QUANTIFYING THE SOCIAL ASPECTS OF DISASTER VULNERABILITY

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ABSTRACT

Measuring the social vulnerability of a community against a natural disastrous event may be qualitatively described in sentences. For example, we can say that the community is prone to disasters due to their extreme poverty, or due to the weak medical and health insurance scheme in their region. The dynamic and subjective nature of social issues however, has made its quantification and consideration extremely difficult in a risk assessment.

To respond to this need, this study proposes a new risk index ***R****, which considers the social aspects. The approach used in this research utilizes community participation and partnership to come up with a framework of empirically and observation based method for risk assessment. Briefly, the calculation of risk that incorporates social issues can be described in equation form as:*

$$\textbf{Total Risk } \underline{R} = \Sigma_{i=1,j=1,k=1}^{n\quad n\quad n} w_i H_i * (\alpha_{ijk}) w_j V_{ij}$$

where (α_{ijk}) *is the social factor parameter that increases or decreases the hard vulnerability,* w_j *is the weight of a physical vulnerability factor to the total physical vulnerability factors and* w_i *is the weight given to a hazard of a certain type with respect to all hazards considered. Each of the weights* w_i *and* w_j *should add to1.0*

A framework for assessing disaster risk that considers the social aspect of disaster vulnerability and its quantification in the risk equation is presented using a case study in Manila, Philippines. Initial work shows that this decision making tool can be part of a planner's tools, but more research is needed to validate its applicability in various settings of hazards and vulnerabilities.

1. INTRODUCTION

A statement of risk that combines the magnitude of the natural hazard and the vulnerability of the exposed elements at a determined moment is commonly in the form:

Risk = *function* (hazard, vulnerability) **(1)**

Depending on the type of risk assessment, the expression can only suggest an approach in qualifying and even quantifying what adds up to a risk. In the book "Disaster Mitigation, A Community Based Approach," risk is defined as follows.

$$\textbf{Risk = Hazard + Vulnerability} \qquad \textbf{(2)}$$

This expression may indicate that disasters are characteristics of a natural hazard and another that disasters are characteristics not of hazards, but of socio-economic and political structures and processes. This adds up to the risk. Another formulation states that risk is a result of the interaction of both, and there is no risk if: a) there are hazards (H) but vulnerability (V) is nil, or b) there is a vulnerable population but no hazard event. In a simple expression form,

$$\textbf{Risk R = H * V} \qquad \textbf{(3)}$$

In cases that many vulnerability factors contribute to a hazard or a set of hazards, the total risk can be expressed as

$$\textbf{Total Risk } R = \sum_{i=1,j=1}^{n\ \ n} w_i H_i * w_j V_{ij} \qquad \textbf{(4)}$$

In this equation, $\mathbf{H_i}$ represents the different hazards, and the $\mathbf{V_{ij}}$ represents the different vulnerabilities corresponding to these hazards. The $\mathbf{w_j}$ is a weight of importance of a selected physical vulnerability factor to all physical vulnerability factors considered and wi is the weight given to a hazard of a certain type with respect to all hazards considered. Each of the weights $\mathbf{w_i}$ and $\mathbf{w_j}$ should add to1.0. The value or risk is normalized.

However, this type of risk equation is usually based on hard vulnerabilities (potential to damage of a certain type of construction - e.g. reinforced concrete, etc under a certain magnitude of an earthquake) and for planners, its use is limited simply because the risk misses out the social aspects like for example, occupancy, age and condition of the occupants which can modify it. In a recent study by Tanhueco, R., Velasquez, G (UNU, 2003), they proposed a new risk index that incorporates the social aspect of risk using a social factor parameter (α_{ijk}) that increases or decreases the hard vulnerability $\mathbf{V_{ij}}$. Total Risk is therefore,

$$\textbf{Total Risk } \underline{R} = \sum_{i=1,j=1,k=1}^{n\ \ n\ \ n} w_i H_i * (\alpha_{i\,j\,k}) w_j V_{ij} \qquad \textbf{(5)}$$

2. GENERAL METHODOLOGY

The process of determining the physical and social vulnerability of the City of Manila (Figure1) initially identifies the nature, extent and risk of threat in the city. The degree of vulnerability is then determined based on

the socio-economic conditions and geographical factors that affect the community's ability to respond to events. Information was primarily determined from surveys among residents and interviews with the barangay heads. Two conditions were studied - the physical and social vulnerability of the area. Factors considered in assessing the physical vulnerability include: the geographical pattern of the severity of hazard(s), the spatial distribution of affected groups, the numbers, density and population distribution, special characterization of population groups, the effect of local conditions and capabilities in modifying the effects of the hazard. A quantification of the social aspects of disaster vulnerability-which considers the ability of the community to cope with the impending disaster followed.

