POSTER 22

The Estimation of Drought in Gyeonggi Province According to RCPs Scenario

Okjung Ju*, G. J. Lim, H. S. Soh, S. W. Han, and C. S. Kang

Department of Agricultural Environment, Gyeonggido Agricultural Research & Extension Services

I. Introduction

As the global warming has brought in more frequent floods and droughts to the East Asian region than the past, Korea also has observed the growing events of disasters such as spring flood (Lee, 2015). In Korea, 304 times of drought had occurred for 2,000 years from Three Kingdom Period to Joseon Dynasty including 23 severe droughts, 82 times of great famine and 199 famine, averaging a drought event every 6 years and a great famine every 20 years (National Archives of Korea, 2006). Drought refers to a natural disaster occurring when the water resource is not supplied where it is needed, due to the lack of rainfall, and is classified into 4 categories of climatological, meteorological, agricultural, and hydrological drought (Table 1). As it is hard to define the beginning and the end of the gradually-occurring drought caused by the prolonged water deficiency, the disaster is not easily recognized until the real damage happens (Lee *et al*., 2015). Recently, besides deciding the severity of drought by the duration of non-rainy days, the drought intensity is determined by the amount and the duration of water deficiency and the extent of affected area, or by calculating water balance based on precipitation, evapotranspiration, up and down water movement in soil, and runoff. In case of agricultural drought, the time period of damage over crops is not clear in the short term and different depending on soil condition and crop types. Therefore, this study aims at estimating the drought risk of agricultural fields according to the climate change scenarios of RCP4.5 and RCP8.5 based on APKAE 0.5 model (Seo *et al*., 2012).

II. Materials and Methods

For the Fifth Assessment Report of IPCC, the scientific community has defined a set of four new scenarios, denoted Representative Concentration Pathways (RCPs). Among the RCPs, the two scenarios were used in this study to predict drought in Gyeonggi province. The scenarios are RCP4.5 and RCP8.5 identified by their approximate total radiative forcing in year 2100 relative to 1750: 4.5 W m^{-2} for RCP4.5, and 8.5 W m^{-2} for RCP8.5. The cities and counties' weather data of Gyeonggi province such as daily mean, maximum, minimum temperature, precipitation, insolation,

* Correspondence to : okjung3@gg.go.kr

and mean wind speed used in this study offered from the climate change scenario of 1 km × 1 km high resolution produced by Regional Climate Model (RCM) was provided by KMA (Korea Meteorological Adminstration). The Assessment Program for Korean Agricultural Environment v. 0.5 (APKAE 0.5) used for evaluating the drought risk of Gyeonggi province was developed by the Seo *et al*. in 2012, which designates the soil at 300 mm depth as the target of water movement and storage, and the direction and the speed of water movement are decided by the difference of water potential of soil. The change of soil water content is calculated by subtracting evapotranspiration, runoff and the amount of downward water between the subjected soil and beneath soil from the sum of precipitation, irrigation and the amount of upward water between the subjected soil and beneath soil (Seo *et al*., 2012). For estimating the future drought risk of Gyeonggi province, the meteorological data from scenarios of RCP4.5 and RCP8.5 were used to predict and analyze the water potential of soils of 31 cities and counties in Gyeonggi province for the next 30 years from 2031 to 2060.

III. Results and Discussion

As the result of drought risk estimation for the future 30 years (2031~2060) by APKAE 0.5 based on the meteorological data from two scenarios of RCP4.5 and RCP8.5, the drought risk for the spring season was high, with the average of 1.8 times of drought frequency and 34 times of soil dryness. In 2030s (2031~2040), the average of soil dryness and drought frequency in RCP 4.5 scenario was 1.8 times while it was 2.0 times in RCP8.5, which was higher but not significantly different. In 2050s (2051~2060), the average in RCP4.5 scenario was twice higher than those of RCP8.5, which was similar with 2030s. South-western regions of Gyeonggi province such as Bucheon, Siheung and Ansan showed high drought risk for the future 30 years (2031~2060) in both RCP4.5 and RCP8.5 according to the result of the frequency and period of soil dryness and drought.

