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REGIONAL RESILIENCE IMPROVEMENT COPED WITH FLOODING DISASTER BY CLIMATE CHANGE EFFECT (I)

– DEVELOPMENT OF RESILIENCE ASSESSMENT METHODS

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Main research reports are as follows :

- Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS, 2016
- Resilience Strategies for Climate Change and Flooding: Knowledge Sharing, MOLIT, 2016
- The Study of Development Direction for Urban Policy to Intensify Urban Resilience Coped with Natural Disaster, MOLIT, 2015
- The Study for Developing of Flood Analysis Approach Considering Territory Changes, KRIHS, 2014
- A Study on Improvement of the Urban Flooding Disaster Prevention System coped with Climate Change, KRIHS, 2014
- Urban Design Technique Development Adapting to Climate Change Driven Heavy Rainfall Disaster, Korea Agency for Infrastructure Technology Advancement, 2011~2012
- Impact of humans on precipitation variability, climate and the water cycle (water sustainability), U.S. NASA, 2010

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Summary

Due to climate change and urbanization, natural disasters have frequently occurred in recent years. In Korea, floods generate the biggest natural disaster-related damages. It is realistically impossible to prevent natural disasters completely, which have grown in scale. However, recent years have seen active research in advanced economies and by international organizations on the concept of resilience, which emphasizes adaptation and rapid recovery. This special report introduces the first-year research of "Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I) - Development and Application of Resilience Assessment Methods" a joint international study produced over a two-year period. The study has been led and conducted by the Korea Research Institute for Human Settlements (KRIHS) in joint efforts with other four institutes such as the Korea Environment Institute, The Woodrow Wilson Center (WWC), Virginia Tech, and the Metropolitan Research Institute.

Considering Korea's regional characteristics, this study developed methods of resilience capability assessment of flood-affected areas, and applied to both the national local government and individual local governments. The assessment results showed that many of local governments with high levels of flood damages were those with low levels of resilience. They also lacked a disaster policy that takes into account the local characteristics of natural disasters. This study proposes locally customized resilience reinforcement plans as a result of assessing flood damages in the past, disaster vulnerability analyses, resilience assessment results, analyses of disaster management condition review sub-indicators. To improve resilience of local governments, this research suggests: introducing the concept of resilience in urban planning terms; amending disaster vulnerability analysis guidelines; increasing cooperation by central agencies; developing a knowledge-sharing platform for stronger resilience monitoring and information sharing; establishing guidelines and providing consulting for locally customized resilience reinforcement; and support plans for vulnerable citizens and local communities.

CHAPTER I.

Research Overview

1. Research Background and Need

Flood damages have been increasing steadily around the world in recent years and are predicted to accelerate further in the future due to environmental changes such as climate change and urbanization. While there has been steady development in disaster prevention policies and technique to reduce flood damages, the trend is one of increasing damage from natural disasters. The risk of flood damages is accelerating even more in Korea, where floods account for over 90% of financial damages from all natural disasters. Research reports on climate change published by the Intergovernmental Panel on Climate Change (IPCC) and others predict that the rate of climate change will increase in the future, with flood risks growing further due to increased rainfall intensity and volume.

It is not realistically possible to prevent flood disasters completely, which have grown in scale amid climate change and urbanization. Recent years have seen active research by developed countries and international organizations on the concept of resilience, which emphasizes adaptation and rapid recovery. The trend in disaster-related policy has been a shift from the previous concept of prevention or resistance to disaster to the resilience concept which considers the adaption to disaster and recovery capabilities.

Systematically introducing the concept of resilience capabilities to disaster prevention policy will require assessment of regional resilience capabilities, which will serve as a basis for developing measures to enhance those capabilities. As the resilience concept has not yet to be introduced into Korea's disaster prevention policies, developing a local model for assessing resilience that takes into account characteristics of Korea's natural disasters and disaster policies must be given a top priority. Resilience assessments must take into account a range of factors in the event of a natural disaster, including terrain, climate, and other factors contributing to regional disaster vulnerability, as well as disaster response capabilities. Findings from community resilience capability assessments must also be used as a basis for customized measures to bolster resilience capabilities.

“Resilience assessments must take into account a range of factors in the event of a natural disaster, including terrain, climate, and other factors contributing to regional disaster vulnerability, as well as disaster response capabilities.”

2. The Goal of Research

This study consisted of research tasks covering a period of two years, with the first year devoted to developing and applying resilience capability assessment methods (this report) and the second to develop the measures to promote resilience capabilities using urban planning. The chief goal of the first year's task was to develop a methodology for assessing community resilience capabilities to cope with flooding disasters. This involved the formulation of a concept of resilience in addition to disaster prevention, using this concept and an examination of related literature to develop a methodology for comprehensively assessing flood vulnerability and disaster response capabilities while taking into account local climate and terrain characteristics. The resilience assessment methodology was then applied to evaluate capabilities of individual local governments. Findings from the analysis of flood damages, disaster vulnerability, and resilience, as well as from an examination of current disaster management conditions, were used to evaluate the current state of flood disaster response and resilience capabilities across Korea and suggest avenues for community-customized resilience improvement measures. Implications for policies to boost resilience capabilities were also identified.

The chief goal of the second year of the study, which is to be conducted in 2017, is to devise plans for increasing resilience capabilities from an urban planning standpoint. An examination of policies overseas to improve disaster response resilience capabilities shows that it is important to strengthen resilience in cities where the risk of disaster is high and the potential damage is large. Various ways have been suggested for improving cities' resilience capabilities, but the improvement of such capabilities through urban planning standpoint deserves a matter of particular emphasis, because of the lack of such an urban planning standpoint in Korea.

3. Background of Joint Research

Application of resilience capabilities in the field of disaster prevention is still in its early research stages. Because resilience research must inherently take a very broad range of areas into consideration, collaborative research by various related domestic and overseas research institutions is essential. In the US, the resilience concept was incorporated not only into research but into disaster prevention policy with the experiences of major hurricanes in 2005 and 2012. The Woodrow Wilson Center (WWC), the Metropolitan Institute in Virginia Tech have been particularly active in researching and developing policies for application of the resilience concept to disaster prevention. In 2014, the Korea Research Institute for Human Settlements (KRIHS) signed a Memorandum of Understanding (MOU) with the WWC for a joint international study on resilience capabilities in disaster prevention. Through this MOU, the two institutions conducted three different joint studies over a three-year period; this year's research (2017) will be the fourth. For this special report, major content has been summarized from the third joint study (Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect I).

Table 1. KRIHS-WWC International Joint Research

No.	Content	Details
I	Research Title	The Study of Development Direction for Urban Policy to Intensify Urban Resilience Coped with Natural Disaster
	Dates	January 28 – July 26, 2015
	Chief Content	Seeking ways of incorporating the resilience concept into urban policy to build cities that are safe from natural disasters, which have accelerated and grown in scale as a result of climate change
	Institutions	KRIHS, Woodrow Wilson Center, Virginia Tech, University of Maryland
	Major Contribution	- International seminar (February 23, 2015, Washington, DC) - International Seminar coinciding with World Water Forum (April 14, 2015, Daegu) - Economics, Humanities and Social Research Council joint project proposal submitted - KRIHS Special Report #26: Research on Urban Policy Development for Urban Resilience Reinforcement
II	Research Title	Resilience Strategies for Climate Change and Flooding: Knowledge Sharing
	Dates	April 20 – October 16, 2016
	Chief Content	Developing ideas for reinforcing urban resilience in response to flooding and other climate change-related disasters and sharing the urban policies of rapidly growing Korea to developing and other countries
	Institutions	KHIRS, Woodrow Wilson Center, Virginia Tech, Metropolitan Institute
	Major Contribution	- Incorporated the resilience concept into guidelines for formulating city and county management plans
III	Research Title	Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I) : Development and Application of Resilience Assessment Methods
	Dates	January 1 – December 31, 2016
	Chief Content	Developing assessment methodology for community resilience toward flooding disasters
	Institutions	KHIRS, Korea Environment Institute, Woodrow Wilson Center, Virginia Tech, Metropolitan Institute
	Major Contribution	- International Seminar (October 31, 2016, Washington, DC) - KRIHS Special Report (this report) - Woodrow Wilson Center on-line brief published (Regional Approaches to Climate Resilient Flood Management: Lessons for Korea, 2017.05)
IV	Research Title	Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (II) : Reinforcing Resilience in Urban Planning Terms
	Dates	January 1 – December 31, 2017
	Chief Content	Developing ideas for increasing community resilience in urban planning terms through identification of areas for resilience reinforcement and ideas for their application
	Institutions	KHIRS, Woodrow Wilson Center, Metropolitan Institute
	Major Outcomes	In progress

CHAPTER II.

The Resilience Concept and Introduction

1. The Resilience Concept in the Field of Disaster Prevention

The resilience concept was first introduced in the field of disaster prevention by Timmerman (1981), who defined it as "a system's capacity to absorb and recover from a hazardous event." Later definitions of resilience in the field of disaster prevention were linked not only to physical aspects but to social and various other aspects, and the issue remains the subject of ongoing debate.

As it is currently discussed, the concept of resilience encompasses aspects of environmental change (including climate change and urbanization), mitigation and absorption of shocks, trauma and damage, adaptation and recovery capabilities, and system maintenance. To summarize what current discussions of resilience share, the concept is presented as a necessary capability to maintain systems, which involves reducing damage associated with climate change, urbanization, and other environment changes and alleviating the effects through a swift recovery process when a natural disaster occurs.

The introduction of concepts such as vulnerability and resilience to the field of disaster prevention has resulted in a gradual shift in the research paradigm. Early studies on disaster prevention saw disasters or crises as the results of unavoidable external shocks, stresses, and damage due to environmental factors. Within the recently emergent environmental determinist framework, however, the trend has been to emphasize the concepts of resilience and adaptability in the sense of being able to alter the extent of damage through political, social, and economic conditions. In other words, while the previous approach to disaster response focused on the disaster itself and the resulting damages, recent disaster prevention research has emphasized the importance of "understanding national disaster within the scope of the local community." The trend has thus been a paradigm shift in the disaster prevention research field from a preemptive response approach of assessing vulnerability while taking only prevention into account to emphasizing the importance of adaptability and other resilience capabilities. Moreover, whereas vulnerability refers to conditions before a disaster occurs, resilience is understood as a broad concept that encompasses not only normal conditions but also an after-the-fact adaptation process of promoting systems' capabilities to learn how to face disaster and respond to risks under the influence of a natural disaster.

To introduce the resilience concept in disaster prevention, research is under way on the elements that constitute resilience. The elements of resilience most commonly discussed are the so-called "4R" cited by the Bruneau et al. (2003) of the Multidisciplinary Center for Earthquake Engineering Research (MCEER), namely Robustness, Redundancy, Resourcefulness, and Rapidity. Robustness is closely connected to the capacity to cope with external shocks prior to the occurrence of natural disasters through shock absorption and buffer mechanisms and decentralized modularization. Redundancy is strongly related to surplus capacity and diversity, rapidity to cooperation and the swift mobilization of resources, and resourcefulness to self-organization and other capacities to adapt to and recover from disasters once they occur. Adger (2000) represented resilience in terms of resistance to external shock, ability to recover from external shock, and ability to adapt to new circumstances, while Lorenz (2010) posited it in terms of adaptive capacity, coping capacity, and participative capacity.

In summary, the major components of resilience can be tailored to the stage of disaster occurrence and response (prevention and preparation before occurrence, response and recovery after occurrence), and resilience may be seen as encompassing anti-disaster capabilities across all stages of the disaster response. During the prevention and preparation stages, which are concerned with vulnerabilities in preventive terms, it is closely connected to robustness and resistance components, where community resilience capabilities can be enhanced through various plans and systems to boost physical anti-disaster capacities. During the response and recovery stages, which are concerned with the period after a disaster has occurred, it is closely connected to the redundancy, rapidity, resourcefulness, adaptability, response capacity, and participation capacity components, where community resilience can be enhanced through swift disaster response capabilities, interdepartmental cooperation, and community involvement capacities.

"The major components of resilience can be tailored to the stage of disaster occurrence and response (prevention and preparation before occurrence, response and recovery after occurrence), and resilience may be seen as encompassing antidisaster capabilities across all stages of the disaster response."

Resilience has also been discussed as an essential element in disaster prevention in terms of a response to the uncertainties associated with climate change, urbanization, and other forms of environmental change. An IPCC working group (2007) has argued that uncertainties associated with climate change can be mitigated through sustainable development with increased adaptability and resilience capabilities. Where the qualities of safeness, robustness, and reliability were once the chief emphases in terms of improving cities' sustainability in response to disasters, present uncertainties associated with environment change and the growing likelihood of associated natural disasters have resulted in additional emphasis on the importance of resilience as a category encompassing adaptation and recovery capabilities as well.

If a concept of resilience in disaster prevention may be reformulated to take into account changes in its use, common keywords, and recent studies in anti-disaster research, it may be defined as a general concept encompassing all disaster response stages of prevention, preparation, response, and recovery with the aim of improving the sustainability of urban systems by responding to uncertainties associated with a changing environment (i.e., the possibility of disasters occurring).

2. Resilience in the United States: Introduction and Current Status

The occurrence of large-scale disasters such as Hurricane Katrina (2005) and Hurricane Sandy (2012) in the US has resulted in growing perceptions of problems with the disaster-related system in the US and a changing paradigm in the disaster prevention field with the introduction of the resilience concept. The US laws and systems for disaster management were developed for the most part in the wake of large-scale disasters, and the resilience concept has recently been introduced for the sake of policies that take into account all stages of disaster response (prevention, preparation, response, and recovery) and increased flexibility in federal, state, and local government cooperation. The growing importance of recovery systems for when large-scale disasters have occurred has led to the development of National Disaster Recovery Framework (NDRF), which has developed into a comprehensive management system spanning all stages of disaster management (prevention, preparation, response, and recovery) through introduction of the resilience concept.

In particular, the US has begun introducing policies through Department of Housing and Urban Development (HUD) and other departments and agencies to promote resilience in cities, while encouraging active local community involvement through bidding programs linked to recovery and local development integrating the resilience concept. Recently, HUD held a "Rebuild by Design" competition for recovery from the Hurricane Sandy disaster and the development of a more resilient city; in June 2014, it announced "$1 Billion National Disaster Resilience Competition" to generate innovative ideas for improved disaster resilience and reconstruction through voluntary participation by local communities. In 2009, HUD played a central role in establishing the Partnership for Sustainable Communities (PSC), a pan-governmental consultative body with representation from Department of Transportation (DOT), Environmental Protection Administration (EPA), and Federal Emergency Management Agency (FEMA).

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CHAPTER III.

Domestic and Foreign Examples of Resilience Assessment and Implications

1. Major Korean Policies for Climate Change and Disaster Prevention

1.1 Disaster Vulnerability Assessment

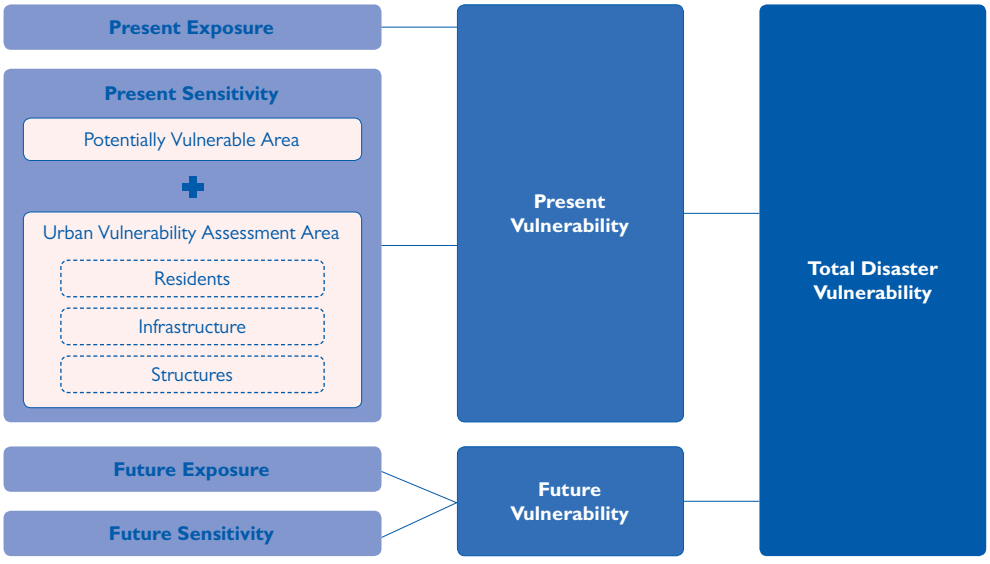
In 2011, the Korean Ministry of Land, Infrastructure and Transport (MOLIT; known as the Ministry of Land, Transport and Maritime Affairs until 2013) amended formulation guidelines for city planning (including basic urban plans, urban management plans, and metropolitan city plans) to introduce disaster vulnerability assessment. In 2015, it amended Articles 20 and 27 of the National Land Planning and Utilization Act to institute mandatory assessments of cities' vulnerability to disaster vulnerability assessment (hereafter "vulnerability assessments") as a basic investigation when establishing city and county framework and management plans. For their format, these vulnerability assessments adopted the framework of the IPCC (2007) in analyzing the impact of various disasters resulting from climate change-related disasters (including flooding, heavy winds, heavy snow, drought, heat, and rising sea levels). In accordance with the IPCC vulnerability concept, analyses comprehensively took into account both exposure and sensitivity aspects to provide a basic framework for investigating cities' vulnerability to disasters associated with climate change.