3. QUANTIFICATION

The quantification (or qualification) of the social aspects of risk involves many steps and are discussed below. The following sub-sections reveal the quantification process.

3.1 Categorizing Individuals, Groups to Vulnerabilities and Risks

Among the concerns involved in vulnerability analysis is assigning individuals or communities to a certain vulnerability or risk criterion. Different scales of issues were established based from a review of damage reports, interviews and surveys, common observations from which the elements considered may be categorized and scored. These issues were then correlated to a range of consequences (e.g. damage to property, injury to person, the potential disruption to a person's livelihood) that had resulted or could result from (possibility or potential) being exposed to a particular hazard (e.g. flooding, typhoon, ground shaking, liquefaction).

3.2 Criterion

Establishing criterion means providing a basis for a decision that can be measured and evaluated. The damage reports, interviews and surveys, observations provided the evidence upon which an individual or community may be assigned in a category. Examples of criteria matrices may be seen in the tables below. Column 3 of the tables shows the range of the scale considered for the factor. Column 2 shows the ranking of the issues and column 1 shows the values used to score a response.

3.2.1 *Effect of Livelihood/Income to Vulnerability*

The respondents were asked about the nature of their work, the lost income they experienced or perceive during a calamity, the availability of savings and the consequence or consequences to their livelihood. A scale of issues and the corresponding scoring may be in Table 1 below.

Table 1: Effect to Livelihood/Income to Vulnerability

No.	Description	Descriptions to Consider
0	**No Effect**	Savings are available, Livelihood not affected by event,
1	**Slight Effect**	Savings available for use, Hazard slightly affecting work performance and corresponding income
2	**Minor Effect**	Savings may be available for use, hazard affects work performance, a lost work day, Savings and/or earnings of a business are lost, Hazard affecting work performance, a lost work day or transaction
3	**Disruptive effect**	Continuous exposure to hazard creates difficulty/ a burden for the person or group, Daily wage earner affected by natural events (construction worker, driver, vendor), No savings available for use, Savings and/or earnings from business are lost. Takes a few days to fully recover lost deals
4	**Major Disruptive Effect**	Daily wage earner, affecting work performance in the longer term, such as prolonged absence from work Possibly affecting business, hazard creates a longer term problem to the business
5	**Irreversible Damage or effect to Livelihood**	Practically difficult to recover, loss of job or loss of business because of hazard

3.2.2 *Condition of Health and Capability to Get Medical Treatment*

The questions on these items pertain to health concerns of the family. Are there health concerns in the family that may compromise their safety? Are there family members who may require assistance or need care (e.g. children, old folks)? Other items in the survey are the following: Availability of savings to address "emergency" expenses, capacity to avail services of the hospitals, or health centers (public or private), ownership of a health insurance (national, private), and capability to get financial support from other people, among others. For rating the individual, the following scoring was devised.

Table 2: Capacity to Get Medical Attention and Insurance Availability

No.	Description	Descriptions to Consider
0	**Very capable to get medical attention**	Can get services from most private hospitals. Owns an insurance policy and national health insurance. Most likely to have savings to pay for expenses even for serious injuries
1	**More than Capable to get medical attention**	Can get services from private or public hospitals. May or may not own an insurance policy but owns a national health insurance. Savings are substantial to cover major injuries.
2	**Capable to get medical attention**	Most of the time goes to public hospitals but c get services from private hospitals. Does not own an insurance policy but owns a national health insurance. Savings are limited to cover minor injuries.
3	**Moderately capable capacity to get medical attention**	Mostly get services from public hospitals or health centers. Does not own an insurance policy nor own a national health insurance. Savings are limited to cover emergencies involving minor injuries. The range of medical services needed may or may not be offered by the public hospital
4	**Limited capacity to get medical attention**	Mostly get services from public hospitals or health centers. They have no national health insurance and nor savings to cover emergencies. The range of medical services needed may not be offered by the public hospital nor by health center
5	**Cannot get medical attention at all**	Does not bother to seek medical attention because of condition, no financial capacity, gets services mainly by charity.

