Geospatial Simulation On The Susceptibility Of Deped Schools To Storm Surge In Surigao Del Sur Province, Philippines

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Abstract
Surigao Del Sur Is One Of The Coastal Provinces Of Caraga Region Identified As One Of The Top 30 Provinces In The Philippines With A High Storm Surge Level And Lecz Population Density. The Possible Threat Imposed By This Kind Of Calamity Especially To Education Sector Compelled The Researcher To Undertake A Study On Identifying The Deped Schools Susceptible To Storm Surge. This Study Uses The Storm Surge Data From The 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. Along With The Generated Maps Of Digital Elevation Model (Dem) And Spatial Distribution Of Schools, This Study Simulates The Possible Storm Surge Height That The Deped Schools Are Prone To. Results Of The Study Revealed That Out Of 534 Schools Utilized In The Study, 96 (17.98%) Are Susceptible To Ssa-1, 128 (23.79%) Are Susceptible To Ssa-2, While 149 (27.9%)Are Susceptible To Ssa-3, And 161(30.15%) Are Susceptible To Ssa-4. Out Of The 17 Municipalities And 2 Cities In The Province, Lingig Has The Highest Number Of Deped Schools Susceptible To Ssa-3 And Ssa-4, Followed By Hinatuan, City Of Bislig And City Of Tandag. Results In This Study Can Be The Basis For Provincial And City Deped Officials And Lgu's Of Surigao Del Sur In Prioritizing A Site-Specific Management Plan To Address The Possible Storm Surge Hazard.

Keywords: *Storm Surge, Gis, Spatial, Deped Schools, Simulation*

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 [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 [3]. Consequently, It Resulted To The Destruction Of Buildings And Property In Low-Lying Areas Caused By Storm Surges [4]. The Philippines, With Its 36,289 Km Of Coastlines, Is Highly Susceptible To The Ill Effects Of Weather Hazards [5], 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, 3171 Schools Have Been Damaged, And 90% Of Schools And Offices Were Damaged In Tacloban City Alone [6] Also, Tremendous Damage To Infrastructure And Loss Of Lives Mainly Due To The Storm Surge And Strong Winds [7]. Disasters Set Back The Investments Made By The Education Sector. The Most Terrible Consequences Are Deaths And Injuries In Schools. There Are Schools That Are Unusable Because Of Damages, Their Prolonged Use As Shelters, Having Unsafe Access, The Loss Of Equipment And Materials, Or Lack Of Teachers Are Some Effects Of Hazards Which Can Hinder Children To Achieve Their Goals [8]. These Brought The Researchers' Interest To Conduct A Study On The Susceptibility Of Deped Schools To Storm Surge In Surigao Del Sur Province. This Study Aims To Help School Administrators, Lgu's And Decision Makers In Planning, Aid For Analysis And Policy Making In Storm-Surge Disaster Risk Mitigation.

1.1. Study Area

The Location Of The Study Site Is Shown In Figure 1. The Red Dots, Are The Spatial Distribution Of Deped Schools. Surigao Del Sur Province Is A Coastal Province In Caraga Region Located In The Eastern Coast Of Mindanao Facing The Pacific Ocean. The Province Has A Land Area Of 4,932.70 Square Kilometers Or 1,904.53 Square Miles. Its Population As Determined By The 2015 Census Was 592,250. The Department Of Education In Surigao Del Sur Has Two (2) Divisions, The Tandag City Division And Surigao Del Sur Division. In This Study, 534 Schools Are Utilized For Mapping And Simulation. Some Schools In The Province Were Unaccounted For Due To Missing Or Inaccurate Geographic Coordinates.

