A Measurement of Community Disaster Resilience in Korea

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Disaster resilience is increasingly recognized as an essential community's capacity to withstand and recover from a hazardous event. More disaster resilient community often experiences less disaster impact and reduces long recovery periods after a disaster. Building a resilient community to disasters has become one of the main goals of disaster management to absorb and mitigate negative disaster impacts. This study examines the degree of community's resilience to natural disasters in Korea. This study provides a set of indicators to measure community's disaster resilience in terms of human, social, economic, environmental, and physical vulnerability and capacity aspects. This study develops a methodology to aggregate constructed disaster resilience index of local communities in Korea. 229 local municipalities are examined to measure their disaster resilience. Geographic Information System (GIS) is also used to analyze and visualize spatial distribution of disaster resilience. Moreover, the aggregated community disaster resilience index is used to examine a relationship with disaster losses in Korea. This study shows the geographic variation of disaster resilience across the country. Identifying the extent of community resilience to natural disasters within the framework of human, social, economic, environmental, and physical vulnerability and capacity would provide disaster management officials or decision-makers with strategic directions how to improve their communities' resilience to natural disasters and to reduce the negative disaster impacts.

Keywords: *Community resilience, natural disasters, assessment methodology, GIS*

Introduction

Korea has experienced continuous increase of economic losses caused by natural disasters. Natural hazards caused over $41 billion in property damage and nearly 10,000 deaths over the past half century period (National Disaster Information Center (NDIC), 2012). Figure 1 shows the geographic distribution of damages and fatalities from all hazard types from 1995 to 2010 at local municipal level. This figure shows that most regions are susceptible to natural hazards in Korea. This is in part due to concentration of people and development in vulnerable areas to natural disasters. It is exacerbated by the climate change causing increase of frequency and intensity of natural disasters.

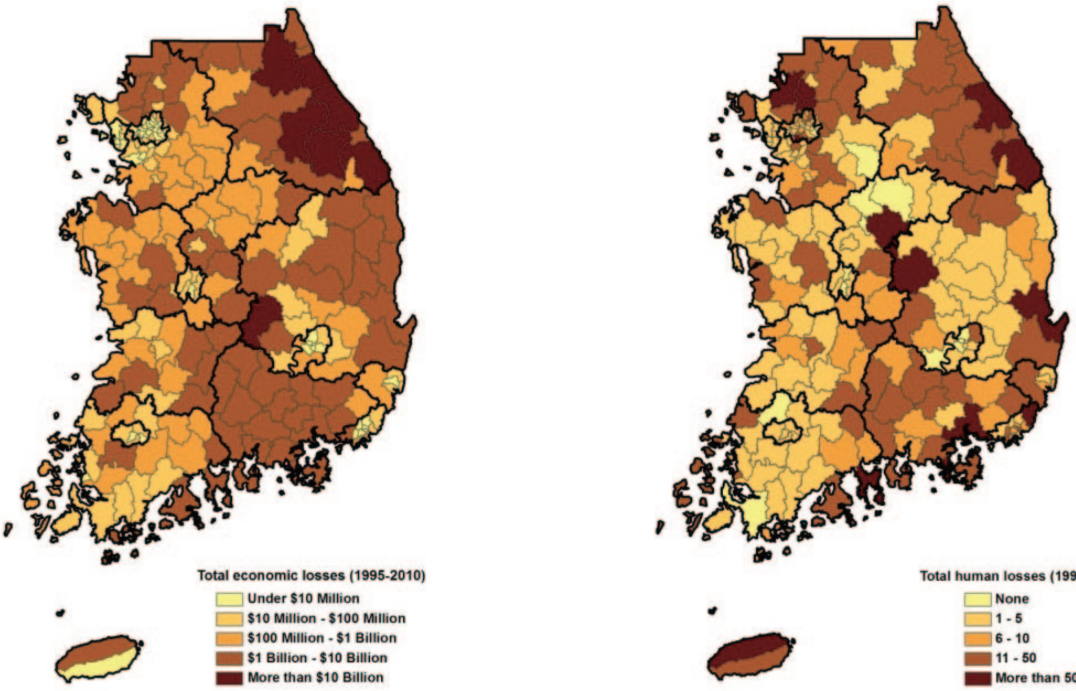


Figure 1. Trends in losses from all hazards, 1995-2010. (a) damages and (b) number of deaths. (Source: National Disaster Information Center (NDIC))

In order to reduce losses from natural disasters, the Hyogo Framework for Action (HFA) requires actions to build the resilience of nations and communities to disasters by 2015 (United Nations International Strategy for Disaster Reduction (UN/ISDR, 2005). To attain a disaster resilient community for reducing disaster damages, the HFA asks to adopt the following three strategic goals: (1) the integration of disaster prevention, mitigation, preparedness, and vulnerability reduction considerations into sustainable development policies, planning and programs; (2) the strengthening of local capacities to build hazard resilience; and (3) the incorporation of risk reduction into of emergency preparedness, response, recovery, and reconstruction programs in affected communities (UN/ISDR, 2005).

