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Examining the magnitude of natural disasters in the Philippines and the country's level of readiness and vulnerability to climate change stressors

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Abstract: *The Philippines is one of the most vulnerable and susceptible country to the negative consequences of climate change and natural disasters. Located at one of the areas along the Pacific Ocean's Ring of Fire, the Philippines had endured thousands of deadly types of disaster that killed more than thousands of lives and accumulated significant economic damages throughout the history. With the presence of climate change, the Philippines is expected to experience frequent and more common natural catastrophic events that will ultimately test the government's efforts in disaster risk and management as well as the resilience of the population at risk This article aims to examine the relationship of two climate change-related variables, i.e. (1) country's level of vulnerability and (2) readiness to combat climate change stressors, and identify their explanatory capacity on the severity of natural disasters, i.e. natural disaster-related deaths, in the Philippines. Using the data set over the period of 1995 to 2016, the study estimated the influence of two independent variables on the magnitude of natural disasters in the country through correlational and regression analyses. The research findings suggest that both country's measure of vulnerability to climate change and its readiness to establish important mechanisms to combat climatic stressors do not statistically influence the magnitude of natural disasters in the Philippines. However, the overall research provides emphasis on examining other socioeconomic and political factors influencing the severity of natural disasters and their interlinkages and complex relationships. In addition, the study contributes to the previous reports about how the impact of natural disasters can potentially outweigh those established and on-going disaster risk and management efforts. Such misfortune, however, should not undermine the importance of climate change adaptation and mitigation strategies. Future scholars may examine other important indicators that shape the country's vulnerability and capacity to endure natural catastrophic events.*

Keywords - The Philippines, natural disaster, typhoon, adaptation, climate change,
Research Area: Social Science
Paper Type: Research Paper

1. INTRODUCTION

Some notable natural disaster-related literature suggest that the negative consequences of natural disasters have much to do with the way the country adapt and prepare for such catastrophic event, as well as the condition of population at risk. In their study, Neumayer and Plümper (2007) stressed that people are not equally impacted by the negative consequences of natural disasters. Particularly, women become the frequent casualties of natural disasters than their male counterpart in a country where women's socioeconomic status is lower (Neumayer & Plümper, 2007). In a different study, Kahn (2005) argued that geography and institutions play a significant role in lowering the natural disaster deaths. He argued that less democratic countries characterized by the presence of inequalities produce a high number of natural disaster-related casualties than those countries with stronger institutions (Kahn, 2005).

In 2010 UNDP report, natural disasters have disproportionately impacted most developing countries worldwide. The severity and risks from natural disasters present in most developing countries are associated with poverty and slow economic growth (United Nations Development Programme, 2010). With the presence of climate change, natural catastrophic events are expected to be more evident in countries that are highly exposed and inadequately ready from the threats of natural disasters (Intergovernmental Panel on Climate Change, 2014). This caught the attention of the international community in supporting and financing most developing countries that are vulnerable and highly exposed to natural disasters.

The Philippines had endured numerous natural disaster types every year. In fact, the country experiences an average of 20 tropical cyclones each year (cited in Yumul, Cruz, Servando, & Dimalanta, 2010). Among the inexhaustible disaster events include typhoons, volcanic eruptions, landslides, earthquakes, etc. These catastrophic occurrences are due to the country's geographical location along the so-called *Ring of Fire*, or typhoon belt – a large area in the Pacific region where most of the Earth's volcanic activities and earthquakes take place. This attribution made the country at the forefront of climate change vulnerability and exposure to natural disasters. For instance, in a 2016 World Risk Index, the Philippines ranked as the third highest disaster risk among the 171 surveyed countries by the research institute (Bündnis Entwicklung Hilft, 2016). The country scored third highest exposure (52.46%) and fourth highest risk (27.69%) worldwide. According to the same report, the Philippines has qualified to a category that requires "an urgent need for action" in improving the country's transport infrastructure, electricity supply, and "logistics friendliness" (Bündnis Entwicklung Hilft, 2016). In a different report provided by the University of Notre Dame's Notre Dame Global Adaptation Initiative (ND-GAIN) in 2017, the Philippines ranked 113 in overall 'readiness' and 'vulnerability' index, with a score of 42.9, among the 191 surveyed countries. The index measures the "country's exposure, sensitivity and capacity to adapt to the negative effects of climate change" and "ability to leverage investments and convert them to adaptation actions" (Notre Dame Global Adaptation Initiative, 2017).

