TIME SERIES MAPPING UTILIZATION ON THE SUSCEPTIBILITY ASSESSMENT OF SAN POLICARPO, EASTERN SAMAR, PHILIPPINES

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ABSTRACT
To assess changes in typhoon susceptibility in San Policarpo, Eastern Samar, the study compared and mapped Typhoon Hagupit before and after. Understanding the susceptibility dynamics through time can help reduce the likelihood of deaths and other losses. The central research questions were: Which barangays were most susceptible in both years? What has changed since Typhoon Hagupit? How did government resilience efforts affect susceptibility? Using catastrophe risk reduction approaches reduced susceptibility from 2010 to 2015. San Policarpo census statistics were used to assess 17 barangays (2010 and 2015). The researcher created an index that measured sensitivity, exposure, and adaptive capacity (Krishnamurthy et al., 2014). The susceptibility index scores were compared to depict geographical dynamics. The outcome was that susceptibility fell to a low level. This drop could be attributed to recovery operations after Typhoon Hagupit.

Keywords: Susceptibility Assessment, Exposure, Adaptive Capacity, Sensitivity, Mapping

INTRODUCTION
Tyyphoons expose human existence and the associated resources and inclinations in seaside urban communities, resulting in unstable effects from this harms (Baas, 2006). Every year, 20 storms hit the Philippines, an archipelago in Southeast Asia (ADCR, 2017). When these storms are extraordinary, as was the case with Typhoon Hagupit in 2014, the severe impact onshore networks can signal the start of a public fiasco (Toda, 2015).

Researchers contend that ecological change can amplify the strength of storms, increasing the likelihood of disasters when they strike a susceptible region (Yusuf and Francisco, 2009). Due to limited resources and time, administrations must prioritize provinces with more significant risks to repair for the most susceptible (Tuhkanen et al., 2018). Perilous effectivity could be achieved if neighborhood administrations and disaster managers could identify which barangays (Philippines) are most susceptible to storm effects by developing susceptibility maps of the city that incorporate the occupants' social characteristics. Susceptibility evolves as a result of neighborhood characteristics and public transportation. As a result, a one-of-a-kind examination that reviews over a year support in determining its drivers and changes (Cutter and Finch, 2008). By concentrating indicator values from information databases that are refreshed on a predetermined timescale, it is possible to deconstruct a period arrangement to assess spatial weakness over time. This approach enables a low-cost evaluation using satellite geological data and statistical databases.

Previously used techniques for surveying susceptibility in the Philippines incorporated evaluation data. They relied on selecting registration factors to create a Social Susceptibility Index (SoVI), which aided in identifying differences in susceptibility levels between various neighborhoods (Cutter et al., 2003).

However, conducting a multitemporal risk assessment utilizing comparable pointers from different years is beneficial for analyzing spatial susceptibility elements over time (Monterroso-Rivas et al., 2018).
The accessibility of subsequent evaluation data allows for a correlation of weakness indicators following a significant cataclysmic event, allowing for a complete understanding of the components of weakness and the effects of the storm intercessions on larger worldly and spatial scales. Additionally, it is critical to assess and screen disaster assistance projects and flexibility procedures.
By mapping and planning the points of susceptibility before and after Typhoon Hagupit, this research examined the progressions of weakness to storms in San Policarpo, Eastern Samar, Philippines. Storms have a disproportionate impact on coastal networks in the Philippines due to their inadequate housing, lack of access to data, and inability to adapt and recover from systematic risks. Over time, recognizing the weak points can reduce the risk of fatalities and other misfortunes by assisting the focused execution of disaster risk reduction techniques.

OBJECTIVES

1. Present a clever strategy for reducing vulnerabilities over time using enumeration and satellite geographic data
2. Investigate the typhoon susceptibility of barangays in San Policarpo, Eastern Samar, Philippines.
3. Consider the city's responsibility for spatial and material elements by analyzing San Policarpo evaluation data from 2010 and 2015.
4. Identify methodological flaws that should be addressed in specific urban spaces to increase flexibility while minimizing common harms.

SCOPE

The system used in this test measures susceptibility using public data. The method helps determine spatial weaknesses before an on-site evaluation. However, certain impediments arise due to the researcher's lack of presence in San Policarpo, Eastern Samar, Philippines, and the lack of immediate subjective data sources like studies or interviews.
The irregularity of the statistics polls from 2010 to 2015 is one of the obvious impediments to the database.
This study aimed to create a Susceptibility Index to depict the social susceptibility of local communities to typhoons at the barangay level in San Policarpo, Eastern Samar, Philippines. The susceptibility index was created using Krishnamurthy et al.'s four-step stages (2014).

