ウズベキスタン・チルチック川流域における持続可能な水資源管理のための統合型水収支モデルの構築

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論 文 名　　：Construction of an Integrated Hydrological Model for Sustainable Water Resources Management in the Chirchik River Basin, Uzbekistan
（ウズベキスタン・チルチック川流域における持続可能な水資源管理のための統合型水収支モデルの構築）

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論　文　内　容　の　要　旨

The Republic of Uzbekistan is a doubly landlocked country in Central Asia. Therefore, most water resources are supplied from neighboring countries. In the last few decades, the water supply into the country has significantly decreased due to the mismanagement of trans-boundary water resources by Central Asian countries. Consequently, most river basins in the region suffer from water shortages and increased aridity. The Chirchik River Basin is considered one of the country's largest and most important basins. It is located in the northeastern province of Tashkent, and its economy relies heavily on agricultural production; employing most of the region's population and consuming the available water through irrigation practices. Unsurprisingly, the Chirchik River Basin is facing several potentially severe water related problems, including increased aridity and land salinization, and has been declining in agricultural production. Continuously rising groundwater level and the inefficient use of river waters are assumed to further cause these problems.

Poor management of water resources due to limited knowledge of hydrological processes has been identified as a root cause of water resource problems in the basin. Efficient management requires accurate estimation and modeling of water balance and main hydrological parameters. In order to obtain useful results, irrigation processes, which play an important role in the hydrological cycle, should be included in the model to account for the contribution of irrigation water to other hydrological parameters.

Concerning this issue, the main aim of this work is to study hydrological processes in the basin territory through detailed water balance estimation using an integrated hydrological model. This research aims to contribute to the knowledge of groundwater and surface water interaction and spatial variability of hydrological parameters.

In Chapter 1, the background information of Tashkent Province and Chirchik River Basin, including water sources and hydrological characteristics are described. Then the objectives of this thesis are introduced. The integrated hydrological modeling system and simulation specification are analyzed in Chapter 2. The chapter then introduces governing equations of hydrological process and its solution methods.

Chapter 3 describes the modification of the Hargreaves model under local climatic conditions of the Tashkent province using standard Penman Monteih FAO 56 (FAO-56 PM) and spatial modeling of reference evapotranspiration (*ETo*) over the Tashkent province using modified Hargreaves model estimates. The modified Hargreaves model provided the best performance to estimate *ETo* in Tashkent province as an arid and semiarid climate. Over and under estimations of *ETo* with the original Hargreaves model were reduced by 65 % as an average using new empirical coefficients for all 16 weather stations. The best interpolation

model of *ETo* was obtained from the Co-kriking method using elevation data as an auxiliary secondary variable. The results revealed that the incorporation of elevation data improved spatial prediction of *ETo* in Tashkent province.

In Chapter 4, the generation process of the fully integrated hydrological model of the Chirchik River Basin and estimated water balance results are presented. Firstly, spatially distributed hydrological parameters were prepared in ArcGIS platform and integrated within the hydrological modeling system. Secondly, stream flow was simulated in main rivers using the 1 dimensional Saint-Venant equation and then coupled to the full hydrological modeling system to simulate the irrigation process. Parameters in the model were calibrated and simulated results were validated for the periods 2009-2011 and 2012-2013 in terms of two observed hydrological parameters; stream flow rate and groundwater table. The model was generally good, simulating daily streamflow discharge with an average of 0.91 (2009-2013) and 0.77 (2009-2013) of R^2 (Regression coefficient) and EF (Nash–Sutcliffe model efficiency coefficient). The simulated groundwater dynamics also show a satisfactory match with observed data at each location. The results show that the hydrological balance is strongly dependent on the intensity of agricultural activity within the basin. An actual evapotranspiration was found as a main water loss element among the water transport components due to large-scale agricultural irrigation activities. This corresponds to 77% of the total water budget on average. A satisfactory water balance simulation error was obtained after adjusting model parameters to the basin environment.

In Chapter 5, the developed GIS based hydrological model to study the spatial-temporal variation of groundwater level and water balance analyses of Quyi Chirchik districts of Tashkent province are presented. Then the relationship between the spatial and temporal variation of groundwater level and salinity are introduced. Finally, groundwater quality status and its physio-chemical properties were analyzed. The spatial analysis shows that the southwestern part of Quyi Chirchik district is impacted by a high groundwater table. It should be noted that about 86 % of this land corresponds to irrigated agricultural land. The water quality analysis shows that 75 % of groundwater samples in Quyi Chirchik district falls in “Fair” classification and 25 % of the samples falls in “Poor” categories of WQI (Water Quality Index). This shows that shallow groundwater in the study area is not suitable for drinking purposes.

In Chapter 6, the conclusions of the thesis are summarized.