Vulnerability Assessment of Korean Forest to Climate Change using CEVSA Model with ArcGIS

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Abstract

Many countries study and access the impacts, vulnerability and adaptation of ecosystems to changing climate in order to sustain forest ecosystem and reduce the damage of forest ecosystem against climate change. Especially vulnerability, which requires various ecosystem parameters for extensive area for the analysis, have not been studied much compare to other impacts and adaptation to climate change studies for Korean forest. In this study, the vulnerability of Korean forest was assessed with the CEVSA (Carbon Exchange between Vegetation, Soil, and Atmosphere) model. As the result of the assessment, the vulnerable area to climate change was estimated as 44,201.95km^2, which occupies the 30.24% of total study area (146,187.45km^2).

Ⅰ. Introduction

According to the IPCC 4th assessment report, it is predicted that the human beings will suffer from the disaster such as severe draught and high heat, as the temperature is sharply increasing (IPCC, 2007). Korean forest, which occupies 67% of whole country land area, also cannot avoid the impact of climate change. So, it is important to assess and estimate the effect and consequences to climate change.

However, it is not easy to evaluate the vulnerability in Korean forest, because it is hard to correctly include topographical characteristics (complex and steep terrain) and social factors (rapid land use changes and protection polices).

In general, Holdridge model has been applied to estimate vulnerability analysis to climate change in Korean forest (Lee et al, 2006). However, Holdrigde model has some limitations, such as 1) simplified ecosystem factors (only precipitation and temperature are considered), 2) ignorance of land use, 3) failure of applying factors such as soil and humidity which make an effect on the forest succession. In this study, we evaluated effects to forest vulnerability by climate change with CEVSA model considering the effect of forest succession which is important factor in forest distribution change.

Ⅱ. Methods

2.1 Study area

To prepare the appropriate data form of CEVSA model, the study area is restricted to South Korea. The target study covers 125°.85' ~129°.55' at longitude and 30°.05 ' ~ 39°. 50' at latitude.

2.2 Study method

There are 4 stages to conduct the model as follows: 1) model analysis, 2) data preparation, 3) modeling of potential vegetation distribution, and 4) vulnerability assessment with comparison between present vegetation distribution and potential vegetation distribution (Figure 1).

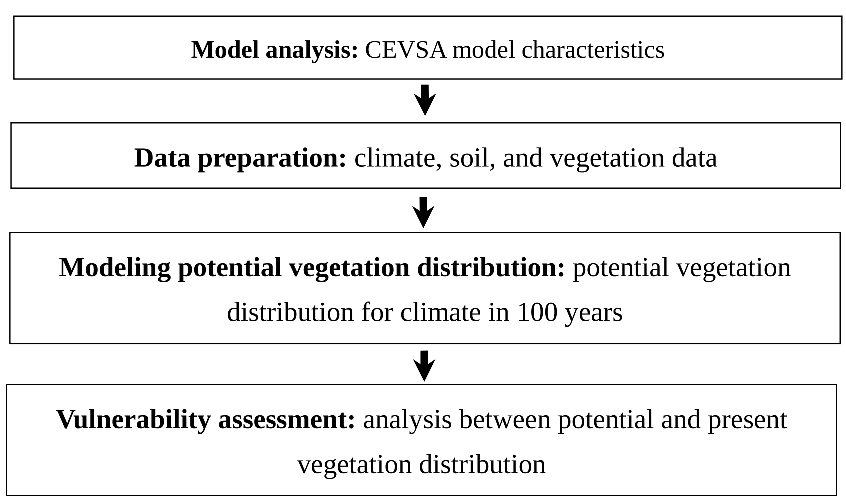

Figure 1. Overview of study process

(1) Model analysis

CEVSA model is biogeochemical model which simulate 1) energy change among the vegetation, soil, and atmosphere in the plant photosynthesis, respiration, and soil microbes, 2) water, C and N cycling, 3) change process of productivity. CEVSA model can assess the potential vulnerable area by integration with physiological response, plant steady-state, and several parameters of ecosystem. Also, it can simulate the dynamic response to environmental changes (Lee et al, 2006). Figure 2 shows the structure of CEVSA model.