Disaster resilience is increasingly recognized as an essential community's capacity to withstand and recover from a hazardous event. Building a resilient community to disasters has become one of the main goals of disaster management to absorb and mitigate negative disaster impacts. While researchers and practitioners in hazard and disaster management filed have been a growing interest in the disaster resilience and intended to employ this concept to policy development, there are little or no empirical studies in Korea. Therefore, this study defines the concept of community disaster resilience which is proper for Korean disaster management.

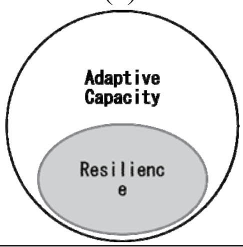
This study develops a disaster resilience working definition based on the literature review and a conceptual framework in which disaster resilience indicators can be identified. For applying the concept of disaster resilience to the real world, the concept needs to be measured. For this measurement, this study develops a systematic and theoretically driven index for measuring community disaster resilience in Korea. Community Disaster Resilience Index(CDRI) is measured by a set of indicators in terms of human, social, economic, environmental and physical aspects. This study also examines the relationships between the community disaster resilience and disaster damages to find what factors affect community disaster resilience level. Finally, this study presents the general discussion of the results and conclusions.

Conceptual framework of community resilience to natural disaster

Building the disaster resilient communities to reduce disaster losses becomes a prominent goal after 168 countries endorsed the Hyogo Framework for Action in 2005. Measuring the degree of the resilience of communities is an important step to make strategies and actions to attain disaster resilient communities and to implement disaster risk reduction. In order to assess clear and realistic disaster resilience of communities, the development of theoretical and conceptual framework of community disaster resilience is an essential process.

After Holling (1973) introduced the concept of resilience in the field of ecology as a "measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables (Holling, 1973)," numerous definitions and conceptual frameworks of resilience have been developed and applied in the field of hazard and disaster over the past years (Timmerman, 1981; Wildavsky, 1991; Clark et al., 1998; Comport et al., 1999; Godschalk et al., 1999; Mileti, 1999; Buckle et al., 2000; Burby et al., 2000; Paton et al., 2000; Klein, Nicholls, & Thomalla, 2003; Pelling, 2003; Walter, 2004; UN/ISDR, 2005; Manyena, 2006; Paton and Johnston, 2006; Maguire and Hagan, 2007; Tierney and Bruneau, 2007; Twigg, 2007; Cutter et al. 2008). However, despite multiple definitions and conceptual frameworks, it reveals that there is no single agreed upon definition of disaster resilience in the field of hazards and disasters among researchers and practitioners (Klein et al., 2003; Manyena,2006; Cutter et al., 2008).

Table 1. Conceptual linkages among resilience, vulnerability, and adaptive capacity

<table>
<tr><th>Themes</th><th colspan="6">Types of conceptual linkages</th></tr>
<tr><td rowspan="2">Resilience vs. Adaptive Capacity</td><td colspan="3">(a)

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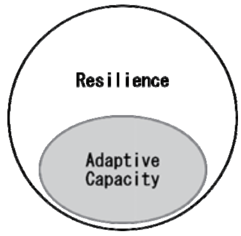
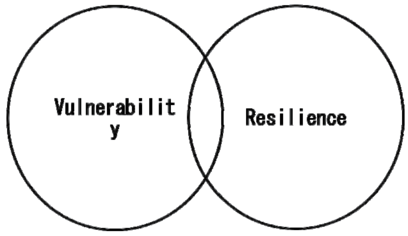
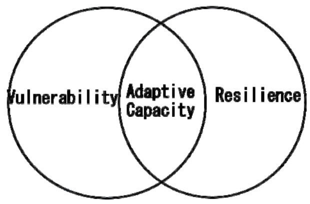
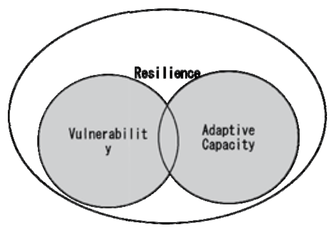

</td></tr>
<tr><td colspan="3">Adger, 2006; Birkmann, 2006; Folke, 2006</td><td colspan="3">Bruneau et al., 2003; Paton and Johnston, 2006; Tierney and Bruneau, 2007</td></tr>
<tr><td rowspan="2">Resilience vs. Vulnerability</td><td colspan="3">(c)

</td><td colspan="3">(d)

</td></tr>
<tr><td colspan="3">Manyena, 2006</td><td colspan="3">Cutter et al., 2008</td></tr>
<tr><td rowspan="2">Resilience vs. Vulnerability vs. Adaptive Capacity</td><td colspan="2">(e)

</td><td colspan="2">(f)

</td><td colspan="2">(g)

</td></tr>
<tr><td colspan="2">Turner et al., 2003; Gallopin, 2006</td><td colspan="2">Engle, 2011</td><td colspan="2">Yoon and Kang (Proposed)</td></tr>
</table>

Note: Diagrams of conceptual linkages are adapted and revised from Cutter et al. (2008)

Table 1 indicates the types of conceptual relations of the resilience. Table 1 shows many authors have defined the concept of resilience in a variety of ways. However, despite their diversities of definitions, two common elements are found in defining the concept of disaster resilience. Adaptive capacity and vulnerability are used by most of the authors as key themes to conceptualize disaster resilience in hazard and disaster research domain. Adaptive capacity is described as an ability of actors in the system to manage scarce resources to respond to perceived or current stress (Engle, 2011). Vulnerability, broadly defined as "susceptibility to harm, has its roots in hazards-risks research, with geography, poverty and development, food securities, and political ecology also influencing its conceptual development (Eakin and Luers, 2006)."