Vulnerability assessments use exposure and sensitivity indicators to assess relative susceptibility to disasters. Exposure encompasses climate and climate change elements such as rainfall, temperatures, winds, and rising sea levels, while sensitivity refers to cities' physical vulnerability to natural disasters and negative effects to city components such as infrastructure, population, and structures.

Current vulnerability assessments in Korea focus only on exposure and sensitivity without taking adaptability into account. While adaptability may be represented through the policies and measures (including physical, social, and economic elements) in place to reduce the potential negative impact of climate change-related disasters on cities, it has not been included in analyses because it has been deemed too difficult to quantify or to derive indicators for offsetting potential vulnerabilities associated with exposure or sensitivity (MOLIT 2011).

Figure 1. Structure of Disaster Vulnerability Assessment

Source: KHIRS 2013, 8.



While an early 2011 vulnerability assessment study did analyze disaster vulnerability at the national level, analyses since 2014 have incorporated included population census units[01] and future sensitivity due to difficulties formulating measures and as a step toward formulation of future measures. Exposure has been categorized according to present and future influences, while future exposure has been analyzed through the use of past to present exposure (based on meteorological observations) and potential climate change scenarios. Sensitivity has been analyzed in terms of present and future vulnerability: Correlation analyses have been conducted for different disaster types to develop indicators for potentially vulnerable regions in the present and future, populations, urban infrastructure, and buildings, and exposure and sensitivity indicators have been applied. Overall city vulnerability has been analyzed in terms of both present and future vulnerability.

01. Statistical divisions for the population census equivalent to roughly 1/23 the typical town/township/neighborhood population.

1.2 Examination of Disaster Management Condition in Local Government

Examination of Disaster Management Condition in Local Government(EDMC-LG) is a form of disaster prevention policy that involves reviewing the status of local government disaster management and using the findings to provide feedback and bolster the efficiency of disaster management operations to create an advanced disaster management system. The focus in EDMC-LG is on strengthening local government disaster management capacities and achieving greater autonomy of and responsible administration by individual agencies. EDMC-LG enables examination of related operations at the agencies responsible for disaster management, and its findings may be used to provide feedback and promote the efficiency of said operations and to build advanced disaster management systems. the EDMC-LG has been held on an annual basis since 2005 as per Article 33-2 of the Framework Act on the Management of Disasters and Safety and Article 42 of its Enforcement Decree. Metropolitan cities and provinces conduct independent reviews of their own municipalities, counties, and districts, after which a central joint inspection team conducts first a written and then an on-site review of 30 outstanding units at the municipality/county/district and metropolitan/provincial levels.

The EDMC-LG is performed for all of Korea's 243 local governments (17 metropolitan cities and provinces and 226 municipalities, counties, and districts). The 72 review indicators used (at the municipality/county/district level) are designed to analyze areas such as individual capabilities, disaster management department capabilities, disaster management network capabilities, and local government capacities. As of 2015, the EDMC-LG assigned a maximum score of 330 points for metropolitan cities/provinces and municipalities/counties/districts alike; scoring and assessment metrics are changed on a yearly basis based on the decisions of a related Ministry of Public Safety and Security (MPSS) committee.

As the supervising agency for EDMC-LG, MPSS has incorporated items reflecting the resilience concept since 2015 in connection with UN-ISDR's Making Cities Resilient (MCR) campaign. The Ministry is currently planning to recommend a local government as a UN-ISDR international Safe City when the local government is selected for outstanding performance in the examinations for three consecutive years.

2. Major Overseas Examples of Resilience Assessment and Application

2.1 US Climate Resilience Toolkit

The US federal government has developed and made the US Climate Resilience Toolkit available through its website to provide a simple and convenient means of gathering and analyzing climate change information at the individual, corporate, and community levels.

The Toolkit offers information on possible disasters that may occur as a result of climate change, along with a five-stage process for improving community resilience to reduce disaster-related damages. The first two stages are concerned chiefly with local climate and physical vulnerability, with the first stage focused on analyzing climate change and its impact on local residents, structures, and economies and the second focused on identifying foreseeable vulnerabilities. The third stage focuses on analyzing community disaster response capabilities and establishing measures to improve resilience, including regional situation diagnostics, establishment of prevention measures, and discussions toward reducing vulnerability. The final fourth and fifth stages are focused on providing practical support for resilience improvement measures, the former in terms of measures to ensure the necessary budget over time and an assessment of costs, and the latter in terms of practical budget procurement and monitoring to boost resilience through repeated experiments and formulation of response measures.

2.2 UN-ISDR's Local Government Self Assessment Tool for Disaster Resilience

To minimize damage to cities from climate change-related disasters, UN-ISDR has implemented a Making Cities Resilient (MCR) campaign, where cities around the world have applied for certification as international Resilient Cities. For its certification of Resilient Cities, UNISDR has developed tools for local governments to conduct the Local Government Self Assessment Tool for Disaster Resilience(LG-SAT). The tools consist of ten scorecards for resilience self-diagnosis, along with a questionnaire consisting of 40 more detailed assessment items. The scorecards include categories to assess general structural and non-structural capabilities across all stages of local disaster response, including community involvement; support for vulnerable populations; reviews of vulnerable infrastructure; disaster prevention infrastructure management; evaluation of important infrastructure; land usage plans; education; linkages with disaster prevention, environment, and spatial planning; early warning systems; and evacuation.

Table 2. Self-diagnosis Scorecards for Ten Essential Areas of Assessment

Source: UN-ISDR 2012a.

1.	Put in place organization and coordination to clarify everyone's roles and responsibilities
2.	Assign a budget and provide incentives for homeowners, low-income families, and the private sector to invest in risk reduction
3.	Update data on hazards and vulnerabilities, prepare and share risk assessments
4.	Invest in and maintain risk-reducing infrastructure, such as storm drainage
5.	Assess the safety of all schools and health facilities and upgrade these as necessary
6.	Enforce risk compliant building regulations and land use planning, identify safe land for low-income citizens
7.	Ensure education programs and training on disaster risk reduction are in place in schools and communities
8.	Protect ecosystems and natural buffers to mitigate hazards, adapt to climate change
9.	Install early warning systems and emergency management capacities
10.	Ensure that the needs and participation of the affected population are at the center of reconstruction

For the LG-SAT, local government employees conduct a self-assessment by assigning ratings at the five stages for each questionnaire. The local government is then asked to provide documentation and government employees are interviewed, after which local disaster vulnerability characteristics are reflected and assessment findings are examined to compute a final score.

The LG-SAT are available through an online system, and assessment results for individual registered local governments are aggregated to assess disaster response capabilities, taking into account the extent of disaster prevention plan formulation and disparities in resilience. The resilience assessment findings may then be used as a basis for local governments to select outstanding projects and as data for the central government to allocate budget monies and select project priorities.

The resilience concept has recently been applied actively in the disaster prevention field, and various methods and policies have been developed for assessing resilience in connection with disaster prevention. In the case of UN-ISDR's LG-SAT, however, the assessment is a general evaluation of structural and non-structure local capabilities across all stages of disaster response, and the findings have even been used for certification of international Resilient Cities. As such, they are widely seen as the most representative of resilience assessment methods.

2.3 QSAND (Quantifying Sustainability in the Aftermath of Natural Disasters)

A resilience self-assessment tool developed by the United Kingdom's Building Research Establishment (BRE)[02], QSAND is used to support various policy decisions to promote resilience, including local community relief, recovery, and reconstruction in response to natural disasters.

02. Government agency first established as the Building Research Board in 1921 for the improvement of British urban environments; privatized in 1990.

QSAND uses both Pre-Assessment and Core Assessment tools to monitor local community resilience in the short, medium, and long terms from the time of disaster occurrence (Pre-Assessment) to the recovery period (Core Assessment).

The QSAND resilience assessment is broad-based, taking into account not only the period before disaster strikes but also the recovery situation in the short, medium, and long terms after a disaster occurs. It encompasses eight areas (evacuation sites and the local community, settlement environment, resources and waste, energy, water resources and sanitation facilities, natural environment, communications, and mutual cross-comparison), each of which is subdivided into two to five subtopics for independent resilience assessment at the local government level. As the local government is typically the smallest administrative unit in charge of disaster prevention and the assessment includes various qualitative as well as quantitative categories, independent assessments are conducted by the government employees in charge of practical duties. The self-assessments allow local government employees to identify issues with community resilience and are used in formulating measures to improve them.

2.4 CDRI

The Climate and Disaster Resilience Initiative was formulated in 2009 as a collaborative effort by Kyoto University, CITYNET, and UNISDR. The CDRI plan was also used to develop a Community Disaster Resilience Index (CDRI) for regions.

The CDRI consists of five key classification systems (physical, social, economic, institutional, and natural), each of which includes five subcomponents. Assessment surveys have also been developed for each subcomponent to assess current conditions, amounting to 125 surveys in total. Assessment surveys are completed by the local government employees best acquainted with local disaster prevention capabilities. Answers are provided independently, after which related base data are examined to ensure objectivity and quantified resilience scores are assigned for the region.

3. Chief Implications

As disasters escalate in scale due to climate change and urbanization, the concept of resilience has recently been incorporated in the area of disaster prevention. Improving community resilience requires a prioritization of resilience assessment. The chief characteristics of the resilience assessment methods examine here are that they ① comprehensively take into account local disaster vulnerability characteristics and response capabilities, ② instruct local government employees to conduct analyses that take into account all stages of disaster response, ③ encourage community involvement, and ④ increase cooperation among related agencies. In Korea's case, adoption of the resilience concept remains inadequate, as regional physical vulnerability to disaster and disaster prevention capabilities are assessed and applied through different policies in connection with the response to disasters associated with climate change.

Incorporating Local Vulnerability and Response Capabilities into Resilience Assessment

In the case of the US Climate Change Resilience Toolkit, the first two of the five stages are concerned with preliminary analysis of local disaster-related characteristics (including climate change factors and disaster factors affecting local residents, structures, and economies) and assessment and improvement of resilience through examination and strengthening of disaster response capabilities. Similarly, the IPCC's climate change vulnerability analysis examines the physical susceptibility of regions in terms of exposure and sensitivity, while applied adaptability (e.g., disaster response capabilities) analyzes general vulnerability. Korean disaster vulnerability assessments are currently lacking in their incorporation of the resilience concept, as they focus their analysis only on exposure and sensitivity.

Resilience Assessed by Local Government Employee for all Disaster Response Stages

Local governments are the smallest administrative units capable of performing disaster prevention functions on a permanent basis, while local government employees are stakeholders who personally perform disaster prevention-related duties and are best acquainted with the details of local disaster prevention policies. In view of this, it is local government employees who conduct resilience assessments using UNISDR's LG-SAT and the evaluation tools provided by QSAND and CDRI. Due to the nature of reliance, assessment is conducted for all stages of disaster response.

Encouraging Community Involvement

The resilience concept takes into account all stages of response in the event of a disaster. While administrative agencies have an important role in recovery after a disaster has occurred, the role of the citizens who experience disaster first-hand and must recover from it is another key element. In view of this, the US Climate Change Resilience Toolkit and other resources encourage community involvement and the building of capacities through the development and provision of various climate change analysis programs and educational materials for the general public.

Strengthening Inter-agency Cooperation

Assessment and improvement of community resilience is a very broad area in scope, as it must not only evaluate disaster prevention infrastructure but also take into account the periods before and after disaster. As a reflection of this, the US has established the PSC to improve resilience capabilities and develop the Climate Change Resilience Toolkit. Korea has also recognized the importance of linking disaster prevention with spatial planning and is currently attempting a linkage between the comprehensive plan for storm and flood damage reduction and spatial plans.

Disaster vulnerability assessment and other disaster prevention policies are currently in place in Korea to response to the potential for climate change-related disasters. Because the disaster vulnerability assessment only consider exposure and sensitivity while ignoring adaptability, it does not adequately reflect the resilience concept. If adaptability in disaster prevention is understood to refer to disaster response (i.e., disaster management) capabilities, then Korea does have disaster prevention policies in which the EDMC-LG are reviewed on an annual basis. Even those reviews, however, fail to reflect the physical disaster susceptibility of localities and thus do not adequately incorporate the resilience concept.

CHAPTER IV.

The Development and Application of the Resilience Assessment Methodology

1. Direction of Resilience Assessment Methodology Development

This section uses the implications of existing domestic and foreign resilience assessment methodologies and climate change-related disaster response policies to suggest the direction for developing resilience assessment methodologies. The direction for methodology development include ① conducting priority assessment for disaster vulnerability in local area, ② conducting assessments at the local government level, ③ assessing resilience by local government employees at each stage of disaster response, ④ focusing resilience assessments on organizations, budgets, and community involvement, and ⑤ strengthening partnerships among agencies.

Table 3. Basic Principles and Chief References for Improvement of the Resilience Assessment Framework

Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

No.	Principles	Chief References
1	Priority assessment for disaster vulnerability in local area	US Climate Resilience Toolkit, IPCC vulnerability analysis
2	Assigning local government at spatial scope of assessment	UNISDR, CDRI, QSAND
3	Assessing regional resilience by local government employee at all stages of disaster response	UNISDR, QSAND, NDRF
4	Assessing resilience in terms of organizations, budgets, and community involvement	UNISDR, QSAND
5	Bolstering partnership among agencies	PSC, linkages to General Storm and Flooding Reduction Plan and National Land Planning and Utilization Act

2. Developing Resilience Assessment Methods

Based on the direction for resilience assessment methodology development presented in the previous section, a basic concept has been formulated for the spatial scope, assessment targets, disaster response stages, source materials, and avenues for resilience assessment methods. The spatial scope for resilience assessment is the local government, where resilience is evaluated in terms of regional disaster response capabilities that take local climate and physical disaster susceptibility into account. Areas for assessment broadly include organizations, budget, and community involvement, where capabilities are to be evaluated for all stages of disaster response. Data used for assessment should be the latest available and be objective or documentable.

