学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Study on Assessment of Water Resources in Agricultural Watershed in Northwestern Cambodia Facing Climate and Land Use Changes
（気候変動と土地利用変化の影響を考慮したカンボジア北西部農業流域の水資源評価に関する研究）

Economic and population growth have expanded agricultural land, and the sustainability of water and natural resources like forest preservation has become a concern for future development. Cambodia's water resources depend on abundant freshwater from the Mekong River and Tonle Sap Great Lake. However, the northwestern part of the nation, the largest rice production area, has faced significant influence on water resources, leading to water scarcity, flooding, and droughts. Additionally, limited information is available to analyze these issues. This study aims to identify and predict the impacts of land use and climate change on water resources and examine problems and countermeasures for future agricultural water use.

1. Evaluation of the water balance in the irrigation system

There are always concerns about water deficits in cultivating rice at the onset of the dry season. First, this study evaluated the irrigation water resources in the upper Sangkae River basin for agricultural production. The study used the Soil and Water Assessment Tool (SWAT) model to estimate stream water volume, and its performance was assessed using statistical metrics. It was calibrated for the period from 2007 to 2013 and validated for the period from 2014 to 2018. Flow rates in the main irrigation canals were also measured from June 2018 to October 2019 to evaluate the actual irrigation water supply by comparing supplied water volume and irrigation water demand. The SWAT model provided reliable river discharge estimates, as confirmed by statistical metrics (NSE = 0.69, RSR = 0.55). The results showed that water shortage rates exceeded 20% of the monthly water requirement between April and June, 2014 to 2017. The actual irrigation water supply during the study period showed rates of water shortage of 52% and 41% in the two main canals, respectively, at the headwork during the wet season months

(September and October). The findings suggest the need for regular maintenance of water infrastructure to provide a sustainable water supply to paddy fields.

2. Prediction of future land use changes

After a meticulous evaluation of agricultural water use, this study utilized remote sensing and GIS modelling techniques for analyzing satellite data from 2014, 2018, and 2022. Integrating the cellular automata (CA)-Markov model and GIS tools allowed for predicting land use changes by 2030 considering policy intervention. The model's simulation, which compared actual and predicted land use in 2022 for accuracy assessment, revealed a stark contrast in outcomes with and without a land use policy. Without a policy, built-up areas will increase, and natural forest cover will decrease by 2030. However, with a policy, the model predicted an increase in forest cover by 2030 despite some areas being allocated for industrial agriculture. These findings underscore the transformation in land cover in the upper Sangkae River basin and reiterate the crucial role of forest conservation in preserving ecosystem services and water cycles.

3. Assessment of the impact of land use and climate change on water resources

The final part of this study focused on evaluating the impact of land use and climate variability on water resources in the Upper Sangkae River basin using the SWAT model. It projected changes in rainfall and temperature from the Coordinated Regional Climate Downscaling Experiment-Southeast Asia (CORDEX-SEA). The dynamic changes in land use within the watershed and the projected land use for 2030 were derived from the previous section. The study revealed that land use changes resulted in increasing trends in mean annual (30. 9%), wet season (39.7%), and dry season (9.8%) river discharge comparing the simulation period (1986–2001). However, the combined effects of land use and climate change scenarios for the projection period (2030–2045) indicated a significant shift in river discharge patterns between wet and dry seasons. The mean annual streamflow decreased from 30.9% to 5.7% and 3.2% for RCP4.5 and RCP8.5, respectively, comparing the simulation period. Seasonal analysis showed that average streamflow in the wet season continued to increase by 23.3% (RCP4.5) and 10.9% (RCP8.5) but decreased by -36.9% (RCP4.5) and -15.5% (RCP8.5) in the dry season.

Furthermore, there is an expected slight increase in water yield and surface runoff, while evapotranspiration is likely to experience the most significant decrease in agricultural land for both climate scenarios (RCP4.5 and RCP8.5). The impact of climate change outweighs that of land use change. Reforestation efforts within land use development projects will minimize impacts on water resources. This study highlights the importance of reforestation in the upper catchment area to enhance basin water resources and mitigate flood risks.

Overall, the results reveal essential factors affecting water resources in the Upper Sankae River Basin under climate change and land use change. Based on these results, this study suggests the need to promote water-efficient agricultural practices, cultivating climate-resilient crops, and making significant investments in conserving and restoring natural resources.