Some researchers defines resilience is an integral part of adaptive capacity (Figure 1(a))

(Adger,2006; Birkmann,2006; Folke, 2006) while other researchers embed adaptive capacity within resilience (Figure 1(b)) (Bruneau et al., 2003; Paton and Johnston, 2006; Tierney and Bruneau, 2007). Figure 1(a) indicates that adaptive capacity is a broader concept than resilience while others view resilience is a broader concept than adaptive capacity (Figure 1(b) and Figure 1(e)). Manyena (2006) and Cutter et al. (2008) define resilience associated with vulnerability. Manyena (2006) views resilience as nested concepts within a vulnerability structure (Figure 1(c)) while Cutter et al. (2008) sees resilience is separated from vulnerability, but linked concept (Figure 1(d)). Turner et al. (2003), Gallopin (2006), and Engle (2011) define resilience connecting with adaptive capacity and vulnerability, albeit they differently conceptualized connection. Engle (2011) expands upon Cutter et al. (2008)'s concept of resilience and defines that vulnerability and resilience are separated, but linked through adaptive capacity (Figure 1(f)).

From previous concepts of resilience, the authors (Yoon and Kang) view disaster resilience as a broader concept than vulnerability and adaptive capacity and vulnerability and adaptive capacity as separate but linked concept (Figure 1(g)). The authors define the concept of disaster resilience that encompasses the interrelationship between community's vulnerability to hazards and community's ability to absorb, cope with disaster impacts, and bounce back in a relatively rapid fashion. Disaster resilience is understood as the flip side of vulnerability (Paton & Johnston, 2006) and adaptive capacity is the positive dimension of the concept of disaster resilience (Engle, 2011). Disaster resilient community implies that a community has the capacity to cope with a disaster by reducing its vulnerabilities and exploiting its capacities. So it could be said that the degree of disaster resilience could be determined by the degree of capacity and the degree of vulnerability to disasters (see the following equation).

$$Degree\ of\ Disaster\ Resilience = \frac{\text{Degree of Capacity}}{\text{Degree of Vulnerability}}$$

This equation indicates that disaster resilient communities are less vulnerable to disasters and more capacity to cope with disasters than less resilient communities (Klein et al., 2003).

