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Index Assessment of Household Social Vulnerability to Climate Change: A Case Study of Laguna Province, Philippines

ABSTRACT

This study empirically investigated the social vulnerability of two municipalities of Laguna Province, Philippines, on the impacts of natural disasters associated with climate change. Data were obtained from interviews with seventeen experts and surveys for thirty-seven households conducted in the two municipalities. The results of the index analysis, using the weight average method and ordered probit regression, can be summarized as follows: First, the characteristics of low educational attainment, low labor rate and lack of economic resources were crucial in determining the social vulnerability class of households. Second, the social vulnerability index is determined by multiple factors, and therefore, it should not be assessed by a single variable. Third, the weights for components of the vulnerability index were insignificantly affected by geographical features and the speciality and personal traits of the experts. This suggests that local governments should develop an information system that identifies socially vulnerable households and that this should be utilized to provide the residents with education about climate change and strategies for households to reduce their potential risks from severe climatic events.

Keywords: *household social vulnerability, Pairwise Comparison Method, household survey, expert survey, Index Analysis*

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INTRODUCTION

Many people are affected by global climate change. Climate-related phenomena, such as super typhoons, could be particularly destructive. These events have adversely affected developing countries in recent years in terms of serious economic damage and human casualties, and such events highlight the need for the construction of stronger infrastructure and the development of better support systems for victims. To allocate scarce resources to the people who need them most, it is necessary to use scientific research to identify vulnerable households and regions.

The index analysis approach can be used to summarize particular information related to climate vulnerability and can thus contribute to the classification of households and the identification of vulnerable groups. Climate vulnerability is generally considered as a function of three components: exposure, sensitivity, and adaptive capacity (*IPCC 2001*). Exposure is the degree of experience to climate change (for example, how often droughts or floods are experienced in a particular region), sensitivity measures how susceptible a community or a household is to climate change, and adaptive capacity reflects the level of income or the level of knowledge pertaining to potential disasters. Out of these components, the degree of exposure is geographically or climatically determined, while the other components are primarily related to social or economic characteristics of a community or of an individual household.

Vulnerability, that is socially or economically determined is known as social vulnerability. *Adger* (*1999*) assessed the social vulnerability of villages using the Gini coefficient, and that of households using a variable of the ratio of income dependent on natural resources to total income. While *Adger* (*1999*) used a single variable to create a social vulnerability index, *Cutter et al.* (*2003*) and *Vincent* (*2004, 2007*) used multiple variables to create representative indexes.

Given the increasing trend of community exposure to severe events associated with global climate change, it is necessary to reduce social vulnerability and construct infrastructure that will withstand climate-related damage. Furthermore, it is necessary to measure vulnerability at the level of each household because these are often heterogeneous within a region or even within a village. Most of the previous studies, which employed multiple variables, have focused on the regional or collective aspects of social vulnerability, and there have only been a few studies conducted at the household or individual level. This means that there is a gap between public needs and academic resources for vulnerability analyses at the individual level. This study, therefore, is to fill this gap by constructing a household-level index of social vulnerability index to climate change in a systematic way and examining its determinants.

MATERIALS AND METHODS

Literature on a calculation method of the index were collected from Google scholar and Scopus in relation to search results using the keywords "social vulnerability index," "climate change," and "natural disaster."

The process used to construct the index are as follows. First, items to be assessed were determined based on the literature survey. Second, the weights for each component (a group of the items) were then decided on the basis of data gathered from local experts. The experts were selected to cover various academic background related to social vulnerability to climate change, such as medical/social care, economics, forestry/ecology, agriculture, and environmental science, belonging to International Rice Research Institute (IRRI) and University of the Philippines Los Baños (UPLB). Seventeen experts were interviewed for the analysis. Third, household data for use in the calculation index were gathered from household surveys made in Los Baños and Pila, Laguna. The income level of the two municipalities tends to be higher than the national average. In the study, therefore, to keep representing the average Philippine household, the area with slightly low income was first selected in the villages of each municipal, and then households were randomly surveyed in the area. At the same time, the sample was constructed to reflect the employment structure of Laguna as much as possible. Finally, data were obtained from interviews with 15 households in the Pila, and 27 households in Los Baños; five observations were deleted in the sample used for analysis due to missing information. In addition, the differences in social vulnerability based on geographical features were examined by analyzing the data separately by households living on flat land and on slopes. These surveys were conducted from September to November 2014 (**Figure 1**).