METHODS

Research Design

This study used data from 2010 and 2015 to describe the social susceptibility of nearby networks to environmental hazards such as floods, storm floods, and hurricanes. The list used PSA's accessible and late datasets. Sensitivity, Exposure, and Adaptive Capacity were measured using GIS.

Research Locale

San Policarpo is a 5th-class municipality in the Philippines' Eastern Samar province. According to the 2015 census, it has 14,687 residents. Arteche borders the Pacific Ocean in the north and Oras in the south.
San Policarpo Municipality was established in 1948 by Republic Act No. 281 and was inaugurated on February 5, 1949. The town was once called "Bunga" after a local plant called Bunga. The name "Bunga" refers to the founders' labors.

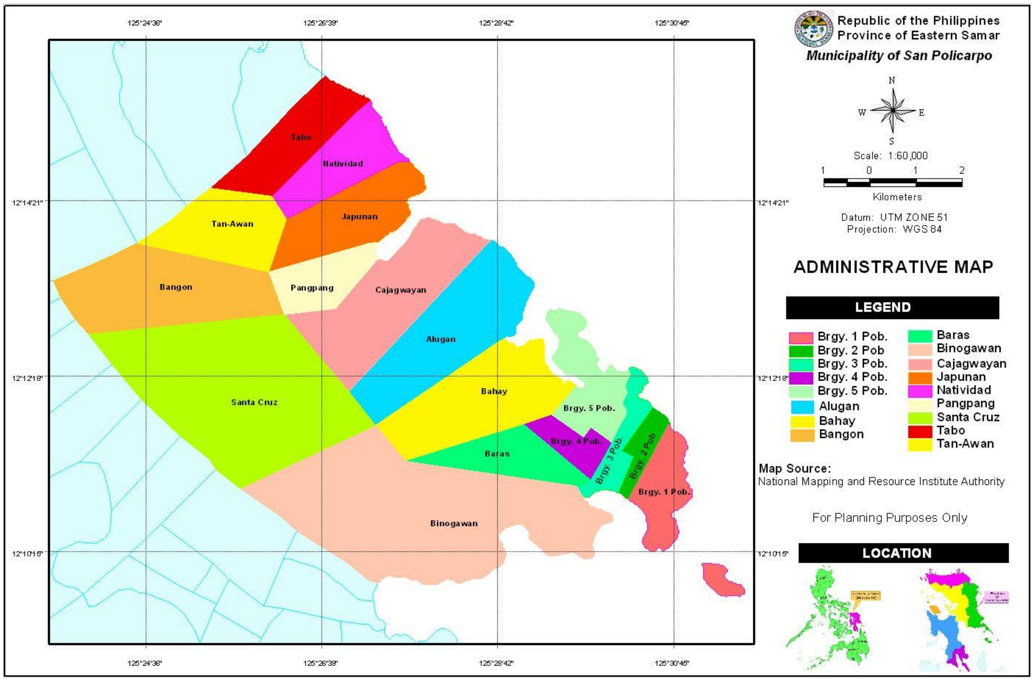

Figure 1. San Policarpo's Map

Procedure and Data Gathering

The variables for each barangay were gathered from PSA census files from 2010 and 2015. Every five years, the PSA conducts and distributes a nationwide survey to update the data. Thus, the index is a composite of indicators reflecting each barangay's overall typhoon sensitivity.

Geographic imagery and elevation models from HDX and demographic databases 2010 and 2015 were used to obtain exposure data. The geographic models chose low elevation and proximity to the coast.

The PSA's demographic databases provided 2010 and 2015 sensitivity data. The variables extracted were: population, % children under ten, and % elders (above sixty). These variables were used to count the people in danger.

Finally, between 2010 and 2015, census data for adaptive capacities were extracted. The variables were the owner's share of houses owned or rented, an inverse proxy for poverty. Indicator of education was the percent of the population with college degrees. The barangay's urban or rural status was used to assess livelihood susceptibility.

Statistical Treatment

Each pointer had its unit and scale. Standardization and normalization were required for the susceptibility index (Krishnamurthy et al., 2014). To convert the values, each barangay's population was represented and indexed. The variables were then normalized and expressed as a % of the leading indicator (Gonzales, 2019).

