KRIHS Gazette

SPACE AND ENVIRONMENT

SPACE & ENVIRONMENT
September 2013, Vol. 56

SPACE & ENVIRONMENT is primarily intended to help foreign experts and professionals in relevant fields understand overall present situations of spatial planning and policy of Korea, and published quarterly by KRIHS.

KRIHS is a government-sponsored research institute founded in 1978 to carry out research on territorial planning and policies of Korea.

Assessment of Urban Disaster Vulnerability and Measures for Adaptative Capacity Improvement

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Need for creation of cities adaptive to climate change

Natural disasters have recently taken place at a larger scale in more diverse forms due to the influence from climate change. Furthermore, urban development without any consideration of disaster prevention has further increased the damage from natural disaster.

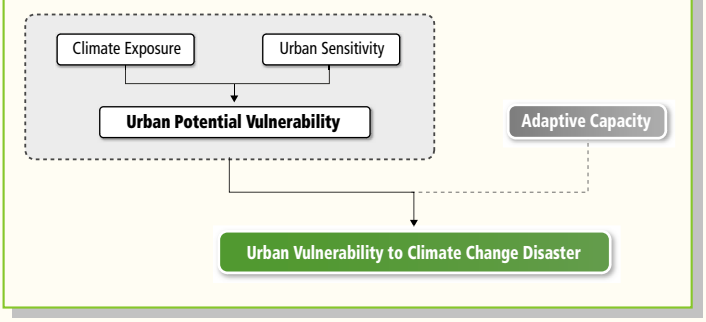
For effective adaptation of cities to disasters caused by climate change, spatial assessment is needed to find out vulnerable areas and the level of vulnerability to climate change. It is also necessary to develop projects for urban adaptive capacity to mitigate the risk of disasters in vulnerable areas, depending on their spatial characteristics. In this regard, this study presents the framework for disaster vulnerability assessment method including the setting of indicators and methodologies for climate change vulnerability assessment. It aims to develop and introduce projects for improvement of urban adaptive capacity to reduce the vulnerability to climate change disasters.

Vulnerability assessment for urban disaster by clmate change

In accordance with the IPCC (Intergovernmental Panel on Climate Change)'s concept of vulnerability assessment, the climate change disaster vulnerability is analyzed based on the climate of each region (climate exposure) and the physical/structural characteristics of disaster vulnerability (urban sensitivity), which is rated from Grade I to Grade V. It should be noted, however, that the assessment in this study does not include quantification of each municipality's adaptive capacity to disasters including their disaster policy which is significantly difficult to be quantified.

Based on research on creation of cities adaptive to climate change conducted by the Ministry of Land, Transport and Maritime Affairs in 2011, disaster vulnerability assessment was carried out across

Figure 1: Concept of analysis on urban vulnerability to climate change disasters



Source: Ministry of Land, Transport and Maritime Affairs (2011), Research on Creation of Cities Adaptive to Climate Change (the first annual research)

diverse types of climate change disasters such as floods, heat wave, heavy snowfalls, drought, strong winds, and sea level rise. A municipality-specific data base (DB) was built regarding the indicators that give or receive dominant influence from each disaster type, and was divided into spatial information and attribute information. This assessment presents the present and future (the year of 2100) disaster vulnerability of 232 cities, districts and boroughs in Korea. This is shown in Figure 2.

As a result of the flood vulnerability assessment, 88 municipalities (37.6%) were analyzed to be vulnerable to floods at present. Vulnerable areas included Seoul Capital Area, Gangwon Region and the southern coastal area in Honam and Youngnam Regions. The assessment shows that in the future areas vulnerable to floods will slightly increase to 93 municipalities (40.1%) across the country, with Gangwon Region showing an increase in vulnerable areas.

In the heat wave vulnerability assessment, it was found that 64 municipalities (27.6%) are vulnerable to heat wave at present. Youngnam Region as well as Seoul Capital Area showed a higher vulnerability figure. In the future vulnerability assessment, areas vulnerable to heat wave slightly decrease to 52 municipalities (22.4%), but the future heat wave vulnerability spreads from southern areas through the west coast to the central part of the country.