Adaptive capacity was composed of "lack of economic resources", "lack of knowledge and technology" and "inadequacy of support systems"; sensitivity was composed of a "large number of weaknesses in relation to a disaster" and the "level of income stability." For the "relationship with vulnerability", a plus sign indicated an increasing score, where households are becoming more socially vulnerable, and a minus sign represents the opposite trend. Exposure is another important category. It is geographically or climatically determined, and households cannot or hardly control it, the study does not include the assessment of exposure (**Table 1**).

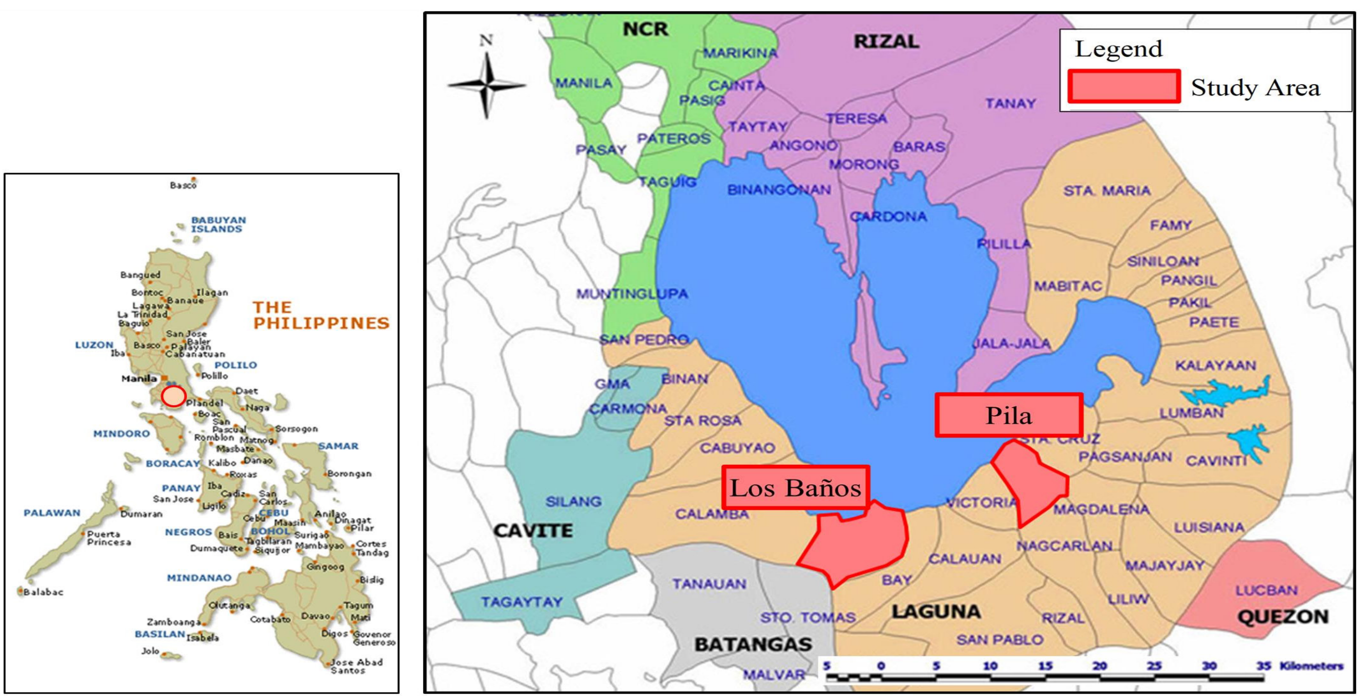

Figure 1. Study site in Laguna Province, Philippines. Adapted and modified from Laguna Lake Development Authority (https://llda.gov.ph/geographical-jurisdiction/) and map of the Embassy of the Philippines in Belgium (http://www.brusselspe.dfa.dov.ph/geography).

Table 1. Average and standard deviation of the components and scores used in the index calculation and expected relationship, positive or negative, to household vulnerability*.

