The Impact to Groundwater Recharge Quantity due to Climate Change

Moungjin Lee, Jeongho Lee , Seongwoo Jeon, Hyun Jung Houng
1) Korea Environment Institute
E-mail: leemj@kei.re.kr, sr87sr86@gmail.com, swjeon@kei.re.kr, hjhong@kei.re.kr

ABSTRACT

Global climate change is destroying the water circulation balance by changing rates of precipitation, recharge and discharge, and evapotranspiration. The Intergovernmental Panel on Climate Change (IPCC 2007) makes “changes in rainfall pattern due to climate system changes and consequent shortage of available water resource” a high priority as the weakest part among the effects of human environment caused by future climate changes. Groundwater, which occupies a considerable portion of the world’s water resources, is related to climate change via surface water such as rivers, lakes, and marshes, and “direct” interactions, being indirectly affected through recharge. Therefore, in order to quantify the effects of climate change on groundwater resources, it is necessary to not only predict the main variables of climate change but to also accurately predict the underground rainfall recharge quantity.

In this study, the authors selected a relevant climate change scenario, and extracted future temperature and rainfall changes. By using data on temperature, rainfall, soil, and land use, the groundwater recharge rate for the research area was estimated by period and embodied as geographic information system (GIS).

The average groundwater recharge quantity was estimated to be 158.71mm/30years between 2000 and 2030, 163.74mm/30years between 2031 and 2060, and 159.01 mm/30years between 2061 and 2090. The results of this study may be significant in that they may play a role in general water management and water security in the future.

KEY WORDS: Climate change, GIS, Ground water, Recharge

Ⅰ. Introduction

1. Background and Purpose

Changes to climate variables, including temperature, rainfall, and evapotranspiration, affects the shape and use of surface water resources, but the relation between climate change and groundwater is yet unknown because of its complexity. Groundwater resources are affected by climate change through ‘direct’ interactions with surface water resources such as rivers, lakes, and marshes, and indirectly through the process of rainfall recharge.

In this context, in order to quantify the effects of climate change on groundwater, it is necessary to not only predict the main variables of climate change but to also accurately predict the underground rainfall recharge rate.

The purpose of this study is to develop measures to calculating the underground rainfall recharge quantity in relation to the results of climate change predictions, to identify differences between this studies measures and existing measures for calculating groundwater recharge quantity, and to predict modes of groundwater recharge, in Korea, according to the phenomena of climate change.

First, among the climate change scenarios provided by the IPCC, a scenario that is most appropriate for climate statistics in the past and for the actual status and directions of development of Asian nations according to GCM and RCM. Second, a literature review was conducted in order to identify and select areas where the use of groundwater was most frequent. The actual status was identified by analyzing spatial geographic information and data. Third, land use in the study areas were identified by using spatial geographic information. Fourth, the groundwater recharge quantity was calculated by using weather data on prediction of future climate change. Fifth, the future groundwater recharge quantity affected by climate change was calculated by overlaying the land properties by land properties built by using spatial geographic information and groundwater recharge quantity data.

Ⅱ. Methodology and Contents

1. Research area

Research area, with a size of 500.75㎢, includes Chilgok-gun, part of Kumi City, and part of Buk-gu in Daegu City, adjacent to Dalsun-gun, Sungju-gun, Kimchun City, and Gunwi-gun. The main stream of Nakdonggang runs through part of the research area. In order to identify the actual status of the area, a forest map, geologic map, soil map, leaf area index (LAI), and land cover map, as well as the impervious stratum were analyzed. Six materials were used, and a total of nine items were used as analysis materials. The LAI was constructed using the Landset ETM and the impervious stratum was constructed using the land cover map created by the authors.

2. Selection of the climate change model

Quantitative data on climate is needed to study the future effects of climate change. Because standard data and scenarios have a particular affect on future climate, data of the present may be more important than data in the future. For this study, the climate change scenario should be consistent with global predictions, show no contradictory values against general forecasts, and be able to provide various space-time data. In addition, the scenario should be scientifically proper and present a resolution corresponding to the purposes of this study.

In this context, the authors selected A1B from the Special Report on Emission Scenario (SRES) that was published as a report by the Intergovernmental Panel on Climate Change (IPCC) in 2002. A1B predicts climate change under the assumption that economic growth in the future is still high, the global population has decreased after peaking in the mid 21st century, and high-efficiency and energy-related technology has been rapidly introduced.

