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Climate Change Adaptive Implementation Assessment Proposal for Local Governments Utilizing Vulnerability Index

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Abstract

This study applies the concept of climate change vulnerability assessment in order to suggest climate change adaptation effects in a quantitative manner, given that previous studies have hitherto rely on qualitative assessment, as climate change adaptive policies are currently being implemented by local governments of Korea. The vulnerability assessment tool used in this study is VESTAP ("Vulnerability assESsment Tool to build a climate change Adaptation Plan"), which was developed by the Korea Adaptation Center for Climate Change (KACCC), and applied to gauge the vulnerability of pine trees to diseases and pests within Chungcheongnam-do. The climate change adaptation project for vulnerability improvement was assessed only in terms of forest disaster prevention and change in regional climate change vulnerabilities within 16 regions of Chungcheongnam-do as the result of 2016 Climate Change Adaptation Project (Forest Disaster Prevention Project). As a result, it was observed that climate change adaptive capacity has improved according to change in the area of forestland with disaster prevention, and the vulnerability indicator decreased, confirming the impact of the climate change adaptation (forest disaster prevention) project. Also, analysis of regional climate change adaptation project scales and change in vulnerabilities allowed us to determine the regional propriety of climate change adaptation (forest disaster prevention) projects launched in 2016.

Key Words: climate change adaptation, vulnerability assessment, adaptation policy, VESTAP, forest disaster prevention

Introduction

Korea has designated climate change adaptive policies to be executed under law by local governments since 2011, and all local governments have established, and are in the process of executing, these adaptation plans over a 5 year period. The first stage of the adaptation plan is now complete, and all local governments are currently either executing or establishing the second stage of the adaptation plans. However, the debate surrounding the necessity of such establishment and execution of climate change adaptation plans, as well as demand for improvements in the current progress assessment system, continues to persist. The current progress assessment system relies on qualitative evaluation, and it utilizes indicators that cannot directly confirm the effects of climate change adaptation, such as budget spending rate, so this appears to require improvement. This study utilizes the concept of climate change vulnerability assessment for establishing climate change adaptive policies and attempts to confirm the effects of adaptation projects quantitatively by applying this concept to progress assessment.

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Current status of climate change adaptive policies and progression in developed countries

Interest in adaptation for climate change is rising even in developed countries due to global temperature increase and increase in frequency of extreme climate occurrences. IPCC Working Group II (WG II) is also emphasizing the importance of mutual relationships between vulnerabilities of social, economic, and natural systems, along with the positive and negative effects, as well as vulnerabilities, adaptation, and sustainable development. Each nation is actively responding to climate change through enactment of laws relevant to climate change and the operation of dedicated institutions. The U.K. has established a systematic foundation for climate change relief and adaptive policies via enactment of its Climate Change Act of 2008, and the government has established a climate change risk assessment and a National Adaptation Program (NAP) as climate change adaptive policies. The law states that this program has the authority to request a report (Yu and Yun 2015). The Adaptive Policy Framework (APF) was created according to NAP aims in order to reflect the priorities of government policies as part of the plan to promote the climate change adaptation strategies suggested by the 5-year strategy of the Department for Environment, Food, and Rural Affairs (DEFRA) (Kim and Kim 2010). A risk assessment is conducted every 5 years, and the first NAP from 2013 that included 11 climate change risk areas and 5 topics, is currently in progress. France is adapting to climate change through its National Adaptation Plan (2011-2015), SRCAE, and PECT led by the Ministry of Ecology. Germany has established a DAS in 2008 and APA in 2011 in order to conduct climate change vulnerability assessment of 14 areas including health and architecture (Myeong et al. 2013), while the U.S. has announced the Climate Action Plan (CAP) in 2013, and climate change adaptation plans have been drafted in 15 states so far, with 5 more states currently in the drafting process (Yu and Yun 2015).

