ANALISIS DAMPAK PERUBAHAN IKLIM TERHADAP HIDROLOGI DAS CITANDUY HULU MENGGUNAKAN PEMODELAN STATISTICAL DOWNSCALING DAN SWAT

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ABSTRAK

Perubahan iklim global diproyeksikan mengubah karakteristik hidrologi regional secara signifikan, termasuk di Daerah Aliran Sungai (DAS) Citanduy Hulu. Penelitian ini bertujuan untuk menganalisis dampak perubahan iklim terhadap ketersediaan air dan risiko debit ekstrem di DAS Citanduy Hulu hingga tahun 2050. Metodologi yang digunakan mengintegrasikan pemodelan *Statistical Downscaling* untuk memproyeksikan curah hujan masa depan dari luaran *General Circulation Model* (GCM) dengan pemodelan hidrologi *Soil and Water Assessment Tool* (SWAT). Basis data historis dalam penelitian ini menggunakan data ERA5 periode 2000–2024 yang telah melalui proses koreksi bias dengan metode regresi power terhadap data observasi lapangan. Proyeksi masa depan disimulasikan menggunakan dua skenario emisi, yaitu skenario moderat *Shared Socioeconomic Pathway* (SSP2-4.5) dan skenario ekstrem (SSP5-8.5). Hasil penelitian menunjukkan adanya kestabilan tren pembasahan regional, di mana akumulasi curah hujan tahunan periode 2045–2049 diproyeksikan meningkat sebesar 26,19% pada skenario SSP2-4.5 dan 25,12% pada skenario SSP5-8.5 terhadap *baseline* historis (1.645,40 mm). Secara bulanan, lonjakan hujan masif terdeteksi pada musim kemarau (Juni–Oktober) dengan kenaikan berkisar antara 50% hingga 139%. Perubahan iklim ini memicu pergeseran garis dasar (*baseline shift*) limpasan permukaan yang signifikan. Rata-rata debit sungai meningkat dari 9,44 m^3/s pada periode historis menjadi 29,24 m^3/s pada skenario masa depan. Kondisi kritis banjir (*peak flow*) meningkat drastis sebesar 115% dari debit puncak historis 33,57 m^3/s menjadi 72,44 m^3/s pada skenario ekstrem SSP5-8.5. Sebaliknya, meskipun tren curah hujan minimum bulanan di musim kemarau diproyeksikan menurun ($y = -0.2689x + 630.6$), debit minimum sungai tetap terjaga stabil pada rentang 6,00–11,00 m^3/s (SSP2-4.5) dan bertengger lebih tinggi pada kisaran 16,00–28,00 m^3/s (SSP5-8.5). Fenomena ini membuktikan bahwa peningkatan hujan di musim basah mampu mengoptimalkan laju infiltrasi untuk pengisian ulang akuifer air tanah dangkal, sehingga *baseflow* bertindak sebagai penyangga hidrologis yang mereduksi risiko kekeringan ekstrem di DAS Citanduy Hulu.

Kata Kunci: Perubahan Iklim, DAS Citanduy Hulu, *Statistical Downscaling*, SWAT, *Baseflow*, Infiltrasi.

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CLIMATE CHANGE IMPACT ANALYSIS ON THE HYDROLOGY OF THE UPSTREAM CITANDUY WATERSHED USING STATISTICAL DOWNSCALING AND SWAT MODELING

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ABSTRACT

Global climate change is projected to significantly alter regional hydrological characteristics, including in the Upper Citanduy Watershed. This study aims to analyze the impacts of climate change on water availability and extreme flow risks in the Upper Citanduy Watershed up to the year 2050. The methodology combines Statistical Downscaling modeling to project future precipitation from General Circulation Model (GCM) outputs with the Soil and Water Assessment Tool (SWAT) hydrological model. The historical baseline data utilizes the ERA5 reanalysis data for the 2000–2024 period, which has undergone a bias correction process using the power regression method against field observation data. Future projections are simulated under two emission scenarios: the moderate Shared Socioeconomic Pathway (SSP2-4.5) and the extreme scenario (SSP5-8.5). The results indicate a stable regional wetting trend, where the annual accumulated precipitation for the 2045–2049 period is projected to increase by 26.19% under the SSP2-4.5 scenario and 25.12% under the SSP5-8.5 scenario relative to the historical baseline (1,645.40 mm). On a monthly scale, massive rainfall surges are detected during the dry season (June–October) with increases ranging from 50% to 139%. This climate change triggers a significant baseline shift in surface runoff. The average river discharge increases from 9.44 m^3/s in the historical period to 29.24 m^3/s in future scenarios. Critical flood conditions (peak flow) escalate drastically by 115% from the historical peak discharge of 33.57 m^3/s to 72.44 m^3/s under the extreme SSP5-8.5 scenario. Conversely, despite the projected decline in minimum monthly dry season rainfall ($y = -0.2689x + 630.6$), the minimum river discharge remains stable within the range of 6.00–11.00 m^3/s (SSP2-4.5) and is elevated to around 16.00–28.00 m^3/s (SSP5-8.5). This phenomenon demonstrates that the increased rainfall during the wet season enhances infiltration rates for shallow groundwater aquifer recharge, enabling baseflow to act as a hydrological buffer that reduces the risk of extreme droughts in the Upper Citanduy Watershed.

Keywords: Climate Change, Upper Citanduy Watershed, Statistical Downscaling, SWAT, Baseflow, Infiltration.

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