3. Future climate prediction data

Weather data for rainfall and temperature between 1997 and 2090 was used in this study. Actual observation data from the Korea Meteorological Administration from 1970 to 2000 was used and the weather data obtained from the SRES A1B scenario was used for the data between 2001 and 2100. The 30-year observation and prediction averages were used in order to promote efficiency in processing the enormous amount data.

With regard to the research area, average temperature and accumulated rainfall were calculated as 8.60℃ and 793.80mm between 1970 and 2000, 9.60℃ and 769.83mm between 2001 and 2030, 10.55℃ and 692.58mm between 2031 and 2060, and 12.51℃ and 933.51mm between 2061 and 2090.

4. Identification of land properties by land use

From the data analyzed to identify the actual status of the study area, a detailed soil map and level-2 land cover map were used to extract soil properties based on land use. The total number of soil groups in the study area was 153, and were categorized into four groups, including alluvial soil, transported soil, gley and alluvial soil, and gley and alluvial soil in consideration of hydrogeological correlations. The two datasets were cross-cut to calculate each soil layer for land use, and a relevant curve number (CN) was assigned (Mikko Jyrkama, 2005, waterloo).

5. Calculation of groundwater recharge quantity

With regard to the groundwater recharge quantity, the climate data obtained according through the above-mentioned process was used as input data, and the soil map organized for calculation of CN values was used, and the data provided by USGS was used for the material properties of the soil. In order to calculate the groundwater recharge quantity, Visual HELP3 software was used and the physical properties of weather, temperature, and soil layers were used as data. The recharge quantity for the study area between 1970 and 2090 was calculated to correspond with the data for climate change at 30-year-averages: 2.2976mm/30years between 1970 and 2000, 2.4097 mm/30years between 2001 and 2030, 2.4861 mm/30years between 2031 and 2060, and 2.4142 mm/30years between 2061 and 2090.

6. Analysis of groundwater recharge quantity based on climate change

The spatial distribution of the CN values from the research was overlapped with the data for groundwater recharge quantity in the study area in order to analyze the groundwater recharge quantity according to climate change. The groundwater recharge quantity was 71.81mm/30years at the maximum, 240.97 mm/30years at the minimum, and 158.71 mm/30years on average between 2000 and 2030; 74.10 mm/30years at the maximum, 248.61 mm/30years at the minimum, and 163.74 mm/30years on average between 2031 and 2060; 71.95 mm/30years at the maximum, 241.42 mm/30years at the minimum, and 159.01 mm/30years on average between 2061 and 2090.

Ⅲ. Results

General changes to water circulation due to climate change have already been predicted. In order to systematically solve problems associated with how the groundwater resource circulation system should be reflected in future policies pertaining to groundwater resources, it may be urgent to recalculate the groundwater recharge quantity and consequent quantity for using via prediction of climate change in Korea in the future and then reflection of the results.

The space-time calculation of changes to the groundwater recharge quantity in the study area may serve as a foundation to present additional measures for the improved management of domestic groundwater resources.

Ⅳ. References

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Figure 1. Study Area

Table 1. Data Composition

Data	Analysis Data	Data Form
Forest Map	Wood diameter	Vector, Shp
	Wood age	
	Wood density	
	Wood type	
Geologic Map	Geologic	Vecter, Coverage
Soil Map	Soil	
LAI	Vegetation	Raster
Land cover Map	Land use	Vecter, Shp
An Impermeability layer	Impermeable layer	

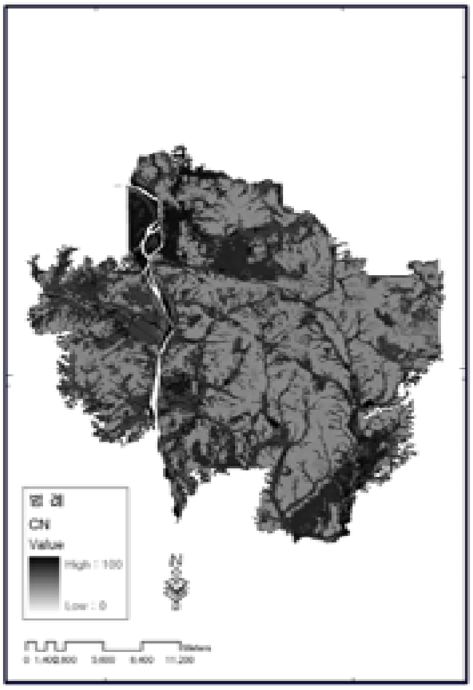

Figure 2. Study Area

Table 2. Groundwater recharge

30Years	1970-2000	2001-2030	2031-2060	2061-2090
Recharge	2.2976	2.4097	2.4861	2.4142