# Impact Assessment of Climate Change on Future Water Balance in a Monsoon Watershed with Mixed Land Use

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# Highlights

* Water balance
* Climate change
* Monsoon Watershed

# Introduction

Comprehending the impact of climate change on future water resources will aid in the development of a sustainable river/stream management systems (Hagemann et al., 2013). Human activities, severe environmental and climatic changes are well documented to have significant impacts on the river basin water balance (Zhang et al., 2012). To assess these changes, climate change models have been developed by environmental organizations in predicting the future consequences of climate change under representative concentration pathways (RCPs) for greenhouse gases extending to 2100.

The study area is the Osan watershed in South Korea which during the summer monsoon periods contributes about 60–70% of the annual runoff and precipitation for the country. Our aim is to understand how future water balance will be affected due to climate changes. Ten downscaled global climate models (GCMs) were used. Soil and Water Assessment Tool (SWAT) model and the GCMs were classified into three periods to evaluate these climate impacts. The baseline, mid-century (MC), and end-century (EC) periods include 1993–2018, 2046–2065, and 2081–2099, respectively. Sensitivity and uncertainty analysis were performed to choose parameters for calibration. For model calibration and validation, six statistical metrics were used. Under RCP 4.5 and 8.5, ten downscaled GCMs in the MC and EC periods were used to assess climate change impact on future water balance in this mixed land-use watershed.

# Methodology

**Study Area**

Our study area is in central South Korea occupying an area of is 96.7 km2, with a total stream length of 16.49 km. The watershed has a precipitation of 1321 mm and a temperature of 12°C per annum. Summer monsoons between June and September contribute for 60–70% of total runoff and precipitation, with the remaining eight months accounting for 30% (Ashu and Lee, 2019). Most of the stream water is utilized for irrigation and the watershed is characterized by mountains and steep slopes.

**SWAT Model**

The SWAT model is a continuous-time model that predicts subsurface and surface flow, sediment, and water quality in agricultural catchments in ungauged watersheds under a variety of long-term land use, soil, and management techniques (Neitsch et al., 2005).

The following data were used for our study: The U. S. Geological Survey (USGS) Earth Explorer provided a resolution of 30 m of digital elevation model (http://earthexplorer.usgs.gov/), Global Land Cover Map 2009 utilized a 300-m land-use layer (http://due.esrin.esa.int/page\_globcover.php), and a 10-km FAO v2 soil layer (http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/) (Abbaspour et al., 2019). The Korean Meteorological Administration (KMA) provided daily weather data such as wind velocity, solar radiation, minimum temperature, precipitation, and maximum temperature from 1993–2018 (https://web.kma.go.kr/eng/index.jsp).

The SWAT model produced 247 HRUs for 35 sub-basins, which was in accordance with the ratio range of 1–10 for HRUs and sub-basins. Digital elevation, soil and land use maps were also created. The SWAT calibration and uncertainty program software package was used in calibrating and validating our model.

# Results and discussion

Results show that under RCP 4.5 and 8.5 scenarios, temperatures are expected to rise by 2-5 °C and precipitation may increase between 15-30% by mid- and end century. A 2009 report from the National Institute of Meteorological Research, Korea indicates that temperatures are projected to rise by 4 °C and precipitation may increase by 17% by 2100, thus it corresponds with our research findings. Due to water stress or a shift in water availability, a rise in temperature may result in longer cultivation periods and lower crop yields.

Precipitation, surface flow, water yield, and lateral flow are projected to increase in June and reduce in July in MC and EC periods under both scenarios. Due to these projections, it may lead to the possibility of both flooding and drought during the summer monsoon periods thus a shift in the monsoon season. The summer monsoon in Korea has two peaks in sub seasonal rainfall structures from late June to mid-July and from mid-August to early September.

Annual precipitation, surface flow, lateral flow, and water yield are predicted to increase whereas evapotranspiration would decrease in both periods under both scenarios during the summer monsoon period which will lead to wetter conditions in the future. With projected increase in precipitation and surface flow, the region may be prone to flooding and possible risks of landslides. Climate change will likely influence water quality as a rise in water temperature would affect water ecosystems. Adaption techniques such as dam construction and enhanced dam/reservoir operation methods will be essential in mitigating these negative effects on water resources due to climate change.

Conclusions and future work

* In the mid- and end century periods, the future results of the ten GCMs showed that temperatures and precipitation increased under RCP 4.5 and 8.5 scenarios.
* Ensemble of downscaled GCMs projected hotter and wetter conditions in the future, which may make it vulnerable to floods. This would provide a major challenge in managing and planning of water resources.

In the present study, we did not consider potential land-use changes or human-related activities. Further research on the potential land-use changes or human-related activities is necessary for decision-makers to efficiently manage the water resources within the watershed.

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