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VULNERABILITY ASSESSMENT ON WATER MANAGEMENT FOR CLIMATE CHANGE ADAPTATION: CASE STUDY TO GOCHANG COUNTY IN SOUTH KOREA

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Climate changes will have significant impacts on various sectors such as water management, ecosystem, natural resources, industry and human health. Especially, it will make water security more difficult and costly to achieve. This study seeks to investigate the current (2000-2010) vulnerability to flood and drought and those in the future (2046~2055) at the case of Gochang County. The vulnerability definition was adopted by IPCC that is a function of exposure, sensitivity and adaptive capacity. The results of flood vulnerability showed that East Gochang area was more vulnerable than West in the present. However, in the future period, the South Gochang area would be potentially more vulnerable than others to flood due to the climate change. In case of drought, the result showed that the drought vulnerability of North Gochang area would increase in the future. The results of the vulnerability assessment could be applicable to the taking measures of water management for climate change adaptation and determining the priority area.

INTRODUCTION

The adaptation to climate change has been one of the most important issues, since a discussion of the 2001 IPCC Third Assessment Report. For the early days of discussions for adaptation to climate change was conducted in the vulnerable developing countries, relatively. But lately impacts of climate change are not limited to developing countries, including the developed countries to expand into the global discussion.

Adaptation is defined as the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities [1]. The climate change caused by greenhouse gas will continue. To prepare for the coming changes and find an effective way to respond to the climate change, mitigation and adaptation must be performed at the same time.

Currently the degree of climate change on the Korean Peninsula is greater than the global average. From 1912 to 2008, the average temperatures of the six major cities in Korea have increased by 1.7℃, which is more than double that of the global average. Also, in the past

century, there was a 19% increase in precipitation and a 14% decrease in the number of days with precipitation, as well as an 18% increase in precipitation intensity.
Korea's average temperatures are expected to increase by 6.0℃ till 2070~2099 period compared to 1971~2000 period (when simulated under the RCP 8.5 Scenario- no measures of mitigation). The precipitation will increase by 20.4% in the same period. Also, increased instances of extreme rainfall in the summer and prolonged droughts in the winter are expected [2]. Therefore, Korean government established climate change adaptation measures. Also, local government is in response to take measures for climate change adaptation by law [3].
Gochang County in Jeonbuk Province (South Korea) is one of the vulnerable areas to climate change, because it is a particularly high dependency to the agricultural industry, increasing proportion of elderly people, and coastal areas where vulnerable to increases in the intensity of storm surge and heavy precipitation. Gochang is located along the southwestern border of Jeollabuk-do. And the county stretches 31km from east to west and 31.5km from north to south.
In this study, vulnerability assessment of flood and drought in Gochang County was conducted investigate the current (2000-2010) risks and vulnerability to those in the future (2046~2055) due to climate change.

Figure 1. Location of Gochang County.

METHODS

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes [1]. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, the sensitivity and adaptive capacity of that system. In this study, the definition of vulnerability followed by below function.

$$\text{Vulnerability} = \alpha \times \text{climate exposure} + \beta \times \text{sensitivity} - \gamma \times \text{adaptation ability} \quad (1)$$

Where, α, β, γ : weight of variables

- Climate exposure : climate change impact, such as temperature and precipitation
- Sensitivity : climate change impact range or vulnerability impact such as slope, soil condition
- Adaptation ability : climate change impact reduction, such as, financial support and supporters

Table 1 and 2 shows the proxy indicators for flood and drought vulnerability assessment, respectively. Weights of proxy indicator were determined by Delphi research with experts. The unit of vulnerability assessment was administrative district-level (town) and Gochang composed of 14 towns. The RCP (Representative Concentration Pathways) 8.5 climate change scenario from KMA (Korea Meteorological Administration) was used for climate exposure.

