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Storm Surge Analysis using Stochastic Simulation

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Abstract:
Storm surge is the sudden rise of sea water generated by an approaching storm over and above the astronomical tides. Such event imposes a major threat in the Philippine coastal areas, as manifested by Typhoon Haiyan on November 8, 2013 where more than 6,000 people lost their lives (Project Noah vol.3, 2014). A developed simulation Storm Surge Analysis using Stochastic Simulation helped the ESSU community become aware of storm surge in case such catastrophe may came. The study used the stochastic model to simulate the occurrence of storm surge in ESSU Main Campus. We used netlogo in simulating storm surge simulation, a programmable modeling environment for simulating natural and social phenomena. ISO 9126 Software Quality Standard was used to evaluate the characteristic of reliability and accuracy of the tool developed. From the result of the evaluation, the reliability and the accuracy of the tool was highly acceptable, and the application storm surge force analysis using stochastic simulation is applicable in Eastern Samar State University, Main Campus.

Keywords: Accuracy, Analysis, Damageable, Flowchart, ISO, kph (kilometer per hour), NetLogo, Simulation, Stochastic, Storm Surge, Tool, Typhoon,

I. INTRODUCTION:

Storm surge is an influx of sea or lake water pushed ashore by the strong winds, and it is caused primarily by tropical storms. Storm surge is one of the dangerous calamities of all calamities because it can cause loss of lives and damage infrastructures. Although people know where the dangerous prone area is, storm surge is always considered as unpredictable. It is not known where it hits, and how vast is its area of coverage. It is considered as dangerous as a tsunami and as fatal. Typhoon Haiyan or Yolanda was considered as both the fastest moving and strongest typhoon measured in the Philippines that causes occurrence in 10 meters high in Tacloban City. Disaster killed thousands of people and damage of infrastructures in some areas of Leyte. The study simulates the occurrence of storm surge so that people would be aware on what to do and for them to know where the appropriate location to evacuate in case the storm surge happens. The researchers used simulation to predict the possible results using secondary data from government agencies such as the Provincial Disaster Risk Reduction and Management Office or PDRRMO, Department of Science and Technology or DOST, Philippine Atmospheric Geographical Astronomical Services Administration or PAGASA and the Philippine Institute of Volcanology and Seismology or PHIVOLCS. The simulation intended to help the residents to be prepared in case storm surge happens in ESSU Main Campus, the location of the study. The measurement of the height and the strength of the wave in storm surge were measured; based on the height of the surge, the strength measured, and based on the strength of the wave, the damage also measured. Computed damages includes mangroves, and residential and school properties. Properties damaged depends on the height of the wave and wind speed.

Objectives

Study aimed to:

1. Simulate the occurrence of storm surge in ESSU Main Campus using the stochastic model, and;
2. Determine the accuracy and reliability of the storm surge simulation.

II. METHODOLOGY

Research Design

The study used stochastic model to simulate the occurrence of storm surge, a kind of model that predicts potential output depends on the variables that affect the developed output. According to Monte-Carlo (1930), in simulations, pseudo-random numbers are used which are generated deterministically by our computer are used. These numbers will approach a desired random behavior if statistics satisfy some properties. Developmental-evaluative research design was used. Storm surge simulation was developed with the support of NetLogo in developing simulation. In evaluation, the researcher used ISO 9126 to check the accuracy and reliability of the system.

Respondents

The respondents of the study are DOST workers, PAGASA employees, PDRRMO employees, MDRRMO personnel and BSCS or Bachelor of Science in Computer Science Students from ESSU, Main Campus. The number of the respondents was derived using the Slovin's formula ($n=N/1+Ne^2$) with the margin of error 0.05.

Table.1. Distribution of respondents

Respondents	Population	N
BSCS 4	30	25
BSCS 3	20	20
PDRRMO	26	10
MDRRMO	25	21
PAG-ASA	3	3
DOST	6	6
Total Respondents		85

III. INSTRUMENT

SOFTWARE QUALITY EVALUATION TOOL (*BASED ON ISO 9126 SOFTWARE QUALITY STANDARD*)
Name(optional): _____
Office/Agency_____
Title of the Study: Storm Surge Analysis using Stochastic Simulation.
Please read all the questions carefully and answer as directed.

Evaluate the tool's performance level. Rate *Strongly Agree* if the tool is very satisfactory in terms of the criteria mentioned with no noted error, *Agree* if the tool is very satisfactory with minimal error, *Neutral* if the tool is satisfactory, *Disagree* if the tool is barely satisfactory and *Strongly Disagree* if the tool is not satisfying. Response statement in **Yes** or **No** if the application developed is applicable.

