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Geospatial Scenario Analysis of Storm Surge in Tandag City

SHEILA KYLENE A. TAWAS[1*], MA. SHELLA R. MILLAN[2], REVELYN G. ENDERES[3], CLARENCE R. LUMCANG[4], JESTONE T. SURILLA[5]

Surigao del Sur State University Tandag Main Campus Tandag City, Surigao del Sur, Philippines
*Corresponding Author
E mail: skyarreza@yahoo.com

Abstract: This paper on storm surge scenario analysis was conducted to determine the geographical extent of storm surge in Tandag City, Surigao del Sur. The study aimed to address the following: (a) to assess the geographic extent of a simulated storm surge (b) to quantify the population distribution reached by the storm surge (c) serve as aid for analysts, policy and decision makers in storm surge disaster risk mitigation. The study overlaid the data in QGIS, and calculated the affected and populated areas exposed to storm surge. The results revealed that majority of the coastal barangays are exposed to storm surge. The storm surge has a tidal level of 3-4 meters which can damage properties and put lives in danger in the affected area. Out of the 21 barangays, four (4) barangays are highly vulnerable to storm surge, with a 55% exposure, and 1 barangay is 100% exposed to 4-meter storm surge. Among these barangays, Brgy. Dagocdoc has a land area and population exposed to 100% storm surge 4-meters high, while Brgy. Bag-ong Lungsod can have the highest percentage of affected population at (86.95%). This study can shed light to LGU to incorporate scientific study to their land use plan and disaster risk management plan.

Keywords: GIS, storm surge ,school, susceptibility, proximity

INTRODUCTION

Storm surge is defined as water level oscillations, over and above the predicted astronomical tides in coastal or inland bodies of water, generated by the wind forcing's from an atmospheric weather system [1]. According to the National Oceanic and Atmospheric Administration, National Weather Service, National Hurricane Center (2014) [2] , there are factors that affects the height of the generated storm surge, these include the storm's central pressure, wind intensity, translational forward speed, storm radius, storm approach angle, coastline geometry, and the local bathymetry. The largest recorded surge in Mexico was the ''Great North Florida Storm'' in September 1873. It was recorded about 6.1 m at the St. Marks Lighthouse and 5.5 m in the town of St. Marks, located about 10 km up the St. Marks (Dukhovskoy and Moery, 2010). Consequently, it resulted to the destruction of buildings and property in low-lying areas caused by storm surges [3] . The Philippines, with its 36,289 km of coastlines, is highly susceptible to the ill effects of weather hazards [4], such as storm surges. For example, coastal areas of the Province of Leyte hardest hit a seven (7) height of storm surge when Super Typhoon Haiyan entered the Philippine Area of Responsibility (PAR) on 7 November 2013. As a result, tremendous damage to infrastructure and loss of lives mainly due to the storm surge and strong winds [5].

With the present destructive elements imposed by this kind of natural calamity specifically by storm surges, these lead scientists from all over the world to conduct research into storm surge risk assessments [6]. In fact, Nationwide Operational Assessment of Hazards (Project NOAH) which is the flagship disaster mitigation program of the Department of Science and Technology (DOST) of the Philippine government undertake a study to determine the vulnerability of all Philippine coastal communities to storm surges [7] . These also brought the researchers' interest to conduct case study on the storm surge simulation using data of the DOST in Tandag City Surigao del Sur to determine the geographical extent of storm surge. The study aims to address the following objectives: (a) to assess the geographic extent of a simulated storm surge in Tandag City, Surigao del Sur; (b) to quantify the population reached by the storm surge; and (c) to serve as aid for analysts and policy and decision makers in storm-surge disaster risk mitigation. The study is very significant to the LGU to provide immediate actions on the emerging needs of the community and to the people to reduce risk and provide stable and resilient community.