3.3 Multi Criteria Evaluation

In this study, the scoring involves step criteria using a numeric range “0” to “5”. The scores are combined using aggregation and simple averaging

procedures. A weighted linear combination of factors can be made by applying weights to each factor. The results give a social vulnerability index to a certain physical vulnerability.

$V = \Sigma w_i v_i$ where V = vulnerability
w_i = weight of factor i
v_i = criterion score for vulnerability factor i
or criterion score for safety factor i

The usefulness of this index is in the weights established to each criterion that shows which aspect is contributing more to the social vulnerability issue in the community studied.

3.4 Criterion Scoring

It is necessary that factors be standardized before combining them in the risk equation. The easiest is to use the maximum and minimum values as scaling points. This linear scaling may give

$X_i = (R_i - R_{min})/(R_{max} - R_{min})$ * standardized range where R = raw score

For example, in a zero to five (0-5) scale, if a factor receives a raw score of 4, then in a standardized range of 0 to 1, this would be (4-0)/ (5-0) = 0 .8.

3.5 Criterion Weights

Assigning criteria weights in this study makes use of a simple pairing procedure utilizing a nine(9) step scale indicating the relative scale of importance. The rater selects a factor and places it as a standard issue giving it a value of one (1). The individual or group makes every possible pairing with the standard issue using the scale given.

1/9	1/7	1/5	1/3	1	3	5	7	9
extremely	very strongly	strongly	moderately	equally	moderately	strongly	very strongly	extremely
Less important?				*standard*	More important?			

A normalized scale of importance is obtained by dividing each score by the highest rated factor considered. This provides a normalized score of each factor relative to the most important factor (having a score of 1). To establish a weight among the normalized scores, the sum is taken and the weights are obtained by dividing the normalized scores by their sum.

4. SUMMARY RATINGS IN THE CITY OF MANILA

4.1 Scoring the Responses

The scores based from the responses of the barangay captains are given in Table 3.The responses of the local chiefs or barangay captains and the information obtained from the various agencies formed the basis for the scoring. The response for each barangay was scored for each factor considered. The scores for a factor were then summed up and divided by the number of respondents. Modifications of the scores or re-scoring could also be done depending on additional information on the factor. The scale carries with it the following meaning: A zero (0) score connotes little membership in the aspect of vulnerability considered. A score of five (5) connotes greater membership in the factor considered that leads to vulnerability. High average scores would mean conditions are less ideal (greater vulnerabilities or risks posed). Table 4 shows the scores from aggregated individual interviews.

Table 3: Summary Scores based on Barangay Interviews

Factors	**Scores**	**Range**
Effect on Livelihood/Income	2.673	0-5
Hazard to Person	1.06	0-5
Damage to Property	1.02	0-5
Barangay Organization/Preparation to Disaster	3.46	0-5
Social Support During Disaster	2.67	0-5
Communications, Logistical Support	4.38	0-5

Table 4: Summary Scores Based on Individual Interviews

Factors	**Scores**	**Range**
Effect on Livelihood/Income	2	0-5
Capacity to get Medical Treatment	1.225	0-5
Social Support During Disaster	2.85	0-5
Hazard Effect Damage to Property (Typhoon and Flood) District1 and 4=2, Districts 2, 3, 5 and 6 = 3	3.	0-5
Hazard Effect Damage to Property (Earthquake) District 2,3, 4 and 5=2 District 1 and 6=3	3	0-5
Hazard Consequence to Person (Typhoon and Flood) District1,4, and 6 =2, District 2,3 and 5=2	2	0-5
Effect of Building Code to Safety	2	0-5

4.2 Interpretation of Responses

In view of the discussions and considering the above scores, the more important aspects of social vulnerability of the barangays, are the following factors : the enforcement of the building code (α11), social support during disaster (α12), city/barangay organization and preparation to disaster (α13), Effect of livelihood and income (α14), and occupancy, land use issues(α15).