Table 4. Basic Concepts in Resilience Assessment Methodology

Assessment Method	Chief Content	Associated Principle(s)
Spatial Resolution	Local government	2
Assessment Orientation	Assess disaster response capabilities in view of community's climate and physical disaster vulnerabilities	1, 3
Assessment Targets	Organizations, budget, community involvement	4
Disaster Response Assessment Stages	All stages of disaster response (prevention, preparation, response, and recovery)	3
Resources	Most recent available data, data that are objective and documentable	3

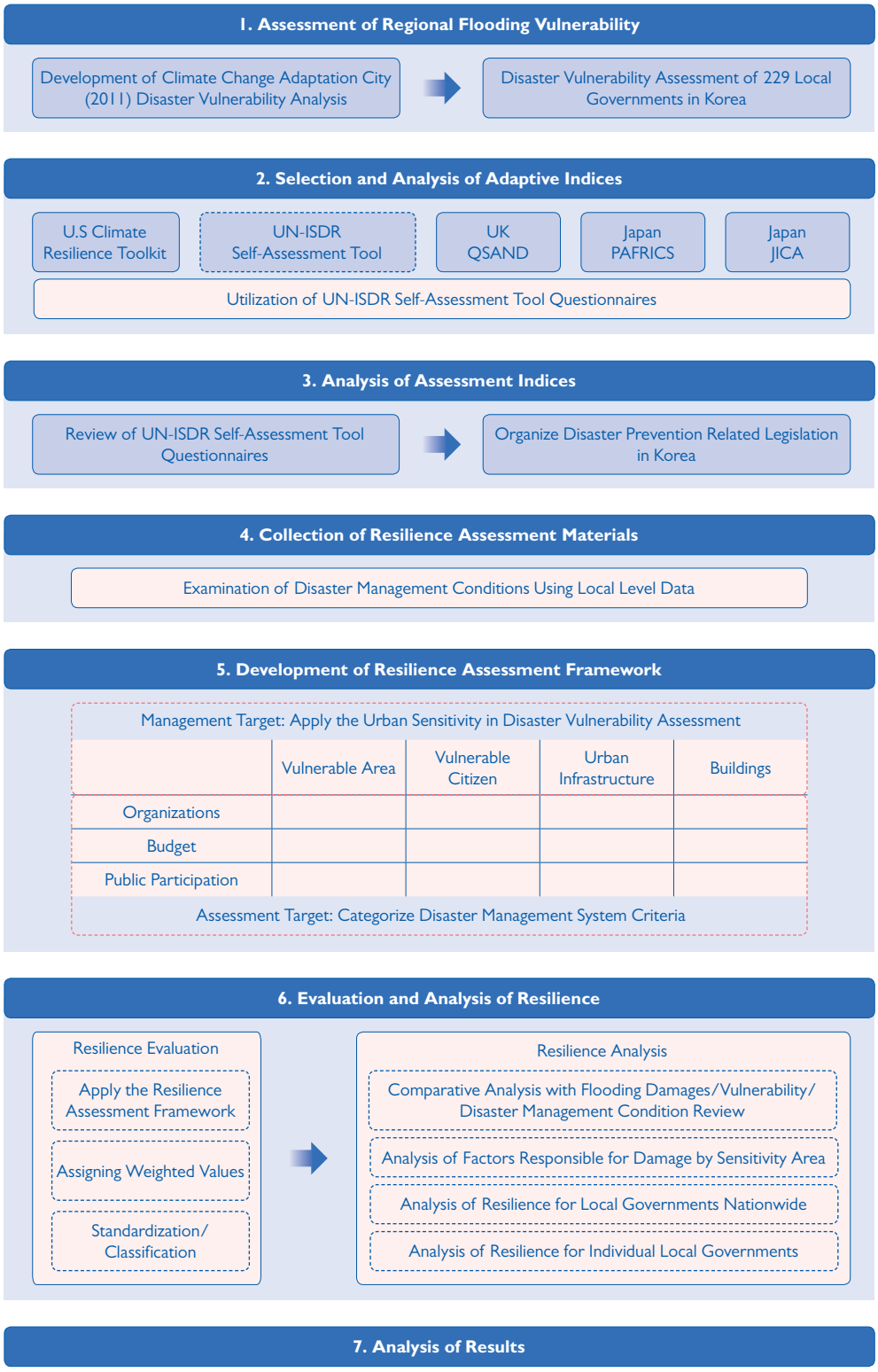
Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

Based on the direction for resilience assessment methodology development, a seven-stage process has been formulated, consisting of a priority assessment of local climatic and physical vulnerability to disaster, as well as an assessment of all disaster response capabilities in consideration of local disaster susceptibility characteristics (Figure 2). The first stage involves an assessment of local vulnerability to disasters, while the second to fourth involve examination of previously developed overseas resilience assessment metrics, comparison with current conditions in Korea, and data acquisition. The fifth involves establishment of an assessment framework for disaster response capabilities to reflect local vulnerability (i.e., regional resilience), while the sixth and seventh involve application to and analysis of reference communities.

“Based on the direction for resilience assessment methodology development, a sevenstage process has been formulated.”

Figure 2. Approach to Resilience Assessment Framework Development

Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.



2.1 Assessment of Local Climatic and Physical Disaster Vulnerabilities

Because each region has different characteristics of disaster vulnerabilities, priority analysis must be conducted and response measures developed for climate and local disaster vulnerabilities when developing measures for natural disaster prevention. Various methods have been developed in Korea and overseas for the assessment of local climate and physical disaster vulnerabilities. In general, however, the approaches developed have been based on the climate change vulnerability analysis methods suggested by IPCC.

The disaster vulnerability assessments currently conducted in accordance with the Land Use Regulations at the National Territory Plan and Use Act were likewise based on IPCC's approach to assessing climate change vulnerability. The Disaster vulnerability Assessment is based on exposure and sensitivity, while adaptability is not currently taken into account.

"Ideas for Building Climate Change-Adaptive Cities" (2011), one of MOLIT's early studies on disaster vulnerability assessment method development, assessed disaster vulnerability for whole country at the local government unit level. Due to spatial difficulties with the development of measures, however, population census units have been used to enhance the resolution of the minimum spatial analysis.

MOLIT's disaster vulnerability assessment approach is based on IPCC's climate change vulnerability analysis framework, which is the most frequently used. For this reason, and because it is the official analytical method according to related legislation, the disaster vulnerability assessment method was used for analysis of local climate and physical disaster vulnerability for the resilience assessment method developed in this study. As the local government is the smallest resilience analysis unit, the early local government assessmnet method (2011) was used, with the most recent data selected for indicators. Flood damage vulnerability indicators were categorized in terms of exposure, vulnerable area, vulnerable citizens, urban infrastructure, and buildings; Table 5 shows the indicators and data sources used for each category.

Table 5. Indicators for Flood Vulnerability Assessment

Indicator Category	Indicator Selected	Unit	Source
Exposure	Annual average number of days with rainfall of 80mm or more	days	Observatories (1986–2015) data from weather station
Vulnerable Area	Ratio of river length of local government to total river length in Korea	m/m	Statistics Korea urban planning status report (2014)
	Ratio of area below local government's average altitude to area of local government	m^2/m^2	GIS data analysis
	Ratio of steep slope area(34° or greater) in local government to total area of local government	m^2/m^2	GIS data analysis
	Ratio of landslide risk area (Levels 1 and 2) to total area of local government	m^2/m^2	Korea Forest Service data
	Ratio of impervious area (land, factories, schools, roads) to total area of local government	m^2/m^2	Statistics Korea urban planning status report (2014)
Vulnerable Citizen	Seniors aged 65+ and children under six	persons	Statistics Korea (2010)

Indicator Category	Indicator Selected	Unit	Source
Urban Infrastructure	Percentage of road area	m^2/m^2	Statistics Korea urban planning status report (2014)
	Percentage of railroad area	m^2/m^2	Statistics Korea urban planning status report (2014)
	Percentage of water supply facility area	m^2/m^2	Statistics Korea urban planning status report (2014)
	Percentage of common duct area	m^2/m^2	Statistics Korea urban planning status report (2014)
	Percentage of oil storage and transport facility area	m^2/m^2	Statistics Korea urban planning status report (2014)
	Percentage of sewer area	m^2/m^2	Statistics Korea urban planning status report (2014)
	Percentage of water contamination prevention facility area	m^2/m^2	Statistics Korea urban planning status report (2014)
Building	Percentage of standalone housing	units/units	Statistics Korea (2010)
	Percentage of semi-underground housing	households/ households	Statistics Korea (2010)

Source: MOLIT 2011. More recent data substituted in some cases.

As Table 5 shows, data for exposure and sensitivity indicators use difficult units and require standardization, while graded stages are necessary to analyze extent of vulnerability. In the 2011 disaster vulnerability assessment method, a z-score method was used for standardization and vulnerability was classified into five stages using the natural breaks method (Jenks optimization). The current study likewise adopted this format for consistent standardization and classification.

In addition to its assessments of the current vulnerability of local governments nationwide, the 2011 disaster vulnerability assessment methodology also used present and future exposure (climate change scenarios) to assess vulnerability. The Guidelines on Analysis of Cities' Vulnerability to Climate Change-Related Natural Disasters and Its Use (2016) offer methods for individual local governments to assess future exposure using climate change scenario data and future city sensitivity using areas urbanized over the preceding ten years, population increase over the preceding ten years, and information about developed projects and anticipated zones. The study, however, possesses many uncertainties, as it focused on local governments nationwide without methods developed to analyze future sensitivity on a national basis. Also, while resilience refers to the capacity to respond to disasters, no methods have been developed to assess local governments' future disaster response capabilities; analyses currently focus solely on present vulnerabilities.

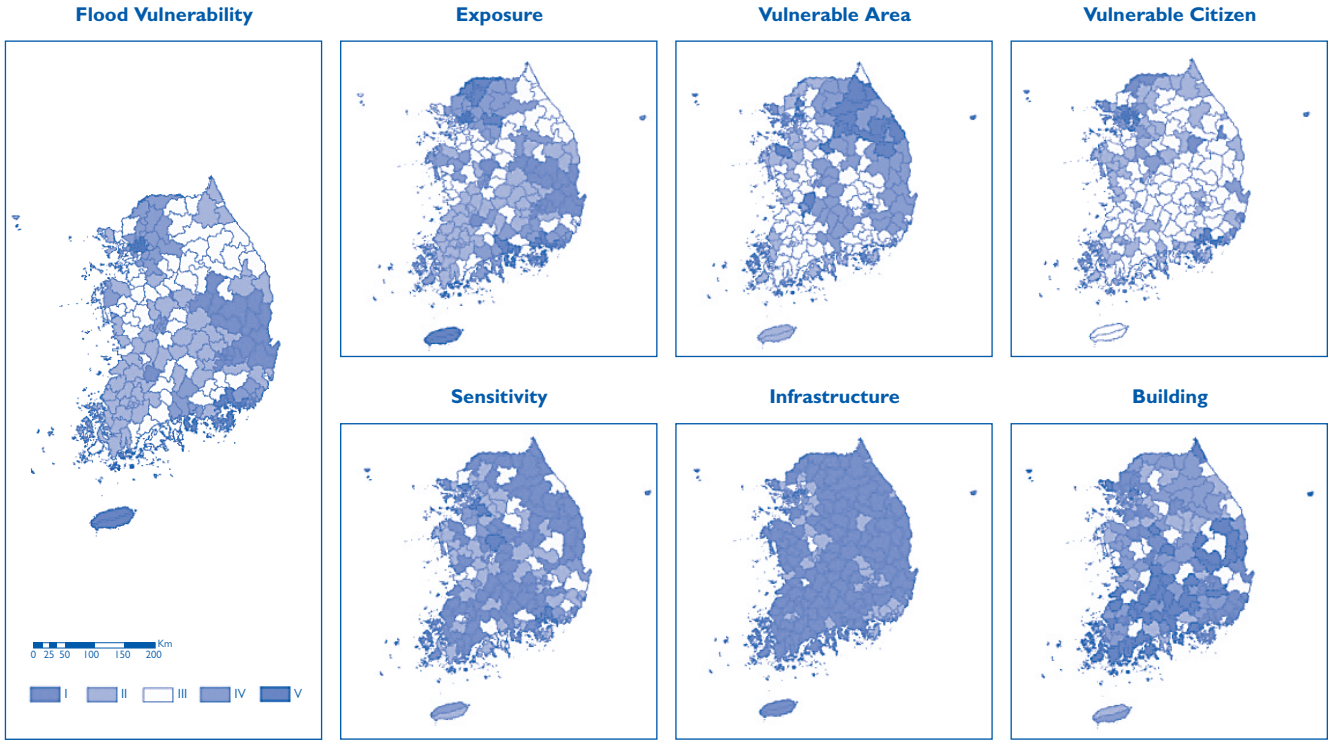
To analyze exposure, daily observation data for 69 weather stations nationwide over a 30-year period (1986 to 2015) were used to compute the average number of days per year with rainfall of 80mm or more. The observatory rainfall information consists of point data that must be converted to area data to compute values for all 229 local governments nationwide. To perform this area data conversion, positional data from weather stations were used to construct a Thiessen polygon and calculate a final total of average days per year with rainfall of 80mm or more for each local government.

For sensitivity, indicators related to vulnerable areas, vulnerable citizens, urban infrastructure, and buildings were updated with the most recent data for analysis. In the case of vulnerable areas, standardization and overlapping was performed for river/stream length percentage, percentage of area below the average elevation for

local governments, percent of area on a sharp acclivity (34° or greater), percentage of landslide risk zones (Level 1 and 2), and percentage of impervious surfaces (land, factories, schools, and roads), and ranks were assigned. Vulnerable citizens were also graded after standardization of the number of seniors aged 65 and older and young children under six years of age. For urban infrastructure, standardization, overlapping , and categorization were performed for the percentage of area occupied by highways, railways, water supply facilities, common ducts, oil storage and transport facilities, sewers, and water contamination prevention facilities. The last category of buildings was also standardized, overlapped and assignedfor percentages of standalone and semi-underground housing. Once assigned to categories, data was aggregated and overlapped to compute sensitivity values.

A comprehensive vulnerability analysis using findings on exposure and sensitivity to flood-related damages showed vulnerable regions to include Seoul and northeastern Gyeonggi-do, Busan and regions of Gyeongsangnam-do near the southern coast, and Jeju Island. The assessment of vulnerability to flood disaster showed the district of Gwangjin-gu in Seoul to be the most vulnerable local government unit, with a Level III rating for the vulnerable citizen category alone and vulnerable Level V ratings for other indicators.

Figure 3. Flood Vulnerability Assessment Findings



Source: "Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I) - Development and Application of Resilience Assessment Methods" Han, WooSuk 2016, KRIHS

2.2 Selecting Disaster Response Capability Assessment Categories

While resilience assessment and improvement methods have been used in various studies and policies in the developed countries, the resilience concept has yet to be adequately implemented in Korea. Assessing resilience will require consideration of previously developed resilience assessment methods. Examination of methods previously developed to assess resilience showed all of them to be used with local government employees and to examine all stages of disaster response, including prevention, preparation, response, and recovery. The Climate Change Resilience Toolkit and CDRI include assessment categories for regional disaster vulnerabilities, while UN-ISDR's LG-SAT incorporate from local vulnerability assessment methods and examination of related documents. Land usage analyses are performed as an assessment category for the UN-ISDR's LG-SAT and CDRI methods; budget procurement analyses for the Climate Change Resilience Toolkit and UN-ISDR's LG-SAT and CDRI methods; disaster prevention facility reviews for the UN-ISDR's LG-SAT and CDRI methods; and community involvement for the UN-ISDR's LG-SAT and CDRI methods.

Despite some differences, the resilience assessment methods generally present assessment categories for estimated regional vulnerability, disaster prevention facilities, community involvement, organizational capabilities, and budget for all stages of disaster response. UN-ISDR's LG-SAT in particular incorporates assessment methods used in nearly all resilience evaluation approaches. UN-ISDR's LG-SAT is also used for certification of international Safe Cities. In view of this, the ten scorecards and 40 detailed assessment indicators from the UN-ISDR's LG-SAT were selected as assessment indicators.

2.3 Analyzing Assessment Categories

The ten scorecards in the UN-ISDR's LG-SAT include content related to community involvement, budgeting for low-income populations, investigation of and responses to vulnerable infrastructure, reviews of flood response infrastructure, assessments of public institution security, plans for land use in disaster response, education, linkage to environmental preservation and spatial usage plans, early warning systems, and disaster recovery. Around 40 detailed surveys have been developed to quantify these. Because the UN-ISDR's LG-SAT is designed to assess resilience in cities around the world, however, its survey content tends to be highly abstract and to inadequately reflect diverse conditions in different countries. To address this issue and ensure objective quantified analytical findings, cities have been asked to provide related data and pass through a stage of interviews, feedback, and scrutiny prior to calculation of the final resilience assessment results.

Adapting these rather abstract LG-SAT questionnaire items to the Korean situation requires linkage of the analyses with related considerations and domestic legislation. For this study, linkages were examined for the 40 questionnaire items in the LG-SAT in terms of major considerations and related Korean laws and regulations. Because the related laws and regulations are quite broad-based, the study focused on examining linkages with survey content for laws specifically related to disaster prevention, spatial usage, and rivers and streams. Disaster prevention-related laws examined for this study included the Framework Act on the Management of Disasters and Safety, the Countermeasures

against Natural Disasters Act, the Disaster Relief Act, the Storm and Flood Insurance Act, and the Reservoir and Dam Safety Control and Disaster Prevention Act. Spatial use-related laws examined included the Land Use Regulations at the National Territory Plan and Use Act, the Building Act, and the River Act, which is closely connected with flooding.

After major areas for consideration were identified, analysis of linkages with domestic disaster prevention, spatial use, and river and stream legislation for the survey items in the UN-ISDR's LG-SAT showed the surveys to bear close connections to different laws and to encompass all stages of disaster response. The examination also showed various linkages extending from the national planning level (including preliminary disaster influence examinations, metropolitan and provincial safety management plans, general river valley flood control plans, and comprehensive plan for storm and flood damage reduction) to the local community level (including prediction and warning systems at the metropolitan/provincial and municipality/county/district level, infrastructure safety and maintenance plans, flood damage condition investigations, education and training, budget planning, independent disaster prevention teams, assistance projects for vulnerable populations, and government-public cooperation planning).

“After major areas for consideration were identified, analysis of linkages with domestic disaster prevention, spatial use, and river and stream legislation for the survey items in the UN-ISDR's LG-SAT showed the surveys to bear close connections to different laws and to encompass all stages of disaster response.”

In terms of UN-ISDR's ten scorecards, Korea's related laws and disaster prevention policies included almost no content related either to item (2) on procuring budget monies for low-income families and other private sector areas or to item (8) on preservation of the environment for a natural response to climate change. In terms of detailed assessment categories for the second scorecards, the areas of local government financial wherewithal to reduce the costs of disaster-related damage, local government perceptions on the use of finances for an effective disaster response, and extent of financial support use for vulnerable populations before disaster occurs were found to be amenable to support through terms regarding disaster management funding acquisition and management and establishment of disaster management funds in the Framework Act on the Management of Disasters and Safety and its Enforcement Decree. Domestic acts and disaster prevention policies were found to be inadequately linked, however, with other areas such as usage of financial resources to support post-disaster recovery, incentivizing investment in reducing disaster-related damages by ordinary families and local businesses, and support plans for the continued operation of local small and medium-sized businesses after a disaster (with a focus on the recovery situation).