METHODOLOGY

a. Locale of the Study

Tandag City its low-lying city, long stretches of coastal areas, concave and gently sloping coastlines contribute to the enhancement of storm surge impacts. The city's geographical location also increases its exposure to storm

surge hazard as it lies in the south western part of the Northwest Pacific basin which is considered to be the most active ocean basin.

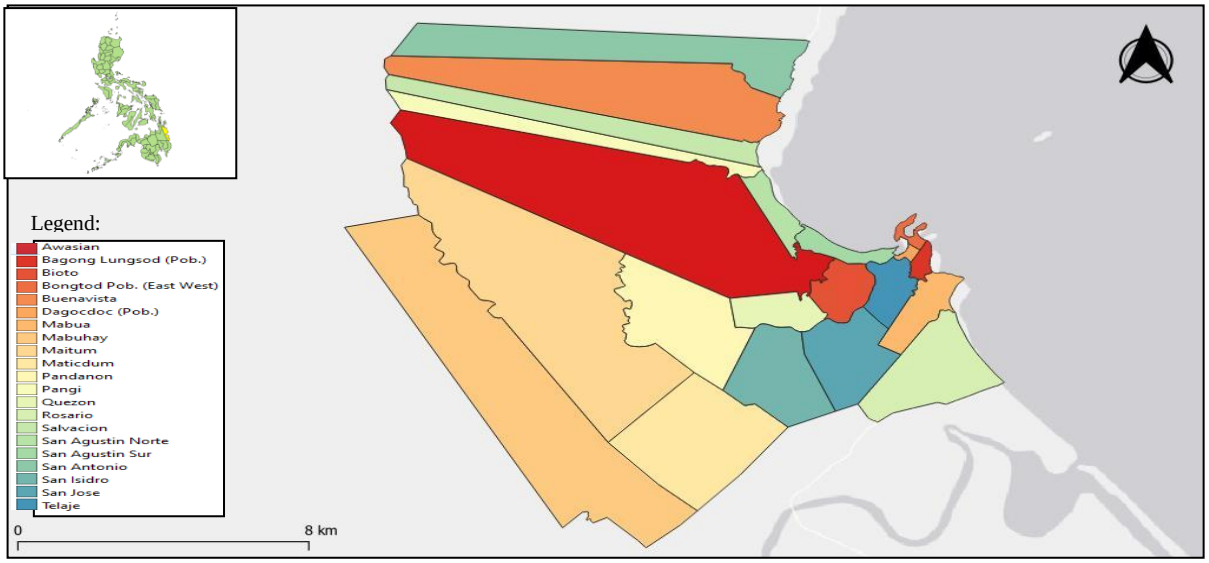

Fig.1: Map of the Study Area

b. Data Gathering

This study adapted a descriptive and percentages research design. Due to the time constraints, the study utilized secondary data. These data were gathered from various sources. GIS data sets were derived from *geoportal.gov.ph* for the political boundaries, storm surge data from the Nationwide Operational Assessment of Hazards (Project NOAH) of the DOST and variable population density map of Tandag City. Likewise, the study employed Openstreet Map.

c. Procedure of the Study

To answer the objectives several techniques were used. Overlay the provincial, municipal and barangay maps. Afterwards, clip out the barangays of the Tandag City. With this, map generated showing the barangays of the city.With the use of the data sets of storm surge of Project NOAH, SSA-1 storm surge category with a tide-level of 2.01-3 meters was used to overlay in this study. SSA-2 (3.01-4 m), SSA-3 (4.01-5 m) as well as SSA-4 (>5 m) were not used for the reason that it needs a more extensive analysis. After the storm surge data having overlaid, the extent of storm surge areas was calculated. Through the use of population data of each barangays, analysis of the affected of SSA-1 level of storm surge was followed.

