

## Analysis of Future Discharge in Nakdong River Basin According to Effect on Climate Change

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**Abstract.** Climate change has affected water resources and environment all over the world and its impacts assessment and adaptation are very important issues that are significant in terms of science and policies. In view of water resources, estimation of discharge is essential to make basic data in watershed management and water environment like flood and drought. The change of discharge has affected both eco-system and human system. So that, using technical methods are necessary to develop nature restoration and disaster reduction. Therefore, this study applied to GCMs (General Circulation Models) using A1B scenario which reflects climate characteristics of Korea well and analyze out the future climate change discharge. The main result of these studies is compared and analyzed at Nakdong River basin about discharge by A1B scenario. The study period (2011~2100) was divided into three periods (F1:2011~2040, F2:2041~2070, F3:2071~2100) and compared with observed data for 1980~2009. This study presents technical methodology for assessing influence on water environment resources. Furthermore, the results of this study expect to be quantitative and reliable data in studying climate change throughout the application to other rivers. If water environment impact assessment and analysis of the future water balance including a forecast of water supply and demand take place based on the results of this study, the results will be sufficiently valuable both as researches on national measures to climate change and policy materials.

### 1. Introduction

Many countries intend to develop assessment techniques for climate change effect that will both reduce and prevent the impacts of such as flood and drought disasters on public security. Thus, increasing the future discharge further activates the hydrologic cycle along with the increase in temperature, which causes appearances of exceptional phenomena, the extreme events, which were not observed in the past. So that, using technical methods are necessary to develop nature restoration and disaster reduction. Therefore, this study applied to GCMs (General Circulation Models) using A1B scenario which reflects climate characteristics of Korea well and analyzed out the future climate change discharge. Based

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on selection of the most appropriate GCMs in Korea, which is the most fundamental and basic stage for climate change analysis, and application of downscaling techniques for precise materialization of meteorological patterns of Korea in terms of space and time, the current climate change scenarios and those forecasting the next 90 years were produced and applied. The SWAT model of hydrologic models was used for analyzing discharge at Nakdong River. The main result of this study is compared and analyzed at Nakdong River basin about discharge by A1B scenario. The study period (2011~2100) was divided into three periods (F1:2011~2040, F2:2041~2070, F3:2071~2100) and compared with observed data for 1980~2009. Climate change effect on frequency based precipitation was assessed quantitatively by using daily precipitation and precipitation frequency map. As a result of this study expect to be quantitative and reliable data in studying climate change throughout the application to other rivers and forecast the future discharge by the impact of climate change.

## **2. Study area and Method**

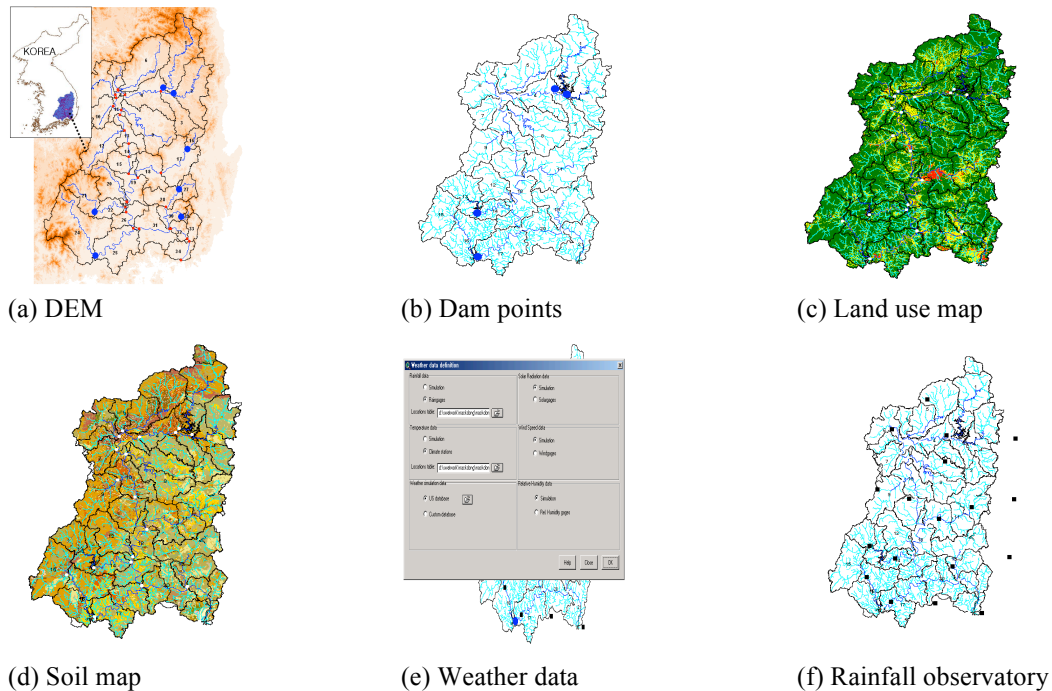
### **2.1. Study area**

The Korea peninsula extends southward from the northeastern part of Asia between 33-45°N Latitude and 124-131°E Longitude. About 70% of the land is covered with mountains, particularly in the east and north. The region of Korea has humid continental climate and a humid subtropical climate mostly. Average temperatures range from about -10°C in winter to about 30°C in summer. Winter temperatures are higher along the southern coast and considerably lower in the mountainous interior. Rainfall is affected by the East Asian moon-son, and rainfall activity experiences diurnal variation with a night-time preference, especially toward heavier precipitation categories. Korea is divided into five major river basins: Han River basin (26,081 km<sup>2</sup>), Nakdong River basin (23,817 km<sup>2</sup>), Geum River basin (9,810 km<sup>2</sup>), Seomjin River basin (4,897 km<sup>2</sup>), and Youngsan River basin (3,371 km<sup>2</sup>). The Nakdong River basin, with about 23.8% of the area, is the second largest among the basins. In this study, two rainfall data sets are considered: (1) rainfall for the period 1980~2009 obtained through downscaling of coarse-scale climate outputs produced by the climate model with the IPCC SRES (Intergovernmental Panel on Climate Change Special Report on Emission Scenarios) 20th Century Climate in GCMs. (2) the future rainfall (2011~2100) is obtained through downscaling of climate outputs projected by the A1B emission scenario of CSMK, CNCM, CT63, MPEH.

