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Multiple Linear Regression Analysis Applied for Modeling in Torrens Community Disaster Resilience Score Card for Flood-Prone Schools in the Schools Division of Misamis Oriental, Northern Mindanao – the Philippines

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Abstract

Accurate assessment of the level and extent of disaster resilience of flood-prone schools and their communities is a complicated task. This is given the various means to measure disaster resilience. This is further complicated by the fact that disaster resilience is context-specific. Therefore, applying one of these measures for disaster resilience modeling proves to be a practical approach, as this model has the advantage of having context-specific viability in predicting disaster resilience. One of the statistical methods that can be used for testing a model in disaster resilience is Multiple Linear Regression (MLR). Therefore, this work aims to test a model for disaster resilience. For this, 26 schools in the Schools Division of Misamis Oriental were identified as flood-prone areas based on the geo-hazard maps of the Department of Environment and Natural Resources. With the use of the Torrens Community Disaster Resilience Score Card, the schools and their communities were rated by their respective School Administrator/Principal; School Disaster Risk Reduction Management Coordinator; Municipal Disaster Risk Reduction Management Officer; President of the General Parents-Teachers Association; President of the Student School Government; and the Barangay Chairperson. The ratings served as the data. Multiple Linear Regression was applied to generate a new model with four explanatory variables, i.e. community-connectedness, risk and vulnerability, planning and procedures, and available resources; and the response variable is Disaster Resilience. The MLR model obtained an Adjusted R Square of 0.965, which means that the four explanatory variables explained 96.5% of the variability of Disaster Resilience. The Goodness of Fit of the model had shown a right-tailed, F=175.9, p-value=7.77156e-16, thus, rejecting the null hypothesis that the model is not a good fit. All four variables are significant predictors of Disaster Resilience, hence, attesting to the adequacy of the model. Thus indicative that in the context of these flood-prone school and their communities, the model justifies that the application of the said scorecard is of great importance to these schools and their communities as well as those people responsible for disaster risk and reduction management regular monitoring and assessment for disaster resilience.

Keywords: Multiple linear regression analysis, Disaster Resilience Modelling, Torrens Community Disaster Resilience Score Card, Flood-Prone Schools, Schools Division of Misamis Oriental, Northern Mindanao-Philippines.

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I. INTRODUCTION

Measuring the disaster resilience of a locality is central to disaster risks reduction and management. Being able to have a tool that measures the disaster resilience of a community, such as questionnaires or scorecards, is crucial to the designing of a proactive intervention to mitigate the negative effect of disaster. Presently, several agencies have developed guides for measuring disaster resilience (Oddsdóttir, Lucas and Combaz 2013). Nevertheless, this has yet to be converted into a context-specific tool, which might be in the form of questionnaires or scorecards.

One of these guides is the one developed by Twigg (2007) that propounded the characteristics of a resilience framework. This is based on five dimensions of resilience, namely, governance, risk assessment, knowledge and education, risk management and vulnerability reduction, disaster preparedness, and response; and it has 28 components and 167 characteristics or indicators.

Another is the Multi-Hazard Disaster Risk Assessment ((DFID 2012). This sets out a framework for undertaking a multi-hazard risk assessment, which is the first step in preparing a disaster resilience country strategy, and it follows the following stages, namely, magnitude and likelihood of hazards, vulnerability analysis, in-country capacity to address, overall impact assessment disaster risk, What is DFID doing and what should it do?

Next, is A Multidimensional Approach for Measuring Resilience (Oxfam GB 2013). This approach for understanding and measuring resilience is based on five dimensions, namely, livelihood viability; innovation potential; contingency resources and support access; integrity of natural and built environment; social and institutional capability.

In addition, there is the Community Based Disaster Preparedness (Catholic Relief Service 2009). This guide was designed to support a community-led disaster preparedness process using participatory methods to collect information for monitoring progress and highlights the value of qualitative information.