Furthermore, adverse impacts of the natural disaster are widely experienced in the Philippines. These adverse consequences of natural disasters have negatively affected the government efforts in stabilizing the socioeconomic growth in the country (Global Assessment Report, 2013; Hillier & Nightingale, 2013; Yumul, Cruz, Servando, & Dimalanta, 2010). Particularly, in some regions prone to natural disasters, key infrastructures for development are frequently affected and other efforts in alleviating poverty were negatively impacted.

In an attempt to further understand the linkages between the Philippine's exposure to climate change and its readiness to combat climate change-related stressors on the severity of natural disaster, this article seeks to answer the following questions:

- As the Philippines' level of vulnerability increases, does the magnitude of a natural disaster also increases?

- As the Philippines' level of readiness increases, does the magnitude of a natural disaster decreases?

- Can the measures for vulnerability and readiness predict the magnitude of natural disasters in the Philippines?

This study aims to quantify the influences of Philippine's exposure to climate hazards and its capacity to adapt and mitigate the adverse impacts of climate change on the severity of natural disasters. It focuses on the empirical findings and limits the scope to the acquired data set of the study's important variables, i.e. magnitude of natural disaster (i.e. natural disaster-related deaths over the population per capita) and the Philippines' measures of vulnerability and readiness to combat climate change stressors.

2. THE IMPACTS AND THE COST OF NATURAL DISASTER IN THE PHILIPPINES

Several natural catstrophes have caused the Philippines significant human losses and economic damages throughout the history. According to the EM-DAT database, the Philippines experienced a total of 332 natural disasters that killed more than twenty-six thousand people from year 1995 to 2016. See table 1 for complete list of disaster types and number of casualties.

Table 1. Natural disasters in the Philippines (1995-2016)

Disaster type	Number of occurrence	Total deaths
Drought	4	8
Earthquake	13	384
Epidemic	12	1,100
Flood	104	1,818
Insect infestation	1	0
Landslide	19	1,978
Mass movement (dry)	1	11
Storm	166	21,172
Volcanic activity	11	0
Wildfire	1	2
Total	332	26,473

Tropical cyclones or typhoon is one of the most common type of meteorological disasters frequently enter the Philippine Area of Responsibility (PAR). In 2013, a large scale typhoon (internationally named Haiyan) devastated the Philippines claiming more than six thousand lives, displaced over four million people and amassed an estimated 12 billion USD worth of damages (Asian Development Bank, 2013). This super-typhoon had significantly impacted the country and exposed the country's high level of vulnerability and readiness to such extreme weather condition.

Studies and reports suggest typhoons are likely to become more frequent and flooding more intense and common as climate change continues to exacerbate extreme weather patterns (Intergovernmental Panel on Climate Change, 2014; cited Carrington, 2016). In particular, those countries who are highly exposed and are not appropriately equipped to mitigate the adverse effects of natural hazards are put at high risk (Global Assessment Report, 2013). In Philippines, a natural disaster type like typhoon has occurred more frequently and deadly throughout the history. Figure 2 and 3 show the increasing number of typhoon occurrences and deaths since 1905 (Guha-Sapir, Below, & Hoyois, 2016).

