GIS-based Vulnerability Assessment of Coastal Dwellers to Climate Change in the Southern Illana Bay of Zamboanga del Sur, Philippines

Arnold T. Tanondong[1*], Jerry B. Superales[2], Ruel S. Lasagas[2] and Mary Jocelyn V. Battung[3]
[1]School of Engineering and Technology
[2]School of Agriculture, Forestry and Environmental Studies
J.H. Cerilles State College
Mati, San Miguel, Zamboanga del Sur, 7029 Philippines
[*]*arnold.tanondong@jhcsc.edu.ph*

[3]Teacher Education Science Department
Western Mindanao State University - Pagadian Campus
Bulatoc, Pagadian City, Zamboanga del Sur, 7016 Philippines

Date received: September 21, 2022
Revision accepted: July 22, 2025

Abstract

The Philippines has the fifth-longest coastline in the world, meaning a significant part of its population depends on fishery resources. Several studies show that climate change greatly impacts coastal communities. This study assessed the extent of climate change effects locally by measuring the vulnerability index of target coastal communities using GIS software to provide scientific information aimed at reducing their vulnerability to climate change. Household heads from coastal barangays in southern Illana Bay, Zamboanga del Sur, were randomly selected and surveyed with a structured questionnaire based on the Fisheries Vulnerability Assessment Tool (FishVool). The coastal residents were found to be moderately vulnerable (2.0) to climate change mainly due to high dependence on fishery resources, decreasing fish catches, low income from fishing, and low literacy rates. These factors contributed to their moderate sensitivity (16.12) and low adaptive capacity (16.08). Stakeholders should work to lower sensitivity and boost adaptive capacity by offering alternative livelihoods to reduce dependency on fishing and improving fishing gear to increase catch rates. Additionally, strengthening information and education campaigns will support conservation and preservation strategies for coastal resources and ecosystems, which can help increase fish catches and, consequently, income from fishing.

Keywords: adaptive capacity, climate change, coastal dwellers, sensitivity, vulnerability

---

1. Introduction

Climate change is one of the biggest challenges today (Urry, 2015). It directly or indirectly impacts all ecosystems and communities (Pecl *et al*., 2017), including coastal areas (Hewitt *et al*., 2016). Coastal ecosystems face the effects of climate change, such as rising sea levels, storm surges, strong winds, and increasing temperatures, which make coastal communities vulnerable to these climate-related events (He and Silliman, 2019).

The Philippine archipelago is not exempt from the impacts of climate change. According to Eckstein *et al*. (2021), the country ranks fourth among the most affected nations from 2000 to 2019, with a long-term climate risk index of 18.17, indicating a moderate to high risks. Additionally, this suggests that the Philippines is moderately vulnerable to long-term climate risks due to its geographic location, socioeconomic factors, or infrastructure sensitive to climate impacts. Furthermore, the country has 36,289 km of coastline, ranking fifth among countries with the longest coastlines (Central Intelligence Agency [CIA], n.d.). With nearly 60% of the population living in 832 coastal municipalities, it is extremely susceptible to the impacts of climate change (Asian Development Bank [ADB], 2014).

The Philippines recognized as one of the most hazard-prone countries in the world due to its geographical and environmental setting, including the effects of climate change (World Bank, 2023), faces extreme vulnerability to natural disasters. This is especially evident in the municipalities of Agusan del Norte, which are among the most vulnerable to climate change impacts (Apdohan *et al*., 2021), and even more so for coastal communities in Western Mindanao, where the threats are explicit. These environmental events threaten progress opportunities and increase the vulnerability of our coastal populations. Interventions cannot be uniform nationwide because vulnerability indices differ by area. They should be allocated wisely by matching resources proportionately. This helps avoid giving more interventions to less vulnerable communities while providing fewer to those more vulnerable. While measuring climate vulnerability indices at the national level is important, assessments at the local level, like those by Apdohan *et al*. (2021), Dela Torre *et al*. (2019), Jocson and Magallon (2018), and this study, are also essential.

Addressing this gap, this study assessed the vulnerability of coastal residents in southern parts of Illana Bay, Zamboanga del Sur, Philippines, to climate change and to identify possible interventions for affected communities. Local vulnerability assessments will help concerned local government units (LGUs) obtain more accurate information about their constituents' socioeconomic status and susceptibility to climate change. The insights gained may assist in developing policies, strategies, and interventions that meet the needs of impacted coastal communities. Additionally, this study explored practical applications of Geographic Information System (GIS) in vulnerability assessments, which can be useful for managing large data sets and visualizing results.

2. Methodology

Six coastal barangays in the southern part of Illana Bay, Zamboanga del Sur, stretching for nearly 74 km, were chosen as study sites (Figure 1). From these locations, 300 heads of coastal households involved in fishing activities were randomly selected as key informants. The sample size was calculated using Cochran's formulae (Cochran, 1977), which are presented in Equations 1 and 2.

$$n_0 = \frac{z^2 p(1-p)}{e^2} \tag{1}$$

$$n = \frac{n_0}{1+(n_0-1)/N} \tag{2}$$

Z represents the z*-value,* p *indicates the target proportion,* e *stands for the margin of error, and* N *signifies the population proportion. For this study,* $z = 1.96$ *for a 95% confidence level,* $p = 0.50$ *for maximum variability,* $e = 0.05$*, and* $N = 1{,}367$ *coastal households engaged in fishing activities as recorded by Barangay records. No validation was performed on the results of this study. The validity and reliability of the results are assured because the implementing and funding agency is a government institution with its own research protocol, system, and in-house experts.*