5 - Strongly Agree
4 - Agree
3-Neutral
2 - Disagree
1 - Strongly Disagree

ISO SOFTWARE METRICS	RATING				
Optional Parameters	5	4	3	2	1
Reliability					
1. The application has a notification to users in concern to invalid data.					
2. The application resumes and restores misplaced data entry due to insignificant failure.					
3. The application is in inconsistent to the attributes of stochastic simulation.					
4. The application produced consistent mathematical force analysis solution.					
5. The application adheres to standards, conventions or regulations relating to reliability.					
Accuracy					
1. The storm surge simulation does what was proposed correctly.					
2. The simulation achieves the expected result.					
3. The behavior of simulation, function is in accordance to the characteristic and components of the scene in a storm surge.					
4. The storm surge simulation encompasses the characteristic and components of the stochastic simulation.					
5. The simulation provides the accurate result of computation.					

ISO SOFTWARE METRICS	Requirements Complied?	
Mandatory Parameters	Yes	No
The application on Storm Surge Force Analysis using Stochastic Simulation in ESSU Main Campus vicinity, applicable?		

Data Analysis: Questionnaire responses analyzed using frequency distribution and weighted Mean. Data were interpreted using the following scales and interpretation:

Scale	**Interpretation**
4.20 – 5.0	Highly Acceptable
3.40 – 4.10	Acceptable
2.60 – 3.30	Neither acceptable nor unacceptable
1.30 – 2.50	Unacceptable
1.00 – 1.70	Highly unacceptable

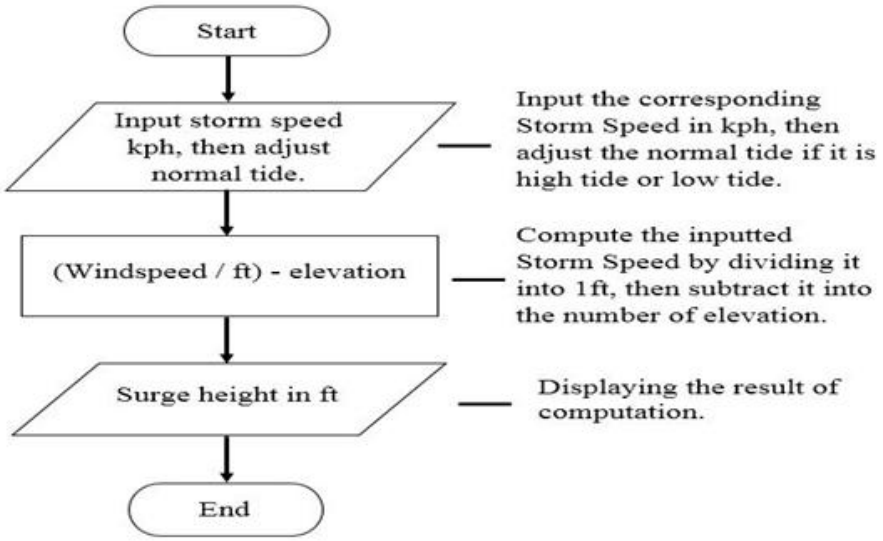

Figure.1. System Simulation Flowchart

IV. RESULTS

Application Tool Developed Using NetLogo.

Figure .2. The Screen Interface

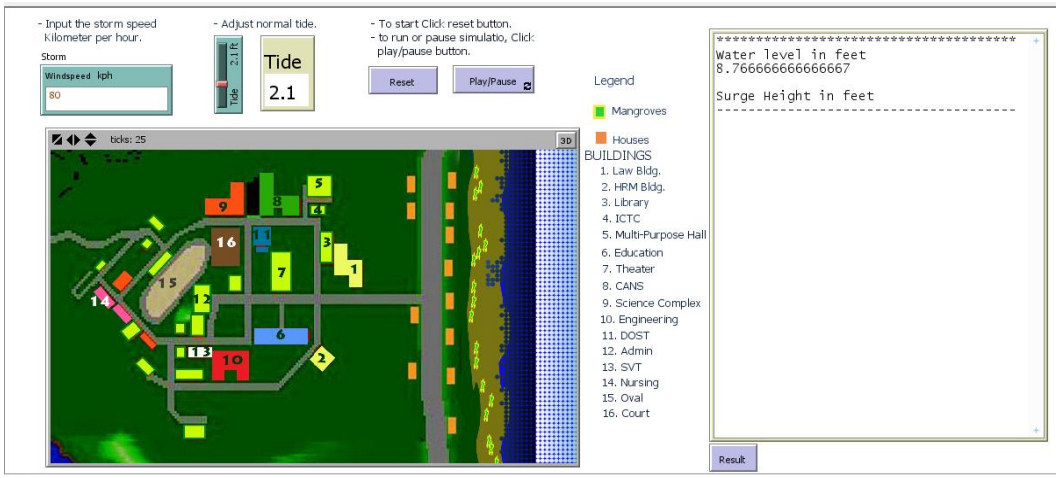

Figure.3. Screenshot of Simulation Output on the affected properties/areas in 80 kph wind speed. 80 kph wind speed got 8.766666666666667 water levels in feet and no damageable objects.