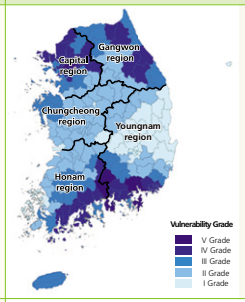
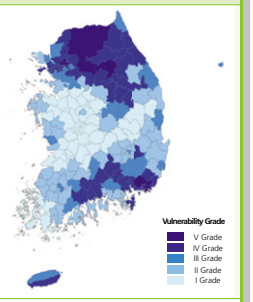
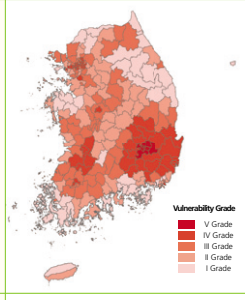
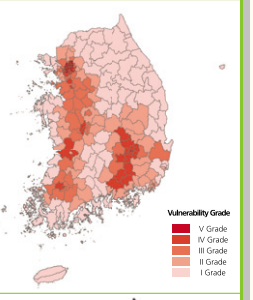
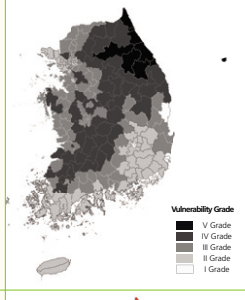
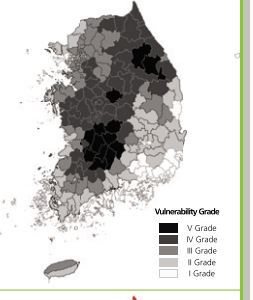
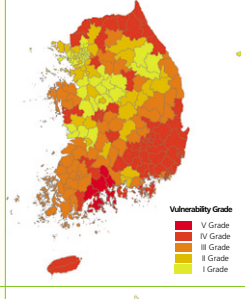
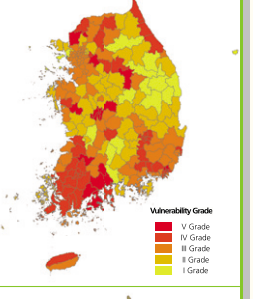
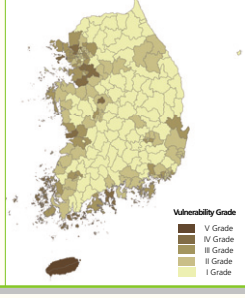
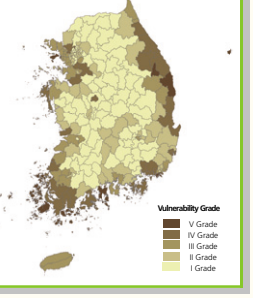
The heavy snowfall vulnerability assessment shows that 61 municipalities (26.3%) are currently vulnerable to heavy snowfalls. Areas from Gangwon Region, Chungcheong Region to Honam Region are highly vulnerable to heavy snowfalls. All areas of Gangwon Region, in particular, were found to be the most vulnerable to heavy snowfalls in the country. For the future, areas with heavy snowfall vulnerability increase a little to 67 municipalities (28.9%) by 2100. The assessment also found that areas vulnerable to heavy snowfalls at present are expected to remain vulnerable in the future, with Chungcheong Region experiencing a big increase in vulnerable areas.

In the drought vulnerability assessment, 84 municipalities (36.2%) were analyzed to be vulnerable to drought at present. Vulnerable areas included Youngnam Region, the southern coastal areas of Honam Region, and Gangwon and Gyeonggi Regions. In the assessment on drought vulnerability for the future, Honam Region will experience a significant increase in the number of areas vulnerable to drought, but vulnerable areas throughout the country will slightly decrease to 78 municipalities (33.6%) by 2100.

In the assessment on strong wind vulnerability, it was found that 14 municipalities (6%) are vulnerable to strong winds at present. Coastal areas around Jeju Island and Honam Region as well as part of the coastal areas of metropolitan areas are vulnerable to strong winds. The assessment shows that in the future the number of areas vulnerable to strong winds will more than triple to 46 municipalities (19.8%) by 2100, due to the influence from higher climate exposure throughout the country.

The assessment on sea level rise vulnerability shows that 27 municipalities (35.5%) of the total 76 municipalities are currently vulnerable. Western and southern coastal areas in Honam region and southern coastal areas in Youngnam took up larger portion in the number of vulnerable areas, and some of the western coastal areas of Chungcheong Region were found to be vulnerable as well. In terms of the future vulnerability, areas that are currently vulnerable to sea level rise are likely to remain so in the future. Vulnerable areas will increase in Youngnam Region, and the number of vulnerable municipalities across the country will be 28 municipalities (36.8%), which is similar to the current level.

Figure 2: Result of vulnerability assessment

Type of disaster	Present	Future (2100)
Floods		
Heat wave		
Heavy snowfalls		
Drought		
Strong winds		

Measures for improvement of urban adaptive capacity to climate change

For cities to adapt to frequent and large-scale disasters caused by climate change, it is necessary to use the existing traditional disaster prevention system as well as the "total disaster prevention system" in connection with all relevant factors such as land use, infrastructure, buildings and citizens. Total disaster prevention system also enables a comprehensive response to disasters by sharing the risk of disasters. To this end, customized measures are required to improve urban adaptive capacity to climate change, based on the disaster vulnerability assessment result stated above and through classification of disaster vulnerability types depending on the disaster characteristics and spatial characteristics. Therefore, this study presents measures for improvement of urban adaptive capacity by classifying the type of vulnerable areas into details to consider the spatial vulnerability characteristics of relevant municipalities based on the disaster vulnerability assessment results using GIS.