Components (IPCC category)	Score items (Unit)	Average	St. Dev.	Expected sign
Lack of Economic Resources (Adaptive Capacity)	Market Value of Real Assets (PhP)	43,862.2	70,778.8	-
	Income per Capita (PhP)	53,985.9	62,546.7	-
	Amount of Money Stock (PhP)	3,94.6	1,790.4	-
	Amount of Debt (PhP)	8,516.2	24,546.8	-
	Amount of Land (ha)	381.1	1,718.2	-
Inadequacy of Support System (Adaptive Capacity)	Number of Neighbor who help Recovery Work (person)	17.8	11.9	-
	Amount of Insurance premiums (PhP)	189.2	465.3	-
	Amount of Money Receive from Government (PhP)	394.6	942.2	-
Lack of Knowledge (Adaptive Capacity)	Accuracy Rate of Quiz about Typhoon (%)	0.55	0.22	-
	Number of Participation for Training (person)	0.78	1.4	-
	Max Years of Schooling (year)	11.9	2.9	-
	Number of Equipment for Disaster (cunt.)	0.35	0.16	-
Unstableness of Income (Sensitivity)	Rate of Losing Income from Typhoon (%)	0.04	0.1	+
	Number of Occupations(cunt.)	3.1	1.8	-
	Labor Rate (%)	0.47	0.24	-
	Amount of Assets in Other Village (PhP)	74,324.3	241,989	-
	Damage from Past Disaster (PhP)	4,269.4	8,073.5	+
Large Number of Weak in Disaster (Sensitivity)	Age of Housing (year)	21.46	15.6	+
	Minutes to Nearest Hospital (minutes)	29.86	10,7	+
	Rate of Sick Person (%)	0.08	0.1	+
	Rate of Old and Child (%)	0.31	0.25	+

*Philippine peso = 0.020661 US dollar (03 October 2016)

Data gathered from household surveys were standardized for scoring by using the max-min method, and components were made by averaging the standardized scores. Finally, the index was constructed using the averaged components (i.e., via the weight average method) and weights (**Table 2**). The weights were calculated as follows. First, the weights were calculated objectively using a pairwise comparison method (Eigenvector method) (*Matteo Brunelli 2015*). Second, the respondents of the pairwise comparison question- experts of various academic fields, were asked about their opinions regarding the assessment weights. In this way, thirty-five answers were gathered from experts in Laguna. The most coherent answers (Consistency Ratio is less than 0.15) were selected and 17 answers were used for the calculations.

The study area consisted of the two municipalities in the Province of Laguna, which is a relatively affluent area in the Philippines (*Family Income and Expenditure Survey, National Statistics Office of the Philippines, 2012*). Laguna is located in the southern part of Manila Luzon Island, and it has higher than average rainfall for the country (*PAGASA 2014*). This province suffered

Table 2. Calculation formulas of scores, comportments, and the household social vulnerability index.

Items	Calculation formulas	Notes
Score	$p_k = \frac{x_k^p - x_{min}^p}{x_{max}^p - x_{min}^p}$ **(for positive variables)** *or* $q_k = 1 - \frac{x_k^q - x_{min}^q}{x_{max}^q - x_{min}^q}$ **(for negative variables)**	p, q : Variable ID, k : Household ID, j : Component ID, s : Topography class (flatland, slope),
Component	$C_{kj} = \frac{\sum_{p=1}^{m} Score_{kp}}{n}$	
Vulnerability-index	$I_k^s = \sum_{j=1}^{5} W_j^s C_{kj}$	W : Weight for aggregation.

considerable damage during Typhoon Rammasun (Glenda) in 2014 (*National Disaster Risk Reduction and Management Council 2014*), and while a number of households have recovered, others have not during the survey period of this study. The area is thus considered suitable for assessing social vulnerability.

The community support plan in the Philippines is known as the Barangay Disaster Risk Reduction Management (BDRRM) plan, and according to this plan, communities train rescue teams and clean up rivers and canals. In addition, the Philippine government provides food for victims (e.g., 2 kg of rice and a few canned goods) and other forms of monetary support via the Quick Response Fund (QRF). Support is currently determined in relation to the amount of damage victims have suffered, and the program funds have been used to support a large number of victims. Therefore, the support provided by BDRRM activities and the QRF are relatively small for an individual victim and sometimes not adequate for victim resettlement.