Table 1. Proxy indicators for flood vulnerability assessment

Part	Indicator	Weight	Unit
Climate exposure **0.388**	Number of day with over 42mm during 5 day antecedent precipitation	0.225	day/year
	Daily maximum precipitation	0.369	mm/day
	Precipitation day	0.188	day/year
	Precipitation intensity	0.219	mm/day
Sensitivity **0.306**	Land area ratio below 10m of sea level	0.188	%
	Flooding expected area	0.231	㎡/㎢
	Runoff curve number(CN)	0.138	-
	Average of official land price	0.106	won/㎡
	Damages by flooding	0.188	won/㎢
	Length of small stream	0.150	km/㎢
Adaptation ability **0.306**	Effective water storages	0.231	㎥/㎢
	River levee maintenance ratio	0.313	%
	Household ratio of insurance to flooding	0.306	-
	Economically active population (15~65 years old)	0.150	person/㎢

Table 2. Proxy indicators for drought vulnerability assessment

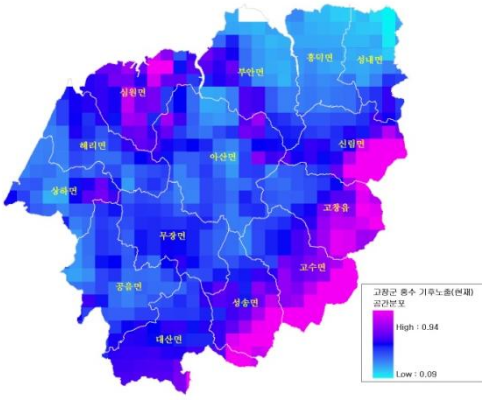
Part	Indicator	Weight	Unit
Climate exposure **0.388**	Average of continuous days without precipitation	0.256	day/year
	Maximum of continuous days without precipitation	0.269	day/year
	Annual precipitation	0.213	mm/day
	Average monthly precipitation in spring (April~June)	0.263	mm/month
Sensitivity **0.281**	Ratio of population in small drainage facilities	0.306	%
	Ratio of field and orchards to cultivated area	0.356	%
	Ratio of irrigation to cultivated area	0.338	%
Adaptation ability **0.331**	Effective water storages per cultivated area	0.238	㎥/㎢
	Total pumping capacity per cultivated area	0.219	㎥/㎢
	Total capacity of underground water well per cultivated area	0.263	㎥/㎢
	Ratio of water supply	0.281	%

RESULTS & DISCUSSIONS

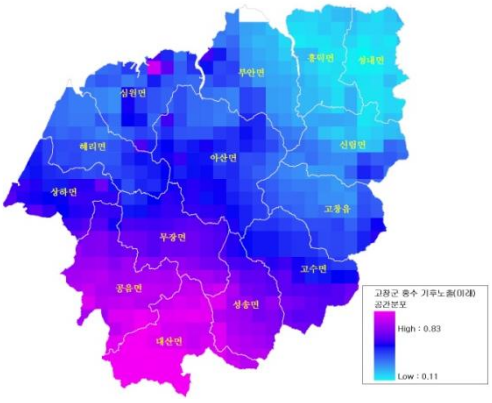
Results of flood vulnerability assessment

Figure 1 shows the results of flood vulnerability assessment of the present and the future in Gochang County. Climate exposures of Gochang towns were high in the order of Gosu > Sillim > Seongsong etc., which indicated the eastern area was higher than any other areas in the present (2000~2010). However, in the future (2049~2055), the climate exposures were expected to increase in the southern area where includes Daesan, Gongeum, Seongsong towns. Sensitivities of flood vulnerability were found to be high in the order of Heungdeok > Gochang > Buan etc. Adaptation abilities were found to be high Seongnae > Sangha > Asan etc. which meant the lower vulnerability towns.