Table 1. Classification of drought and contents

Classification	Contents	Index
Climatological drought	Below-30 year average precipitation	EDI (Effective Drought Index), SPI(Standardized Precipitation Index)
Meteorological drought	Consider evaporation and transpiration as well as precipitation	PDSI(Palmer Drought Severity Index; Palmer, 1965)
Agricultural drought	Not able to secure soil moisture necessary for crop growth	SMDI(Soil Moisture Drought Index; Hollinger *et al.,* 1993)
Hydrological drought (= socio-economic drought)	Expect damage of water deficiency as the water in dam, reservoir and river is depleted. Decide depending on the absolute value of water demand.	

* source : Wikipedia (https://ko.wikipedia.org/wiki/%EA%B0%80%EB%AD%84)

Table 2. Drought Assessment in Gyeonggi province in 2030s (2031~2040)

Cities and Counties	RCP4.5			RCP8.5		
	Frequency of Soil Dryness	Frequency of Drought	Period of drought/month	Frequency of Soil Dryness	Frequency of Drought	Period of drought/month
Suwon	44.4	2.3	19.5/5	47.1	2.7	22.3/6
Seongnam	34.8	1.7	16.2/5	40.1	2.2	19.3/5
Uijeongbu	38.3	1.8	16.8/6	40.3	2.3	15.7/4
Anyang	50.1	2.6	22.6/5	51.9	2.2	24.7/5
Bucheon	63.1	3.3	25.0/5	67.3	2.8	33.7/5
Gwangmeong	55.4	2.7	25.4/5	57.7	2.6	29.6/5
Pyeongtaek	41.2	2.0	22.4/5	51.9	2.7	24.7/6
Dongducheon	17.5	0.9	9.4/3	22.0	1.2	10.1/4
Ansan	64.6	2.8	27.8/5	66.2	3.5	30.4/6
Goyang	43.5	2.1	20.0/5	54.8	2.5	28.3/5
Gwacheon	33.4	1.7	14.4/6	41.1	2.2	19.7/6
Guri	33.7	1.7	15.6/6	37.5	2.0	17.4/5
Namyangju	19.6	1.1	9.1/5	25.7	1.6	12.8/4
Osan	39.9	1.9	17.2/6	46.0	2.4	22.5/6
Siheung	68.8	3.2	29.7/5	70.3	2.8	32.9/6
Gunpo	55.0	2.6	24.3/5	54.7	2.5	25.4/5
Uiwang	40.7	1.9	17.5/6	45.7	2.5	22.6/5
Hanam	32.1	1.5	15.6/5	32.3	1.8	12.5/5
Yongin	24.1	1.5	12.9/6	29.6	1.5	13.2/6
Paju	34.5	1.9	15.2/4	43.4	2.3	20.0/5
Icheon	26.3	1.5	13.5/6	27.9	1.3	10.9/5
Anseong	25.2	1.3	16.9/6	29.0	1.2	13.6/5
Gimpo	51.2	2.4	20.2/4	62.9	2.6	32.6/5
Hwaseong	58.5	2.7	28.8/5	63.0	2.8	30.2/6
Gwangju	22.3	1.3	11.9/6	23.2	1.2	9.1/4
Yangju	28.0	1.6	12.9/3	35.0	2.0	14.4/4
Pocheon	14.4	0.8	7.9/4	21.0	1.2	9.3/5
Yeoju	22.5	1.2	11.6/6	23.5	1.2	10.2/5
Yeoncheon	24.5	1.2	12.6/5	29.9	1.6	12.9/5
Gapyeong	8.0	0.5	5.2/3	13.8	0.8	7.1/4
Yangpyeong	8.8	0.6	5.4/5	28.5	1.3	16.6/5
AVG.	**36.3**	**1.8**	**16.9/5.5**	**41.4**	**2.0**	**19.5/5.5**