RESULTS AND DISCUSSION

According to *Adger* (*1999*), social vulnerability indexes can be classified by differences in assessment targets. For example, there are Collective Indexes, which focus on the social vulnerability of countries or communities, and Individual Indexes, which focus on the social vulnerability of households or individuals. It is shown that the collective index approach is more common than the individual index approach (**Table 3**).

In addition, according to *Yoon* (*2012*), two calculation methods can be used to construct an index. The first method is known as the deductive approach. A limited number of variables are deductively selected and create a social vulnerability index based on a priori theory and knowledge from existing literature. The second method is known as the inductive approach, which uses extensive sets of variables that influence social vulnerability. For the deductive approach, simple or weighted average methods are used. For the inductive approach, principal component analysis or factor analysis is used for constructing the indexes. Deductive techniques were primarily used in the previous studies.

The literature survey, furthermore, revealed several potential problems; some researchers used their own definition of vulnerability, which was not the same as the IPCC definition; the weighting for each component was made using an obscure method or equal weights were used; and the person deciding the weighting factors may not have possessed in-depth knowledge of the target

Table 3. Literature reviews including 11 articles related to the social vulnerability index

Author	Index Name	Targets	Method[a]	Major variables[b]
Hahn et al.(*2009*)	Livelihood vulnerability	Boroughs	Weighted average	Working population rate/Farming income rate/Sick person rate/Number of past disasters
Ahsan and Warner (*2014*)	Socio-economics vulnerability	Boroughs	Weighted average	Population density/Literacy rate/Natural resource income rate/Electricity use rate
Allison et al. (*2009*)	-	Countries	Weighted average	Temperature increase/Literacy rate
Cutter et al. (2003)	Social vulnerability	Boroughs	Principal component	Urban population rate/Age of housing
Ghimire et al. (*2010*)	-	Households	Principal component	Number of livestock/Amount of land/ Irrigation rate
Vincent (*2004*)	Social vulnerability	Boroughs	Weighted average	Poverty rate/Working age population rate/ Rural population rate
Vincent (*2010*)	Household social vulnerability	Households	Weighted average	Total assets/Working age population rate/ Housing information
Lindenberg (*2002*)	Household livelihood security	Boroughs / Households	Simple average	Nutritional status
Lee (*2014*)	Social vulnerability	Boroughs	Simple average	Women population /Poverty population/ Immigrant rate
Eakin and Bojorquez-Tapia (*2008*)	-	Households	Weighted average	Market value of total assets/Crop information

[a]Max-min standardization or z score standardization is used for simple average or weighted average methods.
[b]All indexes include income and education variables.

area. The analytical method, presented in section 2, is designed to provide a solution for those problems.

Information provided in the sample of expert respondents (N=17) showed half of the respondents were less than 40 years of age, and 60% were women (**Table 4**).

No significant differences were found between the averaged weights for geographical features, and it was not possible to ascertain any significant differences for the averaged weights of each of the experts' academic discipline (**Table 5**). However, there were significant differences in the averaged weights in relation to gender, and some researchers have argued that people often have differences in opinion in relation to governments and policies (*Pratto et al 1997; Takeda 2010*).

The experts were also asked for their opinions about efficient support measures to protect communities against climate change. Frequency of the support measures indicated, and that "education related to typhoons and prevention measures" and "efficient cooperation within communities" were selected by the experts as being valuable support measures (**Figure 2**).

There was no variation in the averages of household

Table 4. Academic background of the participants of expert survey

Major	Valid answers	Women rate (%)	Less than 40 yrs (%)	Years lived in Laguna (yr)
Medical/Social	4	67	33	26.0
Economics	5	40	60	28.4
Forestry/Ecology	3	67	33	25.0
Agriculture/Environment	5	80	60	17.2
Total	17	62	50	23.9

Table 5. Averages of the weights derived from pairwise comparison by expert's characteristics and geographical feature[a].