The weighing scheme for the City of Manila is as follows. The income and livelihood issue was taken as the standard as most response indicates that an improvement in this factor will be helpful in preparing themselves against any disaster. The importance of other factors relative to this item is shown below. The contributor and the group who conducted the survey mainly assigned the weights. A better scheme would involve the administrators providing the scores and assigning the weights.

Table 5: Weighing Results

1/9	1/7	1/5	1/3	1	3	5	7	9
extremely	very strongly	strongly	moderately	equally	moderately	strongly	very strongly	extremely
Less important?				*standard*	More important?			
				(α_{11})				
			(α_{12})					
			(α_{13}=1/2)					
				(α_{14})				
					(α_{15}=2)			

In the table above, The highest score is 2 and a normalized weight of importance reveal that stronger enforcement of building code (α11) = 1/2 = 0.5, social support (α12) =1/3 /2 = 0.166, barangay organization and preparation to disaster(α13) =1/2/2 = 0.1, issue of income/livelihood to cope with disaster(α14)= 1/2= 0.5, and solving land issues and occupancy(α15) = 2/2 =1. The sum of the normalized scores is 2.266. Dividing each of the weights by this sum, the relative weights of importance of each issue are w(α11)=0.221, w(α12)=0.073, w(α13) = .044, w(α14) =.221, w(α15)=. 441. The sum of w(α11 to α15) is 1.0.

Based on the evaluations of the researchers on the responses, the quantification process reveal that the social vulnerability issues important in risk assessment are livelihood and income availability, enforcement of the building code and occupancy issues/problems of legal/ illegal structures.

While the evaluations and results are preliminary in nature, the process may be used with various stakeholders providing the responses. This would provide a more accurate picture of the social issues in the City of Manila

5. USES IN THE RISK EQUATION

If the social factors are included in the risk equation, then,

$$\textit{Total Risk } \underline{R} = \Sigma_{i=1,j=1,k=1}^{n\ \ n\ \ n}\ w_i H_i * (\alpha_{ijk}) w_j V_{ij}$$

And assuming that we are considering a single hazard flooding H=0.4 and a single physical vulnerability Vp = 0.35, then the risk may be set up in the following form using the results of the above sample problems. Given that stronger enforcement of building code (α11) = 0.5, social support (α12) =0.3, barangay organization and preparation to disaster (α13) =0.6, issue of income/livelihood to cope with disaster (α14)= 0.5, and solving land issues and occupancy (α15) =0.7, we have a Risk Index of a particular sub-area of

Risk $\underline{R}$ = H_1 * (α_{ijk} = social vulnerability index (α_1) =0.221(α_{11}) + 0.073(α_{12}) + 0.044(α_{13}) + 0.221(α_{14}) + 0.441(α_{15})**) *V_{p1}**

Risk $\underline{R}$ = 0.4 * (α_{ijk} = social vulnerability index (α_1) =0.221(0.5) + 0.073(0.3) + 0.044(0.6) + 0.221(0.5) + 0.441(0.7)**) *.35**

Risk $\underline{R}$ = 0.4 * (α_{ijk} = 0.578**) *.35 = 0.0809**

Experts in various fields of engineering and sciences, among others, may provide for the qualification and quantification of the hazards, the hard and soft vulnerabilities and how this formulation may be improved further in numerical form or in graphical form- as in the use of colors to denote categories in a GIS format.

6. CONCLUSIONS

The approach presented considers the inclusion of the social aspect of vulnerability as critical in risk assessment. A methodology was proposed to quantify social vulnerability that may be used by planners together with experts in the physical and social sciences. Much of the premise in the criteria formulation was based on the characteristics of the City of Manila and more validation is needed to check and establish its validity in other places. Though it is expected that the socio-economic and physical conditions are different in different cities of the country, the approach appears useful in its numerical form or in (graphical format). The experts in the arts and sciences may recommend finer points to this quantification process to make the scheme more robust.