Meanwhile, each nation is operating a separate progress assessment system through cooperation between supervising departments and relevant departments for expanding progress in climate change adaptation. The U.K. has implemented comprehensive monitoring of the entire process based on its Climate Change Act, along with establishment and monitoring of statistical data that affects climate change risks and vulnerabilities, and it has been publishing a climate change adaptive policy progress report every 2 years since 2015 (Myeong et al. 2013). France is conducting progress assessments every year, while Germany is conducting progress assessments every 4 years based on relevant indicators, with the first progress inspection report issued in 2015. The U.S. is publishing a National Climate Assessment (NCA) report, which includes a risk assessment conducted by the Environmental Protection Agency (EPA) every 4 years.

Analysis of domestic and foreign cases show that the difference between Korea and foreign nations is that, in the case of the latter, there are various civilian stakeholders actively participating in the stage of establishing adaptation plans and systematic organization of relative governance. Therefore, a more effective determination of progress in the area of effectiveness and progress expansion is possible. Meanwhile, annual progress assessments take place in Korea, but most nations are conducting progress assessments every 2 years or 4 years, which is relatively weak in terms of reporting.

National climate change adaptation plan and progress evaluation system

Korea has been actively responding to climate change and the concept of sustainable development through establishment and execution of plans relevant to climate change relief (the First Climate Change Response Framework and 2030 Basic Roadmap to Achieve Goals for Reduction of Greenhouse Gas Emission Nationwide) and adaptation (the Second National Climate Change Adaptation Plan (2016-2020)). With the establishment of the Second National Climate Change Adaptation Plan (2016-2020) at the beginning in December of 2015, assessment of smaller promotion projects in 16 local governments excluding Sejong City (2015-2019) is being carried out, based on qualitative and quantitative indicators regarding the effort to execute the budget and achieve the associated progress goals (Yoon and Lee 2017). At the stage of reporting evaluation results, the local governments submit relevant reports to the Ministry of Environment every year, and the lower level local governments must report their evaluation results internally. Also, by the third year (2018) and fifth year (2020), the central government must publish an overall progress assessment and report based on these results, in accordance with the second detailed execution plan.

The Ministry of Environment has supplemented and improved upon limitations of these procedures, such as an induction of voluntary participation, low effectiveness, and lack of any reporting system for the first detailed execution plan, and reinforced the progress assessment system so as to execute regional climate change adaptive policies and subsequently realize the plans while also distributing guidelines for progress assessment of the detailed execution plan for climate change adaptation in August of 2016. Every year since, local governments have conducted progress assessments of the detailed execution plan through the method of self-evaluation, based on guidelines provided. The progress assessment consists of 4 stages which consist of assessment plan establishment, intermediary inspection, self-evaluation, and evaluation results reporting, and this reflects the nature of local governments to conduct smaller annual promotion projects throughout the period of the detailed execution plan (5 years). Assessment of each projects is conducted based on qualitative and quantitative indicators regarding efforts to execute the budget and achieve progress goals. At the stage of reporting the evaluation results, the local governments must submit annual relevant reports to the Ministry of Environment.

Local government climate change adaptation plan assessment system and related issues

The adaptive policy progress assessment system is an important method that serves to continue monitoring plans to establish measures for issues and improvements in execution, and reflects them the next year to ensure effectiveness. However, despite the guidelines established by the Ministry of Environment, local governments—in contrast to the national system—are opting to use self-assessment methods that are unclear in terms of progress assessment methodology and procedure, and include no quantified assessment indicators that are unified between the central government and the local governments. This results in continued debate about the effectiveness of local governments' climate change adaptive policies. Also, consistent management of potential threats and vulnerabilities in local regions is necessary for adapting to local climate change, but the current climate change progress assessment does not consider climate change vulnerabilities. Therefore, this requires urgent development of an assessment plan that does indeed consider such factors.

Materials and Methods

Climate change vulnerability

The general concept of vulnerability in the context of climate change is defined as functions of exposure, sensitivity, and adaptive capacity arising from exposure to various effects of climate change, with exposure to climate change at this time expressed as potential effects depending on the sensitivity and the adaptive capacity of the system, which determines the conclusive vulnerability (Kelly and Adger 2000; Füssel and Klein 2006). Climate exposure refers to the level of exposure to stimulation related to climate, while sensitivity refers to the degree of impact on the system from climate related stimulation. Adaptive capacity refers to the level of the system's ability to adjust to climate change and extreme climate occurrences, as it eliminates potential damage while also utilizing such stimulation as opportunity to aid adaptation (National Institute of Environment Research 2012). Climate change vulnerability can be expressed by the relationship between climate exposure, sensitivity, and adaptive capacity, and all or some of these may be considered, depending on the purpose of the climate change vulnerability indicator (Kim et al. 2010). The IPCC vulnerability assessment method defines the vulnerability assessment method as consisting of exposure to climate, the sensitivity level of the system, and the adaptive capacity of the system to respond to such changes. In other words, vulnerability is greater as exposure and sensitivity are higher, and is smaller as adaptive capacity is greater.