Standardized Indicator=Indicator Value/Indicator Maximum

It was then added to the component's value, where n is the number of pointers for that part (Gonzales, 2019):

Component value = (Indicator 1 + 2 + n) / n

It was added using the balanced weighted approach. In the absence of evidence to the contrary, it was assumed that each Socialcomponent contributed equally to the directory. To compare the two databases, each component was normalized as a percentage of the leading indicator (2010 and 2015). This was done by multiplying the outcome values of each component for each barangay (Gonzales, 2019):

Susceptibility Score= Exposure * Sensitivity * Adaptive Capacity

The susceptibility index computations and their parts were plotted using the Geographic Information System (GIS). The same procedure was used in 2010 and 2015 to show how the susceptibility score changed over five years before Typhoon Hagupit. The databases were linked to a georeferenced layer of barangay boundaries. The susceptibility score was then quantile divided into five classes, with each array representing 20% of the extreme susceptibility (Krishnamurthy et al., 2014).

Table 1. Measures for Typhoon Susceptibility

Susceptibility Index	<0.2	0.2-0.4	0.4-0.6	0.6-0.8	>0.8
Severity of Susceptibility	Very Low	Low	Medium	High	Very High

RESULTS AND DISCUSSION

Results

The 2010 and 2015 indicator databases tracked changes in susceptibility. Finally, the data was mapped for visualization. The map shows that most San Policarpo, Eastern Samar, has been reduced to Medium or Low susceptibility. The 2010 and 2015 Susceptibility Maps results show that the most susceptible barangays in 2010 were Barangay 1, 2, 3, 4, 5, and Alugan (Fig. 2). It was validated when the barangays that suffered the most fatalities and losses from Typhoon Hagupit in 2014 also had the highest susceptibility scores in 2010 (Fig 2).

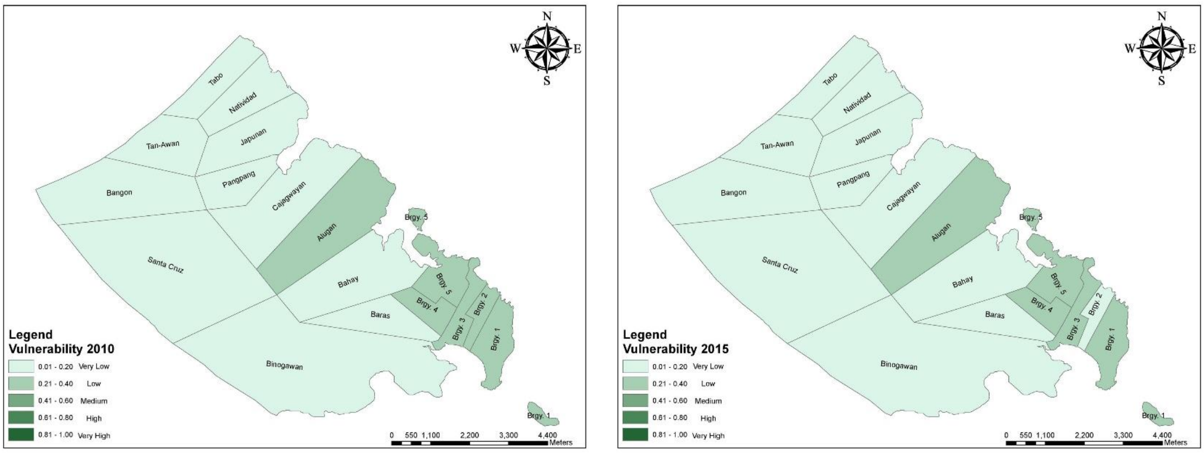

Figure 2. Contrast of Over-all Susceptibility Maps of 2010 and 2015

Table 2. Barangays with maximum susceptibility scores in 2010 and 2015.

Highest Susceptibility 2010	**Score**	**Highest Susceptibility 2015**	**Score**
Barangay No.1 (Pob.)	0.3212	Alugan	0.3008
Barangay No.2 (Pob.)	0.2644	Barangay No.1 (Pob.)	0.2815
Barangay No.3 (Pob.)	0.2552	Barangay No.4 (Pob.)	0.2618
Barangay No.4 (Pob.)	0.2430	Barangay No.3 (Pob.)	0.2268
Barangay No.5 (Pob.)	0.2324	Barangay No.5 (Pob.)	0.2115
Baras (Lipata)	0.1214	Barangay No.2 (Pob.)	0.1950
Bahay	0.1116	Bahay	0.1824

The barangays with the most significant reduction in susceptibility are gray, while the barangays with the most negligible reduction are yellow (Fig 3). The charts show that after Typhoon Hagupit, the most susceptible barangays saw a significant drop in risk (Fig 3).