Lastly, there is another one by Turvill and Turnbull (2012), that is, Participatory Capacity and Vulnerability Analysis: A practitioner's guide. This guide is based on two social development methodologies. The first part is designed to facilitate a program design that is anchored on a community's capacities as well as its vulnerabilities. While the second part is based on the supposition that enabling communities to genuinely participate in program design, planning, and management leads to an increase in ownership, accountability, and impact, and is the best way to bring about change.

However, the guides mentioned above should not be assumed as being comprehensive rather we should be wary of how they will fit a given context. This is because any approach or guide in assessing the disaster resilience of a community must be comparable and even tailored to a specific social group and context (Castleden et al. 2011: 375; Turnbull et al. 2013: 40; Twigg 2009). Nonetheless, once a guide or an approach has been chosen, and from it, a tool has been crafted, researchers typically want to know if the factors being considered in that tool can be acceptable predictors of disaster resilience.

At present, this is the current gap in knowledge in this area since all the abovementioned guides or approaches or strategies in measuring resilience have yet to demonstrate its fitness to a specific social group and context by way of answering the following questions such as: Are there any relation between the predictors/dimensions/indicators being supposed in these guides to disaster resilience? If there is any relation, what is the power of the relation? Is it possible to make future-oriented predictions with regards to their indicators? If certain conditions are controlled, what influence does an indicator or group of indicators have over another indicator or indicators? All these questions implied a kind of modeling wherein the indicators used are being ascertained whether they are good predictors of disaster resilience.

It is on this line of queries that this study had chosen the Torrens Community Disaster Resilience Scorecard Toolkit (Torrens Resilience Institute 2015) to determine whether the predictors used in the said toolkit are good predictors of disaster resilience relative to the school communities who were identified by the Department of Environment and Natural Resources geo-hazard map for Misamis Oriental, Northern Mindanao, the Philippines as disaster-prone areas such as that of flooding. Though the study has used the Torrens Disaster Resilience Scorecard toolkit, nevertheless, it must be underscored that relative to the aforementioned guides or strategies or approaches a questionnaire or scorecard should likewise be constructed using the indicators and/or dimensions to measure the overall disaster resiliency of a disaster-prone locality. Hence, a similar study of this kind needs also to be conducted of course using a questionnaire or scorecard based on one of the abovementioned approaches or guides in ascertaining a community disaster resiliency. Consequently, testing the abovementioned purported indicators and/or approaches/guidelines will validate their fitness in determining a given community disaster resilience. In this way, it can open up new insights into the current debate in disaster risk and management. The first side of this debate emphasized the need for standard sets of indicators while the second advanced the idea for a need to develop locally-relevant indicators through participatory methods involving local communities. It must be emphasized that the Torrens Disaster Resilience Scorecard could be categorized as belonging to the first side of the debate. It sets forth its own standard sets of indicators in which to score a given disaster-prone community.

Methodology

Locale of the Study

The study was conducted in the twenty-six school communities in the Schools Division of Misamis Oriental during the School Year 2019 to 2020. The study covers six municipalities, namely, Balingasag, Lagonglong, Talisayan, Alubijid, Libertad, Initao. These municipalities are all in the province of Misamis Oriental, Northern Mindanao, The Philippines. The identification of these school communities was based on the Department of Environment and Natural Resources geo-hazards map of the said province; hence, the geo-hazards map was the basis by which these school communities were chosen in testing the Torrens Disaster Resilience Scorecard Toolkit.

Research Instrument

The Torrens Disaster Resilience Scorecard was chosen as the tool to be used in the data gathering. The scorecard consisted of four dimensions. These are community connectedness, which has five indicators; risk and vulnerability, which has seven indicators; planning and procedures have four indicators; and available resources six indicators. Each indicator has a scoring scale from 1 to 5 in which the higher the score suggestive of a disaster-resilient community given a particular dimension. The rating for each school community was done by a representative of the following offices, in which they serve as the raters. These representatives were as follows: School Administrator/Principal, School Disaster Risk Reduction Management Coordinator, Municipal Disaster Risk Reduction Management Officer of the concerned municipality where the school community is situated, President of the General Parents-Teachers Association, President of the School Student Government, and the local chief executive (Barangay Captain) of the local government unit in which the school belongs. The tool was tested for its reliability and it yielded a Cronbach Alpha of 0.817, which can then be interpreted as good.