$$\text{Vulnerability} = f[\text{Sensitivity, Exposure, Adaptive Activity}]$$

VESTAP (vulnerability assessment tool to build a climate change adaptation plan)

In Korea, KACCC has been using VESTAP, which is a web-based climate change vulnerability assessment support tool developed in 2014 to support establishment of climate change adaptive policies for local governments to execute a nationwide standardized climate change vulnerability assessment.

The VESTAP system assigns weighted values to functions of climate exposure, sensitivity, and adaptive capacities to assess vulnerability according to the concept of climate change vulnerability. All weighted values are calculated by experts, based on the Analytic Hierarchy Process (AHP).

$$\text{Vulnerability} = [\alpha \times (\text{Sensitivity}) + \beta \times (\text{Expose})] - \gamma \times (\text{Adaptive activity})$$

VESTAP can assess climate change vulnerabilities for

Table 1. Items assessed for vulnerability within VESTAP

Area	Vulnerable items	Area	Vulnerable items
Health	Health vulnerability to infectious diseases from insects and rodents	Forest	Vulnerability to forest fire
	Health vulnerability to other air pollutants		Vulnerability of forest life to drought
	Health vulnerability to extreme heat		Vulnerability of forest trail to landslide
	Health vulnerability to extreme cold		Vulnerability of pine trees to diseases and pests
	Health vulnerability to flooding		Vulnerability of pine trees and pine mushrooms
	Health vulnerability to waterborne diseases		Vulnerability to landslide to localized heavy rain
	Vulnerability to temperature diseases from extreme heat (general)		Vulnerability of forest productivity
	Vulnerability to temperature diseases from extreme heat (low income households)	Ocean	Vulnerability of fishery from change in water temperature (aquaculture industry)
	Vulnerability to temperature diseases from extreme heat (outdoor workers)	Water Management	Vulnerability of water quality and aquatic ecosystem
	Vulnerability to temperature diseases from extreme heat (cardiovascular patients)		Vulnerability of water quality from drought
	Health vulnerability from increase in ozone concentration level		Vulnerability from irrigation
	Health vulnerability from fine dust		Vulnerability of measurement
	Health vulnerability from storms		Vulnerability of spring water from short drought (general)
	Vulnerability to temperature diseases from extreme heat (children below age of 5)		Vulnerability of spring water from long drought (general)
	Vulnerability to temperature diseases from extreme heat (elderly people above age of 65)		Vulnerability of spring water from short drought (industrial water)
Disasters	Vulnerability of infrastructure for heavy snow		Vulnerability of spring water from short drought (agricultural water)
	Vulnerability of infrastructure to extreme heat		Vulnerability of spring water from short drought (water for living)
	Vulnerability of infrastructure to flooding		Vulnerability of spring water from long drought (industrial water)
	Vulnerability of infrastructure for sea level elevation		Vulnerability of spring water from long drought (agricultural water)
Agriculture	Vulnerability of rice productivity		Vulnerability of spring water from long drought (water for living)
	Vulnerability of livestock productivity	Ecosystem	Vulnerability of insects
	Vulnerability of apple productivity		Vulnerability of needleleaf trees
	Vulnerability of harvest/breeding facility collapse		Vulnerability of national parks
	Vulnerability of soil erosion for farmlands		

47 items in 7 areas of climate change adaptation (health, disasters, agriculture, forests, ocean, water management, and ecosystem) for local governments in Korea, and evaluation items are continuing to be added (Table 1). Climate change scenarios consist of past RCP observation data (2001-2010), an RCP4.5 scenario, and an RCP8.5 scenario, which can perform a vulnerability assessment every 10 years until 2050.