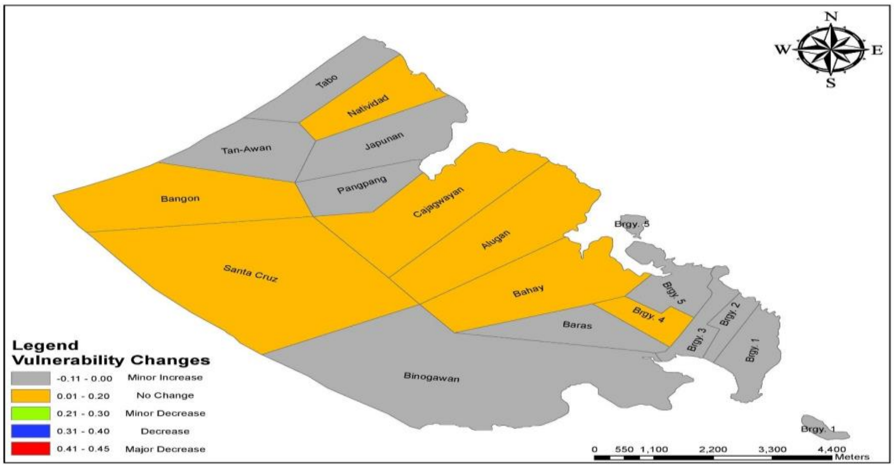

Figure 3. Map Showing Positive Score Change from 2010 to 2015

Barangay No.2, Baras, Barangay No.1, and Barangay No.3 exhibited the most significant reduction in susceptibility following the typhoon (Table 3).

Table 3. Barangays with the highest reduction of susceptibility.

Highest Decrease in Susceptibility	Score Difference	Percentage
Barangay No. 2 (Pob.)	0.0694	6.94%
Baras (Lipata)	0.0429	4.29%
Barangay No. 1 (Pob.)	0.0397	3.97%
Barangay No. 3 (Pob.)	0.0284	2.84%
Barangay No. 5 (Pob.)	0.0209	2.09%

Susceptibility Components

To answer the third study question, "What implications did the government's resilience initiatives enacted after Typhoon Hagupit have on the barangays' susceptibility?" data from 2010, and 2015 were compared and contrasted.

Typhoon exposure has decreased, mainly in coastal barangays (Fig 4). Most of the barangays that were designated Very High in 2010 were downgraded to High in 2015. While physical factors like distance from shoreline and elevation cannot be changed, infrastructure and building materials in San Policarpo, Eastern Samar, have been improved.

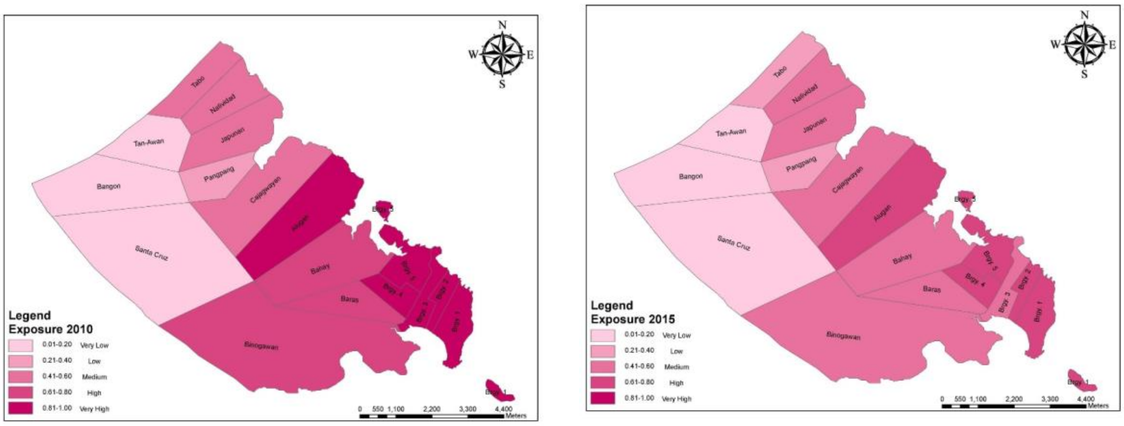

Figure 4. Contrast of the 2010 and 2015 Exposure Level

Separately, most barangays' sensitivity scores were reduced from High to Medium, reducing total susceptibility.