Table 1. Storm surge category and tide level based on NOAH

Storm Surge Category	Tide Level (meters)
SSA - SSA1	2.01 - 3
SSA2	3.01 - 4
SSA3	4.01 - 5
SSA4	>5

RESULTS AND DISCUSSION

A. Geographic extent of simulated storm surge

Overlaying Storm Surge Level A1 (SSA1) into Tandag City map shows the geographic extent of the storm surge in the area. Figure 2, reveals that majority of the coastal barangays of Tandag are exposed to Moderate Storm surge level 2. This storm surge category has a tidal level of 3-4 meters increase during the actual occurrence which can slightly damage properties and even lives in the affected area (Table 1). These barangays include Salvacion, Pangi, Awasians, San Agustin Sur, Bongtod Poblacion, Dagogcoc (Poblacion), Bagong Lungsod (Poblacion) and Telaje.

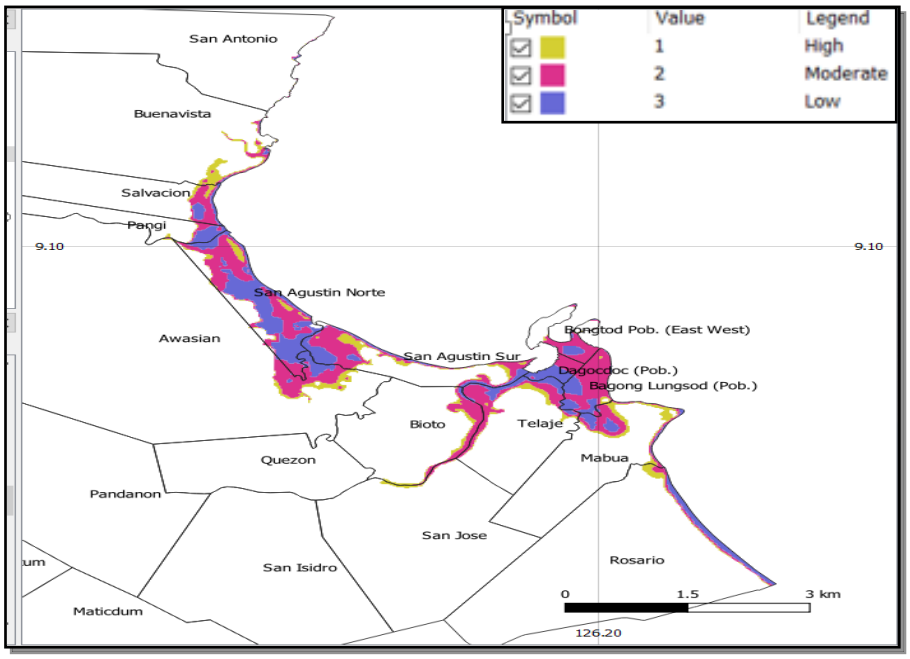

Fig. 2: Geographic extent of simulated storm surge in Tandag City

Of the twenty one (21) barangays of Tandag City, Barangay Mabua is highly exposed to storm surge level 1. The northern portion of Tandag City which is Barangay Salvacion and the southern portion where barangays San Agustin Sur, Bioto and Telaje are located highly exposed to storm surge level 2. Barangays San Antonio, Buenavista, Quezon, Pandanon, San Jose, San Isidro, and Rosario are the identified unaffected areas of storm surge.

B. Percentage of area (has.) per barangay exposed to storm surge hazard

The calculation on the percentage cover of surged area per barangay shows that four (4) of the identified barangays exposed recorded greater than 55% surged area vis-a-vis the total area in each barangay. These barangays include the Bagong Lungsod (Pob), San Agustin Sur, San Agustin Norte, and Dagocdoc. Among these four (4) barangays, the barangay of Dagocdoc has 100% hazard exposure to storm surge wherein, 100% of its total barangay area will be flooded based on this model (Fig. 3). Geographically, these barangays are located closer to the Philippine Sea and are low-lying barangays. These barangays are also the most exposed to typhoons, thus have higher percentage of storm surge occurrence.