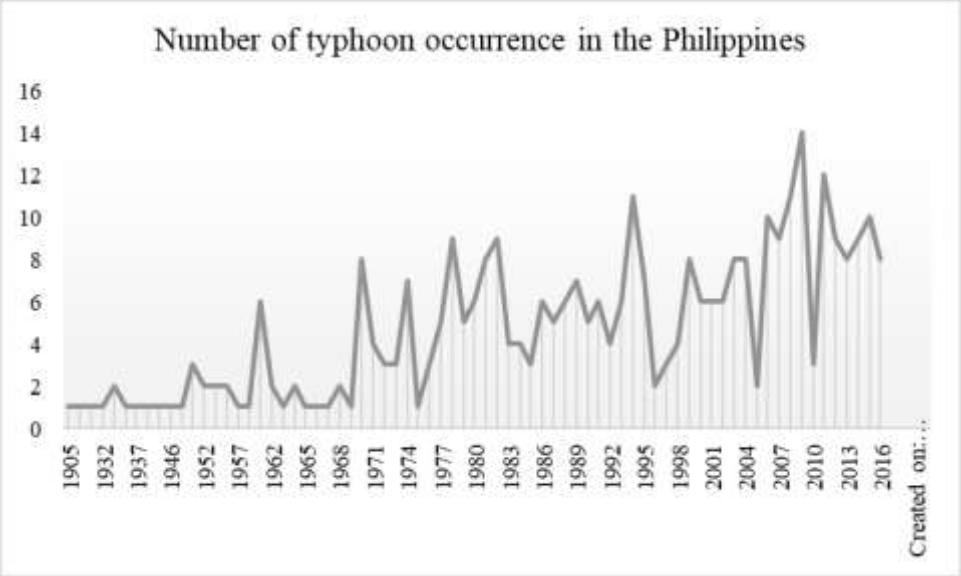

Figure 1 Number of typhoon occurrences in the Philippines (1905-2016)

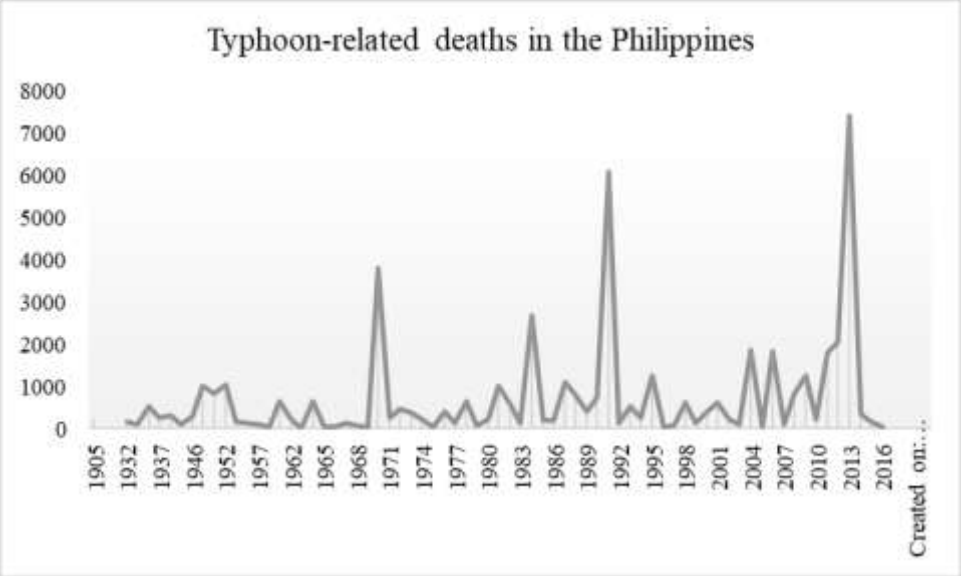

Figure 2 Number of typhoon deaths (1905-2016)

There are burgeoning natural disaster-related literature and scholars that acknowledge the importance of understanding the socioeconomic and political characteristics of a country at risk as a way to estimate the adverse impacts of natural disaster (Escaleras, Anbarci, &

Register, 2007; Strömberg, 2007; Neumayer & Plümper, 2007; Kahn, 2005). That is to say, that the outcomes of natural disasters may be determined by the socioeconomic and political features present in a country. Such features, include human conditions, historical, cultural, socioeconomic, and political structures of the exposed country or population.

There are identified factors that contribute to the risk of the Philippine population and continuous increase of natural hazards vulnerability in face of the adverse impacts of natural disasters. In his Washington Post article in 2013, Brad Plumer enumerated the reasons why the Philippines often experience a severe and deadly outcome from a natural calamity. Among the reasons he mentioned are the country's vulnerability to climate change, different natural calamities that the country experience annually, poor adaptation strategies, and international funding and support (Plumer, 2013).

According to some experts and reports, the interplay between poverty and vulnerability to natural hazards are clearly evident in the Philippines. For instance\, poor housing conditions that are constructed out of light materials and weak infrastructure caused by rapid urbanization growth have contributed to the risk of natural hazards in the country (Fisher, 2013). Particularly, these poor communities – both in urban and rual areas, living in a poor housing conditions disproportionately suffer from frequent flooding when typhoon and storm surge occur. This simply illustrates how socioeconomic and political conditions can potentially shape the country's vulnerability to natural hazard.