Similarly, almost no linkages were found in Korean disaster prevention, spatial use, and river legislation for certain assessment areas from the other 8th scorecards, including coordination with currently implemented plans for the use and preservation of environment resources and with newly introduced policies related to reducing natural disaster-related damages, introduction of local government systems for ecosystem protection, involvement by civic groups and local residents, and private sector involvement in the formulation of local government ecosystem protection plans.

2.4 Acquiring Assessment Data

Using the Examination of Disaster Management Condition in Local Government (EDMC-LG)

While selection of the right assessment indicator is important when evaluating community resilience, it is also very important to acquire related data. Assessing community resilience requires data that can be monitored objectively and regularly to evaluate disaster prevention capabilities at all stages of disaster response. UN-ISDR's LG-SAT, which is currently performing assessment for community resilience, has selected 40 assessment areas for government employees in a given region to perform a self-assessment of resilience for all stages of disaster response, and attempts to ensure objectivity through documentation reviews and on-site inspections. Because of great variation among countries and cities, however, ensuring objectivity is very difficult, and constraints exist on the ability to perform regular monitoring.

Korea currently conducts EDMC-LG to assess and improve local disaster management conditions. As with the UN-ISDR and other tools, the EDMC-LG involve an initial self-review by local government employees and the submission of related documents. A central joint inspection team is also in place to conduct written and on-site inspections for outstanding municipalities, counties, and districts. EDMC-LG are conducted on a yearly basis, and steps are taken to ensure the recency and monitorability essential to resilience assessment data. Objectivity of examinations is also arguably ensured by the examination of documentation and the central joint inspection team's careful written and on-site examinations of outstanding local governments. Detailed indicators for the EDMC-LG were substantially revised in 2015 to incorporate the resilience concept using UNISDR's LG-SAT. Reviewing disaster management conditions and acquiring related data for all local governments nationwide is realistically beyond the capabilities of all but a presiding disaster management agency. To ensure data availability, objectivity, and monitorability, the resilience assessment method in this study uses data from the 2015 EDMC-LG .

The consent of the local governments was required for use of these data. Each of Korea's 229 municipalities, counties, and districts was contacted individually to request data. Some consented only on the condition that the data be used purely for research purposes and that the local government not be referred to by name; false names were used in the study for these local governments. Disaster management condition review data were acquired from 116 local governments for analysis.

Some difficulties were encountered in acquiring and examining data because of perceptions of disaster prevention as closely connected to real estate prices and regional image. These perceptions will need to change in the future, and the presiding disaster management authorities at MPSS will need to devise solutions for improvement to ensure continued assessment and monitoring of resilience.

Correlations between EDMC-LG Indicators and UN-ISDR's LG-SAT

EDMC-LG examine local disaster management conditions for a wide range of disasters besides flooding, including heat waves and heavy snow etc. Because this study is concerned specifically with flooding, only the 56 assessment areas associated with flooding[03] were extracted. Table 6 shows the results of an examination of their correlation with assessment areas in the UN-ISDR's LG-SAT.

03. Related information on selected assessment items is listed in Table 8.

04. EDMC-LG items is listed in Table 8.

Table 6. Connections between EDMC-LG Indicators and UN-ISDR's LG-SAT

LG-SAT Essential	Survey Item	Related EDMC-LG Item(s) I[04]	Score	
			Metropolitan/ Provincial	City/County/ District
(1) Establishing community groups for swift response to and recovery from damages	• Verifying local government capabilities to reduce damages from climate change and disasters	2-1-9, 2-2-4, 2-2-8, 2-2-12, 3-1-6, 4-1-4, 4-3-1, 4-3-2, 4-4-3, 5-1-1	56	56
	• Establishing cooperative system between local government and private sector to reduce disaster damages	2-2-16, 3-1-3, 3-1-4, 3-2-1, 3-2-8, 3-2-10, 4-2-1	26	29
	• Local government support system for socioeconomically vulnerable populations (women, seniors, infirm, etc.)	2-2-15	9	9
	• Local government involvement in national plans to reduce disaster damages	2-1-2, 2-1-5, 2-1-10, 2-2-13	24	10
(2) Ensuring budget for private sector (including low-income families)	• Adequate local government financial conditions to reduce disaster	3-2-6, 4-2-2, 4-2-3, 4-2-6	21	22
	• Awareness of local government use of finances to respond effectively to disaster	3-2-6, 4-2-2, 4-2-6	9	14
	• Extent of financial resource use for vulnerable citizen before disaster occurs	2-2-15, 4-2-6	9	9
	• Extent of financial resource use to support recovery after disaster occurs			
	• Incentivizing disaster damage reduction by ordinary families and local businesses			
	• Support for continued operation of small and medium-sized local businesses after disaster occurs (focus on recovery)			
(3) Identifying vulnerable facilities and establishing disaster damage measures	• Local government awareness of major regional vulnerabilities	2-2-3, 2-2-9, 2-2-17, 3-2-12, 4-1-1, 4-1-2, 4-2-5, 4-4-1, 4-4-2	48	46
	• Regular updates of vulnerability-related information	2-2-3, 3-2-10, 4-2-5, 4-4-1, 4-4-2	23	21
	• Sharing and discussion of disaster-related information between local government and residents	2-1-2, 2-2-16, 3-1-4, 3-2-2, 3-2-4, 3-2-5, 3-2-10, 3-2-12, 4-1-1, 4-1-4, 4-3-1, 4-3-2, 4-4-1	73	73
	• Collaboration with nearby local governments and central government	2-1-10, 2-2-3, 3-1-6, 4-2-3	28	16
	• Collaboration by agencies involved in disaster damage reduction	2-1-9, 3-2-2, 3-2-3, 3-2-4, 3-2-6, 3-2-9	17	19
(4) Invest in and maintain risk reducing infrastructure, such as storm drainage	• Inclusion of disaster damage reduction factors when instituting facilities in city (including housing, transportation, and energy)	2-1-5, 2-2-14	8	8
	• Response measures for public facilities susceptible to devastating damages, including hospitals and schools	2-1-7, 2-2-10, 2-2-11, 2-2-17	23	27
	• Measures to estimate damages of and preserve important public infrastructure when disaster occurs	2-2-17, 4-4-4	15	15

LG-SAT Essential	Survey Item	Related EDMC-LG Item(s) [04]	Score	
			Metropolitan/ Provincial	City/County/ District
(5) Assessing safety of public institutions (including schools and hospitals)	• Risk area classification for schools, hospitals, and health care facilities	2-2-17	7	7
	• Plans for repurposing of schools, hospitals, and health care facilities considering disaster damage	3-2-7	3	3
	• Regular local government safety assessments of public structures	2-2-17	7	7
	• Disaster response training for public building users			
(6) Establishing land usage system that adheres to disaster safety standards	• Inclusion of disaster damage reduction items in current land usage laws	2-1-5, 2-2-14, 4-4-3	14	14
	• Correlations between disaster damage reduction provisions and current building and land usage laws	2-1-5, 2-2-14, 4-4-3	14	14
(7) Disaster risk education by public institutions	• Disaster response education for local residents	3-1-3, 3-1-4, 3-2-12, 4-3-1, 4-3-2	22	29
	• Disaster response education for local government officials and community leaders	1-1-1, 1-1-2, 1-1-3, 2-2-4, 2-2-8, 4-3-1, 4-3-2	39	39
	• Disaster risk education for students	3-1-3, 4-3-1, 4-3-2	15	15
	• Resident awareness of local government's disaster response education and materials	3-1-3, 3-1-4, 3-2-4, 3-2-12, 4-3-1, 4-3-2	26	33
(8) Protect ecosystems and natural buffers to mitigate hazards, adapt to climate change	• Coordination of current environmental resource usage and preservation plans with newly instituted disaster damage reduction policies			
	• Introduction and operation of local government systems to protect ecosystem	4-2-4	5	5
	• Involvement by civic groups and local residents			
	• Private sector involvement in local government ecosystem protection plan development			
(9) Instituting early warning system	• Local institution access to local government disaster budget in event of disaster	2-2-10, 2-2-11, 3-2-6, 4-2-1	22	22
	• Local government early warning system establishment capabilities	2-1-4, 2-2-5, 2-2-6	13	16
	• Individual early warning system verification	1-1-4, 2-1-4, 2-2-6	18	21
	• Local government operation of emergency situation center	2-2-5, 2-2-8, 2-2-9, 3-2-2, 3-2-3	17	21
	• Disaster prevention training with participation by local representatives, central government, and employees of related local government department(s)	3-1-4, 4-3-1, 4-3-2	12	17
(10) Encouraging community involvement in recovery	• Expert involvement in treatment of psychological and emotional impacts of disaster	3-1-2	4	
	• Resident involvement in reconstruction activities when developing disaster damage reduction measures	2-1-6, 3-2-9	4	9
	• Establishment of emergency measures for residential areas after disaster occurs	2-1-6, 3-2-7	3	8

Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

Examination of the 56 LG-SAT indicators in terms of UN-ISDR resilience assessment areas, important conditions for each area, and linkages with related domestic legislation showed them to adequately reflect related examination areas for nearly all UNISDR scorecards, with the exceptions of cards (2) and (8). The EDMC-LG were likewise found to examine disaster management for all stages of disaster response (i.e., prevention, preparation, response, and recovery).

The largest number of detailed assessment areas in the EDMC-LG were found to be closely associated with item (3) on the UN-ISDR scorecard (identifying vulnerable infrastructure to formulate measures for disaster-related damages). The largest number of associated EDMC-LG were in the area of "disaster information sharing between local governments and local residents and questions for discussion," with metropolitan cities/provinces and municipalities/counties/district scoring the highest at 73 points.

At the same time, the UN-ISDR's LG-SAT indicators were not perfectly reflected in the EDMC-LG, as some of the LG-SAT indicators had no counterparts in the review. As noted in the analysis of linkages between UN-ISDR areas and related domestic laws, the review was found to insufficiently reflect content concerning item (2) on procuring budget monies for low-income families and other public sector areas and item (8) on environmental preservation for natural response to climate change. Korea's related legislation and disaster prevention policies will need to be amended in the future to include areas related to items (2) and (8) on the UN-ISDR scorecards.

2.5 Developing a Framework for Resilience Assessment

Resilience refers to a region's capability of responding to disasters in view of its climatic and physical vulnerabilities. For this study, a resilience assessment framework was developed as a means of evaluating disaster response capabilities while taking local climatic and physical disaster vulnerabilities into account. The resilience assessment framework was subsequently reconfigured into a matrix format including targets for management and assessment. To complete the resilience assessment framework, the 56 EDMC-LG indicators most closely associated with flooding were assigned to the matrix of management and assessment target categories in view of their characteristics (e.g., detailed assessment approaches, documentation, and disaster response stage etc.). In other words, detailed assessment areas from the EDMC-LG indicators were classified according to the actor(s) responsible for them (assessment targets: organization, budget, public participation) and the areas that might be improved through their enforcement (management targets: vulnerable areas, infrastructure, vulnerable citizen, and building) and then re-categorized into the resilience matrix to complete the resilience assessment framework.

Management targets are designed to reflect local disaster vulnerabilities to reflect as weighted values using future analysis calculations for vulnerability. Areas chosen as management targets were the sensitivity components in the disaster vulnerability assessment, namely vulnerable areas, urban infrastructure, vulnerable citizens, and buildings. Among these, "vulnerable areas" encompasses flood risk regions and factors, including areas around rivers and streams, low-lying areas, areas on sharp acclivities or at risk of landslides, and impervious surfaces. These risks can generally be mitigated through prevention projects and other construction measures and are closely associated with the prevention and recovery stages of disaster response. The "vulnerable citizens" target refers to population segments susceptible to disaster-related damages, an area closely associated with potential casualties. In terms of the disaster response stages, it is closely related to response and refers to areas where risk can be reduced through publicity, education, and information. "Urban infrastructure" includes not only the waterworks and sewage facilities directly tied to flooding, but a variety of other public facilities such as roads and railways that constitute factors potentially

amplifying secondary damages in the event of flooding. In terms of the disaster response stages, these targets are closely associated with preparation, response, and recovery and may be defined as targets for which risk can be reduced through reviews and the development of related plans. Finally, "buildings" include all privately owned buildings besides infrastructure. They are characterized by damages at the point level in the event of flooding and are closely related to the preparation, response, and recovery stages. In terms of flood preparations, risk may be reduced through publicity and education. Exposure factors are included in the disaster vulnerability assessment, but because exposure is analyzed in terms of area units defined by Thiessen polygons from observed values at 69 weather stations for Korea's 229 local governments, exposure factors were presumed to influence all local governments' sensitivity components equally rather than any specific one of them, and identical weighed exposure analysis values were applied for individual local governments to reflect differing exposure characteristics.

Assessment targets are categories assigned to promote the applicability of assessment findings, i.e., to examine which areas are especially lacking in terms of promoting resilience. They consisted of three areas that are generally used for classification in previously developed resilience assessment frameworks, namely organizations, budget, and public participation. As an assessment target, "organization" refers to the actors involved in local government disaster prevention planning, administration, and technical capabilities and includes factors such as planning and government employee skill and interest levels. "Budget" refers to the financial and material resources available to perform disaster prevention-related duties. "Public participation" includes various educational and other programs through which local governments encourage resident participation.

To complete the resilience assessment framework, the 56 detailed assessment areas in the EDMC-LG were categorized into assessment and management targets. Classification took into account factors such as assessment method, standards, documentation, and disaster response stage for each detailed area. As experts may disagree on these categories, discussion was deemed necessary, and categories were based on brainstorming and advisory conferences with internal and experts rather than expert questionnaires. Around ten experts in disaster prevention, climate, and urban planning took part in the classification process. Based on the results of brainstorming and advisory conferences to classify the detailed assessment areas in the EDMC-LG , the decision was made to allow selection of only one assessment target (organization, budget, or public participation) but multiple management targets (vulnerable area, vulnerable citizens, urban infrastructure, and buildings). While preventive efforts for vulnerable area are included in the general storm and flood damage plan and other disaster prevention plans, it is possible to reduce disaster risks for a variety of management targets through education for vulnerable citizens and inspections of buildings and infrastructure, among other measures. Because it is also possible to reduce risk for all management targets when a disaster prevention plan does not target one in particular, these were all classified as management targets. The assumption is that while risk can be reduced through disaster prevention efforts for vulnerable area, risk reduction for urban infrastructure and buildings is achieved less through preventive efforts than through publicity and reviews at the preparation stage. Table 8 shows the categories for the detailed assessment areas in the EDMC-LG, while Figure 4 shows the resulting resilience assessment framework.