Community disaster resilience model

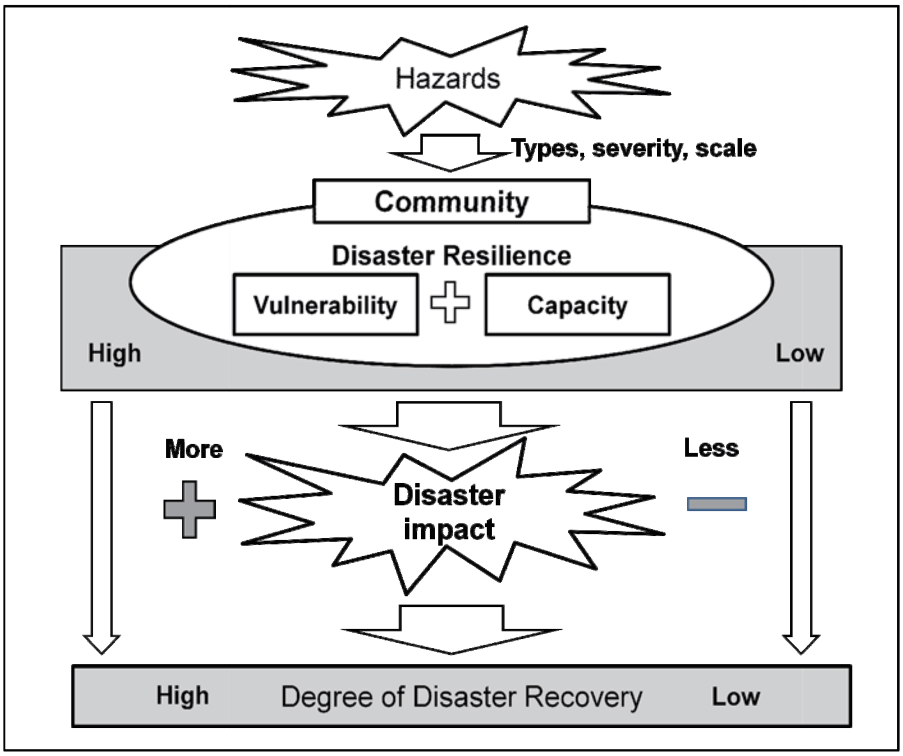


Figure 2. Community disaster resilience model

Figure 2 presents the relationship among natural hazards, community disaster resilience, and disaster impacts. A natural hazard event turns a disaster when the natural hazard event affects people and place of community causing human and economic losses. Community's conditions interact with the hazard event characteristics to produce disaster impact. The degree of disaster impacts producing human and economic losses depends on the hazard event characteristics and the degree of community disaster resilience. The natural hazard event characteristics include hazard types, frequency, magnitude, and scale (Cutter et al., 2008). Along with the hazard event characteristics, the degree of disaster impacts and disaster recovery process are vary depending on the degree of community disaster resilience. The disaster damages are decreased or increased by the degree of community resilience. When a hazard event with the same characteristics affects several communities with the different disaster resilience conditions, the more resilient community are less likely to have the negative disaster impacts compared with the less resilient community. Moreover, the more resilient community in terms of vulnerability and capacity, higher rates of the recovery are reached quickly.

The community disaster resilience, as a multi-dimensional concept, encompasses the integrated vulnerability and adaptive capacity of people and place of a community. Therefore, the degree of community disaster resilience are determined by the degree of vulnerability and capacity of people and place that integrates various community attributes including human, social, economic, physical, and environmental dimension (Figure 3) .

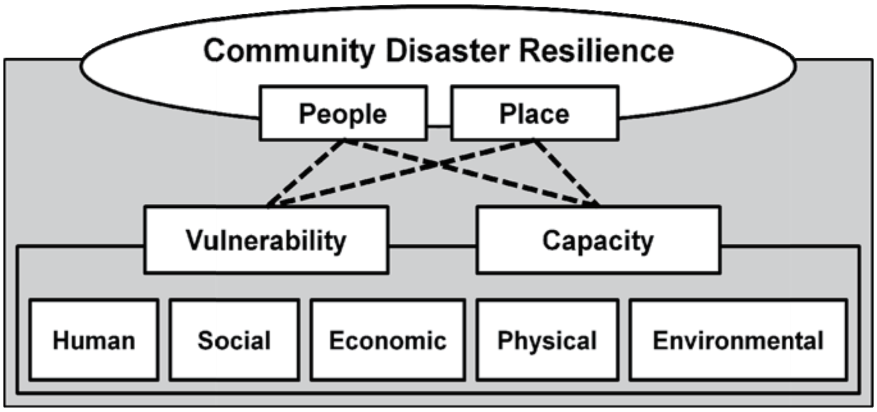


Figure 3. Dimension of community disaster resilience

The following section describes in detail the measurement methods to quantify the community disaster resilience including the selection of disaster resilience indicators in terms of including human, social, economic, physical, and environmental vulnerability and capacity aspects, the mathematical aggregation methods to combine the indicators, and the approaches to calculate the community disaster resilience index and scores for visualize the level of community disaster resilience in Korea.

Methodology

This study employs an index to measure community resilience. In general, an index is composed of several indicators combined using some mathematical formula. An indicator is defined as a variable hypothetically linked to a phenomenon studies which cannot be directly measured (Chevalier et al., 1992) or defined as a proxy measure of some abstract and multidimensional concept (Wong, 2001). Indices are commonly used by both researchers and practitioners because of some advantages. First of all, indices can summarize complex and multi-dimensional aspects. Also, indices are summarized from more complicated and massive data into a simple way and they are easily understandable ways for both experts and non-experts. Third, indices are effective tool in communicating with decision-makers and the public due to their simple and clear representation. Fourth, indices are useful to compare performance and progress in a longitudinal or cross-sectional method.

Indicators are often used in the field of disaster and hazard research. The Social Vulnerability Index (SOVI), the Disaster Risk Index (DRI) and the Earthquake Disaster Risk Index (EDRI) are well-known examples and these indicators are very effective as tools for planning and management in developing policies and facilitating resource allocation (Mayunga, 2009).

As mentioned before, community disaster resilience is a multi-dimensional concept that encompasses human, social, economic, physical and environmental aspects and needs to compare resilience across cities. So, in this research, method of an index and indicators were selected for measuring and comparing their disaster resilience.

Construction of an index requires several steps. The following steps take place in this study. First, we developed a theoretical research framework based on literature review for selecting indicators. The theoretical framework was described in the previous section. Second, we identified proper indicators by each dimension. The proxy variables for representing the indicators were collected from readily available community-level socioeconomic, demographic and spatial data. We initially picked about 45 variables that we believe are associated with community resilience to disaster risk. Third, we lastly selected set of indicators for measuring community disaster resilience after examining the internal consistency of individual indicators within the sub-index. The internal consistency can be measured by the reliability test of a Cronbach's Alpha. A Cronbach's Alpha measures how well each indicator in a dimension is correlated with the sum of the remaining indicators. This test suggests not only their performances in terms of internal consistency but also help to examine whether the sub-indices had adequate precision (Norusis, 2005; Mayunga, 2009). Some indicators with low statistics were dropped and 24 indicators were met the criteria of acceptable reliability test level (greater than 0.7).