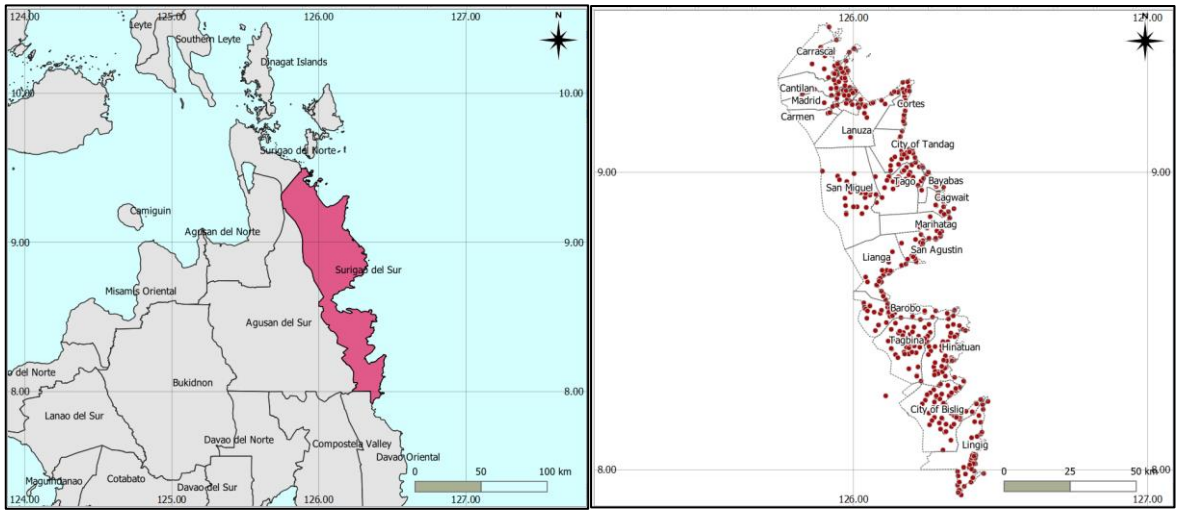

Figure 1. Map of Surigao del Sur Province bounded by Agusan del Sur and Surigao del Norte (right) and spatial distribution of the 543 schools in the province (left).

Materials And Methods

Storm Surge Shapefile Were Downloaded At The Website Of 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. Digital Elevation Mapping, Image Processing, And Overlaying Of Schools Geographic Coordinates Were Conducted In Qgis 3.10 Software. Figure 2. Shows The Process Of Computing The Distance And Azimuth Of Each Deped Schools To The Nearest Potential Storm Surge Level That The School Is Prone To. Azimuth (A) Is The Angle Of The Line Measured From The Vertical Line (0 Degree) To The Direction Of The School To The Nearest Storm Surge, Measuring Azimuth Is Shown In Figure 2.

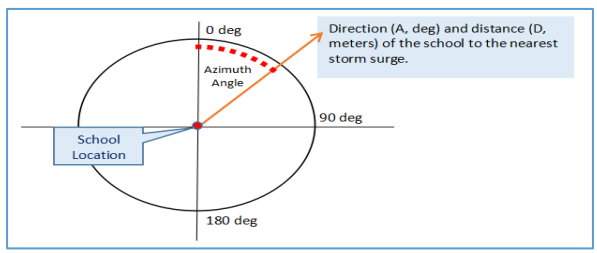

Figure 2. Azimuth measurement

Figure 2 Above Shows The Direction (Degrees) And Distance (Meters) Of The Each Deped Schools Location To The Nearest Potential Storm Surge.

2. Results And Discussion

In This Study, Choropleth Maps Are Used In Visualization Of The Results For Each Municipality With The Number Of Schools Susceptible To Storm Surge. Figure 3 Shows The Digital Elevation Model (Dem)Of The Schools Located In Surigao Del Sur. While Figure 4, Shows The Simulated Storm Surge Across All The Municipalities Of Surigao Del Sur Province. Ssa-1 Shows A Possible Storm Surge Height Of 2 Meters, Ssa-2 Is 3 Meters, Ssa-3 Is 4 Meters, While Ssa-4 Is 5 Meters Storm Surge Height. The Ssa Results For Every School Varies With Respect To Their Geographic Location And Elevation.