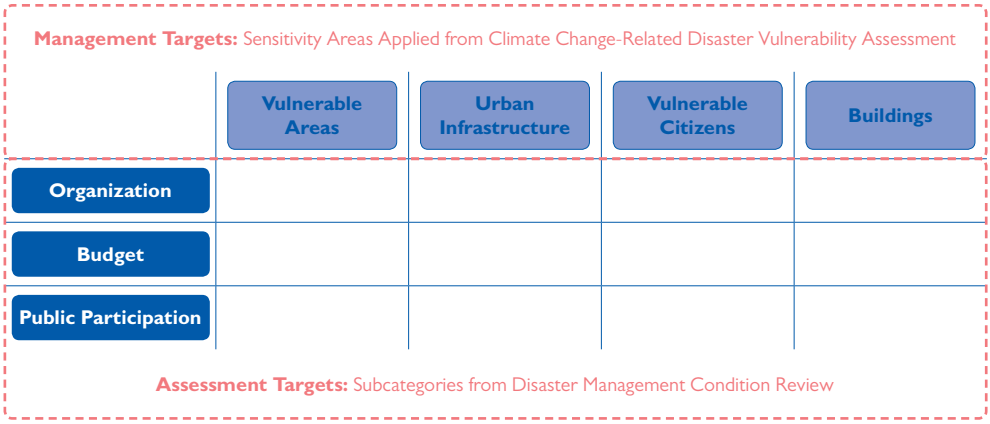
Table 7. Resilience Assessment System Scoring Categories for the Sub Indicators of EDMC-LG

	a. Vulnerable Areas		b. Vulnerable Citizens		c. Urban Infrastructure		d. Buildings	
	Review Item	City/County/ District Score	Review Item	City/County/ District Score	Review Item	City/County/ District Score	Review Item	City/County/ District Score
Organization	1-1-1.	4	1-1-1.	4	1-1-1.	4	1-1-1.	4
	1-1-2.	9	1-1-2.	9	1-1-2.	9	1-1-2.	9
	1-1-3.	4	1-1-3.	4	1-1-3.	4	1-1-3.	4
	2-1-2.	6	1-1-4.	8	1-1-4.	8	1-1-4.	8
	2-1-9.	8	2-1-2.	6	2-1-2.	6	2-1-2.	6
	2-2-4.	4	2-1-9.	8	2-1-5.	4	2-1-5.	4
	2-2-8.	6	2-2-3.	4	2-1-9.	8	2-1-9.	8
	2-2-9.	3	2-2-4.	4	2-2-4.	4	2-2-4.	4
	2-2-10.	10	2-2-5.	3	2-2-5.	3	2-2-5.	3
	2-2-11.	3	2-2-6.	3	2-2-8.	6	2-2-8.	6
	2-2-12.	4	2-2-9.	3	2-2-9.	3	2-2-12.	4
	2-2-13.	3	2-2-12.	4	2-2-10.	10	2-2-13.	3
	2-2-14.	4	2-2-13.	3	2-2-11.	3	2-2-14.	4
	2-2-17.	7	3-1-6.	6	2-2-12.	4	3-1-6.	6
	3-2-5.	4	3-2-2.	4	2-2-13.	3	3-2-3.	5
	4-1-1.	6	3-2-3.	5	2-2-14.	4	3-2-5.	4
	4-1-2.	4	3-2-5.	4	2-2-17.	7	4-1-4.	10
	4-1-4.	10	3-2-7.	3	3-1-6.	6	4-4-2.	11
	4-2-4.	5	4-1-2.	4	3-2-3.	5		
	4-2-5.	5	4-1-4.	10	3-2-5.	4		
	4-4-2.	11	4-4-2.	11	4-1-1.	6		
	4-4-3.	6			4-1-2.	4		
					4-1-4.	10		
					4-4-2.	11		
					4-4-4.	8		
Budget	3-2-6.	4	2-1-4.	10	3-2-6.	4	3-2-6.	4
	4-2-2.	8	2-2-15.	6	4-2-3.	8	4-2-3.	8
	4-2-3.	8	3-2-6.	4	4-2-6.	6	4-2-6.	6
	4-2-6.	6	4-2-1.	5				
			4-2-6.	6				
Public Participation	2-2-16.	6	3-1-3.	3	2-2-16.	6	2-1-6.	5
	3-2-1.	4	3-1-4.	7	3-2-1.	4	2-2-16.	6
	3-2-9.	4	3-2-1.	4	3-2-9.	4	3-2-1.	4
	4-3-1.	6	3-2-4.	6	3-2-10.	7	3-2-4.	6
	4-3-2.	6	3-2-9.	4	3-2-12.	7	3-2-9.	4
			3-2-10.	7	4-3-1.	6	3-2-10.	7
			3-2-12.	7	4-3-2.	6	3-2-12.	7
			4-3-1.	6			4-3-1.	6
			4-3-2.	6			4-3-2.	6

Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

Figure 4. Overview of Resilience Assessment Framework

Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.



Organization — Refers to local government's planning, administration, and technical capacities for disaster prevention; includes plan development and employee proficiency and attention

Budget — Financial and material resources to perform disaster prevention duties

Public Participation — Various local government programs and education to encourage community involvement

Vulnerable Areass — Refers to areass with flood risk or flooding factors, including areas around rivers, low-lying areas, sharp acclivities, landslide risk areas, and impervious surfaces; risk can typically be mitigated through prevention efforts and structural measures; strongly associated with prevention and recovery stages of disaster response

Urban Infrastructure — Includes not only waterworks facilities directly associated with flooding but also highways, railways, and various other forms of public infrastructure, which can exacerbate secondary damages from flooding; closely associated with preparation, response, and recovery stages of disaster response; risks can be reduced through reviews and related planning

Vulnerable Citizens — Vulnerable populations are closely related to the human toll of disasters and include populations that are vulnerable to disasters. This area is closely related to the response stage of disaster response, and risk can be minimized through publicity, education, and information

Buildings — Refers to privately owned buildings not including infrastructure, which suffer damages at the point level in the event of flooding; closely related to preparation, response, and recovery stages; risks can be mitigated through flood prevention publicity and education

Table 8. Assessment and Management Target Indicators for Disaster Management Condition Review Areas

Category	Review Item	Assessment Item	Category		Score
			Assessment Target	Management Target	City/ County/ District
1. Individual Capabilities — 1-1. Individual Capabilities					
1-1-1	Prior awareness of responsibilities and roles of disaster employees in the event of a disaster	Handling of duties and proficiency rate	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	4
1-1-2	Specialized education for disaster safety staff	Specialized education	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	6
		Education and review			3
1-1-3	Participation in disaster-related meetings, etc.	Disaster management condition review briefing and guideline participation	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	4
1-1-4	Transmission of Safe-On situation update system training messages within five minutes	Transmission	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure	8
2. Disaster Management Department Capabilities — 2-1. Disaster Preparation Goals and Planning					
2-1-1	Earthquake resistance reinforcement measures for public infrastructure, adherence to schedule	No corresponding item			
2-1-2	Formulation of the comprehensive plan for storm and flood damage reduction and implementation of reduction efforts	(Metropolitan/Provincial) Implementation	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	
		(City/County) Formulation and reduction effort implementation			6
2-1-3	Pursuit of locally tailored heat wave preparations and detailed implementation plans	No corresponding item			
2-1-4	Formulation and execution of implementation plan for disaster forecasting and warning system	Plan formulation	Budget	Vulnerable citizens	2
		Preparation for implementation plan			2
		Promotion of budget outlays and new installation			
		Budget investment in installation efforts			3
		New warning facility installation			3
2-1-5	Formulation and implementation of review plan for project leader's execution at preliminary disaster impact meetings	Formulation and implementation	Organization	Urban infrastructure, buildings	4
2-1-6	Successful enrollment of storm and flood insurance enrollment targets	Enrollment	Public Participation	Buildings	5
2-1-7	Implementation of prevention measures against multi-level/high-density structure collapse	No corresponding item			
2-1-8	Implementation of prevention measures for livestock diseases (foot-and-mouth, avian influenza, etc.)	No corresponding item			
2-1-9	Formulation of disaster response activity plan by function, degree of attention from institution head	Activity plan	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	5
		Attention from institution head			3
2-1-10	Metropolitan and provincial safety management plan	Suitability of plan	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	
		Adherence to formulation schedule			
		Holding of safety management committee meetings			

Category	Review Item	Assessment Item	Category		Score
			Assessment Target	Management Target	City/ County/ District
2. Disaster Management Department Capabilities — 2-2. Physical Disaster Management System					
2-2-1	Heat shelter reviews	No corresponding item			
2-2-2	Management of infrastructure targets for earthquake-resistance reinforcement	No corresponding item			
2-2-3	Examination and management of areas seen as being at risk of casualties	Survey plan formulation and reporting	Organization	Vulnerable citizens	2
		NDMS inputting			2
2-2-4	Professional training of disaster management officers to ensure continuity in duties	Professional training outcomes	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	4
2-2-5	Ongoing operation of disaster safety situation room and encouragement of ongoing operation	Ongoing operation	Organization	Vulnerable areas, urban infrastructure, buildings	3
		Encouragement of ongoing operation			
2-2-6	Regular reviews and management of disaster forecasting and warning facilities	Regular reviews	Organization	Vulnerable citizens	1
		Operation manual availability, designation of officials, record of management targets			1
		Registration of CCTV and observation equipment			1
2-2-7	Earthquake safety labeling system	No corresponding item			
2-2-8	Planning and execution of timely and effective situation review meetings	Plan formulation	Organization	Vulnerable areas, urban infrastructure, buldings	2
		Execution			4
2-2-9	Operation of SOPs in 17 disaster management system areas for weather alerts	Encouragement of operation	Organization	Vulnerable areas, urban infrastructure, buildings	
		Operation outcomes			3
2-2-10	Preventing reoccurrence of damage through timely disaster recovery efforts	Time taken to commission design	Organization	Vulnerable areas, urban infrastructure	3
		Time taken to commission construction			2
		Emergency bidding outcomes			2
		Completion before June of following year			3
2-2-11	Swift recovery through timely preliminary review request execution	Completion of preliminary review requests within designated time	Organization	Vulnerable areas, urban infrastructure	3
2-2-12	Incentives for disaster management department staff	(Metropolitan/provincial, city/county/ district) Staff incentives	Organization	Vulnerable areas, vulnerable citizen, urban infrastructure, buildings	2
		(Metropolitan/provincial, city/county/ district) Increased staffing			2
2-2-13	Formulation of disaster management condition review plan	(Metropolitan/provincial) Plan formulation and on-site reviews	Organization	Vulnerable areas, vulnerable citizen, urban infrastructure, buildings	
		(Metropolitan/provincial, city/county/ district) Participation by outside experts, incentives			3
2-2-14	Application of disaster-prone land usage regulations and building, health, and safety provisions to all development zones and building types	(City/county/district, Sejong, Jeju) Application to development zones and building types	Organization	Vulnerable areas, urban infrastructure, buildings	
		(Metropolitan/provincial) Encouragement of measures in connection with land usage and building regulations			4

Category	Review Item	Assessment Item	Category		Score
			Assessment Target	Management Target	City/ County/ District
2-2-15	General safety measures for children, seniors, women, and other vulnerable populations (not including heat and cold)	Plan formulation	Budget	Vulnerable citizens	3
		Implementation			3
		Budgeting			3
2-2-16	Encouraging handling by safety petition system	Membership	Public Participation	Vulnerable areas, urban infrastructure, buildings	2
		Safety issue reporting rate			2
		Percentage accommodated			2
2-2-17	Designation and management of facilities for special management	Designation and management	Organization	Vulnerable areas, urban infrastructure	4
		Review			3
3. Disaster Management Network Capabilities — 3-1. Use of Knowledge and Technology					
3-1-1	Local tax reductions of publicity to support earthquake-resistance reinforcement for privately owned structures	No corresponding item			
3-1-2	Psychological support for the stability of individuals experiencing disasters	Ordinance for disaster management fund use and counseling	Budget	Vulnerable citizens	
3-1-3	Self-education to encourage activity by autonomous community disaster prevention team	(Metropolitan/provincial) Encouraging self-education	Public Participation	Vulnerable citizens	
		(City/county/district, Sejong, Jeju) Self-education outcomes			3
3-1-4	Robust on-site training for storm and flood evacuation	Training	Public Participation	Vulnerable citizens	5
		Supplementation of evacuation plan and training			2
3-1-5	Surveying heat-vulnerable populations (single seniors and infirm) and designation and operation of disaster assistant system	No corresponding item			
3-1-6	Drafting and use of crisis management manuals by disaster type	Manual drafting and use	Organization	Vulnerable citizens, urban infrastructure, buildings	6
3. Disaster Management Network Capabilities — 3-2. Cooperation System among Participants					
3-2-1	Degree of disaster prevention collaboration relationship among community, private sector, and local government	Collaborative relationship	Public Participation	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	4
3-2-2	Prior controls on regions vulnerable to typhoon-related casualties and operation of collaboration system with relevant agency	Prior controls	Organization	Vulnerable citizens	2
		Collaboration system			2
3-2-3	Early joint undertaking of emergency duties by relevant institutions in the event of a typhoon	Early undertaking of emergency duties	Organization	Vulnerable citizens, urban infrastructure, buildings	3
		Participating institutions			2
3-2-4	Holding and publicizing preliminary meetings on typhoon measures under institution head's supervision	Holding of preliminary meetings	Public Participation	Vulnerable citizens, urban structures	2
		Publicizing guidelines for resident actions			2
		Institutions requesting publicity			2
3-2-5	Announcement of disaster management conditions	Announcement	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	
		Announcement of disaster management conditions			4
3-2-6	Plan for disaster management resource stockpiling and management and degree of updating of joint usage system resources	Stockpiling management plan	Budget	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	2
		Degree of updating of joint usage system resources			1
		Work agreements			1

Category	Review Item	Assessment Item	Category		Score
			Assessment Target	Management Target	City/ County/ District
3-2-7	Designation and operation of temporary living facilities for evacuees	Designation and management	Organization	Vulnerable citizens	3
		Encouragement of designation and management			
3-2-8	Deputy institution head or higher supervising regular disaster safety network meetings to promote private-government cooperation on disaster safety	Promotion of private-government cooperation	Public Participation	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	
3-2-9	Prior collaboration system among relevant institutions and private groups for emergency recovery	(Metropolitan/provincial, city/county/district) Discussion meetings	Public Participation	Vulnerable areas, vulnerable citizens, urban infrastructure, buildignss	4
3-2-10	Safety culture campaign implementation	(Metropolitan/provincial, city/county/district) Safety culture campaigns (including review of vulnerable infrastructure)	Public Participation	Vulnerable citizens, urban infrastructure, building	3
		(Metropolitan/provincial, city/county/district) Involvement by disaster-related groups			2
		(Metropolitan/provincial, city/county/district) Participation and publicity			2
3-2-11	Epidemiological studies and staffing for possible infectious diseases	No corresponding area			
3-2-12	Safety inspection day events	(Metropolitan/provincial, city/county/district)	Public Participation	Vulnerable citizens, urban infrastructure, buildings	7
4. Institution Capacities — 4-1. Leadership by Institution Head					
4-1-1	On-site visits and publicity by deputy institution head or higher to storm and flood disaster-vulnerable regions and facilities (not including typhoons or heat)	(Metropolitan/provincial, city/county/district) On-site visits	Organization	Vulnerable areas, urban infrastructure	4
		(Metropolitan/provincial, city/county/district) Media promotion			2
4-1-2	Preliminary institution head and executive staff reviews for regions and facilities vulnerable to typhoon damage (not including storms, flooding, or heat)	(Metropolitan/provincial, city/county/district) On-site inspections by institution head	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure	2
		(Metropolitan/provincial, city/county/district) On-site inspections by executive staff			2
4-1-3	On-site visits and publicity by deputy institution head or higher to workplaces vulnerable to heatwaves (not including typhoons, storms, or flooding)	No corresponding item			
4-1-4	Interviews by deputy institution head or higher to promote attention to disaster management	(Metropolitan/provincial, city/county/district) Interviews	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	5
		(Metropolitan/provincial, city/county/district) Attention, commitment, incentives, etc.			5
4. Institution Capabilities — 4-2. Administrative and Financial Support					
4-2-1	Budgeting for autonomous community disaster prevention team	(Metropolitan/provincial) Encouraging budgeting	Budget	Vulnerable citizens	
		(City/county/district, Sejong) Budgeting			5
4-2-2	Average annual budget investment in disaster prevention over preceding three years	(City/county/district) Budget investment	Budget	Vulnerable areas	5

Category	Review Item	Assessment Item	Category		Score
			Assessment Target	Management Target	City/ County/ District
4-2-3	Timely recovery plan determination and notification and budgeting for swift disaster recovery efforts	(Metropolitan/provincial) Determination and notification period	Budget	Vulnerable areas, urban infrastructure, buildings	
		(Metropolitan/provincial) Time taken for budgeting			
		(Metropolitan/provincial) Budgeting period			
		(City/county/district) Budgeting			4
		(City/county/district) Budgeting period			4
4-2-4	Degree of local government support for ecosystem restoration and protection and sustainable management	Support	Organization	Vulnerable areas	5
		Support			
4-2-5	Drafting of flood inundation maps	Flood inundation mapping	Organization	Vulnerable areas	5
4-2-6	Yearly budgeting for disaster management fund	Disaster management fund	Budget	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	6
4. Institution Capabilities — 4-3. Education and Training Development					
4-3-1	Independent disaster education plan formulation and implementation for public and government employees	(Metropolitan/provincial, city/county/district)	Public Participation	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	6
4-3-2	Development of independent disaster education programs for public and government employees	(Metropolitan/provincial, city/county/district)	Public Participation	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	6
4. Institution Capabilities — 4-4. Innovations					
4-4-1	Sharing disaster management condition review findings with public	(Metropolitan/provincial)	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	
4-4-2	Improving inadequacies from previous year's disaster management condition review	(Metropolitan/provincial, city/county/district) Improvement plan formulation	Organization	Vulnerable areas, vulnerable citizens, urban infrastructure, buildings	3
		(Metropolitan/provincial, city/county/district) Improvements			8
		(Metropolitan/provincial) Reviews and encouragement			
4-4-3	Improvements in areas identified in review of project leader's execution at preliminary disaster impact review	(Metropolitan/provincial, city/county/district)	Organization	Urban infrastructure	6
4-4-4	Measures to protect major public facilities and infrastructure from damage while disaster is occurring	(City/county/district, Sejong) Implementation of measures	Organization	Urban infrastructure	
		(Metropolitan/provincial) Encouragement of measures			8

Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

2.6 Resilience Assessment and Analysis

Methods of Resilience Assessment

A. Using the Resilience Assessment Framework to Calculate Local Government Values and Apply Weighted Value

To calculate values, results from the EDMC-LG were applied to the resilience assessment framework in Figure 4, which is categorized into management and assessment targets in view of the nature of assessment subareas in the reviews.

