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Hydrological and Water Quality Impacts of Climate Variability and Land-Use Change: A Case Study of the Muda River Catchment

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Abstract

Land-use changes, driven by development and climate variability, particularly extreme rainfall and drought, significantly affect river water quantity and quality. This study assesses the impacts of these changes on the upstream catchment of the Muda River (499 km^2) using the Soil and Water Assessment Tool (SWAT) model. Data collection included hourly water level measurements and water sampling from May 2018 to April 2019, taken every hour from 9 am to 5 pm for two weeks each month. Peak discharge was recorded on September 29, 2018, at 9:00 am (45.305 m^3/s), while the lowest was on July 23, 2018, at 11:00 am (4.2954 m^3/s), with an average discharge rate of 1.236 Mm^3/day from April to October 2018. The catchment displayed "flashy" characteristics, with rapid increases in discharge in response to rain events. Water quality was measured using in-situ methods. Average values were as follows: electrical conductivity (50.34 µS/cm, Class I), total dissolved solids (31.87 mg/L, Class IIA), water temperature (26.14°C, Class IIA), nitrate concentration (4.70 mg/L, Class III), pH (7.08), turbidity (130.29 NTU, Class IV/V), and total suspended solids (87.87 mg/L, Class III). Turbidity was the only parameter showing significant seasonal variation ($p<0.001$), while no notable differences were observed in water quality between pre- and post-logging years. These findings indicate that water quantity and quality in this catchment are more strongly influenced by climate variability than by land-use changes. Five SWAT model simulations were conducted to evaluate different land-use and climate change scenarios. Scenario S1 yielded optimal discharge and water balance, reflecting the highest water storage rate, essential for future use, while Scenario S5 showed the lowest. In scenarios involving development, simulations S2 and S3 demonstrated no significant differences in discharge and water balance. Surface runoff remained low across scenarios, likely due to forest cover, though it is projected to rise by 25% by 2050 (reaching 4293 mm) due to anticipated rainfall increases. These results suggest that preserving the catchment is vital to maintaining water storage, as disturbances or changes could lead to excess water accumulation, elevating flood risks downstream in the Muda River catchment. In conclusion, climate change factors appear to have a greater impact on water quantity and quality than land-use changes in the Muda River catchment. To mitigate future flood risks and protect water resources, it is recommended that forested areas within the catchment be preserved, minimizing disturbances that could increase surface runoff and downstream flooding.

Keywords: *Climate variability, Land use change, Water quality, SWAT modelling, Muda River Catchment*