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VIKOR Application For Climate Change Adaptation Strategies Under Uncertain Environments

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VIKOR APPLICATION FOR CLIMATE CHANGE ADATPATION STRATIEGES UNDER UNCERTAIN ENVIRONMENTS

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This study developed a decision making frame for climate change adaptation strategies under an uncertain environment. We developed a VIKOR-based procedure, providing a compromise solution with the objective weights of multiple climate change scenarios. We chose a watershed in South Korea and established adaptation alternatives of using the effluents of wastewater treatment plants (WWTPs) in potential sub-watersheds to improve the water quantity and quality situations. Under multiple climate scenarios, the environmental and hydrologic responses of treated wastewater (TWW) use were determined with a hydrologic model and the results were used to derive the sustainability scores of TWW reuse. Finally, sustainability scores under multiple scenarios were integrated using the VIKOR and the objective weights among the climate change scenarios, and the final decision for adaptation strategies were made. This framework can be a very effective decision making tool for climate change adaptation strategies as it consider not only uncertainties but also the relative importance of various climate change scenarios.

STUDY WATERSHED

The Anyangcheon watershed in central Korea (Figure 1) has experienced serious water quantity and quality problems, resulting in devastating flood damage, depleted streams, and even occasional fish deaths. The main channel length of the Anyangcheon River is 32.38 km, draining a watershed area of 287 km2, in which 388 million people reside (a population density of 13,500 persons/km2). The land cover consists of 43% urbanized land, 40% forest, and 13% agricultural land as of 2000 and since then there have been no significant activity that change the land cover characteristics.

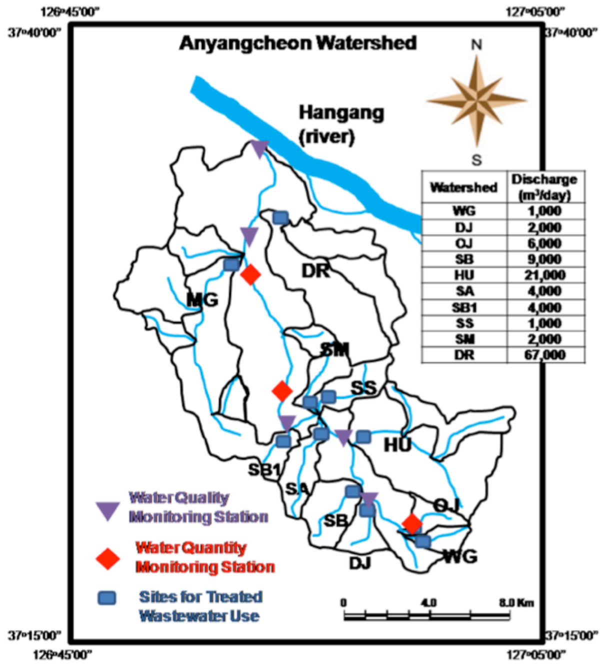

Figure 1. Map of study watershed and potential sites for the reuse of TWW

MAIN RESULT

The sustainability of sub-watersheds without and with reusing TWW is determined with a indicator-based approach. The Driver-Pressure-State-Impact-Response (DPSIR) framework [1] is utilized to quantify the sustainability of sub-watersheds. [2] have already established the indicators, i.e., decision criteria for the sustainability, which are used in this study. Physical indicators such as the low flow ratio, drought flow ratio, BOD etc. are determined with the simulation results of the hydrologic simulations with the Hydrological Simulation Program-FORTRAN (HSPF) model [3] while the socio-economic indicators are obtained in the governmental databases. In this study, we perform the HSPF simulations with multiple climate change scenarios, leading to multiple sustainability scores for the sub-watersheds.

For a compromise solution between a maximum group utility and a minimum individual regret among different climate change scenarios, we use the VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) technique [4] and thus here we investigate how the VIKOR scores and rankings vary with different levels of risk aversion. In addition, this study employs the objective weights to determine the weights for different scenarios because it is impossible to obtain reliable subjective weights among different climate change scenarios.

Figure 2 shows a sensitivity test with a varying degree of risk aversion (α) from zero (risk affine) to one (risk averse) with an increment of 0.1. DR is the best regardless of the degree of risk aversion for all cases. For water quantity, different α values lead the constant VIKOR rankings for each sub-watershed, as sustainability scores with different scenarios are consistent. For water quality, the VIKOR rankings vary according to the different degrees of risk aversion. Looking for the three most sustainable options, we find a different set of sub-watersheds for TWW use with a different choice of α for the water quality criteria. DR, OJ, and HU would be chosen when considering the maximum group utility only, whereas DR, OJ, and SA would be chosen when considering the minimum individual regret only. In particular, HU rankings range from third (α=1) to seventh (α=0), and DJ rankings ranged from fourth (α=0) to ninth (α=1).

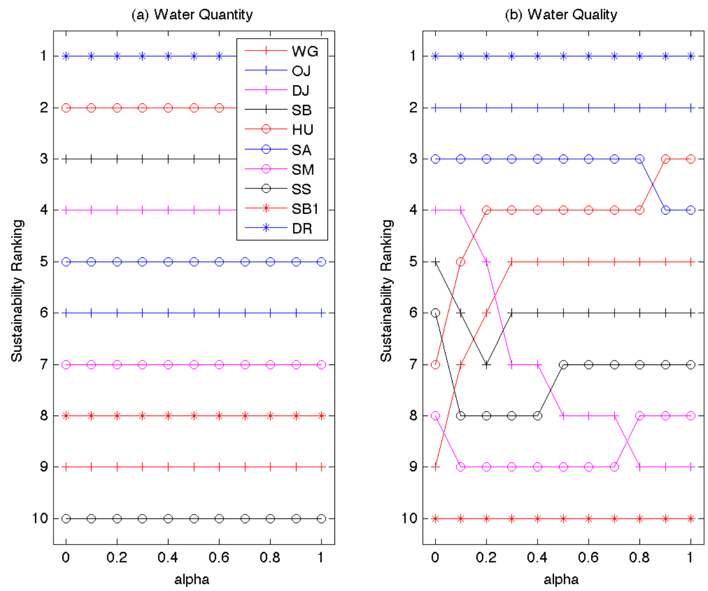

Figure 2. Sensitivity results of sustainability rankings according to the risk aversion of VIKOR approach

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