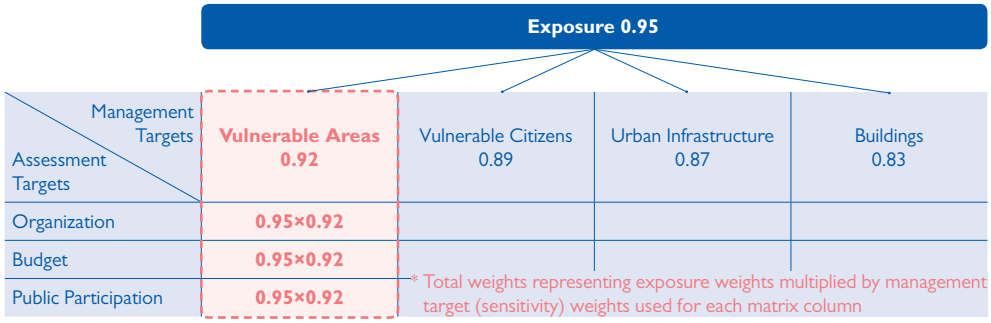
Once the resilience assessment framework has been used to calculate local government values, weighted value is applied with results from the standardized disaster vulnerability assessment. For weighting, management target values (for vulnerable area, vulnerable citizens, urban infrastructure, and buildings) and exposure values are used as calculated through the local government disaster vulnerability assessment. The exposure and four areas of sensitivity (management targets) used for weighting are based on calculations for Korea's 229 local governments, which are respectively standardized with values between 0 and 1. Standardized sensitivity value from the disaster vulnerability assessment are applied as weighted values for each of the four management targets (columns) in the resilience assessment framework; for exposure, the same approach is used for each column (Figure 5a). Once weights have been applied through the resilience assessment framework, they can be used as resilience assessment values, as response capabilities reflect local climate and disaster vulnerabilities.

B. Ranking Resilience Assessment Values

For the resilience assessment values calculated through the framework, local government weights and the EDMC-LG scores will differ, and the values are not capable of representing facility design standards or absolute phenomena such as rainfall. Effective assessment of local government resilience therefore requires ranking as a simple way of representing degree of resilience through relative comparison. While ranking should be performed for all 229 local governments nationwide, this study calculated and ranked resilience values for 116 local governments due to difficulties acquiring additional data. Ranking was performed for 20 items: 12 resilience assessment framework cell values composed of management and assessment targets, 4 management target resilience items representing the sum of each column, 3 assessment target items representing the sum of each row, and 1 general resilience value representing the sum of all values (Figure 5b). For ranking, the natural breaks method (Jenks optimization) applied in the disaster vulnerability assessment was used. As in that analysis (2011), five levels of I to V were assigned, where V represented the lowest level of resilience.

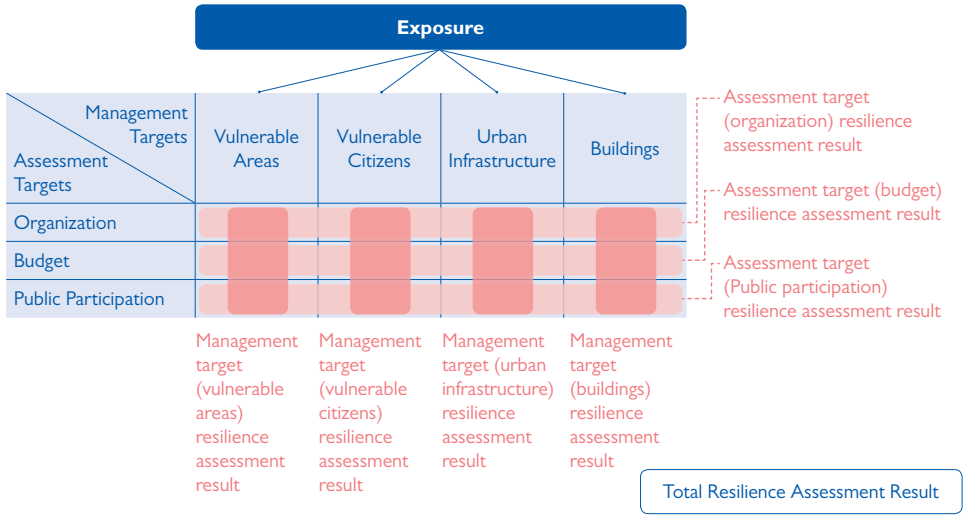
Figure 5. Weighting and Results of Resilience Assessment (Conceptual Diagram)

a. Weighting



Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

b. Resilience Assessment Results



Method of Analysis

The resilience analysis method consisted broadly of three nationwide analyses and analyses for 1 individual local governments. The three nationwide analyses examined not only resilience but also amount of flood-related damages, disaster vulnerability, and resilience assessment findings. While flood-related damages represent a precise value through which the scale of disaster losses can be quantitatively examined, they are limited in their applicability to analysis of causes of disaster or development of response measures. The disaster vulnerability assessment involves a causal analysis of damages to identify indicators for the relative assessment of regional vulnerability, while the resilience assessment is a relative evaluation of the local governments used in the analysis, which presents difficulties in terms of absolutization. To maximally address potential limitations of an analysis at the unitary level, the study compared and analyzed local government flood-related damages and disaster vulnerability assessment, EDMC-LG, and resilience findings at the national level. Through comparison and analysis of

EDMC-LG data for local government sensitivity vulnerabilities and management targets through which sensitivity might be improved, the extent to which regionally customized response measures are being developed was also analyzed. The local government resilience analysis was conducted to present avenues for use of the resilience assessment methodology through application to local governments with different disaster vulnerability characteristics. Table 9 presents an overview of the analysis methods used.

Table 9. Overview of Analysis Methods

Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

Type	Title of Analysis	Reason for Analysis	Analysis Approach	Comments
National	Comparative analysis of flood damage, flood vulnerability, and EDMC-LG findings	Comparison of damages, vulnerability, and response capabilities for local governments nationwide	i) Comparison for damages/ vulnerability for all 229 local governments ii) Comparison of damages, vulnerability, and EDMC-LG findings for 116 local governments	EDMC-LG reflects total of 56 sub-indicators not applied to resilience assessment framework
National	Analysis of disaster response capabilities by area of sensitivity	Comparison of disaster capabilities in terms of local vulnerabilities	The results of sensitivity in Disaster Vulnerability Assessment compared against management targets in EDMC-LG	EDMC-LG findings re-categorized in terms of resilience assessment framework, weighting for exposure and sensitivity not applied
National	Resilience assessment for local governments nationwide	Assessment and analysis of resilience at national level	Comparison of total resilience for local governments nationwide	Resilience assessment framework and weighting applied
Individual	Resilience assessment for individual local governments	Analysis of local government resilience characteristics by management target	Comparison of total resilience and management target resilience assessment findings for individual local governments	Use of management target, assessment target, and total resilience data for reference governments

Due to difficulties in representing values besides damages from the disaster vulnerability assessment, EDMC-LG, and resilience in terms of absolute values, an approach of ranking relative findings for national level or analyzed local governments must be applied. Comparison of ranked values also requires damages to be represented in terms of a relative ranking. For classification of these values, the natural breaks (Jenks optimization) method was used to rank them in five levels from I to V, where a V ranking was selected to represent the most negative effect on flooding damages. In other words, a V ranking represents the highest level of flood damages and vulnerability and the lowest levels of disaster response capacity (lowest disaster management condition review score) and resilience.

Table 10. Meaning of Assessment Ranks

Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

Rank	Damages	Disaster Vulnerability Assessment	EDMC-LG	Resilience
Level V	Most damages	Most vulnerable	Lowest EDMC-LG score	Least resilience
↕	↕	↕	↕	↕
Level I	Least damages	Least vulnerable	Highest EDMC-LG score	Most resilience

A. Comparative Analysis of Flood Damages, Flood Vulnerability, and EDMC-LG

The first of the analyses at the national level examined flood damages, flood vulnerability, and EDMC-LG. Flood damages represent the direct results of flooding, while flood vulnerability is a value identified through analyzing disaster vulnerability in terms of factors influenced by exposure and flooding. Because even regions with climates and urban characteristics that leave them practically vulnerable to flooding may experience lesser flood damages due to their disaster response capabilities, and because lesser damages may be experienced due to lack of flooding during the damage calculation period, it is impossible to conclude that damages conform precisely with flood vulnerability. Because each analysis value carries limitations, however, this should be examined and used to increase the precision of the analysis. Accordingly, this study instituted a stage of comparison and analysis for flood damages, flood vulnerability, and disaster response capabilities. The comparative analysis process for flood damages, flood vulnerability, and EDMC-LG findings consisted broadly of two analyses.

The first analysis involved comparing and analyzing flood damages and flood vulnerability for Korea's 229 local governments. The analysis consisted of two parts, a national map-based comparison of flood damage and flood vulnerability data ranked into five levels and a comparison of flood vulnerability assessment findings for high-damage local governments (Levels IV and V). For these high-damage local governments, flood vulnerability values were grouped into high vulnerability (Level IV and V), medium vulnerability (Level III), and low vulnerability (Level I and II) categories to compare their distribution.

The second analysis consisted of ranking, comparing, and analyzing flood damages, flood vulnerability, and EDMC-LG scores for the 116 local governments for which review data could be obtained. Flood vulnerability and EDMC-LG ranking distributions were compared and analyzed for high-damage local governments (Levels IV and V).

The data used for this analysis broadly consisted of flood damages, flood vulnerability findings, and EDMC-LG scores. For the first of these (flood damages), disaster annuals were used to calculate yearly average flooding damages (public infrastructure and structures) over the 20-year period from 1995 to 2014 for local governments throughout Korea. Because local government areas could potentially distort the findings by influencing damage values, damages were calculated by unit area (km^2) and damage values were converted into 2015 currency values. The flood vulnerability assessment used ranked values for local governments nationwide from a general flood vulnerability assessment using the flood vulnerability assessment methodology (2011). For EDMC-LG data, totals were ranked for the 56 detailed assessment indicators' values closely related to flooding by each local government. The resilience analysis framework and weighted values were not applied for the comparison and analysis of flood damages, flood vulnerability, and EDMC-LG scores.

B. Analyzing Disaster Response Capabilities by Sensitivity

Disaster vulnerability varies from one region to the next, and reducing damages requires the development of customized measures that take vulnerability characteristics into account. In this sense, it is crucial to examine how to bolster customized disaster response capabilities that reflect regional disaster vulnerabilities. The analysis of disaster response capabilities by area of sensitivity consisted of a comparison of local

vulnerabilities by area of sensitivity with EDMC-LG findings for different management targets. In other words, highly vulnerable local governments in terms of areas of sensitivity (vulnerable area, urban infrastructure, vulnerable citizens, and buildings) were identified, and the distribution of their EDMC-LG rankings for management targets according to the resilience assessment framework (vulnerable area, urban infrastructure, vulnerable citizens, and buildings) were compared and analyzed. The analysis was performed for the 116 local governments for which EDMC-LG data could be obtained, and consisted of categorization of EDMC-LG subarea assessment scores according to the resilience analytical framework and the calculation of scores for management targets, which were not weighted for climate or sensitivity.

C. Analyzing Local Government Resilience at the National Level

The final analysis at the national level concerned resilience. For the national local government resilience analysis, high risk local governments were first identified based on flood damage data and compared and analyzed in terms of total resilience, resilience in terms of the four management targets, resilience in terms of the three assessment targets, and ranking distribution. For the resilience assessment in this analysis, EDMC-LG findings were re-categorized according to the resilience assessment framework, and standardized and ranked data were used with weighting for local government exposure and management targets.

D. Resilience Analysis for Individual Local Governments

Individual local governments were selected for resilience analysis based on vulnerability assessment and resilience analysis findings for local governments with high levels of flood-related damages. Local flood damages and climate/sensitivity vulnerability and general vulnerability analysis findings were compared and analyzed for the selected local governments. Analysis was also performed for results related to the 20 areas in the resilience assessment framework, including the 12 cell values, 4 management target resilience results, 3 assessment target resilience results, and total resilience result. To examine why resilience analysis scores were low, analysis was performed on disaster vulnerability findings and EDMC-LG subarea ratings. Methods for bolstering resilience were suggested.

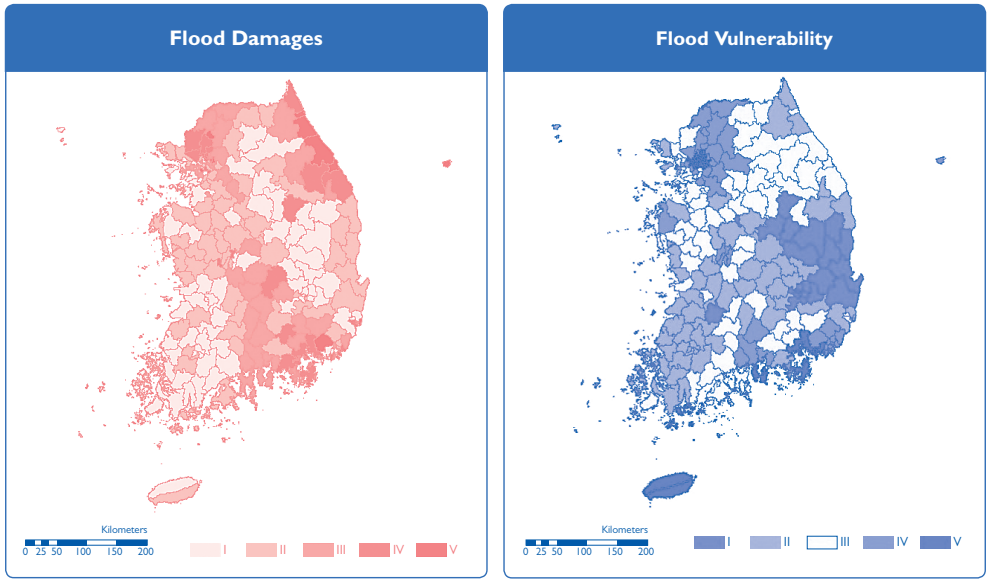
2.7 Result Analysis

Comparative Analysis of Flood Damages, Flood Vulnerability, and EDMC-LG Findings

A. Flood Damage and Vulnerability Comparison for all 229 Local Governments

As shown in Figure 6, comparison of Korea's 229 local governments in terms of damage and general vulnerability rankings showed the Seoul, Gyeonggi-do, southern coast, and Busan area regions to have both high damages and high levels of vulnerability. For additional analysis, local governments with high levels of damage (damage rankings of IV and V) were identified and the distribution general flood vulnerability rankings compared and analyzed. The analyses showed 61% of high risk local governments to also be highly vulnerable (Levels IV and V for flood vulnerability), 21% to be moderately vulnerable (Level III), and 18% to be low-vulnerability (Levels I and II). According to the analysis findings, local governments with large amounts of flood-related damages generally also exhibited high flood vulnerability.

Figure 6. Comparison of Flood Damages and Flood Vulnerability Rankings



Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

B. Comparison Flood Damages, Flood Vulnerability, and EDMC-LG Findings for 116 Local Governments

As previously noted, complete data could not be obtained for all 229 local governments for this study. Accordingly, flood damage, flood vulnerability, and EDMC-LG findings for 116 local governments for which review data were available were re-ranked and submitted to comparison and analysis. The analysis showed around 44% of high risk local governments (Levels IV and V) to rank high for flood vulnerability (Levels IV and V), 16% with moderate vulnerability (Level III), and 40% with low vulnerability (Levels I and II). Among high risk local governments, 28% rated as inadequate in the EDMC-LG (Levels IV and V), 32% as average (Level III), and 40% as outstanding (Levels I and II). Sixty percent of high risk local governments (Levels IV and V) were either highly or moderately vulnerable, while around 50% of local governments were found to be distributed in the "inadequate" or "average" categories for EDMC-LG rankings. This indicates that local governments with high amounts of damages also tended to have high flood vulnerability and poor disaster management.

Disaster Response Capability Analysis by Sensitivity Area

This analysis examines whether disaster response capabilities are being bolstered in view of local vulnerabilities.

General flood vulnerability assessment findings were used to identify high vulnerability local governments (Levels IV and V), and distribution diagram analysis was formed for EDMC-LG rankings. Among high vulnerability local governments (Levels IV and V), around 54% had inadequate general EDMC-LG ratings (Levels IV and V), while 28% had outstanding results (Levels I and II); only 14% had average results. In other words, many local governments were found to have inadequate EDMC-LG scores in addition to their high flood vulnerability.