2.1. Schools Elevation

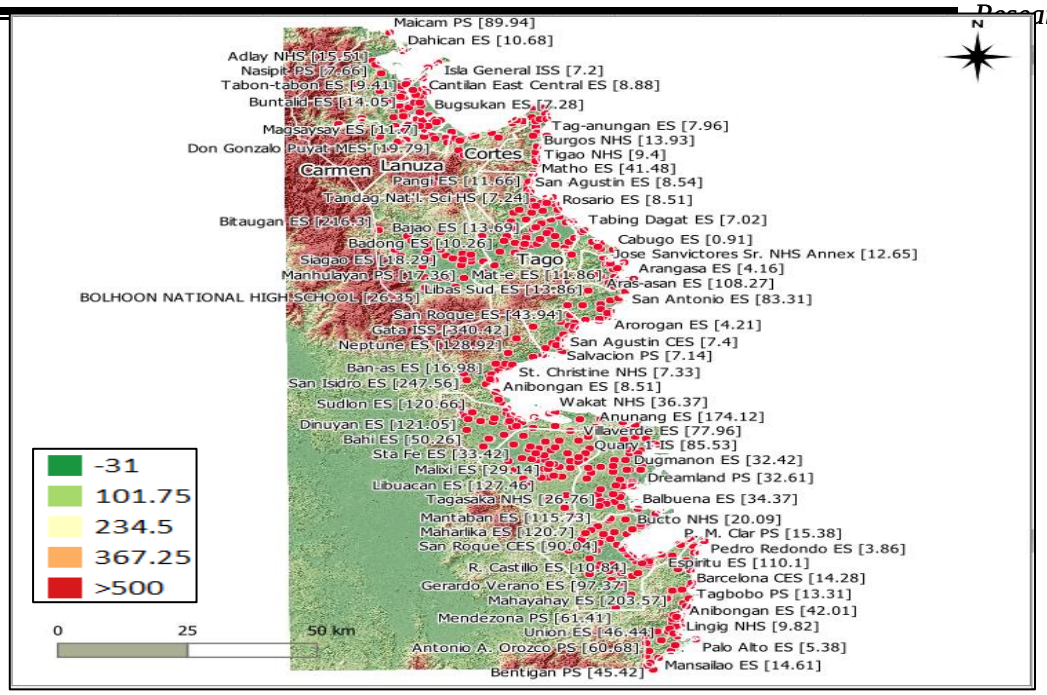

Figure 3. Digital Elevation of the DepEd Schools in Surigao del Sur Province

Figure 3 Above Shows The Distribution Of Deped Schools (In Red Dots) With Respect To Their Elevation. There Are 37 Identified Schools With High Elevation Compared To Other Schools, Which Makes Them Not Susceptible To Storm Surge.

Percentage Of Schools Susceptible At Different Ssa Level

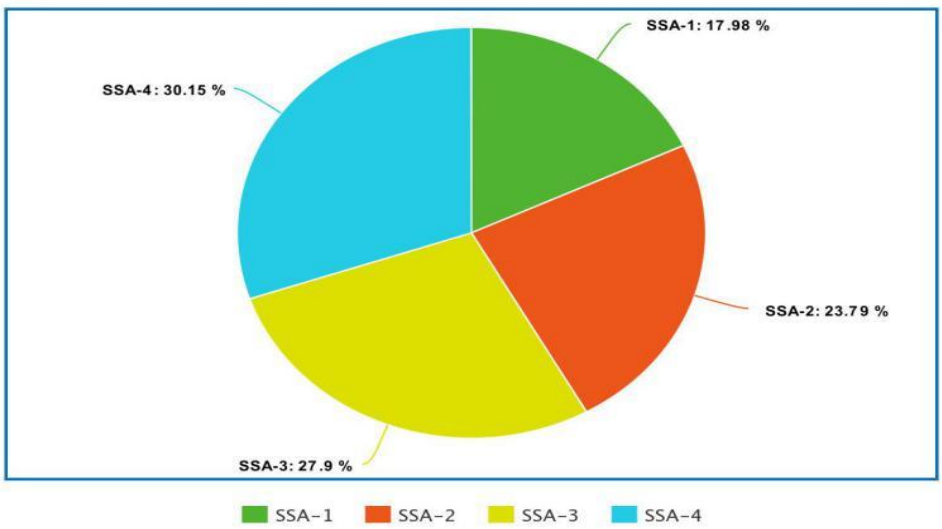

Figure 5. Distribution of Schools Susceptible to Different SSA Level of Storm Surge