Table 2: Percentage of Area (has.) per Barangay that will be Exposed to Storm Surge Hazard

Barangay Name	Area_ha	Sum_Hazard_ha	Percent_ Hazard_ha
Bag-ong Lunsod (Poblacion)	52.16	51.72	99.16
San Antonio	1180.45	1.62	0.14
Bongtod Poblacion (East West)	42.45	20.24	47.68
San Agustin Sur	134.91	74.36	55.12
Rosario	694.88	29.72	4.28
Telaje	212.82	50.06	23.52
Pangi	436.54	12.39	2.84
Bioto	251.31	26.73	10.64
Mabua	263.51	41.44	15.73
San Jose	541.9	4.42	0.82
San Agustin Norte	164.26	139.51	84.93
Awasian	3200.49	49.52	1.55
Dagocdoc (Poblacion)	18.79	18.79	100
Buenavista	1705.73	20.91	1.23
Salvacion	629.72	23.26	3.69

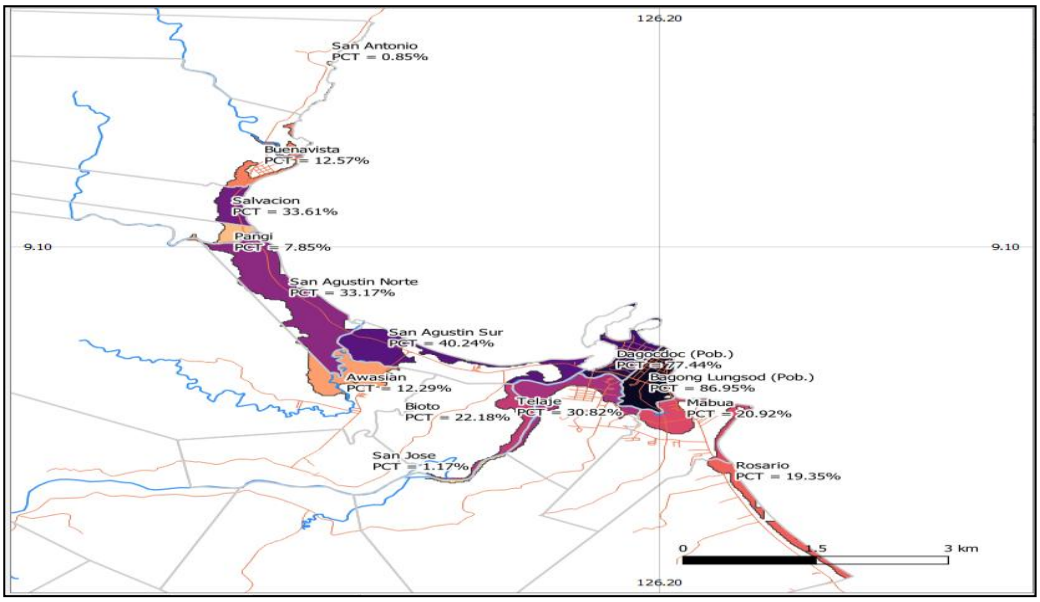

Fig.3: Percentage of area (has.) per Barangay that will be Exposed to Storm Surge Hazard

C. Population Affected by Storm Surge per Barangay

Among the fifteen (15) barangays identified that can be affected by storm surge, Brgy. Bagong Lungsod (Pob.) can have the highest percentage of affected population (86.95%) and Brgy. San Antonio can have the least percentage of affected population (0.85%) to storm surge (Fig. 4). Based on population data of year 2015, Barangay Lungsod (Pob.) recorded having the highest population while Bry. San Antonio recorded the least populated barangay.