Table 3. Drought Assessment in Gyeonggi province in 2040s (2041~2050)

Cities and Counties	RCP4.5			RCP8.5		
	Frequency of Soil Dryness	Frequency of Drought	Period of drought/month	Frequency of Soil Dryness	Frequency of Drought	Period of drought/month
Suwon	30.6	1.9	12.8/5	37.8	1.9	19.5/5
Seongnam	27.3	1.9	11.8/5	31.3	1.5	18.5/5
Uijeongbu	21.3	1.4	9.6/5	26.4	1.3	16.0/5
Anyang	36.7	2.3	12.3/5	42.3	2.2	20.4/5
Bucheon	59.9	3.5	20.6/5	66.8	3.1	27.8/6
Gwangmeong	49.9	3.3	14.7/5	53.7	2.5	22.7/5
Pyeongtaek	36.1	2.4	12.7/5	41.0	2.4	18.3/6
Dongducheon	13.8	0.9	5.9/4	20.1	1.1	11.5/4
Ansan	57.1	3.4	17.3/6	59.4	3.0	22.4/5
Goyang	38.2	2.4	14.1/5	47.6	2.6	22.5/5
Gwacheon	27.1	1.8	11.7/4	31.0	1.4	18.7/5
Guri	28.0	1.6	13.0/5	32.2	1.4	18.3/4
Namyangju	16.0	1.1	6.8/5	22.0	1.0	13.9/5
Osan	31.2	2.0	13.1/5	37.4	1.9	19.1/5
Siheung	60.8	3.3	18.0/6	65.9	3.5	24.1/4
Gunpo	42.6	2.5	13.2/5	45.5	2.5	20.5/5
Uiwang	29.3	1.9	11.7/5	36.4	1.8	18.9/5
Hanam	24.5	1.4	10.6/5	30.3	1.6	18.4/5
Yongin	15.8	1.0	8.8/5	22.1	1.2	15.0/6
Paju	26.8	1.8	10.2/5	35.2	1.7	19.8/4
Icheon	18.9	1.0	11.2/5	21.7	1.2	14.5/6
Anseong	19.7	1.1	10.9/5	22.2	1.5	13.8/5
Gimpo	45.3	2.9	16.0/5	57.6	2.8	23.1/5
Hwaseong	54.7	3.5	17.2/6	54.3	2.7	23.4/6
Gwangju	14.6	0.8	7.9/5	19.5	1.1	13.5/5
Yangju	21.1	1.4	8.8/5	29.7	1.5	17.5/5
Pocheon	12.0	0.7	5.5/5	18.0	1.1	9.5/4
Yeoju	15.0	0.8	7.6/5	19.7	1.0	12.9/5
Yeoncheon	19.5	1.2	8.4/5	22.0	1.0	13.4/4
Gapyeong	8.0	0.4	3.2/6	13.0	0.9	6.6/4
Yangpyeong	6.3	0.4	4.1/5	12.2	0.8	9.0/5
AVG.	**29.3**	**1.8**	**11.3/5**	**34.7**	**1.8**	**17.5/5**

Table 4. Drought Assessment in Gyeonggi province in 2050s (2051~2060)