Categories (N)	Lack of Economic Resources	Large Number of the Weak in disaster	Unstableness of Income	Lack of Knowledge/ Technology	Inadequacy of Support System
Flatland Sample (17)	0.21	0.12	0.27	0.21	0.19
Slope Sample (17)	0.20	0.16	0.24	0.21	0.19
Academic Background					
Flatland: Medical/Social (4)	0.20	0.09	0.28	0.21	0.22
Economics (5)	0.24	0.14	0.24	0.19	0.20
Forestry/Ecology (3)	0.20	0.09	0.30	0.25	0.15
Agric./Environ. (5)	0.20	0.17	0.25	0.18	0.20
Slope: Medical/Social (4)	0.18	0.22	0.19	0.20	0.20
Economics (5)	0.24	0.14	0.26	0.17	0.19
Forestry/Ecology (3)	0.21	0.08	0.30	0.26	0.16
Agric./Environ. (5)	0.19	0.19	0.20	0.21	0.20
Gender					
Flatland: Men (6)	0.19	0.17	0.26	0.13*	0.25*
Women (10)	0.22	0.11	0.27	0.24*	0.16*
Slope: Men (6)	0.19	0.17	0.26	0.17	0.22
Women (10)	0.22	0.16	0.23	0.23	0.17
Years lived in Laguna					
Flatland: Under 26 yrs (9)	0.21	0.14	0.28	0.20	0.19
Over 27 yrs (8)	0.21	0.11	0.25	0.20	0.20
Slope: Under 26 yrs (9)	0.20	0.19	0.21	0.22	0.18
Over 27 yrs (8)	0.21	0.13	0.27	0.19	0.20
Age					
Flatland: Under 40 yrs (8)	0.24	0.14	0.23	0.22	0.17
Over 41 yrs (8)	0.18	0.12	0.30	0.17	0.22
Slope: Under 40 yrs (8)	0.23	0.13	0.23	0.24	0.17
Over 41 yrs (8)	0.19	0.19	0.24	0.17	0.21

[a]Tukey-Kramer method for multiple comparison are used for mean quality test and * denotes the statistically significance at 5% level. Gender and age had missing data.

members between each village, but the average family income differed between villages because data were gathered from relatively low income households in Santa Clara Sur. Employment data were gathered from all villages (**Table 6**).

In this study, the different weights were used in index calculation in relation to geographical features, as the structure of social vulnerability would differ in relation to geographical features. It is expected that the results for the "ratio of income loss in relation to typhoons" and "damage incurred from past disasters" would differ depending on the various geographical features. However, no significant differences were found in this respect, and therefore, references to geographical features were omitted from the index determination.

