

HYDRO-ENVIRONMENTAL IMPACTS OF CLIMATE CHANGE IN LARGE RIVER BASINS IN KOREA

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Abstract:

The hydro-environmental projection corresponding to water resources availability in the major Korean multipurpose dams based on the IPCC climate change scenario(A1B) is suggested. The projection by 2040 for precipitation and dam inflow gives 7.8~13.1% and 6.7~24.6% increase. The inflow projection for 7 major dams shows highest increasing ratio of 24.6% in Chungju and lowest of 6.7% in Juam, and 13.6% increase on the average under the Foreseeable Future scenario. The dams (Soyanggang and Chungju dams) in Han river basin shows relatively higher increasing trend than the dams in the other regions, Nakdong river basin in particular. As a result the availability of surface water resources can be expected to be improved, but, at the same time, the vulnerability against flood risk can be aggravated. The hydro-environmental impacts are lowest in Juam. Sediment impact is expected highest in Soyang. Total-Phosphorous impact is relatively low in most areas, but highest in Imha.

Keywords: Downscaling, Climate Change, Water Resources, Artificial Neural Network, SWAT

1. INTRODUCTION

The hydro-environment depends largely on hydrologic cycle and is impacted directly by climate variability and change. The regional projection using GCM (Global Climate Model) accompanies significant amount of uncertainties which are propagated and amplified when the projection is extended to applied dimensions using impact models.

In this study, the hydro-environmental projections in the 7 major Korean multipurpose dam basins based on the IPCC climate change scenario(A1B) will be suggested. The coupled downscaling scheme consisting of ANN (Artificial Neural Network), NSQM (Nonstationary Quantile Mapping), and STS (Stochastic Typhoon Simulator) sub-modules was applied for the regional daily hydrologic projection. The basin inflow to the dam reservoir was computed using SWAT, the long-term continuous rainfall-runoff model which is one of most popular models used for climate change impact models.

2. REGIONAL DOWNSCALING FOR GCM OUTPUT

The RCM (Regional Climate Model) output for the future climate scenario was provided by KMA (Korea Meteorological Administration). It has 30km of spatial scale and provide daily scenarios to the public. The KMA's RCM was developed by calibrating NOAA's MM5 to Korean climate

environment and coupled with ECHO-G model. It provides scenarios of 5 atmospheric variables; precipitable water, relative humidity, temperature (average, minimum, maximum). As the emission scenario for the projection in this study was SRES A1B of AR4.

The ANN is one of the MOS (Model Output Statistics) tools for calibration of regional biases embedded in RCM or GCM (Kang and Lee, 2011; Kuligowski and Barros, 1998). The predictor variables for input to the ANN are precipitable water, relative humidity, temperature (average, minimum, maximum). Additional data fitting was implemented with NSQM which utilizes the temporally variable statistical parameters reflecting the variable trend captured by the original RCM, thus more realistic projection with seamless connection with baseline scenario fitted to historical observation. The GCM or RCM does not include the local heavy rainfall and typhoon generation mechanism, which can be a reason of underestimation for the summer precipitation (Cheng, et al., 2009). The uncounted typhoon rainfall by GCM was simulated for the projection period using the STS which generates occurrence (and duration) and intensity of typhoon using the mixed Poisson and Gumbel distribution, respectively (Moon, et al., 2012). The projections of annual precipitation at multipurpose dam basins are suggested in Table 1.

Table 1. Projection of annual precipitation at 7 major multipurpose dam basins in Korea

Dam	Baseline(Obs) 1991~2010	Baseline(Sim) 1991~2010	Foreseeable Future (2010~2040)	Mid-Term Future 2041~2070	Long-Term Future 2071~2100
Chungju	1445.4	1449.7 (0.3%*)	1651.1 (13.9%**)	1800.3 (24.2%**)	1998.3 (37.8%**)
Soyanggang	1459.0	1452.6 (-0.4%*)	1714.9 (18.1%**)	1900.5 (30.8%**)	2119.4 (45.9%**)
Andong	1245.2	1245.6 (0.0%*)	1379.9 (10.8%**)	1520.8 (22.1%**)	1720.0 (38.1%**)
Imha	1103.2	1105.1 (0.2%*)	1227.8 (11.1%**)	1393.2 (26.1%**)	1577.9 (42.8%**)
Hapcheon	1324.3	1349.9 (1.9%*)	1500.6 (11.2%**)	1747.3 (29.4%**)	1974.6 (46.3%**)
Namgang	1474.6	1481.7 (0.5%*)	1622.4 (9.5%**)	1811.3 (22.2%**)	2018.1 (36.2%**)
Juam	1501.6	1502.2 (0.0%*)	1619.6 (7.8%**)	1664.5 (10.8%**)	1788.1 (19.0%**)