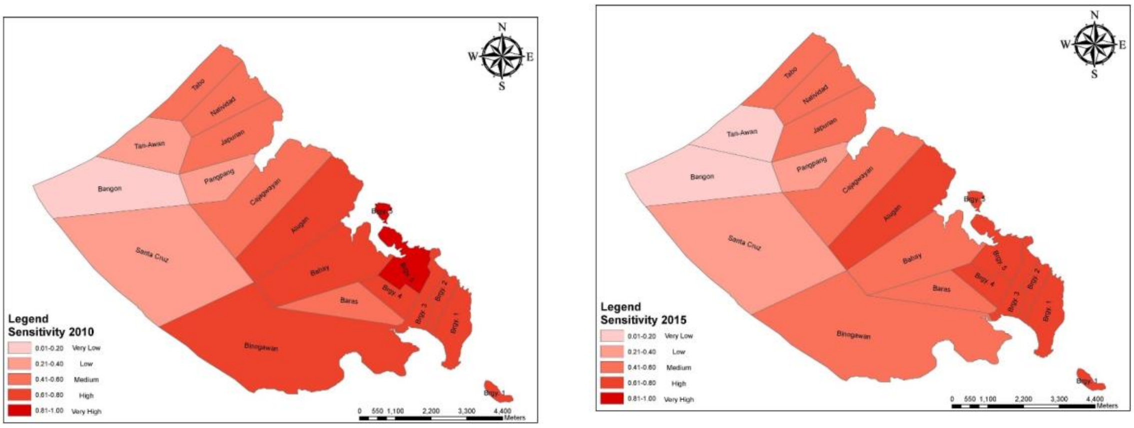

Figure 5. Contrast of the 2010 and 2015 Sensitivity Level

Adaptive capacities should be strengthened to reduce susceptibility. Between 2010 and 2015, only a few barangays improved their adaptive capacity.

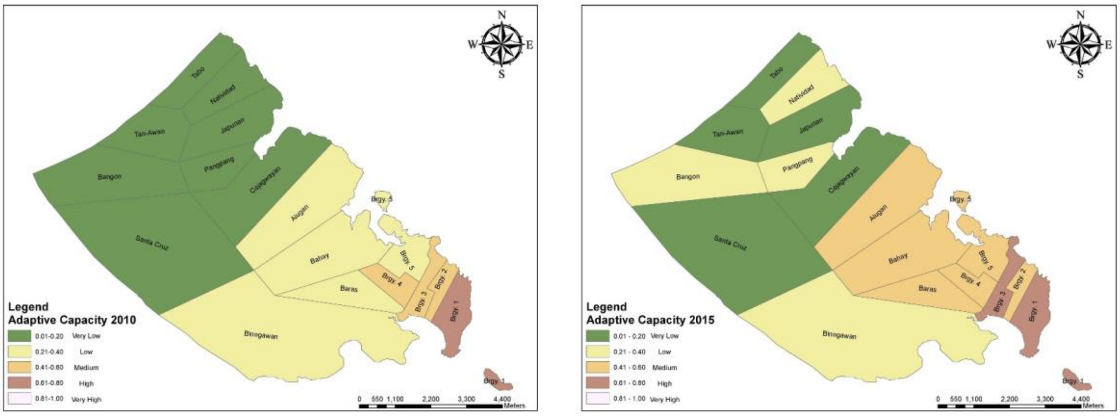

Figure 6. Contrast of the 2010 and 2015 Adaptive Capacity Level

DISCUSSION

The data showed that the lowest risk barangays in 2010 were those classified as Very High Risk. Subsequent to mapping and calculating the overall susceptibility, every barangay in 2015 was rated medium, low, or very low risk. Moreover, barangays like Brgy. 2, hit the toughest by Typhoon Hagupit, saw the most significant reduction in susceptibility. Following Typhoon Hagupit, the top five barangays in San Policarpo, Eastern Samar, showed a drop of over 2%, which was considered a good gain in resilience.