The Fisheries Vulnerability Assessment Tool (FishVool) is a participatory and simplified framework developed by Jacinto *et al*. (2015) to evaluate the vulnerability of fishing communities and fisheries sectors to the impacts of climate change. It is based on vulnerability as a function of sensitivity, exposure, and adaptive capacity. Sensitivity refers to how these disturbances affect the fishery or community. Exposure refers to the extent to which a system is subjected to extreme weather disturbances. Adaptive capacity, on the other hand, indicates the ability of communities to adjust or respond to these changes. This study was aligned with the instructional manual developed by Aguila *et al*. (2021) in accordance with the goals of the Department of Agriculture - National Fisheries Research and Development Institute and Bureau of Fisheries and Aquatic Resources (BFAR). Data were analyzed and reclassified using the developed GIS-based algorithm, emphasizing the vulnerability index of coastal dwellers.

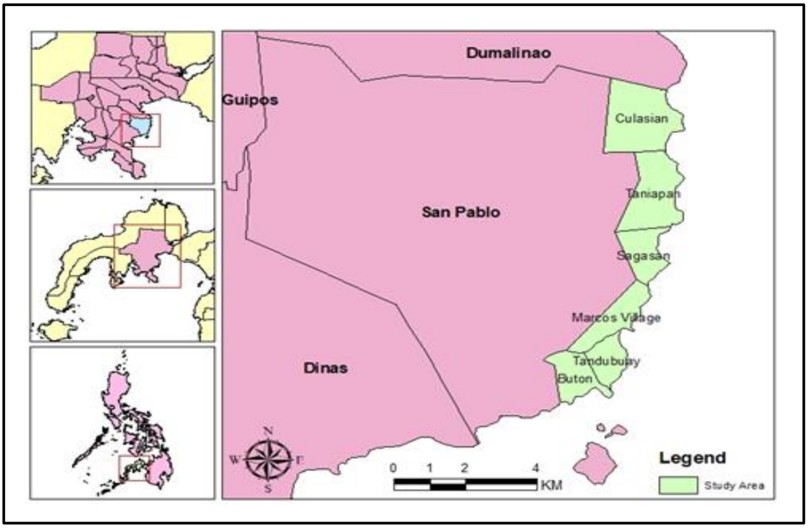

Figure 1. Map of study sites

The Fisheries Vulnerability Assessment Tool (FishVool) is a participatory and simplified framework developed by Jacinto *et al*. (2015) to evaluate the vulnerability of fishing communities and fisheries sectors to the impacts of climate change. It is based on vulnerability as a function of sensitivity, exposure, and adaptive capacity. Sensitivity refers to how these disturbances affect the fishery or community. Exposure refers to the extent to which a system is subjected to extreme weather disturbances. Adaptive capacity, on the other hand, indicates the ability of communities to adjust or respond to these changes. This study was harmonized with the instructional manual developed by Aguila *et al.* (2021) in consonance with the goal of the Department of Agriculture - National Fisheries Research and Development Institute and Bureau of Fisheries and Aquatic Resources (BFAR). Data were analyzed and reclassified through the developed GIS-based algorithm emphasizing the vulnerability index of coastal dwellers.

The first step in assessments using FishVool is selecting a study site and identifying the fishery sector to be evaluated. The second step involves developing or adapting a questionnaire based on the three vulnerability components tailored to the local context. Data is then collected through structured interviews with fishers and key informants. The responses are scored using predefined indicators for each component (exposure, sensitivity, and adaptive capacity) on a scale from one (1) to five (5). Next, the average score for each component is calculated and combined to determine an overall vulnerability score. The results are then analyzed to classify communities or sectors into low, medium, or high vulnerability categories and to guide the development of localized adaptation strategies (Jacinto *et al.*, 2015).

FishVool operates on certain assumptions. It assumes that the indicators used for sensitivity, exposure, and adaptive capacity vary significantly across communities, making equal weighting an unbiased way to measure overall vulnerability. It also assumes that self-reporting is dependable and that the respondent sample accurately represents the entire fishing community (Jacinto *et al.*, 2015).

FishVool has some limitations despite being useful. The results may not be widely applicable when used with small sample sizes. The tool is a simplified framework that could overlook important factors. Equal weighting of indicators might misrepresent their importance because not all indicators have the same influence. Key informants might introduce biases if they provide data based on subjective perceptions.

The survey questionnaire used in this study was custom-designed based on the FishVool assessment matrix by Jacinto *et al.* (2015). It was used to collect data from coastal dwellers in the study sites who are engaged in fishing activities as key informants.

Several studies have used this tool to assess vulnerabilities of fishery-related commodities (Tattao *et al.*, 2023; De Chavez *et al.*, 2021; Eluriaga *et al.*, 2019; Macusi *et al.*, 2022). While existing vulnerability assessment tools such as the Coastal Integrity Vulnerability Assessment Tool (CIVAT) and the Integrated Coastal Sensitivity, Exposure, and Adaptive Capacity to Climate Change (ICSEA-C-Change) Vulnerability Assessment Tool focus more on assessing coastal integrity and the biophysics of coastal ecosystems (MERF, 2013), FishVool's focus is on fisheries vulnerability. Additionally, while the Tool for Understanding Resiliency of Fisheries (TURF) can be used to evaluate fisheries vulnerability, fisheries experts must assist with data analysis and guide data collection (MERF, 2013), which FishVool does not require.