### **2.2. Methods**

Based on selection of the most appropriate GCMs in Korea, which is the most fundamental and basic stage for climate change analysis, and application of downscaling techniques for precise materialization of meteorological patterns of Korea in terms of space and time, the current climate change scenarios and those forecasting the next 90 years were produced and applied. The long-term watershed model that can perform analysis of hydrologic cycle is necessary to evaluate potential of water environment and runoff changes in river by climate change. Therefore, SWAT model was chosen in this study to simulate long-term climate change forecasting based on watershed. SWAT model has developed in order to forecast phenomenon of hydrology, sediment, and nutrients in complicated watershed in large scale according to land-use. Thus, it calculates emission of pollutant and hy-

drologic quantity by HRU (Hydrologic Response Unit) consists of soil map and land use. Moreover, the watersheds are divided into sub-watersheds using data of stream network and digital terrain elevation data linked to Arc-view GIS software. To build SWAT model based on GIS, the DEM is created by 1:50,000 topographic maps from National Geographic Information Institute. So that, soil map applied to land use map using 1:50,000 reconnaissance soil maps by Korea Rural Development Administration and classification map of land coverage by Korea Ministry of Environment. This study performed calibration and verification of daily rainfall at points using general Kriging technique through collecting data in selected rainfall observatory. On top of that, computation of average rainfall at watershed was implemented in order. The model adapted daily rainfall of average in watershed from selected 56 rainfall observatory to simulate daily volume of runoff. Thus, SWAT model is required meteorological data such as solar radiation, air temperature, wind speed, and relative humidity to compute evaporation. In addition, this model used modified monitoring data and collected data of daily inflow and outflow for watershed simulation in upper reach of the dam. The figure 1 shows detailed process of constructing SWAT model.



**Figure 1.** The detailed process of constructing SWAT model

### 3. Results

The main result of this study is compared and analyzed in two points about the future discharge by A1B scenarios that are divided into 3 periods. Annual and the seasons averages of discharge by GCMs in the 2 points (Andong Dam, and Jindong which are located in the upper, and downstream points of Nakdong river) to compare between the present and the future during 90 years (2011~2100) using GCMs. The annual discharge of CT63 model at Andong Dam and CNCM model at Jindong was the highest value both in F3 (2071~2100) period. By the seasons, spring in the upper site presented the highest discharge compare to summer, fall, and winter and the future discharge in the downstream showed lots of increasing all seasons. In particular, MPEH model was the highest all over

the seasons at Andong Dam then CNCM in spring and winter, CT63 in fall and MPEH in summer was the highest values at Jindong. Overall, the future discharges which were forecasting by GCMs were higher than present.

**Table 1.** Discharge by impacts on climate change at Nakdong river sites based on GCMs

Year	GCMs	Andong Dam (Q: cms)					Jindong (Q: cms)				
		Annual	Spring	Summer	Fall	Winter	Annual	Spring	Summer	Fall	Winter
Present		30.57	16	55	36	6	429.62	218	753	567	148
	CSMK	32.60	19	56	44	12	501.63	249	931	644	175
2011-2100	CT63	36.08	21	59	51	13	518.35	264	926	696	179
	CNCM	33.75	19	57	45	14	515.43	261	931	661	201
	MPEH	36.47	22	54	56	13	525.80	261	931	661	201
	CSMK	33.81	18	58	44	12	514.60	229	885	624	166
	CT63	34.93	17	59	41	11	502.23	230	955	610	166
2011-2040	CNCM	30.10	19	49	38	19	463.56	233	757	537	168
	MPEH	33.59	20	69	56	13	483.88	249	1067	772	190
	CSMK	32.19	19	62	52	13	492.32	236	961	705	174
2041-2070	CT63	36.49	20	55	51	14	521.16	259	883	694	190
	CNCM	34.40	18	53	53	14	513.09	232	830	744	186
	MPEH	38.14	22	57	46	12	560.02	292	897	670	184
2071-2100	CSMK	31.81	20	52	39	11	497.96	241	791	543	153
	CT63	36.83	22	53	63	14	531.68	272	827	867	184
	CNCM	36.74	21	56	62	13	569.64	292	897	670	184
	MPEH	37.67	22	55	58	19	533.50	273	878	831	184

#### 4. Conclusion

In this study, a set of A1B climate scenarios derived from CNCM, CT63, CSMK and MPEH have been used for analysis of impact of climate change on frequency based precipitation in Korea. For the daily rainfall data from stations in Korea peninsular was forecasted considering future climate scenarios and the increasing discharge which showed the trend of increase comparing between 2011~2100 and 1980~2009. Climate is continuously changing and the signature of change is evident in historical hydrology records and rainfall patterns, and current state or predicting future state, the studies on climate are getting active in order to further understand the possibility and potential impacts on hydrologic cycle instead of figuring out past events and predicting future based on tem. So, this study presents technical methodology for assessing influence on water environment resources. Furthermore, the results of this study expect to be quantitative and reliable data in studying climate change throughout the application to other rivers. If water environment impact assessment and analysis of the future water balance including a forecast of water supply and demand take place based on the results of this study, the results will be sufficiently valuable both as researches on national measures to climate change and policy materials.

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