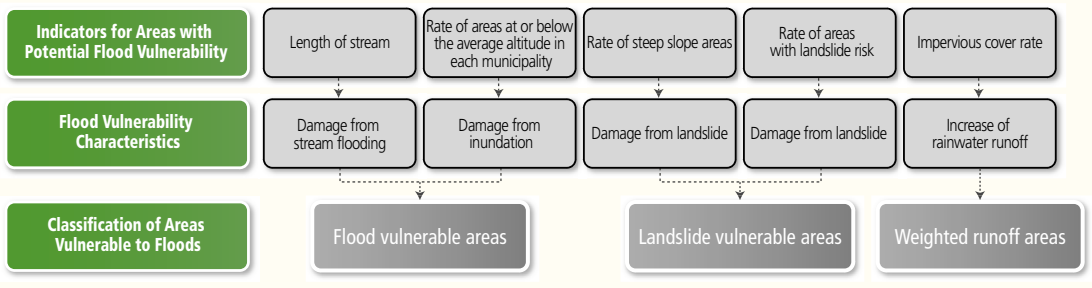
Areas vulnerable to floods were classified into 'flood vulnerable areas', 'landslide vulnerable areas' and 'weighted runoff areas', considering the vulnerability characteristics such as damage from stream flooding, inundation, landslide and increase of rainfall runoff.

Flood vulnerable areas need to create cities with sound water cycle through a prompt rainwater exclusion as well as green/water/earth methodology for improving the fundamental attribute of cities from a long-term perspective. For landslide vulnerable areas, it is important to create a buffer zone near the mountain area and to undertake slope management preparing against any landslide or debris flow. Such influence on the nearby weighted runoff areas should be minimized through a project aimed at minimizing impervious areas. This is summarized in Figure 3.

Heat wave vulnerable areas were classified into 'urban high-temperature areas' and 'heat wave-weighted areas' in consideration of the vulnerability characteristics including the damage from high temperature and aggravation of urban temperature rise.

For urban high-temperature areas, it is necessary to lower the urban temperature itself by

Figure 3: Classification of vulnerable areas in consideration of flood vulnerability characteristics



Source: Ministry of Land, Transport and Maritime Affairs (2012), Research on creation of cities adaptive to climate change (the second annual research): Analysis on the disaster vulnerability characteristics and research on the measures for adaptive capacity improvement of cities

improving the fundamental attribute of cities through the use of green/water/wind methodology. Damage on human life should also be minimized through projects aimed at improving urban adaptive capacity to high temperature. For heat wave-weighted areas, it is important to focus on adopting projects to lower the land surface temperature such as urban greening and wind path projects.

Heavy snowfall vulnerable areas were classified into 'vulnerable building areas', 'avalanche vulnerable areas', and 'isolation vulnerable areas' in consideration of the vulnerability characteristics including the damage from collapse of buildings, damage from avalanche, and isolation in mountain areas.

Vulnerable building areas need to implement stricter design standards to prevent collapse of buildings and carry out repair and maintenance for old and temporary buildings. For avalanche vulnerable areas, it is needed to install snow fences in the steep slope areas in order to minimize the damage on buildings and roads due to avalanche. Efforts should be made to prevent isolation vulnerable areas from being cut off due to road closures by using rainwater, wastewater, underground water and waste heat or by conducting road freezing prevention projects including installation of heating cable.

Drought vulnerable areas were classified into 'areas short of water resources' and 'areas lack of water supply'.

It is important for areas short of water resources to effectively manage limited water resources through projects to establish decentralized stormwater management system or to install wastewater reclamation and reusing system. For areas lack of water supply, it is necessary to carry out diverse water resource development projects and gushout water/underground water conservation projects, which will help secure water resources for stable water supply. These areas also need recycling projects such as treatment and recycling of stormwater/wastewater and installation of wastewater reclamation and reusing system.

Areas vulnerable to strong winds were classified into 'areas with vulnerable facilities' and 'areas exposed to strong winds' in consideration of the vulnerability characteristics such as the damage on facilities including signboards and telephone poles and the damage due to inflow of winds.

Damage on areas with vulnerable facilities should be minimized by conducting repair and maintenance projects for the outdoor signboards of buildings as well as for street trees and telephone poles. For areas exposed to strong winds, it is necessary to create windbreak forest around coastal areas and deploy block housing for repair and maintenance of housing.

Areas vulnerable to sea level rise were classified into 'areas vulnerable to coastal erosion/flooding' and 'areas vulnerable to coastal inundation' in consideration of the damage from sea water flooding/coastal erosion and the damage from coastal inundation.

For areas vulnerable to coastal erosion/flooding, it is needed to reinforce the design of infrastructure and buildings in the short term, while improving the use of land such as preparing a buffer zone in the long term. Areas vulnerable to coastal inundation require stronger functions of inundation prevention and ground elevation of low lands.

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