2.1 Sensitivity

The Intergovernmental Panel on Climate Change (IPCC, 2007) defines sensitivity as a system's inherent traits and vulnerabilities that increase its likelihood of suffering adverse effects from external pressures. This concept is vital for assessing overall vulnerability. In FishVool, the following parameters can be clarified: the comparative fish catch rate over 20 years (a), average fish catch lengths (b), dependence on fishery resources (c), household age structure (d), and health conditions (e). For example, children, who are physically weaker and less capable of dissipating heat than adults, are notably more vulnerable to environmental factors such as heat and pollution (Hanna and Oliva, 2016). Similarly, people with preexisting health issues are at a higher risk of climate-related diseases and death (United States Environmental Protection Agency [US-EPA], 2016a). These insights emphasize the importance of understanding sensitivity to evaluate vulnerability in various coastal communities effectively.

2.2 Exposure

Regarding the vulnerability of coastal residents, exposure refers to how much these communities are exposed to environmental hazards and stressors like sea-level rise, storms, and erosion (Jacinto *et al*., 2015). Weather disturbances in fishing areas focus on their frequency and severity. Events such as typhoons and storms increase sea surface temperatures, which disturb fish and lead to migration (Jacinto, 2015, as cited in IPCC, 2007; Santos *et al*., 2011). Exposure of households or communities to weather disturbances disrupts the security and efficiency of fishing activities because fishers are less likely to fish during such conditions. Additionally, exposure to extreme weather events causes damage to homes, services, and infrastructure in the community (Santos *et al*., 2011).

2.3 Adaptive Capacity

Adaptive capacity refers to the ability of a system, group, or individual to adapt to potential hazards, benefit from opportunities, or respond to the effects of climate change and other stressors (Jalang'o *et al*., 2022). It includes various elements such as resources, knowledge, and institutional support, enabling effective adaptation strategies to reduce negative impacts

(Mastrorillo *et al*., 2016). This study considered factors like annual income from fishing, awareness of climate change, access to information, adaptive strategies, literacy, gear modification, and climate change support. Recognizing and strengthening these factors are crucial for helping coastal residents better adapt to and manage issues caused by climate change.

2.4 Integration with GIS

FishVool was integrated into the assessment of potential impact and vulnerability indices for coastal residents using GIS. Three components of the vulnerability index were necessary to achieve this: sensitivity, exposure, and adaptive capacity. As mentioned earlier, sensitivity included five parameters, exposure had three, and adaptive capacity comprised seven.

Figure 2 illustrates the algorithm used in the study through ArcMap version 10.4, a key GIS application within the ArcGIS Desktop suite developed by Environmental Systems Research Institute, Inc. (ESRI), based in the United States. ArcMap can create map layouts for printing or publication, assign symbols, and analyze GIS datasets relevant to a research topic (ESRI, 2021). S represents sensitivity, E indicates exposure, AC stands for adaptive capacity, PI for potential impact, and VI for vulnerability index. Reclassified sensitivity, exposure, adaptive capacity, potential impact, and vulnerability index are denoted by RS, RE, RAC, RPI, and RVI, respectively. The parameters in the questionnaire were also scored using the FishVool matrix. ArcMap was used to save respondents' average scores for each parameter onto a digital base map of the study area downloaded from PhilGIS.

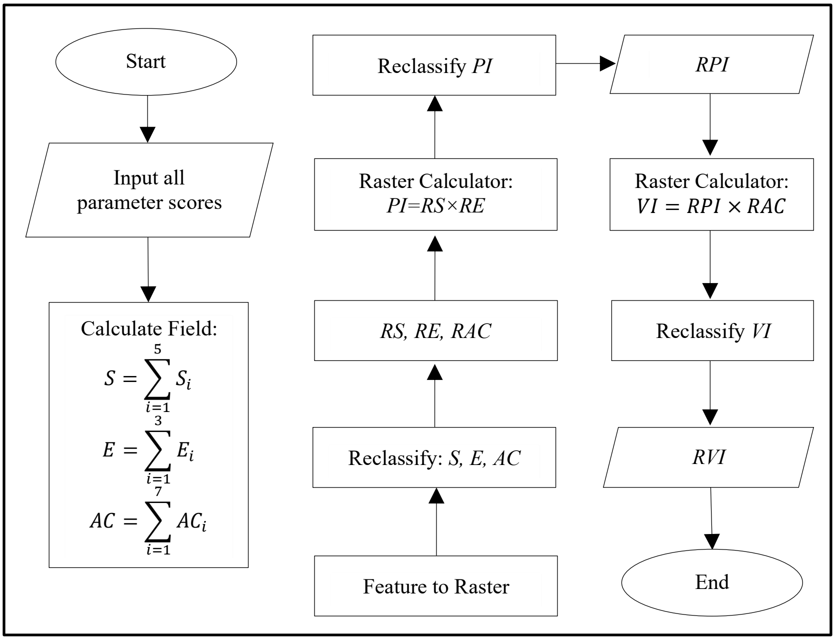

Figure 2. GIS-based algorithm for vulnerability assessment

The overall sensitivity, exposure, and adaptive capacity scores for each study site were calculated by summing the scores of each parameter within each component using the Calculate Field tool in ArcMap. The resulting feature class was then converted into a raster file because the Raster Calculator can only process raster data types. Next, sensitivity, exposure, and adaptive capacity scores were reclassified using the matrix in Table 1 with the Reclassify tool in ArcMap. Potential impact scores were subsequently calculated by multiplying the reclassified sensitivity scores by the reclassified exposure scores using the Raster Calculator. The resulting raster was reclassified once again with the same tool and table for easier interpretation. Finally, the vulnerability index was derived by multiplying the reclassified potential impact scores by the reclassified adaptive capacity scores with the Raster Calculator. Likewise, vulnerability indices were reclassified using the same tool and table to facilitate interpretation.