Figure.4. Screenshot of Simulation Output on the affected properties/areas in 90 kph wind speed. 90 kph wind speed got 9.8 water levels in feet and no damageable objects.

Figure.5. Screenshot of Simulation Output on the affected properties/areas in 100 kph wind speed. 100 kph wind speed got 11.533333333333335 water levels in feet and no damageable objects.

Figure 6. Screenshot of Simulation Output on the affected properties/areas in 130 kph wind speed. 130 kph wind speed got 14.033333333333335 water levels in feet and some damageable objects in infrastructures.

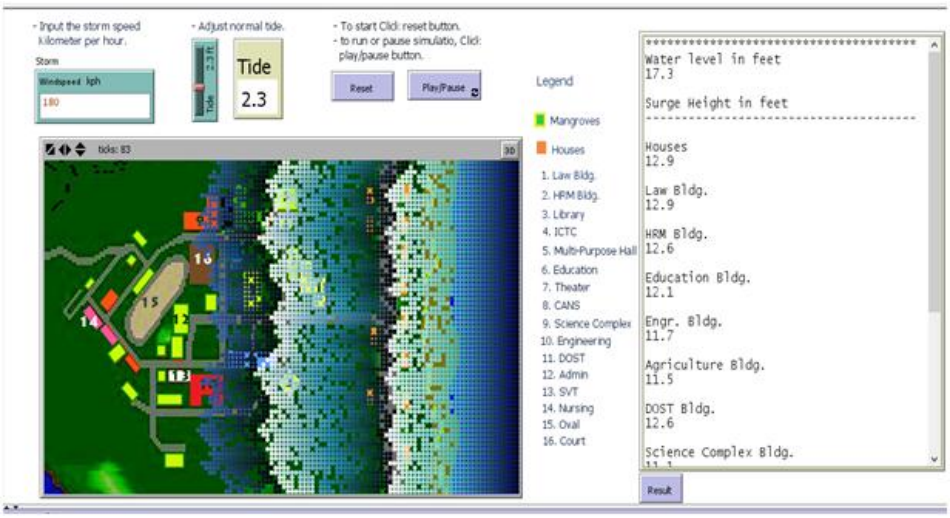

Figure 7. Screenshot of Simulation Output on the affected properties/areas in 180 kph wind speed. 180 kph wind speed got 17.3 water levels in feet and have some damageable objects in infrastructures.

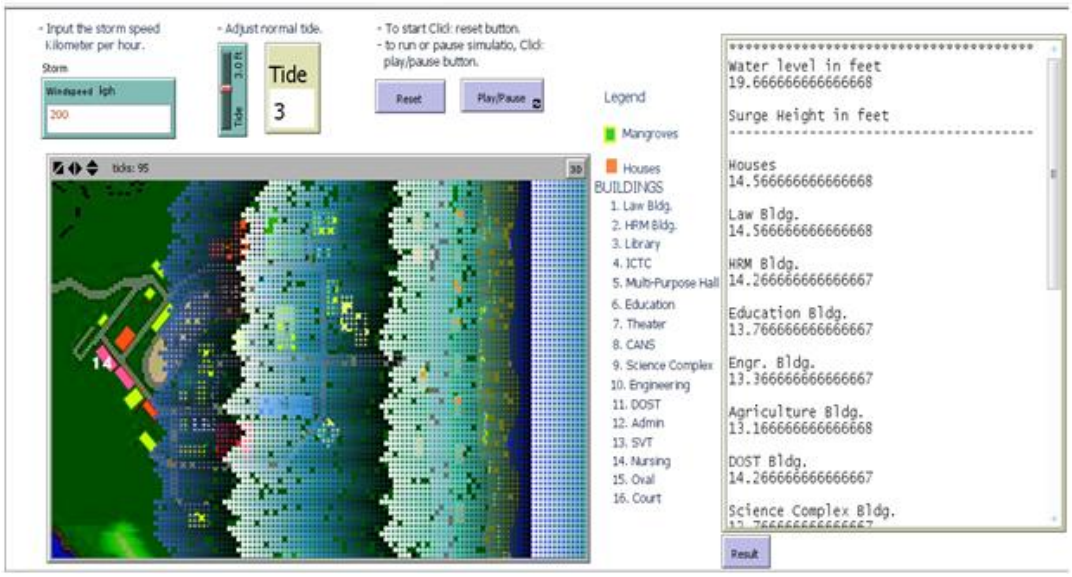

Figure 8. Screenshot of Simulation Output on the affected properties/areas in 200 kph wind speed. 200 kph wind speed got 19.666666666666668 water levels in feet and have highly damageable objects in infrastructures.