To examine whether EDMC-LG were taking local disaster vulnerability into account, highly vulnerable local governments were identified for areas of sensitivity (vulnerable area, urban infrastructure, vulnerable citizens, and buildings) and the EDMC-LG ranking distribution was examined for the respective management targets. Only 32% of highly vulnerable local governments in terms of the vulnerable area sensitivity area received "outstanding" rankings for the vulnerable region management target in the EDMC-LG; another 43% were rated as inadequate, while 25% received average ratings. For the urban infrastructure sensitivity area, 64% of high vulnerability local governments were found to rank as inadequate for the infrastructure management target in the EDMC-LG, while 9% ranked as average and 27% as outstanding. For vulnerable citizens, a relatively high 61% were ranked as outstanding for the vulnerable citizens management target in the EDMC-LG, while 8% ranked as average and 31% as inadequate. Finally, in terms of buildings management target rankings in the EDMC-LG for local governments rated as highly vulnerable for the "buildings" sensitivity area, 27% rated as outstanding, 50% as average, and 23% as inadequate.

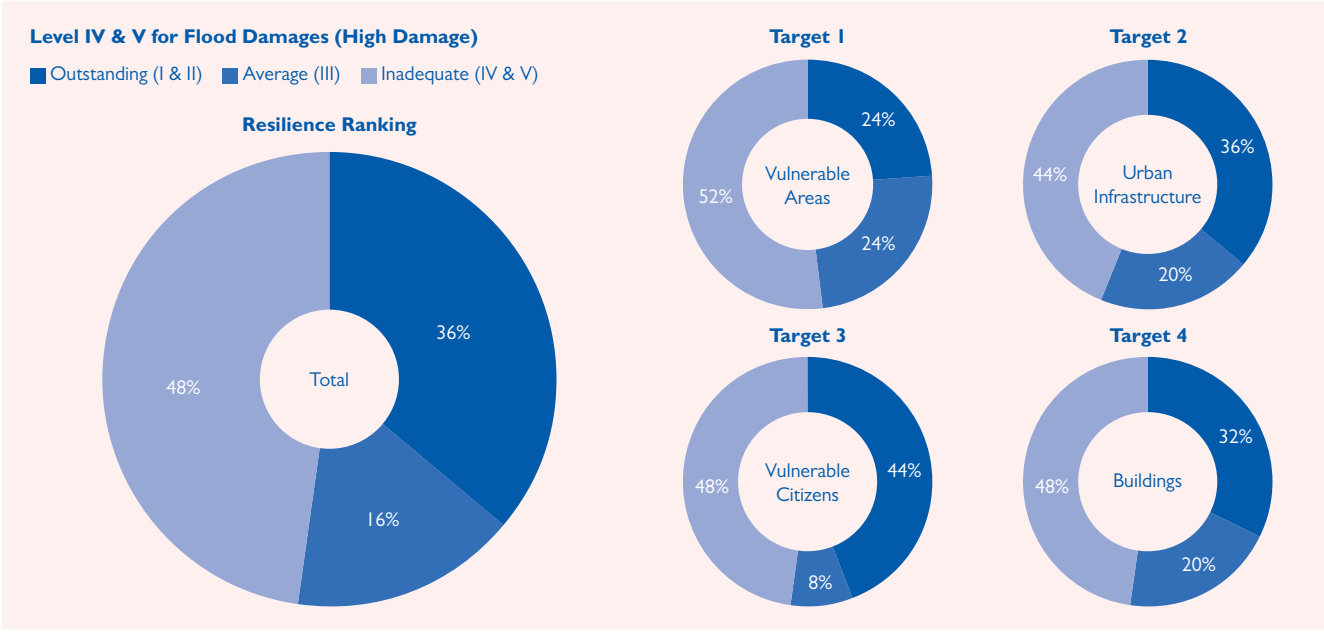
Analysis findings for disaster response capabilities by area of sensitivity showed many highly vulnerable local governments in terms of the vulnerable citizens sensitivity area to generally rank as outstanding in their EDMC-LG findings on their response to vulnerable citizens. For the remaining areas of vulnerable area, urban infrastructure, and buildings, however, many governments were found to rate as inadequate or average. This may be interpreted as showing that disaster response is not taking local disaster vulnerability into consideration.

National Local Government Resilience Analysis

For the national local government resilience analysis stage, local governments rating high for damages (Levels IV and V) were analyzed in terms of their general resilience findings and their resilience findings for management targets (vulnerable area, vulnerable citizens, urban infrastructure, and buildings) and assessment targets (organizations, budget, public participation). Around 48% of high damage local governments were found to have low general resilience ratings; 16% rated as average and 36% as outstanding. This suggests that local governments with high levels of damages are also low in resilience.

Analysis of resilience for management targets among high damage local governments showed around 40–50% of them to rate low for resilience for the four management targets (vulnerable area, vulnerable citizens, urban infrastructure, and buildings). Among management targets, 52% of local governments were found to rate as inadequate for resilience in terms of vulnerable area, while 24% rated as average and 24% as outstanding. A large 48% rated inadequate for resilience in terms of vulnerable citizens, while 8% rated as average and 44% as outstanding. Similarly, a large 44% rated as inadequate for resilience in terms of urban infrastructure, while 20% rated as average and 36% as outstanding. For resilience in terms of the buildings management target, 48% rated as inadequate, which was the same percentage found to be inadequate in terms of vulnerable citizens; 20% were rated as average and 32% as outstanding.

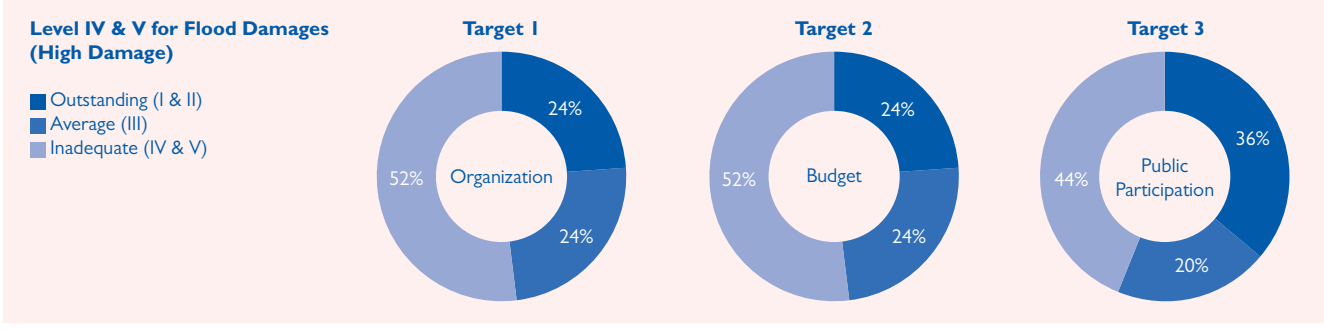
Figure 7. Resilience Rankings for Management Targets among High-damage Local Governments



Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

Analysis of resilience in terms of assessment targets for high-damage governments showed a rather large number to rate as inadequate for resilience in terms of the organization, budget, and public participation targets. At the same time, 44% of local governments were found to rate as outstanding for resilience in terms of the public participation assessment target. For resilience in terms of the organization assessment target, a large number of local governments rated as inadequate at 48%, compared to 32% rated as average and 20% as outstanding. As with organizational resilience, the largest percentage of local governments (48%) were rated as inadequate on the budget resilience assessment target, while 28% rated as average and 24% as outstanding. Resilience for the public participation assessment target was stronger than for other assessment targets, with 44% rated as outstanding, 40% as inadequate, and 16% as average.

Figure 8. High-damage Local Government Resilience Ratings for Assessment Targets



Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

Individual Local Government Analysis

At the request of the local governments providing EDMC-LG data, false names were used in the individual local government analysis, and the actual names were not stated. For weighting of local climate and sensitivity, disaster vulnerability assessment were conducted for the 229 local governments nationwide, and findings were standardized and ranked.

<Resilience Analysis: Local Government "A">

Damages due to flooding for local government "A" amounted to around 35.3 billion won over the 20-year period from 1995 to 2014. Particularly severe damage occurred due to heavy rainfall in 2001 and 2011, which accounted for more than half of total damages. Average annual flooding damages were calculated at 59.64 million won per unit area (km^2), or roughly 3.4 times the national average annual for flood-related damages, which was 17.32 million won per unit area.

The flood vulnerability assessment for Korea's 229 local governments showed A to rate as highly vulnerable, with rankings of Level V for exposure, sensitivity, and total flood vulnerability. It also rated as generally vulnerable in terms of sensitivity subareas, with rankings of Level IV for vulnerable area, Level IV for vulnerable citizens, Level IV for urban infrastructure, and Level V for buildings. The buildings subarea in particular showed greater vulnerability than others.

Table 11. Flood Vulnerability Assessment Findings for Local Government "A"

Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

Analysis Metric	Local Government "A"	
	Standardized Value	Level
Current exposure (average number of days per year with rainfall of 80mm or higher)	0.7500	V
Vulnerable area(river length, area with elevation below local government average, impervious surfaces, sharp acclivities, landslide risk area)	0.3098	IV
Vulnerable citizens (total aged below six years and over 65 years)	0.4683	IV
Urban infrastructure(Infrastructure area)	0.4113	IV
Buildings(Percentage semi-underground and standalone housing)	0.4664	V
Sensitivity	0.4140	V
Flood Vulnerability	0.5820	V

Application of flood vulnerability assessment weights through the resilience assessment framework showed A rating as highly inadequate for all categories, including Level V ratings for resilience in each of the management targets of vulnerable area, vulnerable citizens, urban infrastructure, and buildings. Similarly, it received ratings of Level V for the resilience assessment targets of organization, budget, and public participation, resulting in a general resilience rating of Level V. In terms of resilience subareas, A earned high Level V flood vulnerability ratings in all categories except budgeting for vulnerable area and public participation (Level IV), and its overall disaster response capabilities were found to be inadequate.

Table 12. Resilience Ratings for Local Government "A"

Local Government "A"	Vulnerable Area	Vulnerable Citizens	Urban Infrastructure	Buildings	All Assessment Targets
Organizations	V	V	V	V	V
Budget	IV	V	V	V	V
Public Participation	IV	V	V	V	V
All Management Targets	V	V	V	V	V
Total Resilience				V	

Source: Han WooSuk.2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.

Local government A's general resilience rating of Level V indicates a need for improvement in all areas, but the flood vulnerability assessment findings suggest a need for priority measures to address buildings, which had the lowest vulnerability rating among sensitivity sub-indicators. EDMC-LG sub-indicators reflecting diagnostic item (6) from UN-ISDR's MCR campaign[05] showed no results in terms of regulations on the usage of disaster-sensitive land or provisions on buildings, health, and safety being applied to development zones and buildings within the local government. The local government should therefore make a priority of discussing permits for development actions in disaster prevention zones, areas with sharp acclivities, and natural disaster risk improvement zones and permits for alteration of architecture and land quality. Based on these discussions, disaster risk improvement zones should be designated and announced, and ordinances should be enacted for permits on architecture and alterations of land quality. Guidelines should also be established to limit architectural permits for semi-underground structural units in the interest of disaster prevention. Additionally, the rate of voluntary reporting of vulnerable area, urban infrastructure, and buildings by the community should be encouraged through active publicity by a safety petition system to promote community involvement, and the disaster prevention response and support for recovery should be bolstered through timely on-site inspections.

05. UN-ISDR MCR campaign review indicator (6): Formulation of land usage plans based on adherence to disaster prevention safety standard; inclusion of damage reduction provisions in current land usage laws; correlation between disaster reduction provisions and current laws concerning buildings and land usage.

"The local government should therefore make a priority of discussing permits for development actions in disaster prevention zones, areas with sharp acclivities, and natural disaster risk improvement zones and permits for alteration of architecture and land quality."

CHAPTER V.

Ideas for Improving Resilience in Response to Flooding-related Disasters

1. Incorporating Resilience Concepts in Urban Planning

The most prominent example of resilience assessment and reinforcement policy worldwide is UN-ISDR's Making Cities Resilient (MCR) campaign. As the name indicates, urban planning measures are a very important component in bolstering resilience.

For this study, subareas for the UN-ISDR resilience assessment were compared and analyzed with respect to Korean laws related to disaster prevention, spatial use, and rivers and its disaster prevention policies. Among the ten scorecards, deficiencies were found in terms of the second (budgeting for the private sector, including low-income families) and the eighth (environmental preservation for a natural response to climate change). Assessment subareas for scorecard (8) include the coordination of current environmental resource usage and conservation plans with newly introduced disaster damage reduction policies, introduction and maintenance of local government systems related to ecosystem protection, involvement by civic groups and local residents, and private sector involvement in the formulation of local government ecosystem protection plans. Examination of the scorecard (8) subareas shows "environment," "ecosystem preservation," and "community involvement" to be important keywords, but consideration of actual applications underscores the importance of linkages with city/disaster prevention/environment policies (including the use of urban green infrastructure to bolster resilience) and of community participation in reflection of the large amounts of privately owned land and structures within the city. For New York City's current PlaNYC, over 250 different plans have been formulated for bolstering resilience in connection with the city, disaster prevention, and the environment to increase urban infrastructure, building, and environment resilience in response to climate change, and efforts have been made to include residents in bolstering resilience in the city center. PlaNYC's most prominent resilience reinforcement plan, the "Big U Project"[06], may be the best example of linking city, disaster prevention, and

06. The Big U Project is an award-winning program from the New York-centered Rebuild by Design project which received the equivalent of 396.2 billion won in resilience budgeting from HUD.

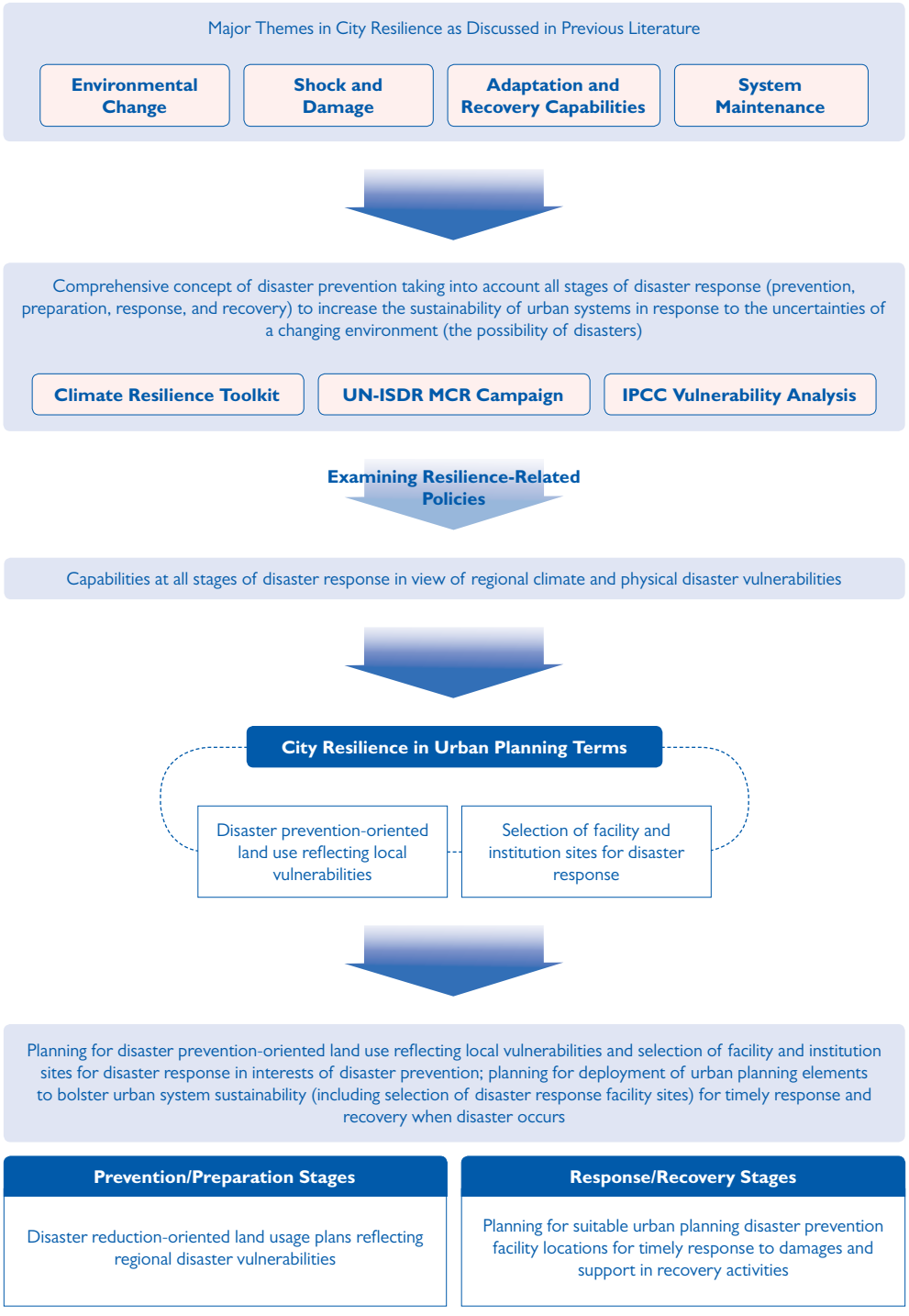
environmental planning through green infrastructure. Examination of other examples of and policies for resilience reinforcement show a trend of increased linkage among different plans to bolster resilience within cities.