Table 1. Reclassification matrices of vulnerability and its components

Component / Index	Raw Score Interval / Calculated Value (Jacinto *et al*., 2015)	Reclassified Value (RV)
Sensitivity*	[5, 12)	1
	[12, 19)	2
	[19, 25]	3
Exposure*	[3, 8)	1
	[8, 12)	2
	[12, 15]	3
Adaptive Capacity+	[7, 18)	3
	[18, 28)	2
	[28, 35]	1
Potential Impact*	1, 2	1
	3, 4	2
	6, 9	3
Vulnerability*	1, 2	1
	3, 4	2
	6, 9	3

**Legend (RV): 1 = Low, 2 = Moderate, 3 = High*
+Legend (RV): 3 = Low, 2 = Moderate, 1 = High

3. Results and Discussion

3.1 Sensitivity of Coastal Dwellers to Climate Change

Using GIS-generated maps (Figure 3), the indices for each vulnerability component can be visualized and compared. Figure 3a shows the comparative sensitivity scores among the six study sites. Based on the five sensitivity parameters considered, the coastal dwellers in the southern part of Illana Bay have low sensitivity values, ranging from 1.69 to 4.76. However, they are moderately sensitive to climate change based on the aggregate score (16.12) obtained. The majority, 82.14% of the respondents, had moderate sensitivity, while the remaining 13.78% and 4.08% had high and low sensitivity, respectively. Table 2 shows the average scores from the study sites for each sensitivity parameter.

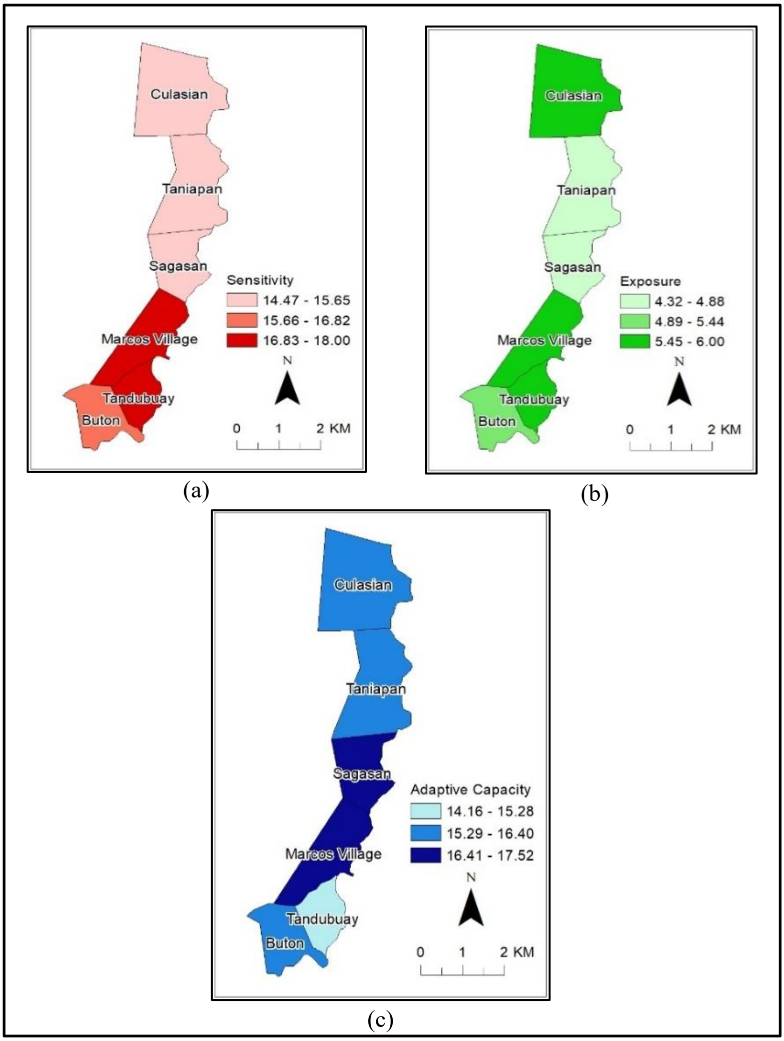

Figure 3. Sensitivity (a), exposure (b), and adaptive capacity scores (c) of the coastal residents

The major factors which contributed to this score were the high dependency on fishery resources since most (80%) of the coastal dwellers had a significant proportion (at least 60%) of their income coming from the fishery resources. Another factor that raised their sensitivity was the decreasing trend in fish catches of the fisherfolks. Around 43% of the coastal dwellers in the southern part of Illana Bay in Zamboanga del Sur have been experiencing a decrease in fish catch rates, in which small and immature fish are abundant, while 41%

have been catching a mixture of small and large fish. This observation is similar to that of Food and Agriculture Organization (FAO) (2018) that the tropics are the most affected by decreasing fish catches due to climate change, resulting to changes in the primary productivity of world fisheries (Sumaila *et al.*, 2011), environmental changes and destruction of habitats were considered as the drivers of fish catch declines (Silas *et al.*, 2020), causing mortality in a number of aquatic species (Mohanty *et al.*, 2010) and alters fish distribution causing decreasing catches in some regions (Mohammed and Uraguchi, 2013), especially in the tropics (FAO, 2018).