Three barangays (Brgy. 2, Baras, and Brgy. 1) reduced their susceptibility scores by 6.94%, 4.295%, and 3.975%, respectively (Table 3). Brgy. No. 3 (Pob) also showed a 2.84 percent decrease in susceptibility. When Typhoon Hagupit hit in 2014, these barangays had some of the highest mortality rates (UNDP, 2017). Thus, comparing susceptibility scores for both years can answer two research questions. The second hypothesis that the most susceptible barangays would suffer the most damage and deaths was proven correct. While the reduction in susceptibility between 2010 and 2015 suggests that resilience methods were successfully implemented, each component must be evaluated separately to determine which factors contributed the most. More research and information on the ground in San Policarpo are required to fully understand the local dynamics that contribute to the citizens' susceptibility.

Separately, the risk of exposure has decreased, especially in coastal barangays, where the score went from Very High in 2010 to High in 2015 (Fig. 4). Because of their location, barangays' exposure risk was assumed to be unchanged. Coastal and low-elevation barangays are at greater risk than non-coastal barangays, but the infrastructure is an essential non-geographical factor to consider.

A typhoon like Hagupit could cause problems in barangays in San Policarpo's northern areas. Improved evacuation communications were one of Hagupit's lessons. Surge warnings went unheeded in 2014 due to general inexperience resulting from inexperienced citizens underestimating the risks (Ahmed et al., 2015). In typhoon season, early warnings and evacuation planning are critical. Since 2018, the Philippines' LGUs have been conducting disaster education campaigns (Palagi et al., 2018).

Sensitivity was calculated using the percentage of elderly (60+), population, and children (10+). The sensitivity component had an odd dynamic when studied and mapped separately. The risk of most barangays in San Policarpo decreased from High to Medium when each indicator was evaluated separately (Fig 5). However, within barangays, the percentages of elders and children varied due to relocation efforts and normal population dynamics. The population indicator revealed a significant increase in northern barangays (Fig 7).

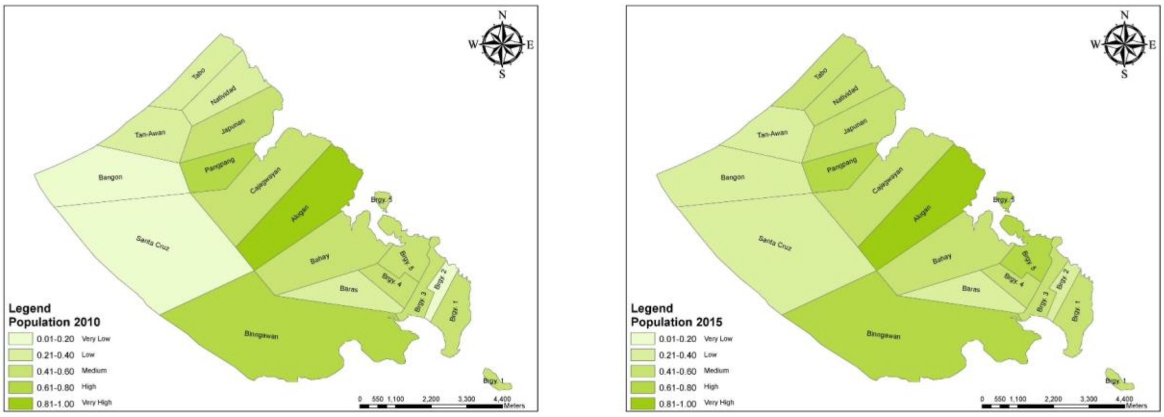

Figure 7. Contrast of the 2010 and 2015 Population

The Adaptive Capacities component measures how families will cope with future disasters. Disaster-resilient communities must be built. Even if the risk of death and destruction of infrastructure is eliminated, the ability of families to quickly recover is critical for long-term development (Fuchs & Thaler, 2018). More impoverished families also have fewer resources to reduce disaster risk and withstand repeated disasters. Building adaptive skills is critical to boosting welfare recovery and community resilience.

This study used low poverty and high education as positive indicators of Adaptive Capacities. These indicators are essential for adaptive capacities, but they do not provide a complete picture of local adaptive capacity dynamics. This index's inability to measure livelihoods should be addressed in a future study with on-site surveys. The census databases revealed comparable educational data. However, the census lacked a precise measure of poverty.

Initially, it was expected that increasing San Policarpo's resilience would significantly improve adaptive capacities. With little effort to address adaptive catastrophe capacities, tiny gains were seen. A livelihoods program was created to help the most susceptible households with money management, livelihood planning, and cash to start a small business.