Data Collection Method

The data collection method was done by the following aforesaid representatives using the Torrens Disaster Resilience Scorecard. Each of these representatives was given this scorecard which they used as the basis in rating a particular school community situated in their locality. The collected scorecards were tabulated using Excel in which a table was made with five main columns. One main column heading is that of Name of Schools and each of the four dimensions has its corresponding main column heading with sub-columns under it that represent the respective indicators of each dimension.

The highest score that a rater can give is 5 and the lowest is 1. In the column Name of Schools, it has 26 rows with the names of the 26 schools in it. These schools were as follows: Camuayan Elementary Schools (ES), Rosario National High School (NHS), Rosario ES, Baliwagan NHS, Naparilan ES, Misamis Oriental NHS, Mandangoa ES, Cogon ES, Cala-Cala ES, San Isidro NHS, Kauswagan ES, Babanlangan ES, Luyong Baybayon ES, Talisayan Central School, Talisayan NHS, Pook ES, Bugdang ES, Lourdes Alubijid NHS, Lourdes ES, Baybay ES, Alubijid NCHS, Taytayan ES, Kanitioan ES, San Pedro ES, Paniangan ES, Cabalantian ES. The data collection was done during the School Year 2019-2020.

The average scores of the four dimensions become the overall disaster resilience for that school community. The scores given by the raters for each of the schools in each dimension of disaster-resilient was then average and were summed up from it derived the average to get the Disaster Resilient score of the community. The disaster resiliency scores are then interpreted in this manner.

Scores	Interpretation
3.7 – 5.0	Going Well
2.4 – 3.6	Caution
1.0 – 2.3	Red Zone

Data Analysis

The data in the above table were used to come up with a model with the four dimensions as the explanatory variables of disaster resilience. In so doing, we used the Multiple Linear Regression Analysis and paid particular attention to the assumptions required for this kind of analysis. Such as normal distribution, linearity, multicollinearity, and no extreme scores.

Through the Multiple Regression Analysis, it was checked whether or not the four explanatory variables in the Torrens Disaster Resilience Scorecard are significantly predictive of Disaster Resilience, which was the response variable, according to the ANOVA statistics.

II.RESULTS AND FINDINGS

A. Disaster Resilience Scores and their Interpretation per School Community

Below is the results of the ratings given by the aforementioned raters. At this period in time, these findings could serve as the basis for each of the school communities on their standing relative to disaster resilience with the use of the Torren Disaster Resilience Scorecard.

However, it must be emphasized that these findings should not be considered as something like a permanent ones. Rather, it should be treated as a baseline for future reference as regular monitoring and evaluation of these localities became institutionalized by the respective agencies, concerned offices, and school administrators of each of these schools.