Cities and Counties	RCP4.5			RCP8.5		
	Frequency of Soil Dryness	Frequency of Drought	Period of drought/month	Frequency of Soil Dryness	Frequency of Drought	Period of drought/month
Suwon	49.3	2.6	22.1/5	22.9	1.0	11.2/5
Seongnam	41.9	2.1	20.2/5	18.2	1.0	7.7/5
Uijeongbu	29.6	1.7	17.1/4	13.5	0.5	4.4/3
Anyang	55.5	2.9	24.6/6	26.3	1.4	12.5/5
Bucheon	69.3	3.4	28.9/4	38.9	2.2	17.6/6
Gwangmeong	61.5	3.6	23.9/4	30.6	1.6	15.2/6
Pyeongtaek	49.7	2.7	19.5/5	26.7	1.4	13.1/6
Dongducheon	25.1	1.1	14.0/4	9.4	0.4	3.4/3
Ansan	69.5	3.6	28.4/5	42.0	2.3	22.0/7
Goyang	50.9	2.5	25.9/4	25.4	1.5	11.3/5
Gwacheon	42.6	2.1	21.0/7	19.2	0.9	8.8/6
Guri	37.6	1.9	19.9/4	18.8	1.0	9.8/4
Namyangju	25.5	1.1	14.2/4	10.7	0.5	3.5/3
Osan	46.0	2.8	18.2/5	23.9	1.0	12.8/6
Siheung	73.5	4.1	28.7/6	44.0	2.3	22.0/7
Gunpo	57.6	2.9	24.8/4	29.9	1.7	14.9/6
Uiwang	47.5	2.3	22.4/5	22.4	1.1	11.2/5
Hanam	36.9	1.9	18.1/4	15.3	0.8	6.5/4
Yongin	27.8	1.5	13.2/5	12.7	0.8	5.7/5
Paju	41.3	2.4	18.5/4	18.8	1.1	9.0/5
Icheon	30.7	1.6	15.3/5	14.7	0.7	5.4/4
Anseong	30.3	1.7	14.2/5	15.7	1.1	8.9/5
Gimpo	59.6	2.9	27.8/4	34.5	2.0	15.8/6
Hwaseong	59.1	3.1	23.0/5	38.1	2.0	18.4/7
Gwangju	23.6	1.0	13.6/5	10.5	0.6	4.5/4
Yangju	31.5	1.6	17.0/4	13.0	0.7	5.3/4
Pocheon	23.2	1.0	11.6/4	7.5	0.3	2.5/7
Yeoju	24.6	1.1	13.0/5	11.7	0.6	4.3/4
Yeoncheon	33.9	1.8	16.3/4	13.2	0.5	4.6/5
Gapyeong	16.6	0.8	9.6/4	3.9	0.2	1.2/5
Yangpyeong	14.0	0.6	7.3/4	4.2	0.1	0.9/5
AVG.	**41.5**	**2.1**	**19.1/5**	**20.5**	**1.1**	**9.5/5**

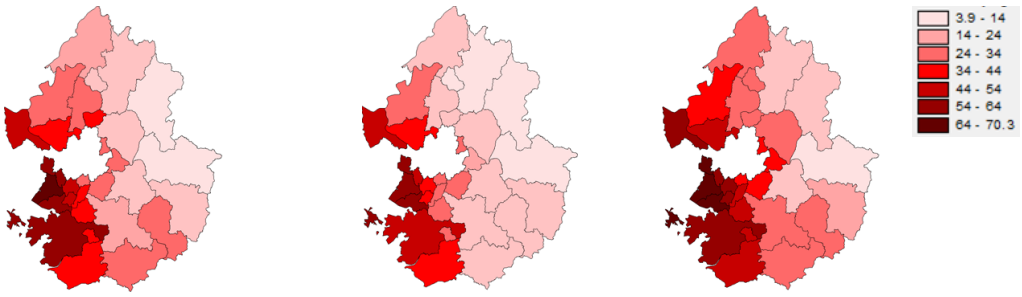
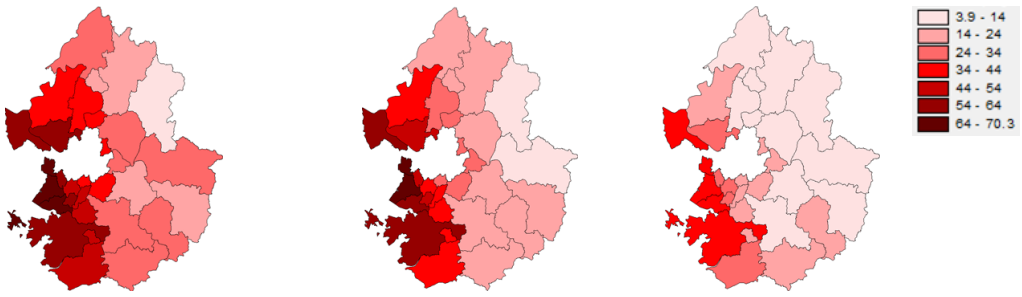
	2030s (2031~2040)	2040s (2041~2050)	2050s (2051~2060)
RCP4.5			
AVG.	36.3	29.3	41.5
RCP8.5			
AVG.	41.4	34.7	20.5