Figure 5 Above Shows The Four (4) Ssa As Categories Of Storm Surge Height Of That The Deped Schools Are Susceptible. In Ssa-1, There Are 96 Identified Schools Susceptible To 2 Meters Height. These Schools Cover The 17.98% Out Of 534 Schools In This Study. At Ssa-2 (3 Meters Height), There Are 128 (23.79%)Identified Schools, While At Ssa-3 (4 Meters Height) There Are 149 (27.90%) Identified Schools, And Ssa-4 (5 Meters) With 161 (30. 15%) Identified Schools. Data Shows That Most Of The Schools In The Province Are Located In Low-Lying Coastal Areas Which Makes Them Susceptible To Storm Surge. As Such As The , Department Of Education, Being A Member Of The National Disaster Risk Reduction And Management Council (Ndrrmc), Has Been Building The Resilience Of Education By Advancing School Safety, School Drill And Exercises Conducted At A School Level Is Limited To Annual Earthquake Drill.

The Data On The Number Of Schools Susceptible To Storm Surge At Different Meters As Simulated In The Study, Can Help The Lgu And Schools Decision Makers To Mainstream In Their School Disaster Risk Reduction And Management Plan, As Well As The Local Drrm Plans To Include Identified Risk Of Each School In Their Locality. Schools With Proper Disaster Awareness Manage The Disasters Risks Very Well. It Is Incumbent To Have The Entire School Community Being Directly Engaged In Learning About Disaster Preparedness And Identifying Solutions To Protect The Schools [9]. While Figure 6 Below, Shows The Visual Representations Of Municipalities With The Number Of Schools Susceptible To Different Ssa Level,S The Data Is Presented Using The Simulated Storm Surge At Ssa 1-4 . Lingig Has The Highest Number Of Schools Susceptible To Storm Surge With 24 Schools, Followed By Hinatuan (18), Lianga (13), San Agustin (9), Cagwait And Marihatag (8), Bayabas (6), Tago (5), And Carrascal (4).