Table 1. Average Scores per Dimensions with Interpretation						
Name of Schools	CC[1]	RV[2]	PP[2]	AR[3]	DR	Interpretation
Camuayan ES	4.1	3.2	4.3	4.0	3.9	Going well
Rosario NHS	4.3	3.2	3.3	3.3	3.5	Caution
Rosario ES	3.7	2.9	3.0	3.4	3.2	Caution
Baliwagan NHS	4.7	2.9	4.4	3.7	3.9	Going well
Naparilan ES	4.3	3.1	3.1	3.7	3.5	Caution
Misamis Oriental NHS	4.6	3.2	4.1	3.7	3.9	Going well
Mandangoa ES	4.5	3.4	3.4	3.8	3.7	Going well
Cogon ES	3.8	3.3	3.7	3.4	3.5	Caution
Cala-Cala ES	4.4	2.7	4.2	3.4	3.6	Caution
San Isidro NHS	3.6	3.3	3.5	3.4	3.5	Caution
Kauswagan ES	4.2	3.1	3.8	3.6	3.7	Going well
Babanlangan ES	4.5	3.3	3.7	3.7	3.8	Going well
Luyong Baybayon ES	4.7	3.9	4.4	4.1	4.3	Going well
Talisayan CS	4.0	3.4	4.2	3.9	3.7	Going well
Talisayan NHS	3.9	2.9	3.1	3.1	3.3	Caution
Pook ES	4.0	3.7	4.3	3.8	3.9	Going well
Bugdang ES	3.8	3.5	2.7	3.0	3.2	Caution
Lourdes Alubijid NHS	3.9	3.1	3.9	3.2	3.5	Caution
Lourdes ES	4.4	3.8	4.2	3.9	4.1	Going well
Baybay ES	4.1	3.2	4.3	4.1	3.9	Going well
Alubijid NCHS	4.8	3.2	4.7	3.9	4.1	Going well
Taytayan ES	4.2	2.5	3.5	3.8	3.5	Caution
Kanitioan ES	4.1	2.8	3.5	3.9	3.6	Caution
San Pedro ES	4.1	3.0	4.0	3.8	3.7	Going well
Paniangan ES	3.7	2.5	3.8	3.1	3.3	Caution
Cabalantian ES	4.0	2.8	4.3	3.9	3.7	Going well
Mean	4.2	3.2	3.8	3.6	3.7	
Standard Deviations	0.334	0.354	0.516	0.319	0.279	
[1]Community connectedness; [2]Risk and vulnerability; [3]Planning and procedures; [4]Available resources						

B. The Model: Relationship of Disaster Resilience (Y) – As response variable and Comunity connectedness (X_1), Risk and vulnerability (X_2), Planning and procedures (X_3), and Available Resources (X_4) – explanatory variables

First and foremost, we would show what is the picture of the correlation of these variables through a correlation matrix.

Table 2. Correlation Matrix										
	DR		CC		RV		PP		AR	
	R	p-value	R	p-value	R	p-value	R	p-value	R	p-value
DR	1.000		0.732	.000021	0.529	.005459	0.817	.00001	0.802	.00001
CC	0.732	.000021	1.000		0.223	.273508	0.472	.014912	0.525	.00589
RV	0.529	.005459	0.223	.273508	1.000		0.171	.40359	0.287	.155155
PP	0.817	.00001	0.472	.014912	0.171	.40359	1.000		0.629	.000577
AR	0.802	.00001	0.525	.00589	0.288	.153658	0.629	.000577	1.000	

Level of Significance set at $p < .05$

We are interested here in looking at the correlation between the response variable, which is disaster resilience, and the four explanatory variables, which are community connectedness (CC); risk and vulnerability (RV); planning and procedures (PP); and available resources (AR). Here it was revealed that the correlation between the response variable and each of the explanatory variables are significantly correlated. Meaning says, there is a 95% probability that in the areas being studied, the correlation between disaster resilience and the four explanatory variables could not be attributed to random chance.

The Regression output had shown that the R Square (R^2) equals 0.971 with an Adjusted R Square equals 0.966. Taking the cue from the Adjusted R Square, it means that in our model community connectedness; risk and vulnerability, planning and procedures; and available resources – taken as a group – explain 96.6% of the variance of disaster resilience. To put it differently, 96.6% of disaster resilience in the flood-prone school communities in the Schools Division of Misamis Oriental can be explained by their combined community connectedness, risk and vulnerability, planning and procedures, and available resources. The coefficient of multiple correlations (R) equals 0.985. It means that there is a very strong direct relationship between the predicted data ($\hat{y}$) and the observed data (y).

C. Goodness of fit

The regression model, as depicted in Table 3, had revealed a right-tailed, $F(4,21)$ equals 175.936, p-value equals 7.77156e-16, and since the p-value < α (0.05), we reject the null hypothesis (H_0), that is, the linear regression model is not a good fit.

The linear regression model, Y = b0+ b1X1 +...+bpXp, provides a better fit than the model without the independent variables resulting in, Y = b0.