These continous phenomenon prompted the country to establish better adaptation and mitigation mechanisms. In 2010, the Philippines' National Disaster Risk Reduction and Management Council (NDRRMC) passed a National Disaster Risk Reduction and Management plan that provides a legal framework for policies, plan and programs that deals with disasters (National Disaster Risk Reduction and Management Council, 2010). The same plan serves a national guide for the country's efforts in shifting from a reactive to proactive disaster risk management mechanisms while promoting disaster awareness, advancing people's resilience and decreasing natural disaster-related vulnerabilities.

3. RESEARCH HYPOTHESES

Drawing from previous literature and other natural disaster-related reports tackling the Philippines' exposure and vulnerability, this article established three hypotheses for testing and analyses.

Number of natural disaster-related casualties could be higher in a country that is more vulnerable to the adverse effects of climate change. That is to say, that the country that is more exposed, sensitive and has less capacity to adapt to the negative consequences of climate change will most likely experience a higher magnitude of natural disaster.

> ***Hypothesis 1:*** *There is a positive relationship between magnitude of natural disasters and the country's level vulnerability to climate change impacts*

Similar with the first hypothesis, number of deaths from natural disasters could be lower in a country that has more ability to mitigate the adverse impacts of climate change stressors.

In particular, a country that is economically, politically and socially ready in advancing climate adaptation actions will less likely to experience the wrath of natural disaster.

> ***Hypothesis 2:*** *There is a negative relationship between magnitude of natural disasters and the country's level vulnerability to climate change impacts*

Taking both hypotheses, the study expects that both measures for vulnerability and readiness can significantly predict the magnitude of natural disaster in the Philippines.

> ***Hypothesis 3:*** *Both measures for vulnerability and readiness have a predictive capacity on the magnitude of natural disasters in the Philippines*

4. RESEARCH METHODOLOGY

As mentioned in previous section, this article examines the relationship of two important variables, i.e. measures for the Philippines 'vulnerability' and 'readiness', vis-à-vis the magnitude of natural disasters in the Philippines. The succeeding section provides the operationalization of the study's important variables.

Using the data set of annual deaths from natural disasters and the Philippines' measured variables of climate change 'vulnerability' and 'readiness' from 1995 to 2016, this article tests the three established hypotheses. First, there is a positive relationship between the magnitude of natural disaster and the country's level of 'vulnerability' to climate change stressors. Second, there is a negative relationship between the country's level of 'readiness' to adapt and mitigate climate change stressors and the magnitude of natural disaster. And lastly, both country's level of 'vulnerability' and 'readiness' to combat climate change stressors have an explanatory power over the magnitude of natural disaster in the Philippines.

In testing the abovementioned hypotheses, the researcher employed correlational and regression analyses.

5. DATA

This section provides the definition and operationalization of the study's important variables. Measures for magnitude of natural disasters and the Philippine's measure of climate change vulnerability and readiness are collected from two major data bank, i.e. Centre for Research on the Epidemiology of Disasters' (CRED) Emergency Event Database (EM-DAT) and University of Notre Dame's Environmental Change Initiative's Notre Dame Global Adaptation Index (ND-GAIN). For the purpose of this study, the researcher limits the period to 1995 until 2016 (17 years).

5.1.MAGNITUDE OF NATURAL DISASTER

The cross-national disaster data are taken from Centre for Research on the Epidemiology of Disasters' (CRED) Emergency Events Database (EM-DAT) collected and made publicly available by the Université Catholique de Louvain's School of Public Health. EM-DAT contains important core data on the occurrence and effects of more than 22,000 mass disaster,

i.e. technological and natural disasters, in the world from 1900 until the present year. The comprehensive database consolidates raw data from various sources, including UN agencies, various international non-governmental organizations, insurance companies, research institutes and press agencies (Guha-Sapir, Below, & Hoyois, 2016).

To qualify as a natural disaster in EM-DAT data recording, at least an event must meet one of the following conditions set by CRED. These include: (1) ten or more people were reported killed; (2) one hundred or more people are reported affected, injured and/or homeless; (3) a country must declare a state of emergency and/or a call for international assistance and support must be made (Guha-Sapir, Below, & Hoyois, 2016).