This study lacked the data needed to assess the post-Hagupit livelihoods program's long-term dynamics. Adaptive capacities would rise faster between 2010 and 2015 if livelihood data were collected on the ground and entered into databases.

CONCLUSION

This method's results show how susceptibility evolves. The findings may help professionals and decision-makers spot critical information that can be used to assess susceptibility and pliability. As the population of emerging nations grows and natural disasters continue to strike densely populated areas, it is critical to have a tool that allows for conceptualizing societal susceptibility components.

This study introduced a novel strategy that may help close a significant gap in the works. The method works in any country that provides low-cost domestic demographic data. Open source GIS and tools are available online to replicate the scrutiny in different locations.

In San Policarpo, Eastern Samar, guidelines and flexibility policies helped reduce barangay susceptibility scores. However, population resettlement strategies are influenced by population behavior, so their success must be monitored over time.

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REFERENCES

1) ADCR. (2017). Country Report 2017 (No. 2017). Retrieved from Asian Disaster Reduction Center
2) Ahmed, A., Kodijat, A., Luneta, M., & Krishnamurthy, K. (2015). Typhoon Haiyan, an Extraordinary Event? A commentary on the complexities of early warning, disaster risk management and societal responses to the typhoon. Asian Diaster Management News 30, 22-27.
3) Baas, S. (2006). The Role of Local Institutions in Reducing Susceptibility to Recurrent Natural Disasters and in Sustainable Livelihoods Development
4) Bonifacio, J. (2015). More than a year after Yolanda: Home sweet home? Retrieved from https://www.rappler.com/nation/91115-poor-quality-relocation-yolanda
5) Cutter, S., Boruff, B., & Lynn Shirley, W. (2003). Social Susceptibility to Environmental Hazards. Social Science Quarterly, 84, 242–261.
6) Cutter, S. L., & Finch, C. (2008). Temporal and spatial changes in social susceptibility to Natural hazards. Proceedings of the National Academy of Sciences, 105(7), 2301–2306.
7) Fuchs, S., & Thaler, T. (2018). Susceptibility and Resilience to Natural Hazards. Cambridge University Press.
8) Gonzalez Rojas, Ana. 2019. Susceptibility Assessment Using Time Series Mapping: A Case Study of Typhoon Haiyan in Tacloban City, Philippines
9) Krishnamurthy, P. K., Lewis, K., & Choularton, R. J. (2014). A methodological framework for rapidly assessing the impacts of climate risk on national-level food security through a susceptibility index. Global Environmental Change, 25, 121– 132.
10) Monterroso-Rivas, A. I., Conde-Álvarez, A. C., Pérez-Damian, J. L., López-Blanco, J., Gaytan-Dimas, M., & Gómez-Díaz, J. D. (2018). Multi-temporal assessment of susceptibility to climate change: insights from the agricultural sector in Mexico. Climatic Change, 147(3), 457–473.
11) Palagi, S., & Javernick-Will, A. (2018). Typhoon Haiyan and Tacloban City Relocation: Summary of Community Outcomes Survey. Boulder University. Retrieved from https://www.colorado.edu/lab/gpo/2018/11/08/typhoon-haiyan-and-tacloban-city- relocation-summary-community-outcomes-survey
12) Toda, L. (2015). Geography of Social Susceptibility of Haiyan Affected Areas to climate-related hazards: Case study of Tacloban City and Ormoc City, Leyte.
13) Tuhkanen, H., Boyland, M., Han, G., Patel, A., Johnson, K., Rosemarin, A., & Lim Mangada, L. (2018). A Typology Framework for Trade-Offs in Development and Disaster Risk Reduction: A Case Study of Typhoon Haiyan Recovery in Tacloban, Philippines. Sustainability, 10(6), 1924.
14) UNDP Philippines. (2017). Haiyan’s Ground Zero Rising by UNDP Philippines. Retrieved from https://undpph.exposure.co/haiyans-ground-zero-rising
15) Walch, C. (2018). Typhoon Haiyan: pushing the limits of resilience? The effect of land inequality on resilience and disaster risk reduction policies in the Philippines. Critical Asian Studies, 50(1), 122–135.
16) Yusuf, A. A., & Francisco, H. (2009). Climate Change Susceptibility Mapping for Southeast Asia (No. tp200901s1). Retrieved from Economy and Environment Program for Southeast Asia (EEPSEA).