacity which cannot handle the demand population per area, (3) unavailability of the road network.

Furthermore, the study found out that there are only 21 shelters feasible location for the evacuation center due to these reasons: (1) they are not located in a floodplain, (2) they can access through the generated evacuation route, (3) they live near to the evacuation shelters that are not affected to flood especially the coastal areas as seen in Figure 5 and

Table 5. In addition, Figure 5 also illustrates the 140 population points, about (51%) of the total (277) points, are vulnerable to flood.

This approach can be implemented using GIS platform technology, which provides a practical tool and flexibility of data availability for investigating a place to assist decision makers and serve as a useful reference for developing and improving emergency management decisions and strategies. The existing evacuation shelters might be efficiently distributed and managed by using advance technology like GIS application. The sharing of information on susceptible locations and vulnerable shelters might aid local governments and policymakers in making decisions on vulnerability assessment.

4.2 Recommendations

This research may be enhanced in the future. The researcher would like to provide the following recommendations for future enhancement and improvement in the vulnerability assessment of shelter demand and population distribution:

1. To include additional vulnerability assessment, by considering children, infants, PWDs (persons with disability), and single parents.
2. To use the latest flooding situation for the verification of existing evacuation shelters.

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