Table 2. The final set of selected indicators

Dimension	Indicator	Direction to CDRI
Human Aspect	Percent of population over 65	negative
	Percent of female	negative
	Percent of the disable	negative
	Percent of single family household with children	negative
	Percent of one person household	negative
	#of disaster manager per capita	positive
Social Aspect	# of health and medical business	positive
	Budget of volunteer organizations	positive
	# of registered volunteers	positive
	# of volunteer organizations	positive
	Community rating score on disaster safety	negative
Economic Aspect	Total budget per capita	positive
	Safety budget per capita	positive
	Disaster relief funding	positive
	Amount of tax collected per capita	positive
Physical Aspect	Percent of aged housing over 30 years	negative
	Rural or Urban	positive
	Percent of impervious surface	negative
	Dam capacity	positive
	Housing density	negative
Environmental Aspect	Average slope	negative
	# of rainy days	negative
	# of days over 80mm	negative
	Average elevation	negative
	Frequency of natural disaster (2001-1020)	negative

Table 2 represents 24 indicators which are categorized into five aspects. Each aspect has different number of indicators from 4 (economic and physical dimensions) to 6 (hu man dimension). Table 3 shows the Cronbach's alpha coefficient of five aspects. The hig hest coefficient is revealed by social aspect indicators (alpha = .851), followed by huma n aspect (alpha = .816), environmental aspect (alpha = .755), physical aspect (alpha = .7 39), and economic aspect (alpha = .737). Table 3 describes that these sub-indices indicates a relatively high level of internal consistency, which means that these measures are reliable.

Table 3. Reliability test result

Dimension	# of indicators	Cronbach's alpha
Human Aspect	6	.816
Social Aspect	5	.851
Economic Aspect	4	.737
Physical Aspect	5	.739
Environmental Aspect	5	.755

The fourth step is the process for calculating the sub-indices and the compose index (community disaster resilience index). For doing this, we normalized, standardized the indicators and then aggregated to compose them. Some variables which do not show the normal distribution were normalized in order to avoid the impacts of extreme values and potential statistical problems. Because indicators are in a variety of units such as won and percentage, it is imperative to standardize them before they are aggregated to a composite index. This study chose the z-score method for standardizing indicators which is one of most commonly used methods. The z-score can be calculated as follows;

$$\mathrm{Z-Score} = \left(\frac{\mathrm{Actual\ Value} - \mathrm{Mean\ Value}}{\mathrm{Standardized\ Deviation}}\right)$$

And then, sub-index of each dimension was created by calculating an average score using the following equation.

$$\mathrm{HI} = \frac{\sum_{i=1}^{N} Z}{N}$$

Where:
HI = sub-index of human dimension
Z = standardized score of an indicator
N = number of indicators of each dimension

The Community Disaster Resilience Index (CDRI) developed to compare the level of resilience of local communities, is a composite of five separate sub-indices: Human, Social, Economic, Physical and Environmental dimensions. The CDRI is an arithmetic mean score of five sub-indices.

$$\text{Community Disaster Resilience Index (CDRI)} = \frac{\text{HI} + \text{SI} + \text{EI} + \text{PI} + \text{EVI}}{5}$$

Where:
HI = sub-index of human aspect
SI = sub-index of social aspect
EI = sub-index of economic aspect
PI = sub-index of physical aspect
EVI = sub-index of environmental aspect

This study created maps of sub-indices and the CDRI to present spatial distribution. In addition, we made the LISA cluster maps for representing hot spots and cool spots based on Moran's I spatial autocorrelation statistic. The high-high and low-low scores suggest clustering of similar values, whereas the high-low and low-high areas suggests spatial outlier. The hotspot indicates high resilience clusters with high resilient neighborhood from disaster. The GIS process using ArcGIS software was used for these works.

Furthermore, this study conducted a simple correlation to examine the relationship between property damage caused by natural disasters and level of community disaster resilience measured by the CDRI. In addition, we conducted an OLS (Ordinary Least Squares) regression model to assess the impact of each sub-index on actual property losses from 2001 to 2010. As mentioned earlier, community resilience is a critical community's capacity to absorb and mitigation negative disaster impacts such as property damage and human loss. Thus, we believe that communities with higher resilience will lead to lower property damage. We tested this hypothesis and identified significant aspects influencing property damage in Korea.

$$\text{Ln}(y) = \beta_0 + \beta_1 HI + \beta_2 SI + \beta_3 EI + \beta_4 PI + \beta_5 EVI + \varepsilon$$

Where:

Ln(y) = natural log of property damage per capita

The study area is the entire South Korea and analysis unit is local jurisdiction which is called as *Sigungu* in Korea. This study includes 229 *Si/gun/gus* (unit of analysis for this study, local jurisdiction) which cover the entire Korea

Results

Assessing Community Disaster Resilience in Korea

This study assessed community disaster resilience using index and indicators method and then we investigated their spatial distribution to find where is needed more attentions. The mean score of the CDRIs of 229 local jurisdictions is 0.00 and the top five local jurisdictions are Seongnam-si (1.66), Changwon-si (1.39), Suwon-si (0.48), Gangnam-gu (1.16), Ansan-si (0.90).