*Percentage of Baseline(Obs)

**Percentage of Baseline(Sim) by periods

3. LONG TERM HYDRO - ENVIRONMENTAL PROJECTION AT THE MULTIPURPOSE DAM BASINS

The long term water budget and hydro-environmental impacts were computed using SWAT, the continuous watershed model. The HRU (Hydrologic Response Unit) was used for the sub-basin delineation. The simulation was carried out daily basis. The groundwater flow was analysed using hydrodynamic storage model and effective rainfall was estimated using SCS-CN method. The geographic digital information for terrain, soil, and landuse are constructed based on 1:5,000, 1:25,000 and 30m scales. The long-term hydro-environmental projections at 7 multipurpose dam basins are suggested in Figure 1. The hydro-environmental impacts are lowest in Juam. Sediment impact is expected highest in Soyang. Total-Phosphorous impact is relatively low in most areas, but highest in Imha.

4. CONCLUSIONS

Due to the temperature increase, the weather in the region of Korea peninsula is likely to get into the sub-tropical band. The projection by 2040 for precipitation and dam inflow gives 7.8~13.1% and 6.7~24.6% increase for all dams.

The projected streamflow into the 7 major reservoirs were decomposed into hydrologic components of direct runoff and baseflow and showed the increasing ratio of dam inflows will be greater than that of precipitation, which can be a noticeable alert for the water resources managers to build strategic plan for adapting to climate change.

The dams (Soyanggang and Chungju dams) in Han river basin shows relatively higher increasing trend than the dams in the other regions, Nakdong river basin in particular. Overall increasing trends of dam inflows are greater than

those of precipitation. As a result the availability of surface water resources can be expected to be improved, but, at the same time, the vulnerability against flood risk can be aggravated. However, the risk of water shortage will exist always due to the increase of weather variability.

The suggested streamflow projection can be used for predicting water quality at reservoirs and its downstream river channels. However, in order to predict sediment detachment from land surface with higher reliability will require finer temporal scales than daily scale.

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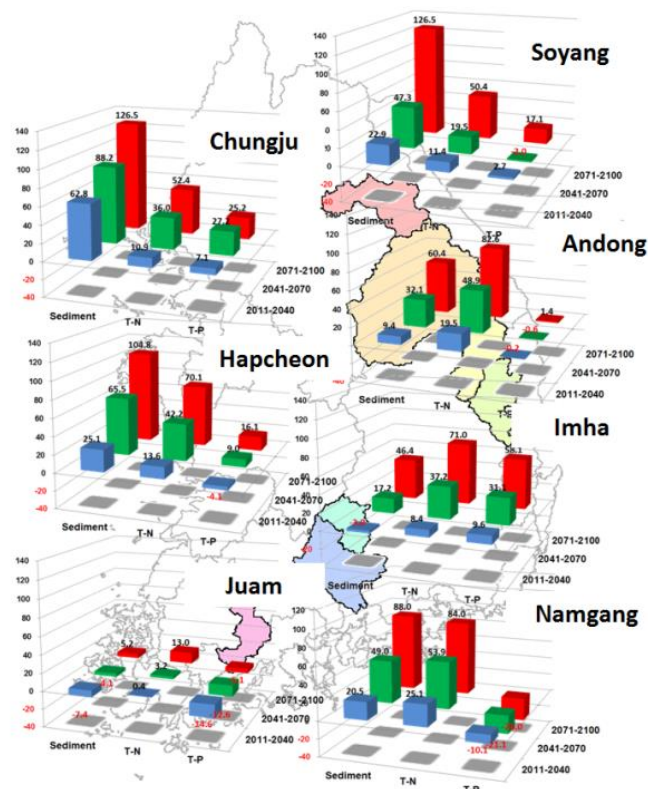


Figure 1: Most meaningful example of a brilliant table with columns and lines filled with a minimum of quantitative information

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