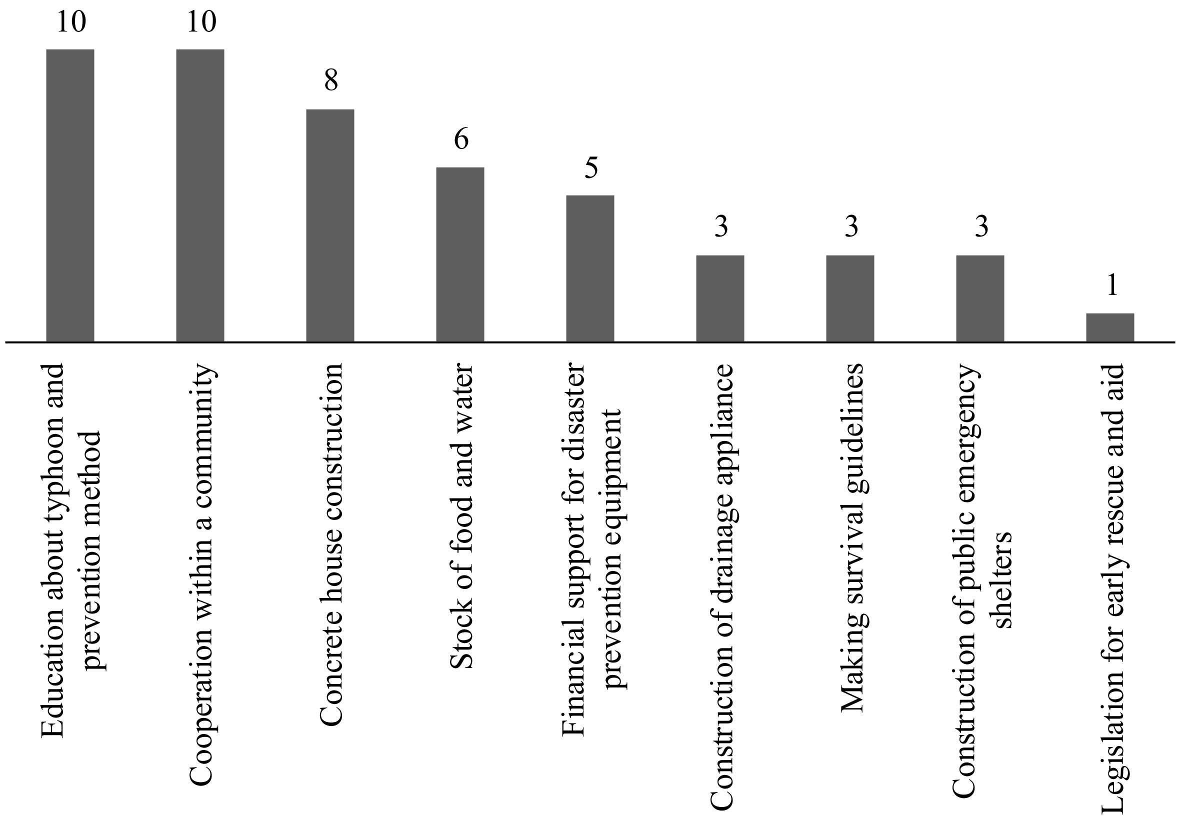

Figure 2. Experts' opinion on a support for climate change damage in Laguna.

Table 6. Summary of the sample household, N=37, collecting in Loss Baños and Pila, Laguna.

Items	Flatland Sample				Slope Sample			
	All	Pila		Los Baños	All	Los Baños		Total
		Santa Clara Sur	Pansol	Bayog		Bagong Silang	Mayondon	
Sample Size	22	5	8	9	15	4	11	37
HH size (persons)[b]	5.6	6.6	5.6	5.1	5.5	5.3	5.5	5.6
HH income[c] (PhP)	30,2964	48,210	437,334	268,017	214,702	101,631	286,437	262,411
HHH age (years)[b]	49.7	56.2	50.8	45.7	52.5	56.8	51.0	51.0
Income loss by typhoon	1.97	6.36	0.92	0.27	0.06	22.08	0.59	3.69
Damage by natural disaster[b]	3,625	4,233	313	8,389	5027	625	5118	4269
Job of HHH (%)								
Agriculture	27	20	0	56	27	100	0	27
Retail	18	20	25	11	20	0	27	19
Salary	77	80	75	78	73	50	82	76
Driver	32	20	13	56	33	0	45	32

[a]HH denotes household; HHH denotes household head. [b]Average values [c]Average values per month

The probability density function of the index has a normal distribution, but some of the frequencies are high at 0.7 (**Figure 3**). While this distribution was examined whether or not being the sum of two different normal distributions via an expectation-maximization (EM) algorithm cluster analysis, the distribution was a single distribution. Therefore, the data was classified according to quantile breaks: The Strong Group (the lower 33%, named C), the Medium Group (34-66%, B), and the Vulnerable Group (67-100%, A).

The explained variable consists of the classes (3 if an observation belongs to A, 2 if belonging to B, 1 if belonging to C) and the predictor variables are the component or the score items (**Table 7**). The predictor variables at less than 5% level of significance were dropped in the model, and the category of "lack of knowledge and technology" was not used because the regression was not able to calculate results when this was used. As a result of the analysis using components as predictor variables, all the components were found to have a significantly positive relationship. "Lack of economic resources" and "level of income stability" had a large influence on the classification. As a result of the analysis using scores, the categories of "maximum years of schooling in household" and "ratio of labor in household" had a significantly negative relationship. It was also shown that scores related to economic status did not have a significant relationship, and it is, therefore, considered inappropriate to use a single variable such as income or assets in a social vulnerability index.