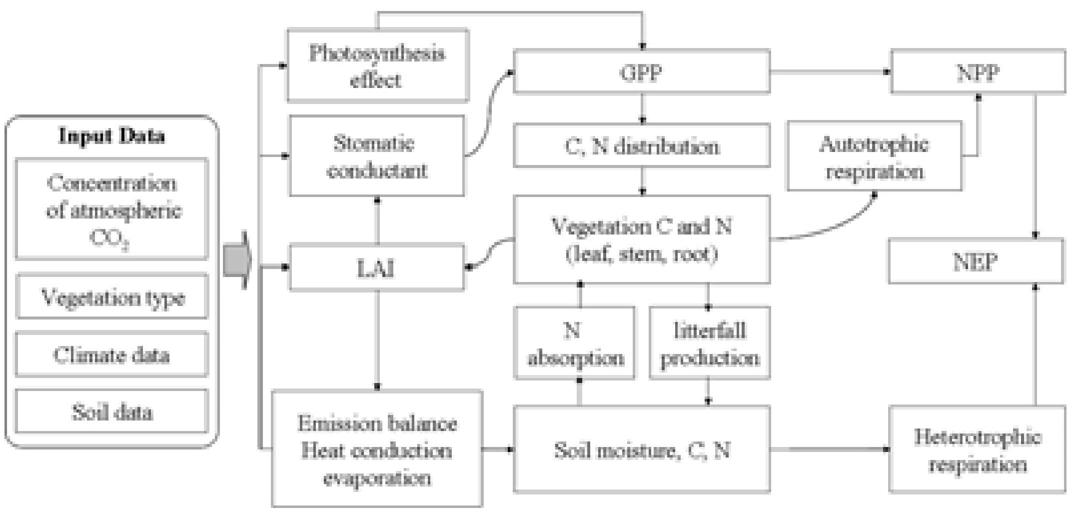

Figure 2. CEVSA model structure

(2) Data preparation

The data used as input to the model in this study consisted of climate data, soil data, and vegetation type data (Table.1). The climate data were prepared from the existing data at Global Historical Climatology Network (GHCN), Korea meteorological administration, and IPCC. Mean temperature, relative humidity, cloudiness every 10 days, and cumulative mean precipitation every 10 days for historical period (1971~2000) were used as climate data. N and C contents data in soil are developed from the soil data created by Jeong et al. (1998, 2000). The fertility of soil data are constructed as sandy soil, fine sandy soil, and clay soils contents using the text form data provided by FAO to 0.08°× 0.08° resolution grid data. Moreover, present vegetation distribution data are constructed by modifying the world land cover map with 1km×1km (Hansen, 2002). All data were resampled into 0.1°× 0.1° resolution grid.

Table 1. Input data preparation

Data		unit	time	Resolution	form	Data source
climate	Temperature	℃	10 days	0.1° x 0.1°	Grid	GHCN[1], KMA[2]
	Precipitation	mm	10 days	0.1° x 0.1°	Grid	GHCN, KMA
	Relative humidity	%	10 days	0.1° x 0.1°	Grid	KMA
	cloudiness	%	10 days	0.1° x 0.1°	Grid	IPCC(DDC)
soil	Fertility of soil	%	-	0.1° x 0.1°	Grid	FAO
	C contents	g/㎡	-	0.1° x 0.1°	Grid	Jeong et al (1998)
	N contents	g/㎡	-	0.1° x 0.1°	Grid	Jeong et al (2002)
vegetation	Vegetation type	-	-	0.1° x 0.1°	Grid	Hansen(2000)

(3) Modeling potential vegetation distribution

The predicted potential vegetation distribution map after 100 years was obtained after putting the all data into CEVSA model. This study is the primary applying step for simulating the potential vegetation distribution with CEVSA model. It is required to reclassify the vegetation type (1. evergreen needle-leaf forest, 2. deciduous broadleaf forest, 3. mixed forest, 4. woodland, 5. wooded grassland, 6. open shrubland, 7. grassland, 8. cropland, 9. urban and built-up, 10. water) to evergreen needle-leaf forest, deciduous broadleaf forest, mixed forest, and etc. for the Korean vegetation condition.