For the purpose of this study, the researcher established important parameters in measuring the magnitude of the natural disaster. First, all types of natural disasters that took place during the years 1995 to 2016 will be accounted. List of disastrous events is restricted to nature-induced disaster types, hence excluding technological and other human-triggered disasters. The measure of natural disasters includes drought, earthquakes, epidemic, flood, insect infestation, landslide, mass movement (dry), storm, volcanic activity, and wildfire.

Further, the number of people killed is necessary in measuring the degree of magnitude of a certain catastrophic event. Consequently, the number of deaths are less arbitrary to measure the negative effect of a disaster on the population instead of using the number of affected people as a proxy for the disaster magnitude (Neumayer & Plümper, 2007).

To account for the overall measure of disaster magnitude, the researcher normalized the size of a catastrophic event by dividing the number of people killed by the total population of the country. In addition, magnitude of natural disaster is measured through dividing the number of natural disaster deaths by the country's population per capita and multiplied by 100,000 to get the final trasnformed value of the variable. The dataset for population per capita are gathered from the World Bank's database (World Bank, 2016).

5.2.THE PHILIPPINES' LEVEL OF 'VULNERABILITY' AND 'READINESS'

To account for the Philippine's level of vulnerability, the researcher used the vulnerability index from University of Notre Dame's Environmental Change Initiative's Notre Dame Global Adaptation Index (ND-GAIN). This particular measure account for the country's "exposure, sensitivity and capacity to adapt to the negative effects of climate change". Likewise, to measure the Philippines' level of readiness, the researcher used the readiness index from the same data bank. This particular measures account for the country's ability "to leverage investments and convert them to three components, i.e. economic readiness, governance readiness and social readiness".

The ND-GAIN's vulnerability index produces the computed values from 0 to 1, where a value closer to zero (0) represents a country that is less vulnerable and a value closer to one (1) determines a high readiness condition to combat the adverse impacts of climate change.

The ND-GAIN country index employs a data-driven approach to illustrate which countries are well equipped and prepared to deal with global changes brought about by overcrowding, resource constraints, and climate disruptions. In addition, ND-GAIN

integrates six 'life-supporting sectors', i.e. food, water, health, ecosystem service, human habitat, and infrastructure in measuring a country's overall vulnerability (Notre Dame Global Adaptation Initiative, 2016).

6. DATA ANALYSIS

Correlation analysis was used in describing the strength and direction of the linear relationship between two variables, i.e. (1) magnitude of natural disaster and; (2) the country's measure of 'vulnerability' (see Table 2). A pearson correlation value of r = - 0.283 suggests a statistically insignificant relationship between the dependent variables, i.e. magnitude of the natural disaster and country's level of vulnerability to climate change impacts (Sig. = 0.202).

Table 2 Correlations of Two Variables (i.e. Magnitude and Vulnerability)

		magnitude	vulnerability
magnitude	Pearson Correlation	1	-.283
	Sig. (2-tailed)		.202
	N	22	22
vulnerability	Pearson Correlation	-.283	1
	Sig. (2-tailed)	.202	
	N	22	22

That is why the *first alternative hypothesis* is accepted. To simply put, there is no statistically significant and positive relationship between the magnitude of the natural disaster and the country's level of vulnerability to climate change impacts for the population of Philippines.