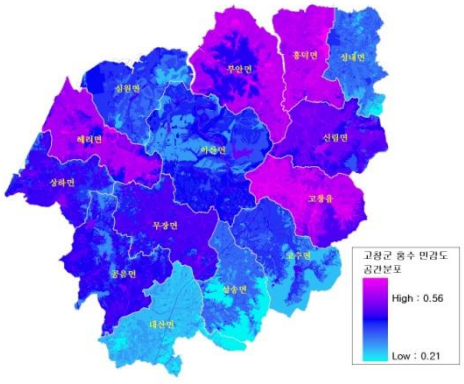
The present and future flood vulnerabilities were high in the order of Gochang > Gosu > Sillim > Haeri and Deasan > Gochang > Mujang > Gongeum, respectively, among the Gochang towns. Gochang town was the most vulnerable town to flood in the present which was caused by high sensitivity, low adaptation ability and medium climate exposure. However, in the future, Deasan was the most vulnerable town to flood among the Gochang towns which was derived by mainly high climate exposure. Sengnae that had low climate exposure, low sensitivity and high adaptation ability was the safest town to flood among the Gochang towns.



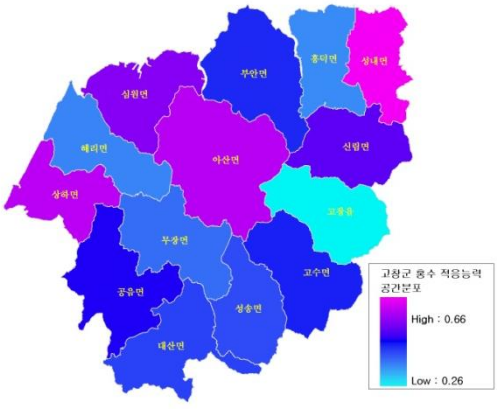
Climate exposure (Present)



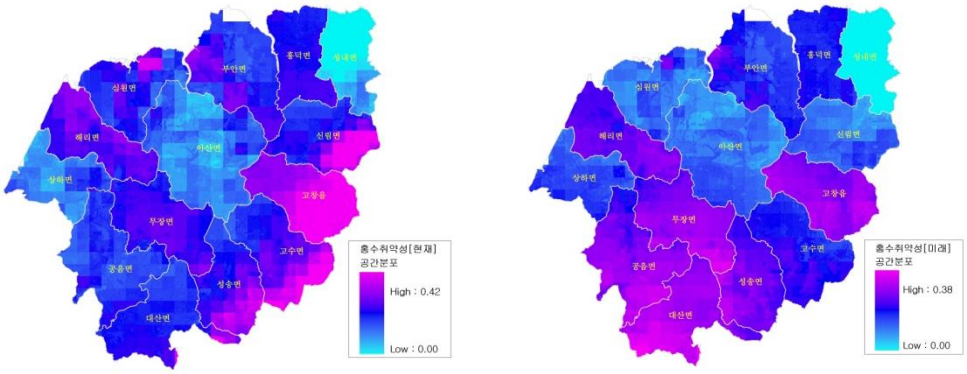
Climate exposure (Future)



Sensitivity



Adaptation ability



Vulnerability (Present) Vulnerability (Future)