Fig. 1. Frequency of Soil Drying in Gyeonggi province in 2030s, 2040s, 2050s according to the scenarios of RCP4.5 and RCP8.5.

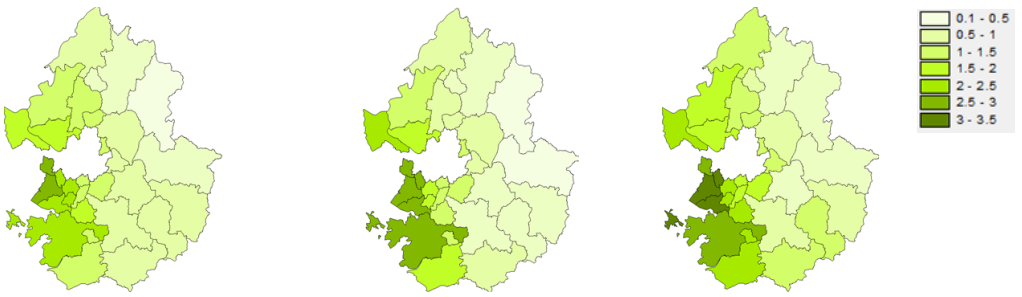
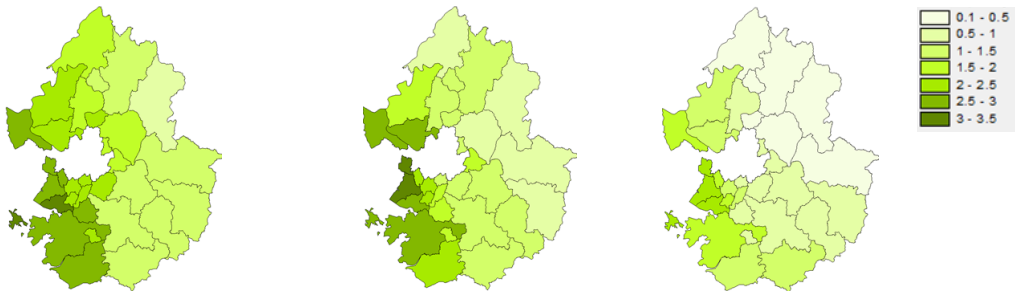
	2030s(2031~2040)	2040s(2041~2050)	2050s(2051~2060)
RCP4.5			
AVG.	1.8	1.8	2.1
RCP8.5			
AVG.	2.0	1.8	1.1

Fig. 2. Frequency of Drought in Gyeonggi province in 2030s, 2040s, 2050s according the scenarios of RCP4.5 and RCP8.5.

References

Lee, E. K., 2015: Current state of agricultural water resource and cases of drought response. *Water and Future* **48**(7) 62-71.

Lee, G. Y., S. H. Han, and S. J. Kim, 2015: Establishment of water disaster management systems using information and communication technology. *GRI report*.

Seo, M. C., S. O. Hur, Y. K. Sonn, H. S. Cho, W. T. Jeon, M. K. Kim, and M. T. Kim, 2012: The development of estimation model (AFKAE0.5) for water balance and soil water content using daily weather data. *Korean Journal of Soil Science Fertilizer* 45(6) 1203-1210.

National Archives of Korea, 2006. http://theme.archives.go.kr/next/koreaOfRecord/drought.do (2016.08.19.)