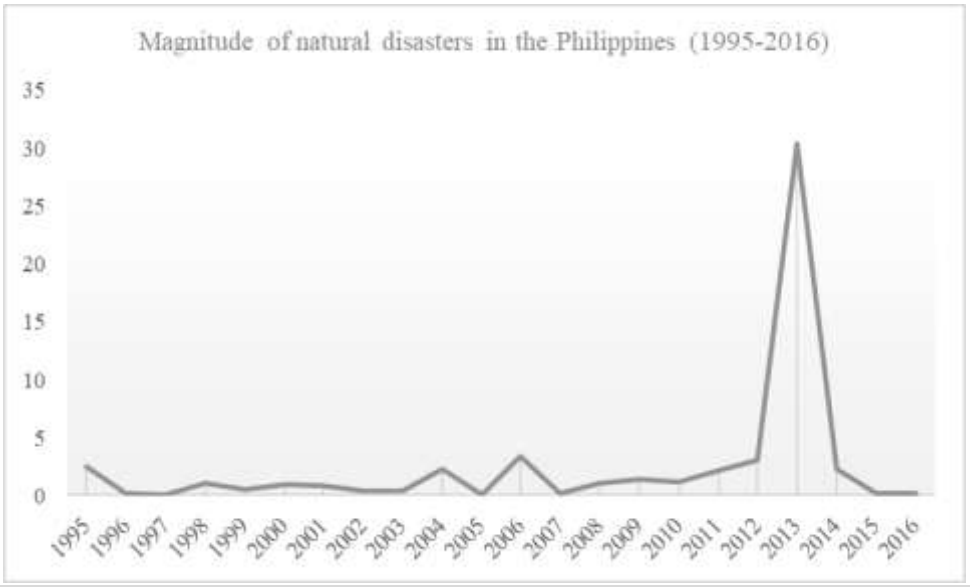

Figure 4 Magnitude of natural disaster in the Philippines (1995-2016)

As mentioned in previous section, magnitude of natural disaster is measured through dividing the number of natural disaster deaths by the country's population per capita and multiplied by 100,000 to get the trasnformed value of the variable.

Figure 4 shows the most deadly natural disaster events happened in 2004 and 2006, while the worst natural catastrophic event took place in 2013.

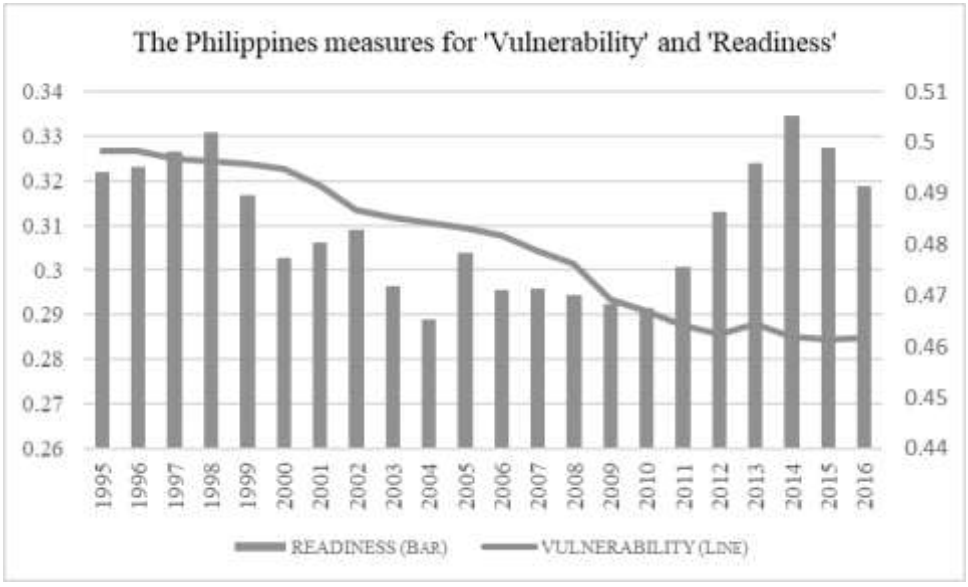

Figure 5 The Philippines' level of 'vulnerability' and 'readiness' to adapt and mitigate the negative impacts of climate change (1995-2016)

Figure 5 illustrates a positive reduction of the country's vulnerability to climate change impacts ('vulnerability') and the up-and-down trend of the country's socioeconomic and political readiness to climate change impacts ('readiness').

Likewise, correlation analysis was used to test the second hypothesis (see Table 3). A pearson correlation value of r = 0.189 suggests a statistically insignificant relationship between the dependent variables, i.e. magnitude of natural disaster and country's level of readiness to adapt and mitigate the impacts of climate change (Sig. = 399).

Table 3 Correlations of Two Variables (i.e. Magnitude and Readiness)

		magnitude	readiness
magnitude	Pearson Correlation	1	.189
	Sig. (2-tailed)		.399
	N	22	22
readiness	Pearson Correlation	.189	1
	Sig. (2-tailed)	.399	
	N	22	22

Simply put, the study *accepts the second alternative hypothesis*. In particular, there is no statistically significant and negative relationship between the dependent variables, i.e. magnitude of natural disaster and country's level of readiness to adapt and mitigate the impacts of climate change for the population of Philippines.