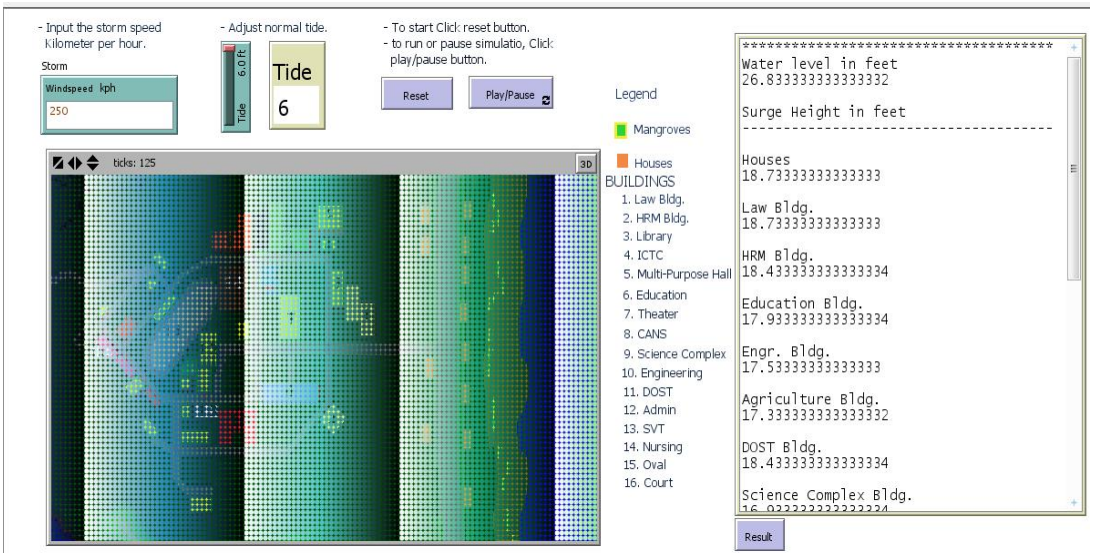

Figure 9. Screenshot of Simulation Output on the affected properties/areas in 250 kph wind speed. 250 kph wind speed got 26.833333333333332 water levels in feet and have highly damageable objects in infrastructures.

Table.2. Percentage distribution of respondents on the reliability and accuracy of the Storm Surge Analysis using Stochastic Simulation, as well as its Applicability.

Software Quality Criteria (Non-Functional Parameters)	RESPONSES (f) 5	4	3	2	1	Weighted Mean	Interpretation
Reliability							
The application has notifies notification users concerning invalid data	23	52	10	-	-	4.2	Highly Acceptable
The application resumes and restores misplaced data entry due to insignificant failure.	20	53	12	-	-	4.1	Acceptable
The application is inconsistent to the attributes of stochastic simulation.	25	42	16	2	-	4.1	Acceptable
The application produced consistent mathematical force analysis solution.	30	41	14	-	-	4.2	Highly Acceptable
The application adheres to standards, conventions or regulations relating to reliability.	28	48	9	-	-	4.2	Highly Acceptable
Accuracy							
The storm surge simulation does what was proposed correctly.	41	43	7	-	-	4.7	Highly Acceptable
The simulation achieves the expected result.	32	42	7	2	-	4.2	Highly Acceptable
The behavior of simulation, and function is in accordance to the characteristic and components of the scene in a storm surge.	33	44	8	-	-	4.3	Highly Acceptable
The storm surge simulation encompasses the characteristic and components of the stochastic simulation.	28	47	10	-	-	4.2	Highly Acceptable
The simulation provides the accurate result of computation.	29	48	5	2	-	4.2	Highly Acceptable
Overall Rating						4.3	Highly Acceptable

ISO SOFTWARE METRICS	Requirements Complied? (Frequency, Percentage)	
Mandatory Parameters	**Yes**	**No**
Is the Storm Surge Force Analysis using Stochastic Simulation in ESSU Main Campus vicinity, applicable?	85 (100%)	-

V. CONCLUSION

Based on the results, the simulation developed concludes:

1. Storm surge 170 kph and below, no damageable objects may occur,
2. The simulates indicates that at the storm surge 180-220 kph with 17.3 feet water level, it will damage same objects and infrastructures, and
3. At the surge of the storm by 250 kph and beyond with 6 feet water level, highly damageable objects and infrastructures may happened.

VI. RECOMMENDATIONS

mended that the software be more realistic eye-catching simulation. And the computation should be in whole number, not in repeating decimal number.

VII. REFERENCES

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