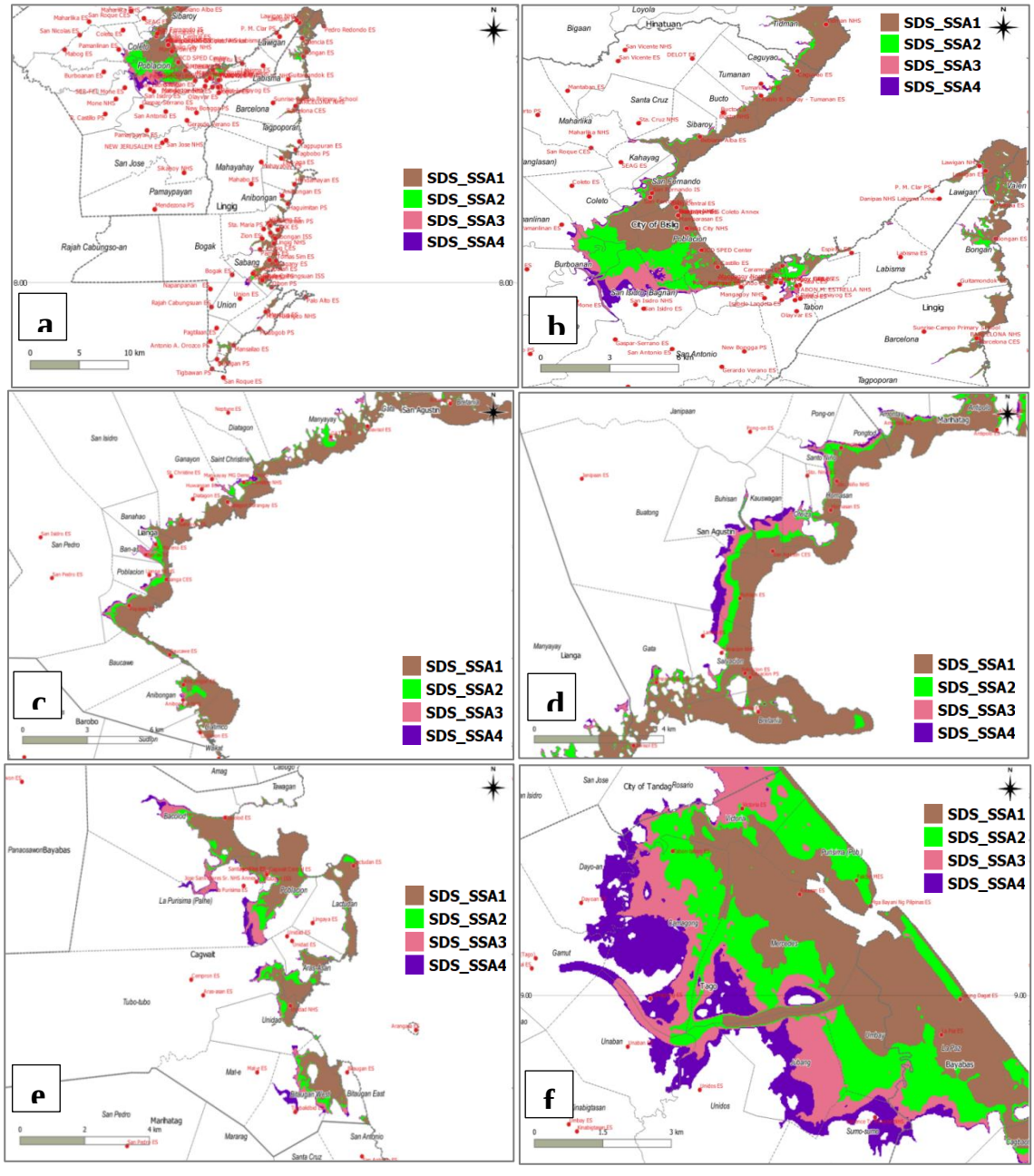

Figure 6. Simulated storm surge at of all the SSA level 1-4 among DepEd schools in municipalities and cities of Surigao del Sur Province, (a) Lingig, (b) City of Bislig (c) Lianga (d) San Agustin, (e) Cagwait (f) City of Tandag