To test the final hypothesis, regression analysis was employed. This estimation method investigates the relationship between a continuing dependent variable (i.e. magnitude of natural disaster) and multiple independent variables or predictors (i.e. country's measures for 'vulnerability' and 'readiness'). Results in table 4 model summary indicate that R-square (r × r) is equal to 0.124. In percentage terms, this means that our model explains only 12.4 percent of the variance of dependent variable 'magnitude'.

Table 4 Model summary

Model	R	R-Square	Adjusted R Square	Std. Error of the Estimate
1	.352[a]	.124	.032	6.20817

a. Predictors: (Constant), Vulnerability, Readiness

b. Dependent variable: Magnitude

Table 5 ANOVA estimated the statistical significance of R-Square that summed up the results of tests of the null hypothesis. Overall result shows the population r^2 is zero value. The model, in this case, is not reaching statistical significance (Sig. = .284).

Table 5 ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	103.608	2	51.804	1.344	.284[b]
	Residual	732.286	19	38.541		
	Total	835.894	21			

a. Dependent Variable: magnitude

b. Predictors: (Constant), vulnerability, readiness

Results of testing multicollinearity are given in Table 6 Coefficients. Tolerance values must be above 0.10 and VIF values below 10, as in this case, that would not be violated the assumption of no multicollinearity. Independent variables 'vulnerability' (Beta coefficient = -.297) and 'readiness' (Beta coefficient = .210) do not contribute a statistically significant explanation of the dependent variable 'magnitude'.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	39.075	53.627		.729	.475	-73.168	151.319					
	readiness	91.653	94.107	.210	.974	.342	-105.316	288.622	.189	.218	.209	.995	1.005
	vulnerability	-135.372	97.946	-.297	-1.382	.183	-340.376	69.633	-.283	-.302	-.297	.995	1.005

Dependent Variable: magnitude

Table 6 Coefficients

Taken together, this result suggests to *accept the third alternative hypothesis*. In particular, there is no statistically significant and empirical evidence to support that the Philippine's level of vulnerability and readiness to adapt and mitigate the climate change stressors can explain the severity of natural disasters.

7. CONCLUSION

This study tests whether the measures for 'vulnerability' and 'readiness' to combat against climate change stressors can contribute to the explanatory power to foresee the magnitude of natural disasters in the Philippines. The overall findings showed that both country's level of vulnerability to climate change and the country's socioeconomic and political readiness to combat climatic stressors do not statistically influence the severity of natural disasters in the Philippines. Simply put, low exposure to natural hazards and high level of preparedness against the threat of climate change do not assure a lesser adverse impacts of natural disasters in the country.

Despite this article's low confidence in attributing the measures for 'vulnerability' and 'readiness' on the negative consequences of natural disasters in the country, the Philippines should not downplay the importance of understanding the level of vulnerability and its sensitivity to climate change impacts. The country's institutional efforts and capacity to establish adequate climate change-ready infrastructure should continue to progress, particularly in safeguarding the population at risk as well as addressing the most vulnerable groups and regions susceptible to natural catastrophic events.

Further, the results presented provide a support to the argument that lowering the impacts and saving more lives require a deeper understanding of the different root causes, associated pressures, and conditions that cause such disasters (López-Marrero & Wisner, 2012). In the case of the Philippines, the effectiveness of dealing natural hazards and disasters will depend on the availability and access to various natural, physical, economic, human, social, and political resources. Another explanation that can be generated from this study is the misfortune of countries, like in the case the Philippines, some major natural disasters can outweight the government's mitigation and adapation efforts and startegies.

Lastly, it is worth noting that this study heavily relies on the data set and unit of measures generated from the Notre Dame Global Adaptation Initiative (ND-GAIN) and the Centre for Research on the Epidemiology of Disasters' (CRED) EM-DAT. Future scholars and researchers may look at the other important indicators that shape the country's vulnerability and capacity to endure natural catastrophic events as well as other data set available in measuring other socioeconomic and political features that significantly contribute to the deadly impacts of natural disasters.

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