Assessment of pine tree vulnerability to diseases and pests

This study utilized the VESTAP vulnerability assessment tool to check improvement in vulnerability indicators when assessing climate change adaptive policies, and compared the before-and-after climate change adaptation project regarding vulnerability of pine trees to diseases and pests within Chungcheongnam-do. The base data of the VESTAP system for assessment of pine tree vulnerability to diseases and pests consisting of climate exposure, sensitivity, and adaptive capacity are shown below in Table 2, and each weighted value consists of values suggested by VESTAP.

The assessed pine tree vulnerability from diseases and pests in Chungcheongnam-do for an RCP8.5 scenario (2011-2020) are shown below in Fig. 1, with Cheongyang, Boryeong, Gongju, and Buyeo being the most vulnerable. As such, this requires establishment of a plan in these locations to improve adaptive capacity as compared with other lower level local governments.

Climate change adaptation projects within the scope of index of the VESTAP system can take place, such as improving financial independence or increasing number of forest service employees. In this study, an area of forestland that includes disaster prevention was selected as the adaptation project. Therefore, the forest disaster prevention area was used as adaptive capacity index. The area of forestland with disaster prevention in 2016 (Table 3), as listed in the Annual Statistics of Chungcheongnam-do (2017), was applied to the VESTAP system, and change in climate change vulnerability indicators was observed following execution of

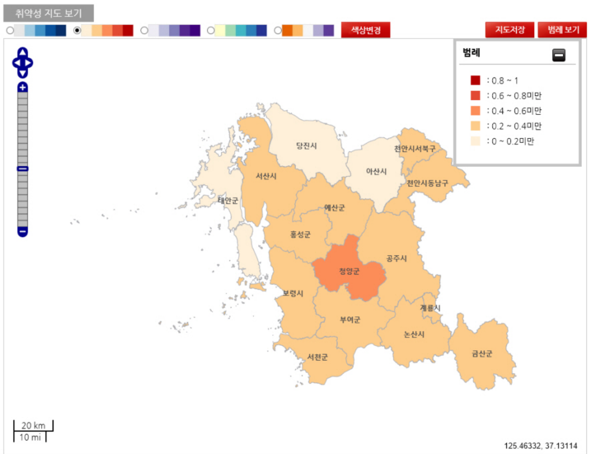

Fig. 1. Pine tree vulnerability to diseases and pests of Chungcheongnam-do.

Table 2. Weighted values of factors and index for assessment of pine tree vulnerability to diseases and pests

Factor	Weighted value	Index	Weighted value
Exposure	0.37	Precipitation from june-august (mm)	0.26
		Average daily high temperature from June-August (°C)	0.31
		Average daily low temperature from June-August (°C)	0.23
		Number of days above maximum wind speed of 14 m/s (Days)	0.2
Sensitivity	0.38	Area of disease and pest occurrence (ha)	0.26
		Area of pine tree forests (ha)	0.49
		Average slope of forests (Degrees)	0.12
		Average altitude within forests (m)	0.13
Adaptive Capacity	0.25	Financial independence (%)	0.15
		Gross regional domestic product (GRDP) (millions of won)	0.11
		Ratio of pine trees per disease and pest prevention area (%)	0.18
		Number of forest service employees (people)	0.21
		Area of forest with disaster prevention (m^2)	0.35

the climate change adaptation project.

As a result, it was shown that Cheongyang, Gongju, and Buyeo were the most vulnerable, and the existence of improvements in adaptive capacity through application of disaster prevention in forests was confirmed (Fig. 2).

Results and Discussion

I compared the pine tree vulnerability indicators for diseases and pests in Chungcheongnam-do before and after climate the change adaptation project, according to results of the forest disaster prevention project in 2016 (Table 4). It was observed that climate change adaptive capacity has improved in accordance with the change in area of forestland with disaster prevention, and vulnerability indicators—confirming the effects of the climate change adaptation (forest disaster prevention) project. An increase in ranking compared to other regions within Chungcheongnam-do was observed, especially for Boryeong, Seocheon, and Gyeryong, due to expansion of the area of forestland with

Table 3. 2016 Chungcheongnam-do climate change adaptation project (area of forestland with disaster prevention) (unit : m^2)