(4) Assessment of Forest Vulnerability

By overlapping future potential vegetation distribution map with present vegetation distribution map, the vulnerable forest area to climate change is extracted. Because the change between present and future vegetation indicate that current vegetation is susceptible to sustaining damage from climate change (IPCC,

[1] Global Historical Climatology Network
[2] Korea Meteorological Administration

2001), we detected different areas between current and future and assigned as vulnerable area

Ⅲ. Results and discussion

3.1 Modeling potential vegetation distribution

Figure 4 and Table 2 show the future potential vegetation distribution, as the result of simulation with CEVSA model. Present evergreen needleleaf forest will reduce by 7,037.74km^2 and exist in partially higher area of Gangwon-do. Deciduous broadleaf forest is mainly predicted to increase from 28,768.31km^2 to 64,697.83km^2, distributing in west east coast area. Mixed forest is simulated to spread over to 65,809.05km^2 from the 7,408.15km^2, bring in some south east area and Jeju island.

Table 2. Distribution change between present vegetation and potential vegetation

Potential vegetation			Evergreen needleleaf forest	Deciduous Broadleaf forest	Mixed forest	Etc.	total
Present vegetation	Evergreen needleleaf forest	㎢	1,605.10	7,284.68	11,729.57	864.28	21,483.63
		%	7.47	33.91	54.60	4.02	100.00
	Deciduous Broadleaf forest	㎢	1,975.51	7,408.15	19,384.65	0.00	28,768.31
		%	6.87	25.75	67.38	0.00	100.00
	Mixed forest	㎢	987.75	1,975.51	4,444.89	0.00	7,408.15
		%	13.33	26.67	60.00	0.00	100.00
	Etc.	㎢	2,469.38	48,029.49	30,249.94	7,778.56	88,527.37
		%	2.79	54.25	34.17	8.79	100.00
	total	㎢	7,037.74	64,697.83	65,809.05	8,642.84	146,187.45
		%	4.81	44.26	45.02	5.91	100.00

3.2 Assessment of Forest vulnerability

Figure 5 depicts that the vulnerable forest area, changing vegetation distribution between present and future. The vulnerable forest area is estimated at 44,201.95km^2, 30.24% of the whole.