Table 4. Top five and bottom five local jurisdictions on the CDRI scores

Rank	Name	HI	SI	EI	PI	EVI	CDRI
1	Seongnam-si, Gyeonggi-do	0.41	2.71	4.66	0.23	0.31	1.66
2	Changwon-si, Gyeongsangnam-do	0.29	2.70	3.59	0.37	0.03	1.39
3	Suwon-si, Syeonggi-do	0.51	2.98	2.27	.-0.17	0.48	1.24
4	Gangnam-gu, Seoul	0.66	3.23	2.14	-0.43	0.66	1.16
5	Ansan-si, Gyeonggi-do	0.39	1.26	2.02	0.40	0.18	0.90
225	Pyeongchang-gun, Gangwon-do	0.08	-0.65	-0.32	-0.70	-1.84	-0.69
226	Boseong-gun, Jeollanam-do	-1.55	-0.71	-0.39	-0.39	-0.54	-0.72
227	Gurye-gun, Jeollanam-do	-1.12	-0.57	-0.55	-0.35	-1.07	-0.75
228	Sancheong-gun, Gyeongsangnam-do	-0.74	-0.75	-0.50	-0.23	-1.74	-0.79
229	Sinan-gun, Jeollanam-do	-1.43	-0.86	-0.38	-0.55	-1.77	-0.99

As listed in Table 4, Seongnam-si in Gyeonggi-do, which is surrounding province of Seoul, is the most resilient community in this assessment with very high scores particularly in economic and social aspects. Gangnam-gu is located inside Seoul and well known as wealthy community indicating comparatively high scores in social and economic dimensions.

Figure 4. Administrative map of Korea (2012)

Seongnam-si, Suwon-si, Ansan-si are nested in Gyeonggido neighboring province of Seoul. Thus, most of top resilient communities except Changwon-si are located in Seoul Metropolitan Area. This result suggests that resources and capitals in terms of human, social and economic aspects are tended to concentrate in these areas and made communities more resilient to natural disasters. In contrast, Sinan-gun, Sncheong-gun, Gurye-gun, Boseong-gun and Pyeongchang-gun are bottom communities of CDRI scores. Sinan-gun is the least resilient community in this assessment and this community has comparatively lower scores in environmental and human aspects due to natural location of island and rural demographic characteristics with a high portion of vulnerable populations. Most communities of bottom listings are comparatively rural and small jurisdictions with not only often exposure to natural disasters and but also small resources and capitals.

Figure 5 displays the overall spatial distribution of the CDRI scores and Figure 6 indicates the hot spot and cold spot clusters with significant local Moran I statistic. The hot spot clusters (high resilience in a high resilience neighborhood) are located in the southern part of Seoul and most Gyeonggi-do jurisdictions. Interestingly, there was a significant difference of disaster resilience scores among communities nested in Seoul. Whereas most northern jurisdictions of the Han-river inside Seoul were not included in hotspot, most southern jurisdictions were contained in the hotspot cluster. This finding suggests that the northern communities are more vulnerable and have lower capacities to respond and recovery to natural disasters than the southern communities even if they are nested in Seoul. Most local jurisdictions in Gyeonggi-do show relatively high resilience scores across human, economic, social and environmental aspects.