Table 3: Percentage of Population per Barangay that will be Exposed to Storm Surge

Barangay Name	POPN_2015	Percent Affected
Bag-ong Lungsod (Poblacion)	5493	86.95%
Dagocdoc (Poblacion)	4153	77.44%
Bongtod Poblacion (East West)	5577	44.06%
San Agustin Sur	5485	40.24%
Salvacion	893	33.61%
San Agustin Norte	2135	33.17%
Telaje	8771	30.82%
Bioto	1186	22.18%
Mabua	6271	20.92%
Rosario	3262	19.35%
Buenavista	2687	12.57%
Awasian	1427	12.29%
Pangi	880	7.85%
San Jose	710	1.17%
San Antonio	669	0.85%

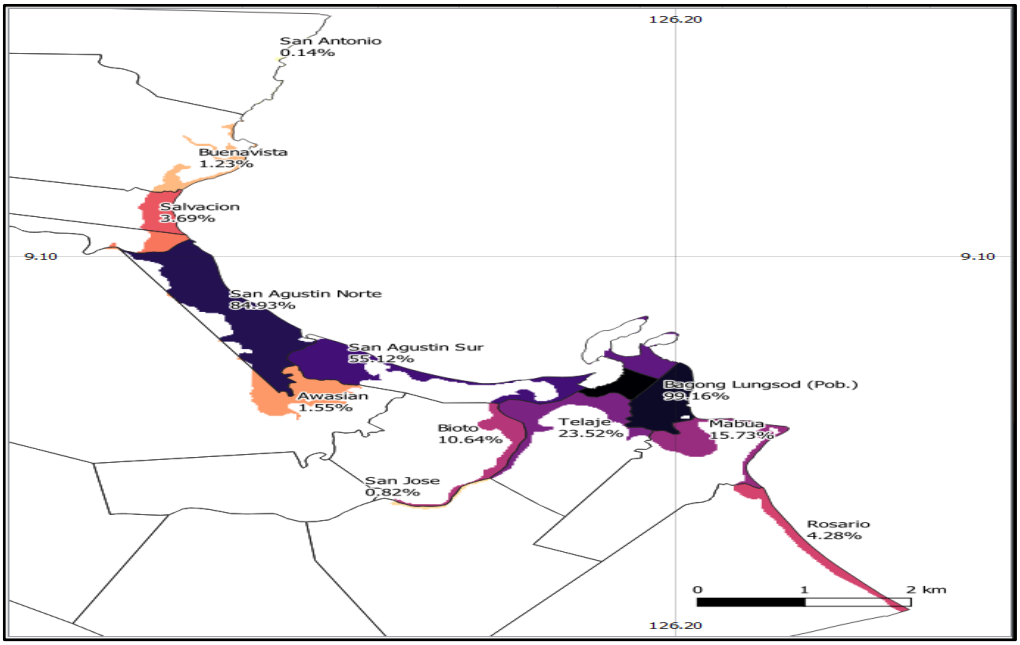

Fig.4: Percentage of Population per Barangay that will be Exposed to Storm Surge

CONCLUSION

In this study, a method was presented to assess and visualize the coastal vulnerability of storm surge (SSA-1) across Tandag City, Surigao del Sur through GIS mapping and processing. Barangays Bagong Lungsod, San Agustin Sur, San Agustin Norte, and Dagocdoc are the most vulnerable to high storm surges. This is because of their geographic location which is found nearest to the shore and facing the Philippine Sea. Besides, these barangays have also the characteristic of gently sloping coasts and shallow bays as well. Using the population data, barangays affected by the storm surge are Brgy. Bagong Lungsod having the highest percentage of affected population (86.95%) and Brgy. San Antonio as the least affected population (0.85%) to storm surge. Clearly, GIS visualization makes a clearer and easily understandable presentation of data. PDRRMC or the city's CDRRMC can now assess the hectarage and the populated areas reached by the storm surge and , thus warn the city's residents about the hazard.The use of geographic information system in disaster risk assessment is very essential in terms of simulating the areas mostly affected by storm surge. It can be a very effective tool to help decision makers plan and focus on areas with higher risk. Also, scenario analysis can play a great role in highlighting areas which needs mitigation.

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