This point is also confirmed which shows the value of the components via representative observations drawn from Class A and Class C, and the average values for comparison (**Figure 4**). It is evident here that Class C is more vulnerable in terms of "lack of economics resources" than Class A, but Class A is vulnerable in the index because the other components of Class C are less vulnerable than those of Class A. Again, this implies that it is inappropriate to assess social vulnerability using single variables.

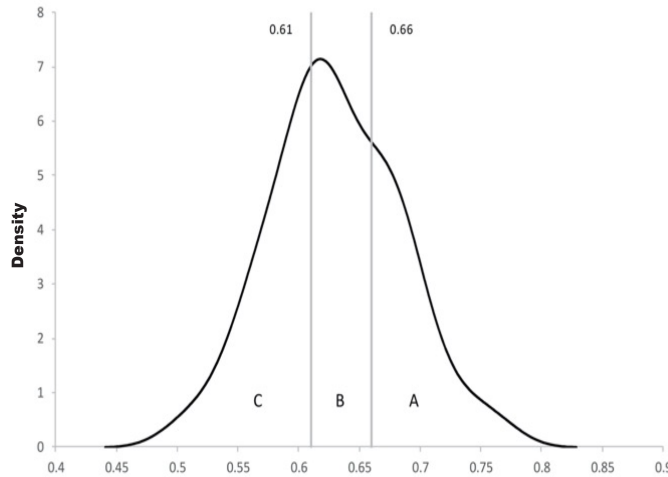

Figure 3. Density function of the social vulnerability index value.

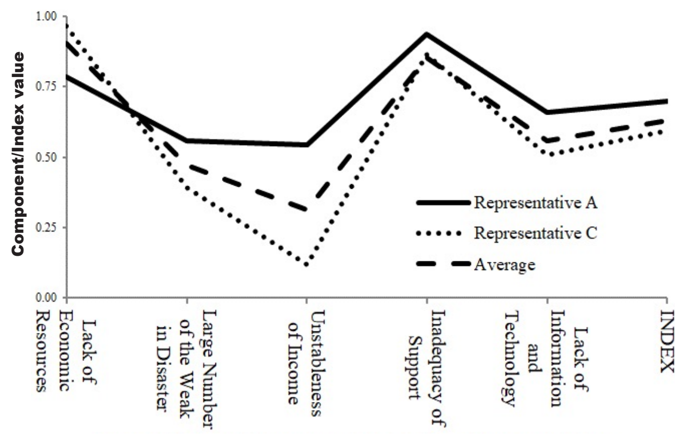

Figure 4. Values of components and index of the representative observation drawn from the class A and class C of Figure 3, showing the average values for comparison..

Table 7. Estimation results of ordered probit regression to examine the determinants of household social vulnerability index class*.

Regression #1 (Dependent variable: Components)			Regression #2 (Dependent variable: Score Items)		
Variables	**Coefficient**	**p value**	**Variables**	**Coefficient**	**p value**
Lack of Economic Resources	11.76	0.002	Labor Rate	-4.68	<0.000
Unstableness of Income	10.12	0.001	Maximum schooling years	-0.36	<0.000
Large Number of the Weak in Disaster	7.29	0.003			
Inadequacy of Support system	5.00	0.037			
C|B	20.98		C|B	-7.26	
B|A	23.23		B|A	-5.83	
Nagelkerke's R^2	0.52		Nagelkerke's R^2	0.33	

Independent variables of the regression are ordered-values, that is, 3: Class A, 2: Class B, and Class C corresponding to Figure 3. A|B and C|B denote the cut-points of ordered regression.

CONCLUSION AND RECOMMENDATIONS

Based on the index analysis, "less education," "lower rate of labor," and "a lack of economic resources" are the main characteristics that determine the social vulnerability class of households. Alleviation of these issues is outside the scope of current support programs such as the Quick Response Fund aid and the BDRRM training scheme. This suggests that local governments could benefit from providing a system that identifies socially vulnerable households and provides the residents with education about climate change and strategies for households to reduce their potential risks from severe climatic events.