Table 2. Summary sensitivity scores by parameter

Sensitivity Parameter	Culasian	Taniapan	Sagasan	Marcos Village	Tandubuay	Buton	Average
Comparative rate of fish catch (20 years)	3.88	4.04	3.98	4.48	4.76	4.35	4.25
Average length of fish catches	3.55	2.42	2.37	4.48	4.76	3.40	3.50
Dependence on the fishery resources	3.82	4.19	4.38	4.76	4.40	4.73	4.38
Household age structure	2.25	2.13	2.27	2.16	2.22	2.17	2.20
Health conditions	1.79	1.69	1.93	1.69	1.86	1.80	1.79
Total Score	15.29	14.47	14.93	17.57	18.00	16.45	16.12

Legend:	*Point class interval*	*Interpretation*
	5 to below 12	*Low*
	12 to below 19	*Moderate*
	19 to 25	*High*

Household ages (55%) were within the range of 21-60 years old and have no special health needs, as chronic diseases are generally correlated with aging (World Health Organization [WHO], 2015), and older people are the most vulnerable to climate change (Filiberto *et al.*, 2008; US-EPA, 2016b). This is why age structure and health conditions were the two factors that prevented the coastal dwellers from being highly sensitive.

3.2 Exposure of Coastal Dwellers to Climatic Disturbances

Table 3 summarizes exposure indices from its three parameters, while Figure 3b shows the comparative exposure indices among the six study sites. Results show that almost all of the coastal dwellers (98.47%) had low exposure to climatic disturbances with an index of 5.32, while the remaining 1.53% had moderate exposure. One of the reasons for having such low exposure is that Mindanao, where the study sites are located, is rarely hit by tropical cyclones. Out of 406 typhoons that hit the Philippines from 1945 to 2013, only ten had made landfall on Mindanao (Takagi *et al*., 2015). For the past five years (2016 to 2020), only six tropical cyclones out of 100 have traversed Mindanao (DOST-PAGASA, 2020), giving an average of one cyclone per year that hits the island. The key informants added that they hardly remember any significant climatic events that hit their community. Their exposure indices are relatively similar (3–8), which means that the southern part of Illana Bay had low exposure to climatic disturbances.

Table 3. Summary exposure scores by parameter

Exposure Parameter	Culasian	Taniapan	Sagasan	Marcos Village	Tandubuay	Buton	Average
Weather disturbances in the fishing grounds	1.85	1.54	1.44	2.00	2.00	1.80	1.77
Weather disturbances in the household	1.85	1.54	1.44	2.00	2.00	1.80	1.77
Weather disturbances in the community	1.85	1.54	1.44	2.00	2.00	1.80	1.77
Total score	5.55	4.62	4.32	6.00	6.00	5.40	5.32

Legend:	*Point class interval*	*Interpretation*
	3 to below 8	*Low*
	8 to below 12	*Moderate*
	12 to 15	*High*

3.3 Adaptive Capacity of Coastal Dwellers to Climate Change

Table 4 shows the summary of adaptive capacity scores of the six study sites by parameter, while Figure 3c compares the relative adaptive capacity scores of the mentioned sites. Results show that 71.94% of the coastal dwellers had low adaptive capacities to the impacts of climate change, with an overall index of 16.08. In comparison, 26.53% had moderate adaptive capacity, and only 1.53% had high adaptive capacity. The two main factors that contributed to this low adaptive capacity were the low income from fishing (1.62) and the low literacy of the respondents (1.93). For every three coastal households in the area, two are considered poor (67%), and the remaining one (33%) is considered a low-income earner but not poor based on the indicative range of monthly family income (five members) in the Philippines for 2017 calculations (Albert *et al*., 2018). This is consistent with the studies of Salleh and Ghaffar (2008) and Frankhauser and McDermott (2013) that low-income earners, marginalized communities, and underdeveloped nations are severely affected by climate change, while Li et al. (2022) concluded that climate change makes the poor poorer. Only 5% of the coastal dwellers have at least started tertiary education, and only 25% have at least started secondary education, making them to have low adaptive capacity in terms of literacy. This result is supported by the studies of Wamsler *et al*. (2012), which show that low educational attainment is observed in areas with high risks of climate-related disasters.