The need to increase linkages with city/disaster prevention/environmental planning has also been recognized in Korea. In 2012, the Enforcement Land Use Regulations at the National Territory Plan and Use Act was amended to require reflection of the Comprehensive Plan for Storm and Flood Damage Reduction in urban planning, but related policies cannot be seen as having taken root effectively to date. In view of this, the definition of city resilience in urban planning terms should be recalibrated, and measures should be developed for incorporation of the resilience concept to Korean city and disaster planning policies through its application to relevant rules and guidelines. Additional functions of resilience in urban planning terms should be identified through the resilience concept as redefined in this study, namely a "comprehensive concept of disaster prevention taking into account all stages of disaster response (prevention, preparation, response, and recovery) to increase the sustainability of urban systems in response to the uncertainties of a changing environment (the possibility of disasters)." As it is not possible to make disaster prevention measures in urban planning as dynamic as disaster response, they may be interpreted as support measures for each disaster response stage. Resilience in urban planning terms may be redefined based on a classification of pre- and post-disaster periods as "planning for disaster reduction-oriented land usage, infrastructure sites, and installation to reflect regional disaster vulnerability in the interest of disaster prevention, and planning for the deployment of urban planning elements to increase the sustainability of urban systems after disaster occurs, including disaster response infrastructure site selection that takes into account a timely response and recovery from damages."

Incorporation of the resilience concept in urban planning terms through linkages with city/disaster prevention/environmental planning will first require introduction of the city resilience concept from an urban planning standpoint in the Ministry of Land, Infrastructure and Transport's urban disaster prevention-related regulations, including metropolitan city plans, city/county framework plans, and management plans. Subsequently, it will require measures for expansion and linking to policies linked to those guidelines in other agencies, including the Ministry of Environment and Ministry of Public Safety and Security etc.

Figure 9. Formulating a Concept of Urban Resilience

Source: Ministry of Land, Infrastructure and Transport 2016.



2. Amending Disaster Vulnerability Assessment Guidelines

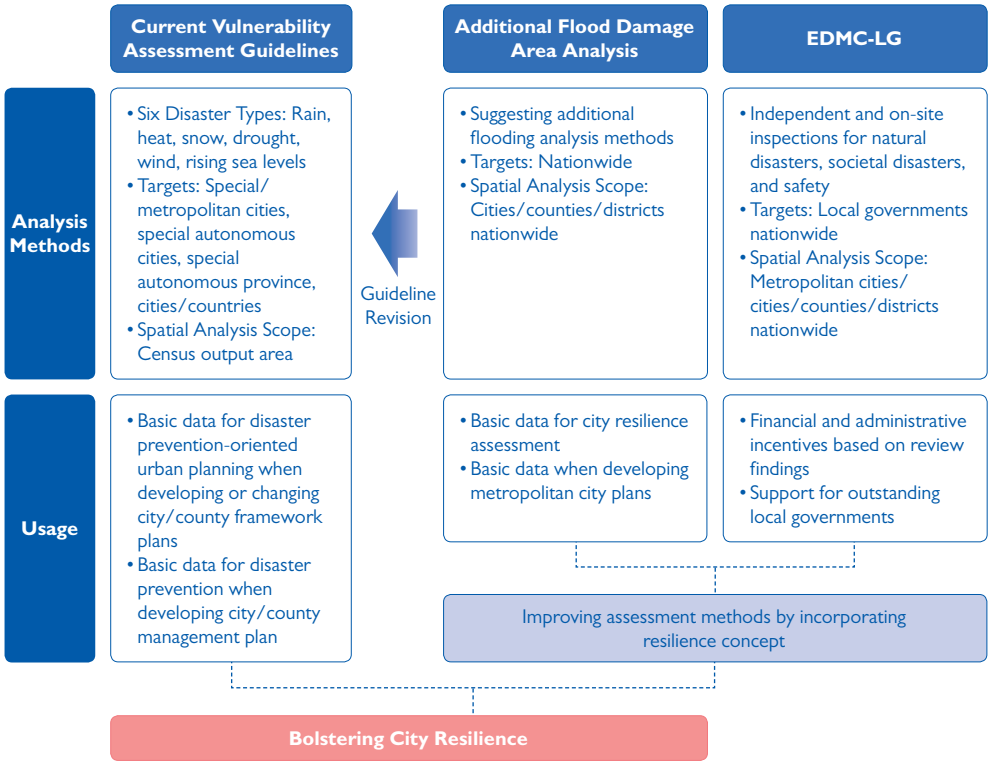
Recent years have witnessed a trend of steadily increasing damages from natural disasters, and future disaster risks are predicted to accelerate further as a result of environment changes such as climate change and urbanization. While advancements have been made in the areas of disaster prevention policy and research, damages from natural disasters have been steadily on the rise. As it is impossible in practical terms to fully prevent natural disasters, which are becoming increasing large in scale, the recent trend among advanced economies has been one of emphasis on the concept of resilience, which takes into account capabilities of responding to a potential disaster, including adaptation and swift recovery.

In Korea, the Ministry of Land, Infrastructure and Transport moved in December 2011 to amend guidelines for city plan formulation (including metropolitan city plans, urban framework plans, and urban management plans) to institute "city climate change-related disaster vulnerability" assessment as a means of responding to the increase in disasters due to climate change. In 2015, Articles 20 and 27 of the Land Use Regulations at the National Territory Plan and Use Act were amended to require performance of disaster vulnerability assessment as basic studies when formulating city/county framework plans and city/county management plans. May 2016 saw enactment of the Guidelines on Assessment of Cities' Vulnerability to Climate Change-Related Natural Disasters and Its Use, which identified methods, procedures, and requirements for the performance of disaster vulnerability assessment and application of their findings.

While city climate change-related disaster vulnerability assessment have led to analysis of region's climatic and physical disaster vulnerabilities in terms of climate change and the development of urban planning measures, their emphasis is purely on prevention, and they inadequately incorporate the concept of resilience to take into account all stages of disaster response, including disaster response capabilities. Moreover, disaster vulnerability assessment are conducted only for individual local governments based on population census units. Making resilience assessments reflect disaster response capabilities requires a stage of analyzing the relative response capabilities of local governments nationwide. This will require amendment of the Guidelines on Assessment of Cities' Vulnerability to Climate Change-Related Natural Disasters and Its Use to establish a base of analytical data for metropolitan cities/provinces and municipalities/counties/districts nationwide. An initial assessment system should be developed through introduction of the resilience concept to flooding, which accounts for the most severe damages in Korea among the six disaster types addressed in the vulnerability analyses (rain, heat, snow, winds, drought, and rising sea levels), and subsequently expanded to other forms of disaster. For information to assess local government disaster response capabilities, the Ministry of Public Safety and Security's EDMC-LG materials should be used, with additional assessment findings shared between agencies to develop a resilience assessment system.

Figure 10. Avenues for Improvement in City Climate Change-related Disaster Vulnerability Analysis

Source: Han WooSuk. 2016. Research on Regional Resilience Improvement Coping with Flooding Disaster by Climate Change Effect (I), KRIHS.



As an amendment of the Guidelines on Assessment of Cities' Vulnerability to Climate Change-Related Natural Disasters and Its Use, the section on goals should have additional provisions added for the shared use of basic analytical data from the Ministry of Public Safety and Security's EDMC-LG in connection with the Framework Act on the Management of Disasters and Safety. Section 3 on the significance, scope, and usage of findings of the disaster vulnerability assessment should also be amended to fully reflect aspects of resilience assessment.

While the current national vulnerability assessment methodology (2011) was used in this study for its flood vulnerability assessment, the data and methods used will require some improvements. While that study (2011) suggests methods of employing the Special Report on Emissions Scenarios (SRES) A1B climate change scenario for future exposure as suggested in the IPCC's fourth report (2007), more recent and advanced data such as the RCP 8.5 climate change scenario data in the IPCC's fifth report (2013) should be used to bolster analysis reliability.

3. Increasing Cooperation by Central Agencies

As a comprehensive disaster prevention concept, resilience is closely related not only to disaster prevention planning but also to spatial use planning. Because such a broad range of areas must be taken into account, cooperation by different central agencies is essential to introduce and bolster the resilience concept. In the United States, the Department of Housing and Urban Development (HUD) organized establishment of the Partnership for Sustainable Communities (PSC) with the Department of Transportation (DOT) and Environmental Protection Agency (EPA). As the concept of resilience has become increasingly emphasized in the wake of Hurricane Sandy in 2012, the program has expanded to the Federal Emergency Management Agency (FEMA) and Department of Agriculture and has been used to support national disaster resilience competitions by HUD, green infrastructure collaborations by the EPA, and FEMA disaster reduction plans for application to climate change. Through development of a Climate Change Resilience Toolkit, it has helped solve climate change-related problems and bolster resilience through sharing of integrated information, as opposed to independent policies by different agencies.

Korea must likewise link and supplement plans and policies by its various agencies (including the Ministry of Land, Infrastructure and Transport [MOLIT], Ministry of Public Safety and Security [MPSS], and Ministry of Environment [MOE]) in response to climate change-related disasters to assess and reinforce resilience. A crucial first step will be cooperation between MOLIT, which currently performs urban disaster prevention duties with its climate change-related disaster vulnerability assessment, and MPSS, which is the agency tasked with disaster management. MPSS's EDMC-LG are currently the only disaster prevention measures to quantitatively assess disaster management capabilities for Korea's local governments, and efforts have been made to ensure their objectivity through document-based and on-site inspections by a central joint inspection team. Limits exist on the ability of other departments besides MPSS (as the presiding agency for disaster prevention) to perform duties to assess disaster management capabilities of local governments nationwide. At the same time, sub-indicators and other details of the current EDMC-LG are being revised on a yearly basis without consultation with other agencies, and findings are not used by departments other than MPSS. As it is realistically impossible for other agencies to review and monitor the disaster response capabilities of individual local governments, MPSS should seek ways of consulting with other departments involved in urban disaster prevention (including MOLIT and MOE) when establishing sub-indicators for its EDMC-LG to develop resilience assessment indicators that reflect urban planning and environmental aspects, as well as ways of sharing the results.

4. Developing a Knowledge-sharing Platform for Stronger Resilience Monitoring and Information Sharing

Unforeseen disasters have been occurring frequently in recent years as a result of climate change. Due to rapid urbanization, urban areas in particular face a high likelihood of isolated incidents escalating into complex disaster situations. Even regions that have no history of disaster-related damages have faced an increased frequency of heavy rains due to the effects of climate change, as well as increasing amounts of impervious surface area due to rising urbanization rates, overloading of existing drainage due to river infilling and diminished stream power, increasing earth and sand leakage, and ground failure and subsidence. The scale of these disasters may vary not only due to local climate change vulnerability and sensitivity, but also according to the local government's disaster response capabilities. With these capabilities, the degree of attention by the chief of the local government's disaster management institution can have a great effect on disaster prevention, recovery planning, and budget development, while regular replacements of that institution head and other disaster management staff can result in problems with education and proficiency. Ongoing monitoring is therefore required to comprehensively assess and bolster resilience for local governments in view of climate change and changes in sensitivity, urbanization rate, and organization capacities.

To help achieve resilient cities around the world through bolstering of their climate change-related disaster response capabilities, the Rockefeller Foundation has selected 100 Resilient Cities[07] for technical support with resilience reinforcement and information sharing; Chief Resilience Officers (CROs) are appointed to monitor resilience-related organizational capacities. Resilience for the 100 cities has also been bolstered through establishment of a network for mutual cooperation and sharing of city resilience knowledge and success stories.

Korea should adopt the 100 Resilient Cities as a role model in developing a knowledge-sharing platform to bolster resilience, including sharing of resilience monitoring findings and success stories among its local governments. This platform should be used to gather related expert opinions and data on an ongoing basis for use in improving resilience assessment methods and encouraging local efforts to bolster resilience. The nature of resilience is such that spatial use measures are a crucial component alongside disaster prevention measures, and the resilience knowledge-sharing platform should therefore be established and maintained on a regular basis by a state or public institution specializing in disaster prevention and spatial use planning. Other plans that should be considered for improving community resilience include ways of incorporating resilience improvement measures into policy.

07. 100 Resilient Cities: This program by the Rockefeller Foundation selects 100 Resilient Cities for investment of US$100 million to achieve city resilience through stronger climate change-related disaster response capabilities for cities around the world. The South Korean city of Seoul was selected in May 2016 as one of the 100 Resilient Cities, with plans for resilience reinforcement and monitoring with support from 100RC partners.

5. Establishing Guidelines and Providing Consulting for Locally Customized Resilience Reinforcement

For this study, Korea's 229 local governments were analyzed in terms of flood damages and vulnerability, and a resilience assessment was performed for the 116 local governments for which EDMC-LG subarea findings could be acquired. For the sake of a detailed assessment of resilience in terms of management and assessment targets, specific local governments were selected as references for resilience assessment, and locally customized resilience improvement plans were suggested through examination of resilience assessment and flood vulnerability findings and EDMC-LG sub-indicators. Limitations to this approach to resilience assessment include the fact that EDMC-LG sub-indicators are revised yearly, and only review findings for 2015 could be used to assess resilience due to difficulties acquiring data.

As noted previously, ongoing monitoring of resilience will require ideas for cooperation and shared use by different departments when selecting sub-indicators for disaster response capability assessment at the national level, as with the EDMC-LG. Additionally, various other forms of resilience data, analysis findings, and success stories will need to be compiled and analyzed on an ongoing basis.

The compiled and analyzed data will then need to be used to support local governments in developing their own locally tailored resilience improvement policies. To encourage maximum use of resilience assessment data and execute locally tailored resilience improvement policies, it is very important that guidelines on customized use of resilience (from assessment to application) are established and that local governments are able to use them. By its nature, resilience encompasses a very broad range of areas, and guidelines alone are inadequate for execution of locally customized resilience improvement plans. Accordingly, efficiency of resilience reinforcement should be bolstered by the provision of consulting services by an expert organization during plan formulation. In terms of consulting for resilience improvement efforts, policy consistency should be ensured through operation by the institution in charge of the resilience knowledge-sharing platform.

6. Support Plans for Vulnerable Citizens and Local Communities

Among the ten "essentials" for bolstering resilience in UN-ISDR's LG-SAT, the second, which concerns budgeting for the private sector and low-income families, emphasizes support for disadvantaged populations. Examination of its subsections shows an emphasis not only on the scope of local government financial resource use for disadvantaged populations before and after a disaster, but also on providing support so that disadvantaged populations can sustain a stable livelihood after disaster strikes, including ongoing operation by local small-scale merchants and enterprises. As the concept of disaster resilience extends to disasters that are growing in scale as a result of climate change and urbanization, rather than small-scale disasters involving partial

flooding and recovery costs, ideas for supporting vulnerable citizens and the local community appear to be a matter of some importance.

Indeed, the city of New Orleans, which suffered large damages as a result of Hurricane Katrina in 2005, experienced a rapid decline in its total population from 500,000 to 200,000 residents due to destruction of their homes and working environments. Many residents relocated to nearby cities such as Atlanta and Baton Rouge. As late as 2013, when recovery from the disaster was more or less complete, the population of New Orleans was calculated at 380,000, or far less than the 500,000 before the disaster.

The population decline resulted in small-scale local businesses experiencing great difficulties finding necessary staff, while damages to the local economy translated into a shortage of tax revenues, causing further decline to the local economy. To prevent the collapse of local economies, the UN-ISDR LG-SAT includes assessment of budget availability for low-income families and the private sector as the second of its essential scorecards.

This study's comparison and analysis of Korea's disaster prevention policies in terms of the UN-ISDR resilience assessment areas found the former to provide direct support for flooding disasters through storm and flooding insurance, but to be greatly inadequate in terms of support to vulnerable populations and local businesses in the event of a disaster. To prevent local economies from deteriorating as a result of large-scale disasters, disaster prevention policies to reduce the direct damages of disasters must be accompanied by policies to support local disadvantaged populations and businesses. A necessary first step to support disaster-vulnerable populations is to survey those populations in each region. Additional steps include the designation of disaster assistants, encouragement of the designation and operation of temporary living facilities for flooding evacuees, and support for psychological stability. This budgetary and administrative support should be provided so that vulnerable populations can continue to survive and earn a livelihood even after a large-scale disaster. Because the collapse of a local economy as a result of large-scale disaster leads in turn to resident flight and tax revenue difficulties that can lead to protracted local underdevelopment, measures should also be sought to support local communities economically through tax benefits and recovery assistance in the event of a major disaster.

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KRIHS SPECIAL REPORT 36

REGIONAL RESILIENCE IMPROVEMENT COPED WITH FLOODING DISASTER BY CLIMATE CHANGE EFFECT (I)

– DEVELOPMENT OF RESILIENCE ASSESSMENT METHODS

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