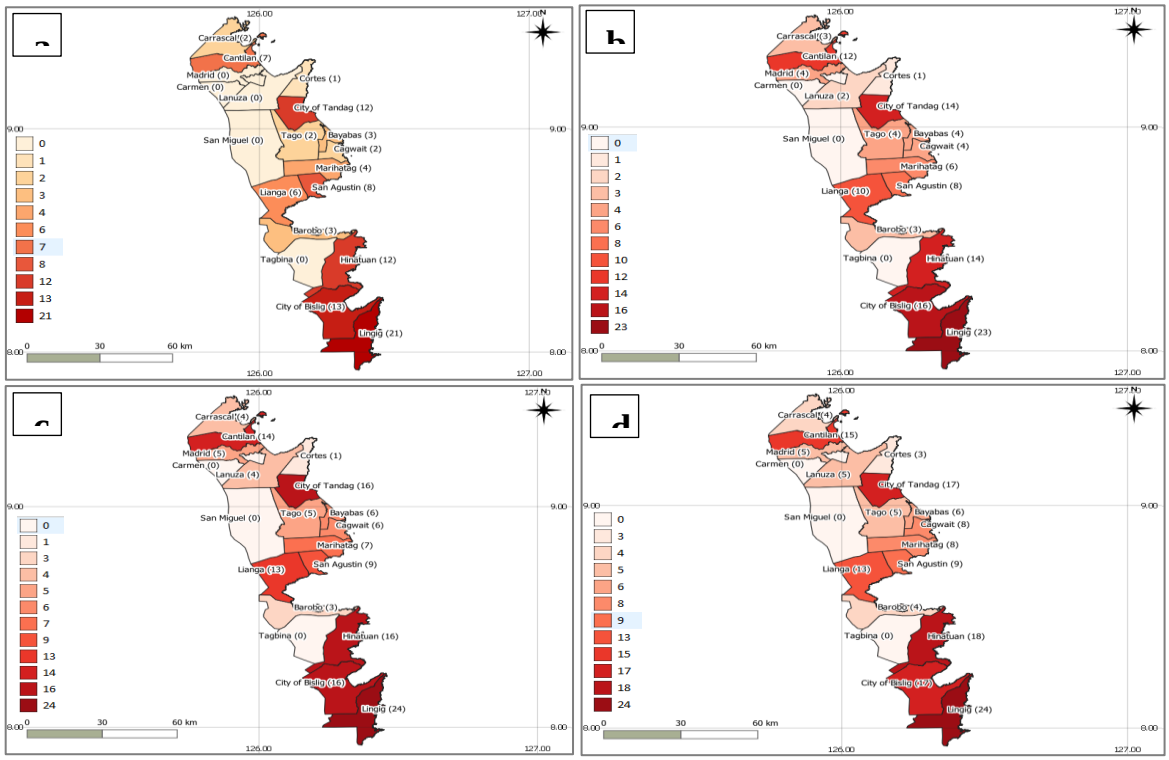

Figure 7. Chloropleth Maps of the Storm Surge Susceptibility of DepEd Schools in Surigao del Sur Province (a) SSA-1 (2 meters), (b) SSA-2 (3 meters), (c) SSA- 3 (4 meters), (d) SSA -4 (5 meters).

As Seen From Figure 7 Above, The Chloropeth Maps Visualized The Number Of Schools In The Province Of Surigao Del Sur Which Can Be Potentially Reach By Storm Surge. For Ssa-1 At A Height Of 2 Meters, Lingig (21), City Of Bislig (13), Hinatuan And City Of Tandag (12), San Agustin (8) And Cantilan (7) Are Among The Deped Schools That Could Potentially Be Reached By Storm Surge. For Ssa-2, Storm Surge Height Of 3 Meters, Lingig (23), City Of Bislig (16), Hinatuan And City Of Tandag (14), Cantilan (12), Lianga (10), And San Agustin (8). For Ssa-3 Storm Surge Height Of 4 Meters, Lingig (24), City Of Bislig, Tandag And Hinatuan (16), Hinatuan And Cantilan (14), While Lianga (13).For Ssa-4 With A Height Of 5 Meters, Linigig (24), Hinatuan (18), City Of Tandag And Bislig (17), Cantilan (15), Lianga (13), San Agustin (9), While Cagwait And Marihatag (8).In Figure 7, It Can Be Seen That The Municipality Of Lingig Has The Highest Number Of Deped Schools That Can Potentially Be Reached By Storm Surge, This Is Followed By Municipalities Of Hinatuan, Lianga, San Agustin, Cantilan, Cagwait, Marihatag, City Of Bislig And Tandag. All Of These Are Coastal Municipalities, The Susceptibility Of Schools To Storm Surge In These Area Can Be Attributed To Characteristics And Shape Of The Coast To Generate Surges

3. Conclusion

In The Context Of School Disaster Management, Natural Hazards Does Not Only Hinder School Operations But Threaten The Lives Of Students, Teachers And Personnel [10]. Surigao Del Sur, Being A Coastal Province Is Prone To Flooding, Storm Surge And Typhoon Which Challenges The Deped School Administrators ,Policy And Decision Makers To Create A “Culture Of Disaster Preparedness”. The Susceptibility Of Deped Schools To Storm Surge Is Not Merely A Geographic Issue, But It Is A Call For A A Localized And Contextualized Risk Assessment For Schools To Identify Potential Hazards, And Improved Coordination Among Lgu’s To Response And Mitigate Disasters.

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