This study stresses the importance of indexing the social vulnerability in an objective or systematic way because the index will contribute to make a consensus of prioritizing households with the highest needs for support measures. The index presented in this study is one of those constructed in systematic way. For further studies, components or score items composing the social vulnerability index could be improved or refined, for example, by considering the differences in human social network (*Cassidy and Barnes 2012*) and local activities (*Sakashita and Uchida 2015*) for reducing damage from a disaster.

REFERENCES

Adger, W.N. 1999. "Social vulnerability to climate change and extremes in coastal Vietnam." *World Development* 27: 249-269.

Ahsan, M.N. and Warner, J. 2014. "The socioeconomic vulnerability index: A pragmatic approach for assessing climate change led risks-A case study in the south-western coastal Bangladesh." *International Journal of Disaster Risk Reduction* 8: 32-49.

Allison, E.H., Perry, A.L., Badjeck, M.-C., Adger, W.N., Brown, K., Conway, D., Halls, A.S., Pilling, G.M., Reynolds, J.D., Andrew, N.L. and Dulvy, N.K. 2009. "Vulnerability of national economies to the impacts of climate change on fisheries." *Fish and Fisheries* 10: 173-196.

Cassidy, L. and Barnes, G.D. 2012. "Understanding household connectivity and resilience in marginal rural communities through social network analysis in the village of Habu, Botswana." *Ecology and Society* 17(4): 11.

Cutter, S.L., Boruff, B.J. and Shirley, W.L. 2003. "Social vulnerability to environmental hazards." *Social Science Quarterly* 84(2): 242-261.

Eakin, H. and Bojorquez-Tapia, L.A. 2008. "Insights into the composition of household vulnerability from multicriteria decision analysis." *Global Environmental Change* 18: 112-127.

Ghimire, Y. N., Shivakoti, G.P. and Perret, S.R. 2010. "Household-level vulnerability to drought in hill agriculture of Nepal: implications for adaptation planning." *International Journal of Sustainable Development and World Ecology* 17(3): 225-230.

Hahn, M. B., Riederer, A.M. and Foster, S.O. 2009. "The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change-A case study in Mozambique." *Global Environmental Change* 19: 74-88.

PCC (Intergovernmental Panel on Climate Change). 2001. "Working Group II: Impacts, Adaptation and Vulnerability."

Lee, Y.-J. 2014. "Social vulnerability indicators as a sustainable planning tool." *Environmental Impact Assessment Review* 44: 31-42.

Lindenberg, M. 2002. "Measuring household livelihood security at the family and community level in the developing world." *World Development* 30(2): 301-318.

Matteo Brunelli 2015. "Introduction to the Analytic Hierarchy Process" SpringerBriefs in Operations Research: P. 83. 978-3-319-12502-2 (electronic).

National Disaster Risk Reduction and Management Council. 2014. "Final Report re Effects of Typhoon "GLENDA" (RAMMASUN) "

National Statistics Office of the Philippines. 2012. "2012 Family Income and Expenditure Survey Final Results."

Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). 2014. "CLIMATE IMPACT ASSESSMENT for Philippine Agriculture (Rice and Corn)."

Pratto, F., Stallworth, L.M. and Sidanius, J. 1997. "The gender gap: differences in political attitudes and social dominance orientation." *British Journal of Social Psychology* 36: 49-68.

Sakashita, R. and Uchino, A. 2015. "Forum "Disaster Preparedness for Community"" *Health Emergency and Disaster Nursing* (2015) 2, 7–11

Takeda, Y. 2010. "The gender gap in political participation: A JGSS-2003 data-based analysis of political resources and political involvement." *JGSS Research Series* 7(10): 323-335.

Vincent, K. 2004. "Creating an index of social vulnerability to climate change for Africa." Tyndall Centre for Climate Change Research, Working Paper 56.

Vincent, K. 2007. "Uncertainty in adaptive capacity and the importance of scale." Global Environmental Change 17: 12-24.

Vincent, K. Cull, T. 2010. "A household social vulnerability index (HSVI) for evaluating adaptation projects in developing countries." Paper presented at the PEGNet Conference 2010: Policies to Foster and Sustain Equitable Development in Times of Crises. Midrand, South Africa. September 2010.

Yoon, D. K. 2012. "Assessment of social vulnerability to natural disasters: a comparative study." Natural Hazards 63: 823-843.