The relatively higher scores in climate change awareness, access to information, and recent fishing gear modifications were insufficient to increase the adaptive capacity. On average, the coastal dwellers had access to information about climate change from two (2) or three (3) sources mainly from TV, radio, and information campaigns, thereby making 80% of them moderately aware (2.81) regarding the issue. This result is in agreement with the study of Iltus (2012) that literacy and access to information both contribute to higher climate change awareness, which in turn enhances adaptive capacity (Marshall *et al*., 2013), and the government assistance programs for small-scale fisherfolks has increased their adaptive capacity to changes (Nenadovic *et al*., 2016; Rosenberg, 2020). Though around 65% of the coastal dwellers were beneficiaries of the Pantawid Pamilyang Pilipino Program (4Ps), a form of subsidy from the Philippine government to poor Filipinos, their adaptive capacity is still low and insufficient. While Superales *et al*. (2016) stressed that coastal management plans, conservation strategies, and other associated awareness efforts can be implemented to increase coastal resiliency and make coastal resources sustainably conserved. Cinner *et al*. (2018) suggested that to build adaptive capacity, five (5) domains are essential to consider: the resources that people can utilize when the time of need arises; the ability to alter from one strategy to another; the capacity to establish groups and act cooperatively; the ability to identify and respond to change; and the judgment whether to change or not. Furthermore, the findings of Ferro-Azcona *et al*. (2019) indicated that more inclusive, comprehensive, and flexible approaches are currently needed for protected area management techniques. In addition to improving ecosystem services and their preservation, protected areas help coastal dwellers become more crucial and adaptable in response to climate changes.

Table 4. Summary of adaptive capacity scores by parameter

Adaptive Capacity Parameter	Culasian	Taniapan	Sagasan	Marcos Village	Tandubuay	Buton	Average
Annual income from fishing	2.18	1.81	1.62	1.24	1.60	1.27	1.62
Climate change awareness	2.94	2.62	2.90	2.72	2.86	2.83	2.81
Access to information	2.55	2.46	2.93	2.62	2.16	2.52	2.54
Adaptive strategy	2.06	2.54	2.12	2.28	2.03	2.24	2.21
Literacy	1.36	1.73	2.54	2.61	1.73	1.63	1.93
Gear modification (past 10 years)	2.88	2.31	2.61	2.79	2.62	2.68	2.65
Climate change support	2.09	2.62	2.80	2.93	1.16	2.28	2.31
Total score	16.06	16.09	17.52	17.19	14.16	15.45	16.08

Legend:

Point class interval	*Interpretation*
7 to below 18	*Low*
18 to below 28	*Moderate*
28 to 35	*High*

3.4 Potential Impact and Vulnerability Index

Based on the article review by Mukhopadhyay *et al*. (2012), vulnerability has become integral to understanding the relationship between man and the environment. Based on the algorithm developed for this study, the coastal dwellers in the six (6) study sites had moderate sensitivity (16.12), low exposure (5.32), and low adaptive capacity (16.08), thus resulting in a low potential impact index (1.00) and moderate vulnerability (2.00). The following findings have been analyzed and interpreted based on the proportions in the total number of samples. Generally, 26% of the respondents exhibited low vulnerability, 62% experienced moderate vulnerability, and 12% demonstrated high vulnerability to climate change.

4. Conclusions and Recommendation

The coastal dwellers of southern Illana Bay are moderately vulnerable to climate change due to their limited ability to adapt to climate changes despite lower levels of physical exposure. The leading causes of this vulnerability were economic and educational issues, including a strong dependence on limited fisheries resources, declining fish catches, low fishing income, and low literacy rates. These factors suggest a low socioeconomic status that may threaten the coastal dwellers' stability and well-being. Based on the FishVool assessment result, coastal dwellers in Culasian, Taniapan, Sagasan, Marcos Village, Tandubuay, and Buton are moderately vulnerable, as indicated by the maps showing the sensitivity, physical exposure to climate change, and adaptive capacity of the coastal dwellers. Some interventions can strengthen the adaptive capacity of coastal dwellers in southern Illana Bay, creating a more resilient socioeconomic foundation to withstand environmental and economic changes. Interventions should focus on improving literacy and climate education, promoting sustainable fishing practices and varying sources of income, such as aquaculture, and launching community literacy initiatives, which are examples of these actions. The resilience of coastal residents may be crucial to increasing proactive socioeconomic initiatives, policy advocacy, and partnerships with governmental and non-governmental organizations. This study area, precisely Illana Bay's geographic location and the availability of local data, can effectively support the validity of the model employed in this investigation and facilitate comparisons with other coastal areas in the region.

5. Acknowledgement

The authors extend their heartfelt appreciation to the Local Government Officials of San Pablo, Zamboanga del Sur, for allowing the research team to conduct this study and to J.H. Cerilles State College for providing technical assistance and guidance until the completion of this study.

6. References

Asian Development Bank. (2014). Republic of the Philippines National Urban Assessment. Retrieved from https://www.adb.org/sites/default/files/publication/42817/philippines-national-urban-assessment.pdf

Aguila, A.C.M., Calderon, G.J.A., Santos, S.B., & Santos, M.D. (2021). Fisheries Vulnerability Assessment Tool (FishVool) Instruction Manual. Department of Agriculture, National Fisheries Research and Development Institute (NFRDI): Quezon City, Philippines

Albert, J., Santos, A., & Vizmanos, J. (2018). Defining and profiling the middle class. Philippine Institute for Development Studies. Retrieved from https://pidswebs.pids.gov.ph/CDN/PUBLICATIONS/pidspn1818.pdf

Apdohan, A.G., Varela, R.P., & Balanay, R.M. (2021). Climate risk vulnerability assessment of the major crops in the province of Agusan del Norte, Philippines. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 46, 27-33. https://doi.org/10.5194/isprs-archives-XLVI-4-W6-2021-27-2021