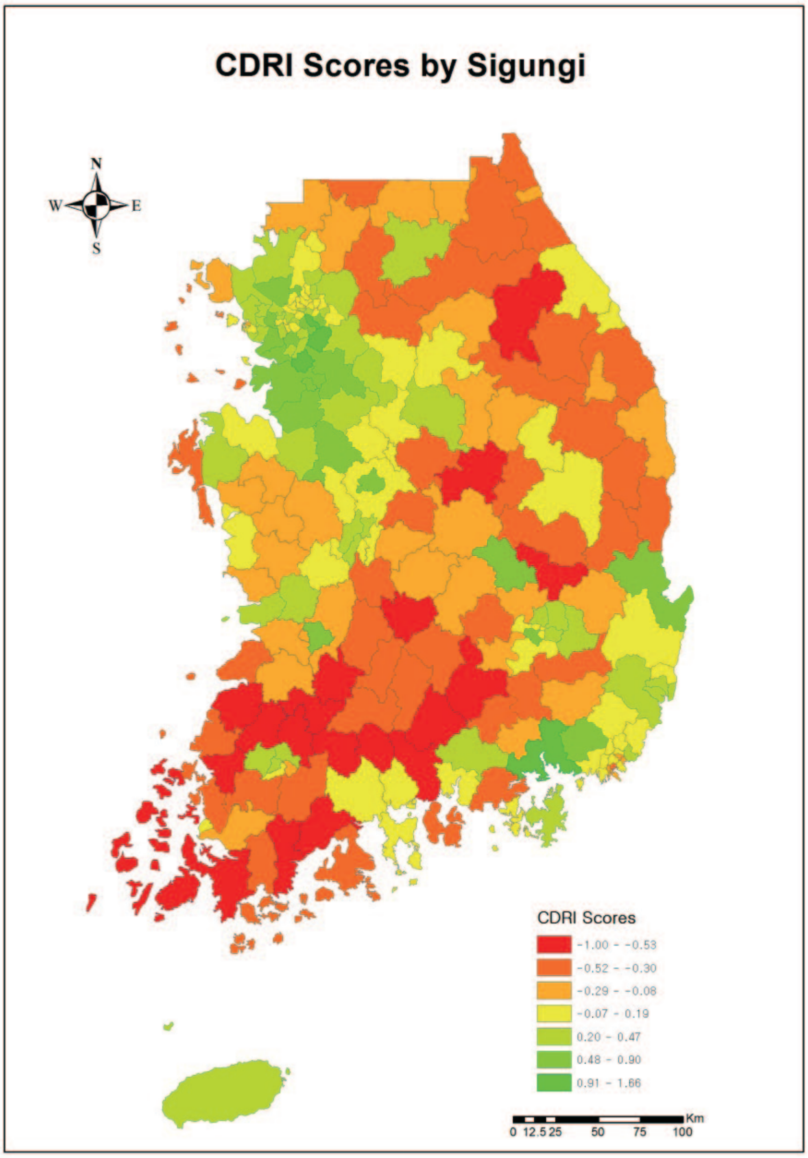


Figure 5. Spatial distribution pattern of CDRI scores

There exist two large cool spot clusters with low disaster resilience score surrounded by similar jurisdictions with low resilience scores (Figure 6). The first cluster of cool spots includes many local jurisdictions of Jeollanam-do and some communities of Jeollabuk-do and Gyeongsangnam-do. Most communities of Jeollanam-do, a province located in southwestern region of Korean peninsula, have a fairly low level of disaster resilience particularly in human and social dimensions. This result indicates that this region has the larger vulnerable population such as the old, women and the handicapped and less participation and involvement in social groups and civic engagement than other areas.

The other cool spot cluster of low resilience includes many local jurisdictions of Kangwon-do (Pyeongchang-gun, Samcheok-si, Yangyang-gun, Inje-gun, Goseong-gun) and some communities of Gyeongsangbuk-do (Uljin-gun, Bonghwa-gun, Yeongyanggun). This region is mountainous terrain and faces the East Sea. These topographical characteristics cause in particular less resilience in environmental dimension.

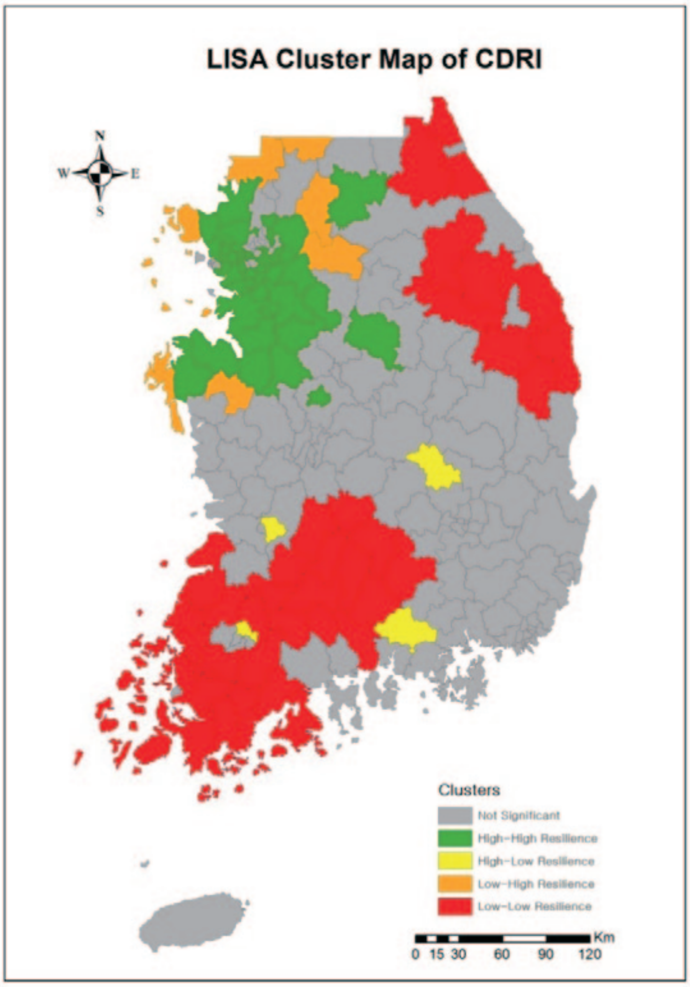


Figure 6. LISA cluster map of CDRI

Impacts of Community Disaster Resilience on Property Damage

We have a belief that communities with higher disaster resilience measured by the CDRI might have less loss because resilient communities have the ability to cope with a disaster with minimum impact and damage. To test this hypothesis and usefulness of the CDRI, we conducted a correlation analysis between logged transformed property damage per capita by jurisdiction (during the 2000s) and the CDRI scores. Analysis result shows that there is a strong negative relationship ($r = -0.601$, $p<0.000$) between property damage and the CDRI scores. This suggests that communities with high disaster resilience scores were likely to have a lower amount of property damage from natural disasters.