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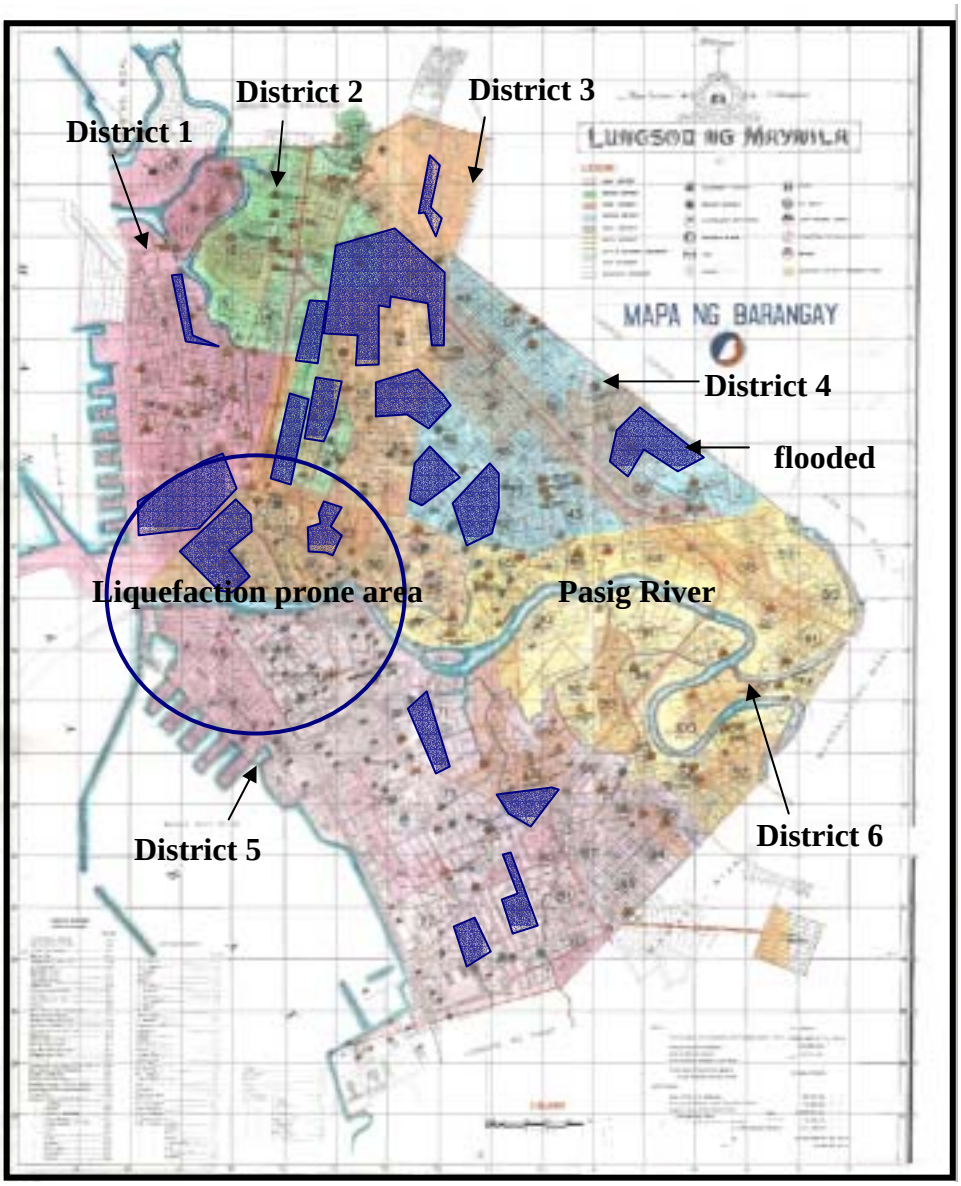

Figure 1: A Map of the City of Manila. Important institutions (appear as spots) are dispersed over the city. Most of the persons and properties vulnerable to flooding and typhoon are generally located along small rivers " esteros" and near the coast of Manila Bay. Generally flooded interior areas are shown above (shaded). Most of the damages to buildings in previous earthquakes are experienced in areas near the mouth of the Pasig River and along the coast of the Manila Bay area.