Central Intelligence Agency. (n.d.). The World Factbook. Retrieved from https://www.cia.gov/the-world-factbook/field/coastline/

Cinner, J.E., Adger, W.N., Allison, E.H., Barnes, M.L., Brown, K., Cohen, P.J., Gelcich, S., Hicks, C.C., … & Morrison, T.H. (2018). Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change*, 8, 117–123. http://doi.org/10.1038/s41558-017-0065-x

Cochran, W. G. (1977). Sampling Techniques (3rd ed.). John Wiley & Sons. New York

De Chavez, P.D., Calderon, G.J.A., Santos, S.B., Vera Cruz, E.M., & Santos, M.D. (2021). Vulnerability to Climate Change of "Giant Squid" (*Thysanoteuthis rhombus*) Fishery in Marinduque, Philippines. *The Philippine Journal of Fisheries*, 28(2), 171-180. http://dx.doi.org/10.31398/tpjf/28.2.2021-0002

Dela Torre, D.M.G., Dela Cruz, P.K.A., Jose, R.P., Gatdula, N.B., & Blanco, A.C. (2019). Geospatial assessment of vulnerabilities of croplands to flooding risks: A case study of Philippine river basins. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-4/W19*, 173–180. https://doi.org/10.5194/isprs-archives-XLII-4-W19-173-2019

Department of Science and Technology (DOST) – Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). (2020). Annual Tropical Cyclone Tracks. Retrieved from http://bagong.pagasa.dost.gov.ph/information/annual-cyclone-track

Eckstein, D., Kunzel, V., & Schafer, L. (2021). Global Climate Risk Index 2021. Retrieved from https://www.germanwatch.org/en/19777

Eluriaga, L.M.T., Garcia, Y.T., Sajise, A.J.U., & Catelo, M.A.O. (2019). Assessment of Sensitivity and Adaptive Capacity to Fisheries Decline: The Case of Small-scale Fisheries in Guimaras. *Philippine Journal of Social Sciences and Humanities*, 20-34.

Environmental Systems Research Institute (ESRI). (2021). What is ArcMap? Retrieved from https://desktop.arcgis.com/en/arcmap/latest/map/main/what-is-arcmap-.htm

Food and Agriculture Organization [FAO]. (2018). Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries and Aquaculture Technical Paper. (Eds.) Rome, Italy: Food and Agriculture Organization of the United Nations.

Ferro-Azcona, H., Espinoza-Tenorio, A., Calderón-Contreras, R., Ramenzoni, V.C., Gómez-País, M.M., & Mesa-Jurado, M.A. (2019). Adaptive capacity and social-ecological resilience of coastal areas: A systematic review. *Ocean & Coastal Management,* 173, 36–51. https://doi.org/10.1016/j.ocecoaman.2019.01.005

Filiberto, D., Pillemer, K., Wethington, E., & Wells, N. (2008). Older People and Climate Change: Vulnerability and Health Effects. *Generations (San Francisco, Calif.)*, 19-25.

Frankhauser, S., & McDermott, T.K. (2013). Understanding the adaptation deficit: why are poor countries more vulnerable to climate events than rich countries? London: Grantham Research Institute on Climate Change and the Environment.

Hanna, R., & Oliva, P. (2016). Implications of climate change for children in developing countries. *The Future of Children*, 115-132.

He, Q., & Silliman, B.R. (2019). Climate change, human impacts, and coastal ecosystems in the Anthropocene. *Current Biology*, 29(19), R1021-R1035.

Hewitt, J.E., Ellis, J.I., & Thrush, S.F. (2016). Multiple stressors, nonlinear effects and the implications of climate change impacts on marine coastal ecosystems. *Global change biology*, 22(8), 2665-2675.

Jalang'o, A.D., Kinyua, I., Templer, N., Wanyonyi, T., & Mwongera, C. (2022). Building the capacity of local partners and government staff on climate smart agriculture technologies and climate change programming: Training workshop report (45 pp.). https://hdl.handle.net/10568/127208

Iltus, S. (2012). Climate Change and Environmental Education. (Eds.) UNICEF. Retrieved from https://www.uncclearn.org/wp-content/uploads/library/unicef31.pdf

Intergovernmental Panel on Climate Change (IPCC). (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. (Eds.). Cambridge, UK: Cambridge University Press.

Jacinto, M., Songcuan, A., & Von Yip, G. (2015). Development and application of the fisheries vulnerability assessment tool (FishVool) to tuna and sardine sectors in the Philippines. *Fisheries Research*, 174-181.

Jocson, M.D., & Magallon Jr, S.V. (2018). Coastal vulnerability assessment: The case of Davao del Norte, Philippines. *Mindanao Journal of Science and Technology*, 16(1).

Jose, R.P., Gatdula, N.B., & Blanco, A.C. (2019). Geospatial assessment of vulnerabilities of croplands to flooding risks: A case study of Philippine river basins.

Li, Q., Sun, P., Li, B., & Mohiuddin, M. (2022). Impact of Climate Change on Rural Poverty Vulnerability from an Income Source Perspective: A Study Based on CHIPS2013 and County-Level Temperature Data in China. *International Journal of Environmental Research and Public Health*, 19(6), 3328.

Macusi, E.D., Albarido, N.A., Clapano, M.B., & Santos, M.D. (2022). Vulnerability Assessment of Pacific Whiteleg Shrimp (Penaeus vannamei) Farms and Vendors in Davao, Philippines Using FishVool. *Sustainability*, 14(8), 4541.