Region	Forest area	Region	Forest area
Gyeryong	24,840,000	Seocheon	25,650,000
Gongju	3,900,000	Asan	2,970,000
Geumsan	2,120,000	Yesan	3,350,000
Nonsan	3,300,000	Cheonan Dongnam	100,000
Dangjin	350,000	Cheonan Seobuk	40,000
Boryeong	29,610,000	Cheongyang	2,480,000
Buyeo	4,000,000	Taean	15,190,000
Seosan	4,750,000	Hongseong	1,400,000

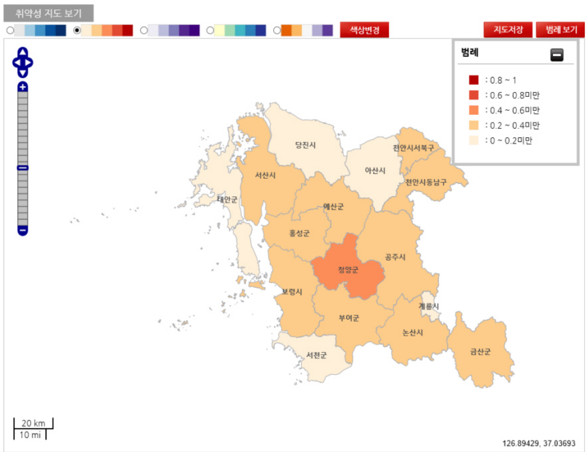

Fig. 2. Vulnerability of pine trees to diseases and pests within Chungcheongnam-do following adaptation project (forest disaster prevention).

Table 4. Vulnerability indicator and change in adaptive capacity before and after the adaptation project

Region	Change in rank		Change in vulnerability indicator		Change in indicator
	Before	After	Before	After	
Gyeryong-si	11	15	0.21	0.14	-0.07
Gongju-si	3	2	0.33	0.32	-0.01
Geumsan-gun	5	4	0.29	0.28	-0.01
Nonsan-si	6	5	0.27	0.26	-0.01
Dangjin-si	15	14	0.17	0.17	0
Boryeong-si	2	7	0.34	0.25	-0.09
Buyeo-gun	4	3	0.33	0.32	-0.01
Seosan-si	7	8	0.26	0.24	-0.02
Seocheon-gun	8	12	0.26	0.18	-0.08
Asan-si	14	13	0.19	0.18	-0.01
Yesan-gun	10	9	0.24	0.23	-0.01
Dongnam-gu, Cheonan-si	12	10	0.21	0.21	0
Seobuk-gu, Cheonan-si	13	11	0.2	0.2	0
Cheongyang-gun	1	1	0.41	0.4	-0.01
Taean-gun	16	16	0.1	0.05	-0.05
Hongseong-gun	9	6	0.26	0.26	0

disaster prevention.

I was able to determine the regional propriety of the climate change adaptation (forest disaster prevention) project launched in 2016 to improve the vulnerability of pine trees to diseases and pests within Chungcheongnam-do. Cheongyang was the most vulnerable region within Chungcheongnam-do, and it was confirmed that it had the greatest need for expansion in forestland area with disaster prevention in order to improve adaptive capacity, but a comparatively smaller project was launched. Also, Taean exhibited the lowest vulnerability indicator within Chungcheongnam-do even before the launch of climate change adaptation project, but of the 16 regions totals, the fourth largest project was launched in this region despite its relatively low necessity for improvement in vulnerability of pine trees from diseases and pests.

The review of propriety of the climate change adaptation (forest disaster prevention) project in this study should consider not only the vulnerability of pine trees from diseases and pests but also the various vulnerability indicators used as part of the adaptive capacity index. Furthermore, this study was limited to assessing the adaptation project effect in terms of change in vulnerability through use of a single index, but for more accurate assessment results, all adaptive capacity indexes should be considered.

This study is an early study that attempts to determine the propriety of adaptation projects by utilizing VESTAP, used to establish climate change adaptive policies for local governments in Korea, and the only method that can utilize quantitative indicators for the climate change adaptive policies that currently rely on qualitative methods. Also, this study should be useful for determining policies related to climate change in local government.

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