Figure 1. Results of flood vulnerability assessment in Gochang County

Table 3. Results of flood vulnerability assessment as town unit

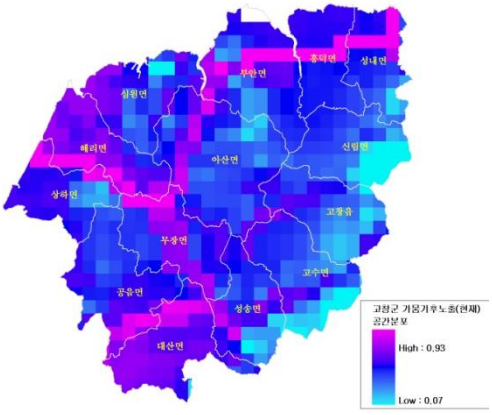
No.	Climate exposure [Present]	Climate exposure [Future]	Sensitivity	Adaptation ablility	Vulnerability [Present]	Vulnerability [Future]
1	Gosu	Daesan	Heungdeok	Seongnae	Gochang	Daesan
2	Sillim	Gongeum	Gochang	Sangha	Gosu	Gochang
3	Seongsong	Seongsong	Buan	Asan	Sillim	Mujang
4	Simwon	Mujang	Haeri	Simwon	Haeri	Gongeum
5	Gochang	Gosu	Sillim	Sillim	Seongsong	Seongsong
6	Daesan	Sangha	Mujang	Gongeum	Mujang	Haeri
7	Mujang	Asan	Sangha	Gosu	Heungdeok	Gosu
8	Haeri	Simwon	Gongeum	Buan	Simwon	Heungdeok
9	Asan	Haeri	Asan	Daesan	Buan	Buan
10	Gongeum	Gochang	Simwon	Seongsong	Daesan	Sangha
11	Sangha	Buan	Gosu	Mujang	Gongeum	Simwon
12	Buan	Sillim	Seongnae	Haeri	Sangha	Sillim
13	Seongnae	Heungdeok	Seongsong	Heungdeok	Asan	Asan
14	Heungdeok	Seongnae	Daesan	Gochang	Seongnae	Seongnae

Results of drought vulnerability assessment

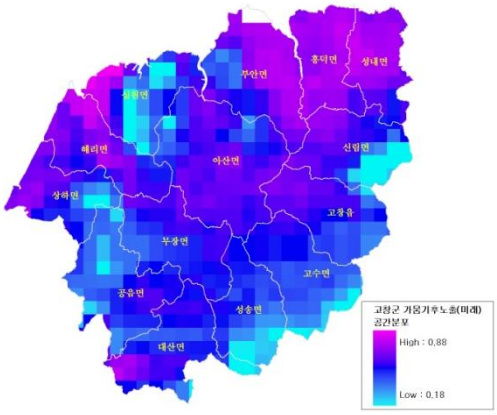
Figure 2 shows the results of drought vulnerability assessment of the present and the future in Gochang County. Climate exposures of Gochang towns were high in the order of Haeri > Daesan > Mujang etc. in the present (2000~2010). However, in the future (2049~2055), the climate exposures were expected to increase in the northern area where includes Heungdeok, Seognae, Buan towns. Sensitivities of drought vulnerability were found to be high in the order of Seongnae > Sangha > Mujang etc. Adaptation abilities were found to be high Asan > Sillim > Simwon etc. which meant the lower vulnerability towns.

The present and future drought vulnerabilities were high in the order of Mujang > Daesan > Seongnae > Gongeum and Seognae > Mujang > Daesan> Heungdeok, respectively. Mujang town was the most vulnerable town to drought in the present, which was caused by low adaptation ability, high sensitivity and climate exposure. However, in the future, Seognae was the most vulnerable town to drought among the Gochang towns which was derived by high

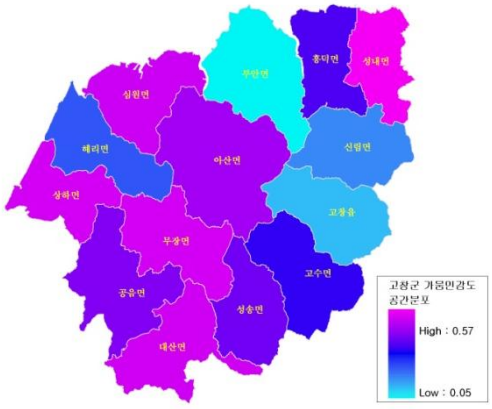
sensitivity, low adaption ability and high climate exposure. Sillim town that had low climate exposure, low sensitivity and high adaptation ability was the safest town to drought among the Gochang towns.