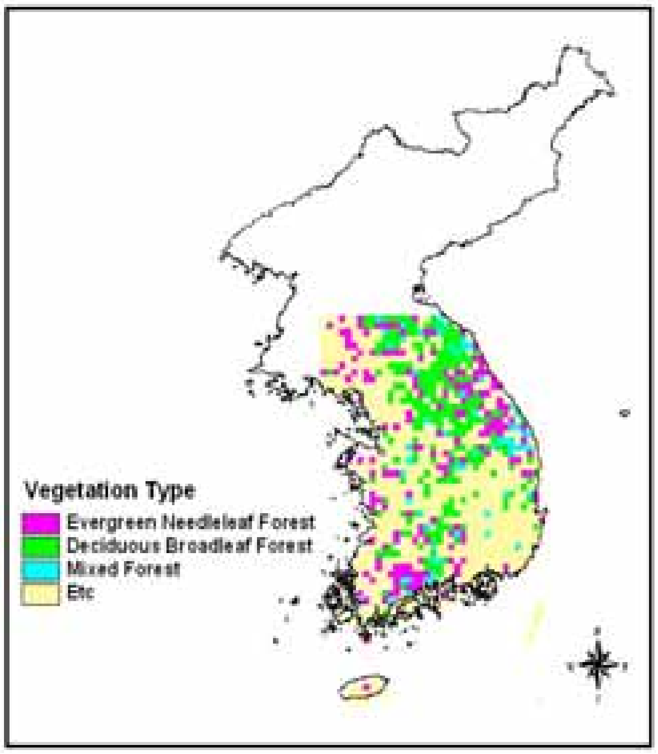

Figure 3 . Present vegetation distribution

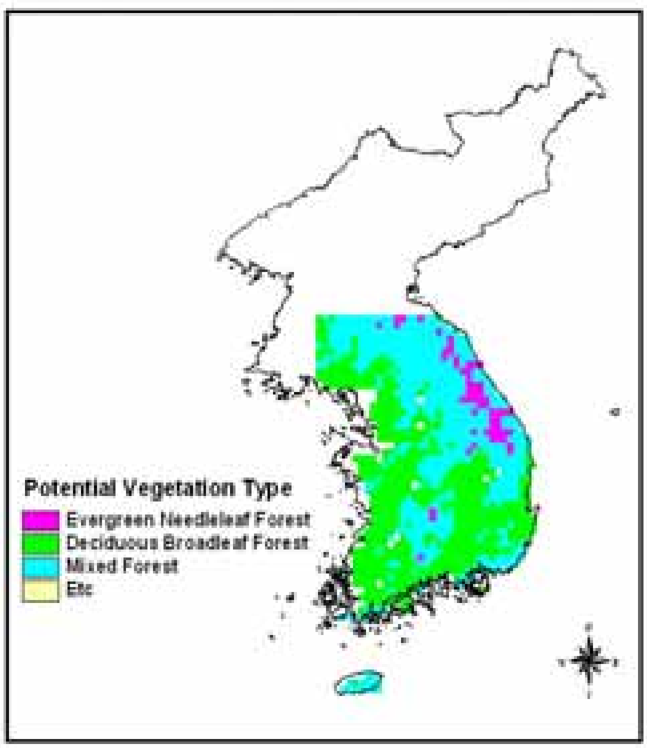

Figure 4. Potential vegetation distribution

Ⅳ. Conclusion

Earlier models to simulate the forest response to climate change mainly considered the climatic data such as temperature and precipitation. Compare to previous studies, we included more ecological variables (forest succession, the fertility of soil, and land cover) so that we was able to get more reasonable prediction and result. However, there are still some limitations like correlation to the surrounding ecosystem where it is not easy to gain the data. Therefore, it is required to study considering the correlation to neighboring environment in a broad scale for the following studies..

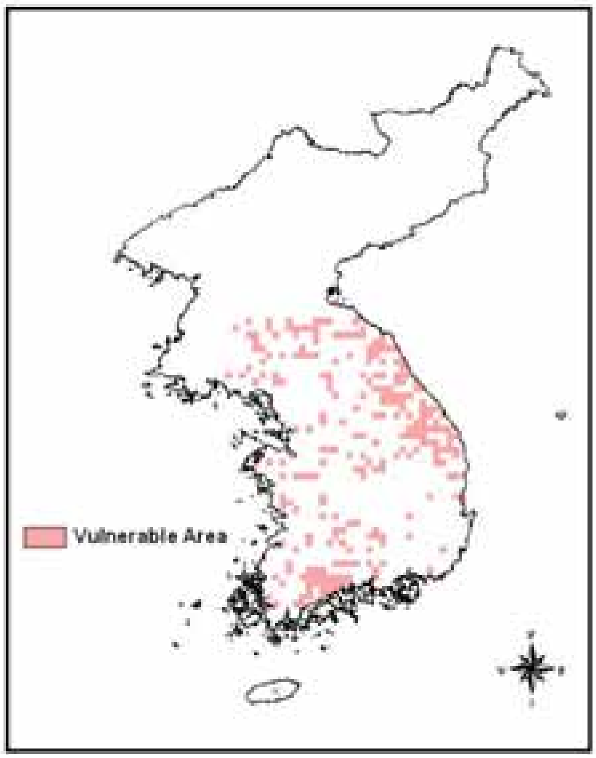

Figure 5 . Vulnerable forest area to climate change

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