Marshall, N.A., Park, S., Howden, S.M., Dowd, A.B., & Jakku, E.S. (2013). Climate change awareness is associated with enhanced adaptive capacity. *Agricultural Systems*, 30-34.

Mastrorillo, M., Licker, R., Bohra-Mishra, P., Fagiolo, G., Estes, L.D., Oppenheimer, M., & Bala, G. (2016). The influence of climate variability on internal migration flows in South Africa. *Global Environmental Change,* 39, 155-169.

MERF. 2013. Vulnerability Assessment Tools for Coastal Ecosystems: A Guidebook. Marine Environment and Resources Foundation, Inc.: Quezon City, Philippines, pp 162.

Mohammed, E., & Uraguchi, Z. (2013). Impacts of Climate Change on Fisheries: Implications for Food Security in Sub-Saharan Africa. In M. Hanjra (Ed.), Global Food Security (pp. 113-135). Nova Science Publishers, Inc.

Mohanty, B., Mohanty, S., Sahoo, J., & Sharma, A. (2010). Climate Change: Impacts on Fisheries and Aquaculture. In S. Simard (Ed.), Climate Change and Variability (pp. 119-138). Croatia: InTech Open.

Mukhopadhyay, A., Dasgupta, R., Hazra, S., & Mitra, D. (2012). Coastal hazards and vulnerability: a review. International journal of geology, earth and environmental sciences, 2(1), 57-69.

Nenadovic, M., Basurto, X., & Weaver, A. (2016). Contribution of Subsidies and Participatory Governance to Fishers' Adaptive Capacity. *The Journal of Environment and Development*, 426-454.

Pecl, G.T., Araújo, M.B., Bell, J.D., Blanchard, J., Bonebrake, T.C., Chen, I.C., ... & Williams, S.E. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. Science, 355(6332), eaai9214.

Rosenberg, J. (2020). Adaptation, Official Development Assistance, and Institution Building: The Case of the Caribbean Community Climate Change Centre. Sustainability, 12(4269).

Salleh, K., & Ghaffar, F. (2008). Vulnerability and Adaptive Capacities of Low Income Economic Systems to the Climate Change Threat. Climate Change: Impacts, Adaptation, and Policy in South East Asia with a Focus on Economics, Socio-Economics and Institutional Aspects. Bali, Indonesia: EEPSEA Climate Change Conference.

Santos, M.D., Dickson, J.O., Velasco, P.E.L. (2011). Mitigating the impacts of climate change: Philippine fisheries in focus. *Fish People*, 9 (2), 103–112.

Silas, M.O., Mgeleka, S.S., Polte, P., Sköld, M., Lindborg, R., de la Torre-Castro, M., & Gullström, M. (2020). Adaptive capacity and coping strategies of small-scale coastal fisheries to declining fish catches: Insights from Tanzanian communities. Environmental Science & Policy, 108, 67-76.

Sumaila, U.R., Cheung, W.W., Lam, V.W., Pauly, D., & Herrick, S. (2011). Climate change impacts on the biophysics and economics of world fisheries. *Nature climate change*, 1(9), 449-456.

Superales, J., Cabasan, J., Bayno, M., & Bacay, A. (2016). Assessment of Economically Important Invertebrate Fauna Present in the Coastal Areas of San Pablo, Zamboanga del Sur, Philippines. *Journal of Biodiversity and Environmental Sciences (JBES)*, 73-79.

Takagi, H., De Leon, M., Esteban, M., Mikami, T., & Nakamura, R. (2015). Storm surge due to 2013 Typhoon Yolanda (Haiyan) in Leyte Gulf, the Philippines. In M. Esteban, H. Takagi, & T. Shibayama (Eds.), *Handbook of coastal disaster mitigation for engineers and planners* (pp. 133-144). Elseveir.

Tattao, J.T., Angeles, I.P., & Ame, E.C. (2023). Climate Change Vulnerability Assessment of the Eel Fishery in Aparri, Cagayan, Philippines.

Urry, J. (2015). Climate change and society. In Why the social sciences matter (pp. 45-59). London: Palgrave Macmillan UK.

US-EPA (United States Environmental Protection Agency). (2016a). Climate Change and the Health of Older Adults. Retrieved from https://www.cmu.edu/steinbrenner/EPA%20Factsheets/older-adults-health-climate-change.pdf

US-EPA (United States Environmental Protection Agency). (2016b). Climate Change and the Health of People with Existing Medical Conditions. Retrieved from https://www.cmu.edu/steinbrenner/EPA%20Factsheets/existing-conditions-health-climate-change.pdf

Wamsler, C., Brink, E., & Rantala, O. (2012). Climate Change, Adaptation, and Formal Education: the Role of Schooling for Increasing Societies' Adaptive Capacities in El Salvador and Brazil. *Ecology and Society,* 17(2). http://dx.doi.org/10.5751/ES-04645-170202

World Bank. (2023). *Disaster Risk Management in the Philippines*. World Bank Open Knowledge Repository. https://openknowledge.worldbank.org/server/api/core/bitstreams/a4a1c553-8974-4ae5-b4c9-2150d78a703f/content

World Health Organization. (2015). World Report on Ageing and Health. Retrieved from https://iris.who.int/bitstream/handle/10665/186463/9789240694811_eng.pdf?sequence=1