The CDRI is composed of five dimensions and each dimension is able to have different influence on reducing property damage. This study conducted an OLS (Ordinary Least Squares) regression model to assess the impact of each sub-index and identify significant aspects affecting log transformed property losses per capita by jurisdiction. As listed in Table 5, this model explained 58 percent of the variance in the actual property damage.

Table 5. Impact of sub-index scores on property damage

Model	Unstandardized Coefficients		Standardized Coefficients	Sig.	R Square
	B	Std. Error	Beta		
(Constant)	1.619	.045		.000**	0.581
Sub-Index of Human Aspect (HI)	-.076	.095	-.041	.425	
Sub-Index of Social Aspect (SI)	-.774	.103	-.571	.000**	
Sub-Index of Economic Aspect (EI)	.162	.093	.118	.082	
Sub-Index of Physical Aspect (PI)	-.014	.111	-.006	.900	
Sub-Index of Environmental Aspect (EVI)	-.548	.085	-.356	.000**	

**p<0.01 level

This model found that the resilience levels of social aspect and environmental aspect had a statistically significant impact on reducing property damage at the 0.01 level. This result indicates that in Korea, social capital including social organizations and networks is a critical factor in building community capacities for dealing with disaster by facilitating social trust and cooperation. Thus, improving and strengthening social capital can be a useful tool to mitigate disaster damage as well as prompt rapid recovery. Also, the environmental aspect including geophysical conditions and meteorological elements is statistically significant condition on causing property losses. Even if sub-index scores of human aspect and physical aspect did not have statistically significance on property damage, they still have negative impact on property damage.

Noticeably, the sub-index scores of economic aspect show positive impact on property loss. Economic aspect is able to have two different impacts on property losses. First of all, a wealthy community is more likely to have the financial resources to implement disaster management measures. Otherwise, rich communities expose more properties and wealth to hazard risk. So, they might have larger amount of property loss from the same intensity disasters then poor communities. The result indicates that wealthy communities tend to have more property damage in Korea.

Conclusions

As natural disasters caused by climate change have increased and are expected to exacerbate, disaster resilience is increasingly recognized as one of critical community capacities. Measuring the degree of the community resilience is an essential step to understand current status and make strategies to implement disaster management. This study developed a systematic and theoretically driven index (CDRI) for measuring community disaster resilience based on the conceptual framework of community resilience to natural disaster.

The assessment of the CDRIs of 229 local jurisdictions shows that the means score of the CDRIs is 0.00 with wide variations from one community to another. Most top resilient communities are located in the southern part of Seoul and Gyeonggi-do region which form a big hot spot cluster (high resilience in a high resilience neighborhood). This result suggests that resources and capitals of human, social and economic dimensions are tended to concentrate in this area and made communities more resilient. The analysis found two notable cool stop clusters of low resilience. The first cluster includes many communities of Jeollanam-do with low scores particularly in human and social dimensions. The other cluster is located in Kangwon-do region indicating less resilience in environmental dimension due to natural geographic risk.

This study examined the relationship between the level of community resilience measured by the CDRI and actual property damage from natural disasters to test validity of the CDRI. We found that communities with higher disaster resilience were likely to have a lower amount of damage and this result supports the usefulness of the CDRI. Furthermore, the regression analysis identified that among five aspects of community resilience, the resilience levels of social and environmental aspects had statistically significant impacts on reducing property damage. This result provides critical insights to facilitate local capacities to manage and mitigate disasters in the long term.

Measuring community disaster resilience is a complex process due to the dynamic interactions of people, organizations, community, society and the environment. Several limitations are encountered in quantifying community disaster resilience like other vulnerability assessment studies. First, this study uses secondary data from the national census bureau to measure community disaster resilience. Using more refined field survey data on disaster management officials, community leaders, and volunteers regarding disaster events for limitation could improve the results of future research on disaster resilience (Mayunga, 2009). Second, subjectivity in the selection of resilience indicators is a critical consideration (Yoon, 2012). The results of community disaster resilience index (CDRI) are mainly determined by the selected indicators by researchers. Future research needs more consideration in selecting better indicators to measure disaster resilience index. Moreover, this study uses relatively few indicators to measure each five aspect (for example, four indicators are used to measure the economic resilience dimension). Reliability of such a measure may be problematic. Therefore, future research should focus on developing more appropriate indicators using secondary and field survey data.

Despite the limitations listed in measurement methods, the authors believe that the results of this study have significant theoretical contributions to improve our understanding of the concept of disaster resilience. Moreover, identifying and measuring of community disaster resilience in Korea provide relevant information that emergency managers and planners can utilize in decision making process for disaster risk reduction.

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