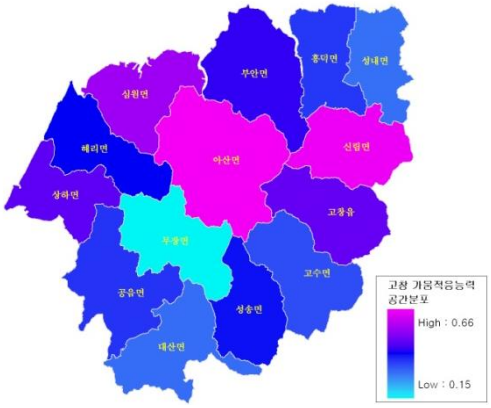
Climate exposure (Present)



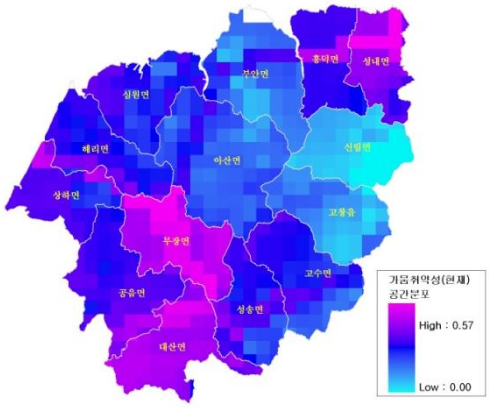
Climate exposure (Future)



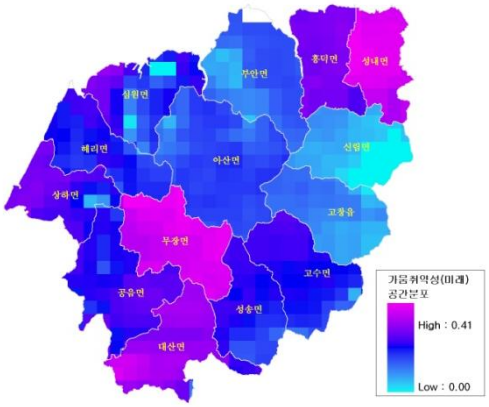
Sensitivity



Adaptation ability



Vulnerability (Present)



Vulnerability (Future)

Figure 2. Results of drought vulnerability assessment in Gochang County

Table 4. Results of drought vulnerability assessment as town unit

No.	Climate exposure [Present]	Climate exposure [Future]	Sensitivity	Adaptation ablility	Vulnerability [Present]	Vulnerability [Future]
1	Haeri	Heungdeok	Seongnae	Asan	Mujang	Seongnae
2	Daesan	Seongnae	Sangha	Sillim	Daesan	Mujang
3	Mujang	Buan	Mujang	Simwon	Seongnae	Daesan
4	Heungdeok	Haeri	Daesan	Gochang	Gongeum	Heungdeok
5	Buan	Asan	Simwon	Sangha	Sangha	Sangha
6	Seongnae	Gochang	Asan	Buan	Heungdeok	Gongeum
7	Sangha	Mujang	Gongeum	Haeri	Haeri	Gosu
8	Gongeum	Sangha	Seongsong	Seongsong	Seongsong	Seongsong
9	Simwon	Daesan	Heungdeok	Gongeum	Simwon	Haeri
10	Asan	Sillim	Gosu	Heungdeok	Gosu	Simwon
11	Seongsong	Gongeum	Haeri	Gosu	Asan	Asan
12	Gochang	Gosu	Sillim	Daesan	Buan	Buan
13	Gosu	Simwon	Gochang	Seongnae	Gochang	Gochang
14	Sillim	Seongsong	Buan	Mujang	Sillim	Sillim

CONCLUSIONS

This study aims to investigate the present (2000-2010) vulnerability to flood and drought and those in the future (2046~2055) due to climate change in the case of Gochang County. In this study, proxy indicators employed to measure the exposure, sensitivity and adaptive capacity those were composed of vulnerability.

The results of flood vulnerability showed that East Gochang area was more vulnerable than West in the present. However, in the future period, the South Gochang area is potentially more vulnerable than others to flood due to the climate change. In case of drought, the result showed that the drought vulnerability of North Gochang area would increase in the future.

The results of the vulnerability assessment could be used for the taking measures for climate change adaptation and determining the priority area.

ACKNOWLEDGEMENT

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