Table 3. ANOVA Table

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Regression	4	1.894618	0.473654	175.935948	7.77156e-16
Residual	21	0.0565362	0.00269220		
Total	25	1.951154	0.0780462		

D. The Extent of the Contribution of community connectedness, risk and vulnerability, planning and procedures, and available resources to disaster resilience

Having demonstrated that the above model is significant, we would now try to ascertain how much each of the explanatory variables could account for the response variable.

Table 4. Coefficients Table

	Coeff	SE	t-stat	lower $t_{0.025(21)}$	upper $t_{0.975(21)}$	Stand Coeff	p-value	VIF
b	0.046	0.153	0.303	-0.272	0.364	0.00	0.765	
CC	0.259	0.038	6.895	0.181	0.337	0.310	8.18552e-7	1.461
RV	0.241	0.031	7.831	0.177	0.305	0.305	1.15794e-7	1.100
PP	0.243	0.027	9.177	0.188	0.298	0.449	8.52436e-9	1.735
AR	0.237	0.045	5.227	0.142	0.331	0.270	0.000035	1.932

At the outset, we need to underscore, as reflected in Table 4, that all the explanatory variables are significant, that is, their p-value is less than .05.

Because of this, let us first look at how much disaster resilience can be accounted for by community connectedness. Of course, we would anchor our interpretation on the standardized coefficients. We found out that for every 1 standard deviation increase in community connectedness, and holding risk and vulnerability, planning and procedures, and available resources constant; disaster resilience increases by 0.310 standard deviations. Such an increase could not be attributed to random chance.

Furthermore, for every 1 standard deviation increase in risk and vulnerability, and holding community connectedness, planning and procedures, and available resources constant; disaster resilience increases by 0.305 standard deviations. Likewise, this increase could not be attributed to random chance.

Moving on, for every 1 standard deviation increase in planning and procedures, and holding community connectedness, risk and vulnerability, and available resources constant; disaster resilience increases by 0.449 standard deviations. This increase could not be attributed to random chance.

Lastly, for every 1 standard deviation increase in available resources, and holding community connectedness, risk and vulnerability, and planning and procedures constant; disaster resilience increases by 0.270 standard deviations. Again, this increase could not be attributed to random chance.

In sum, the biggest increase in disaster resilience comes from planning and procedures followed by community connectedness, risk and vulnerability, and available resources.

E. Assumptions Validation

- Residual normality
  Linear regression assumes normality for residual errors. Shapiro Wilk p-value equals 0.144000. It is assumed that the data is normally distributed.
- Homoscedasticity - homogeneity of variance
  The White test p-value equals 0.970028 (F=0.0304710). It is assumed that the variance is homogeneous.
- Multicollinearity - intercorrelations among the predictors (Xi)
  As reflected in Table 4, there is no multicollinearity concern as all the Variance Inflation Factor (VIF) values are smaller than 2.5.

III. CONCLUSION

In the context of the twenty-six (26) school communities in the Schools Division of Misamis Oriental, Northern Mindanao, the Philippines; we can conclude that our model based on the Torrens Disaster Resilience Scorecard, is a good model in predicting disaster resilience of the flood-prone schools and their communities. Hence, the said scorecard is a good tool in predicting disaster resilience as far as these school communities are concerned.

IV. RECOMMENDATIONS

Given the above conclusion, we would like to advance the following recommendations:

- The Torrens Disaster Resilience Scorecard is a good predictor of disaster resilience relative to the localities covered in these studies, hence, it is proper and appropriate that such a tool should be utilized by the respective Municipal Disaster Risk and Reduction Management Officer and school administrators.
- There is also a need to come up with a questionnaire or scorecard for each of the guides or approaches propounded above. In doing so, empirical evidence can be gathered to come up with models thereby testing their effectiveness in predicting disaster resilience.
- The more models we have based on the aforementioned approaches/strategies, the better for the disaster-prone localities to have choices as to which one is effective relative to their context.

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