Rainfall Trend Analysis of Bangladesh using the Mann-Kendall (MK) Slope Method

Bangladesh is an agricultural country and vulnerable to hydroclimatic variability. Understanding Rainfall variability is very important for water resource and environmental management. This study evaluates monthly rainfall trends across 35 meteorological stations (1981–2022) using the Mann-Kendall (MK) test with Sen's slope estimator. The MK test quantifies the statistical significance of trends ($\alpha = 0.05$), while Sen's slope calculates trend magnitudes, providing a comprehensive representation of rainfall variability. The Z-value from the MK test assesses the significance of Sen's slope. A positive Z-value indicates an increasing trend, while a negative value suggests a decreasing trend. Trends are statistically significant if the Z-value exceeds ±1.96, corresponding to a 95% confidence level. Sen's slope is reported only for statistically significant trends, with slopes for non-significant trends excluded

The analysis revealed seasonal rainfall variability, with decreasing trends across 27 station-month combinations. For instance, Khulna (April: $Z = -2.03$, Sen's slope = −1.48 mm/year) and Satkhira (April: $Z = -3.01$, slope = −2.23 mm/year) exhibited sharp declines in in pre-monsoon rainfall posing critical risks to groundwater-dependent agricultural systems in these regions. In Rangpur, statistically reductions in November ($Z = -2.24$, slope = −4.31 mm/year) and December ($Z = -2.50$, slope = −2.50 mm/year) rainfall underscore emerging vulnerabilities for winter crop cycles reliant on residual soil moisture. Extreme dry-season anomalies were further highlighted in Sitakunda (March: $Z = -2.38$, slope = −1.38 mm/year) and Dinajpur (July: $Z = -5.84$, slope = −5.84 mm/year).

On the other hand, four station-months showed increasing trends, predominantly localized to October. Rangamati recorded a wet-season rainfall rise ($Z = 2.35$, slope = +2.50 mm/year), while Khepupara exhibited a pronounced spike ($Z = 2.82$, slope = +6.38 mm/year), suggesting potential shifts in short-duration, high-intensity precipitation patterns. Similarly, M. Court ($Z = 2.54$, slope = +4.66 mm/year) and Patuakhali ($Z = 2.27$, slope = +4.16 mm/year) demonstrated October increases, which may necessitate revised stormwater management strategies.

Additionally, an IDW interpolation method was employed to visualize the spatial distribution of monthly rainfall trends across Bangladesh, providing a clear representation of regional variations. Although most stations show no trend, understanding rainfall variations is crucial for policymakers. Declining pre-monsoon and winter rainfall necessitates better groundwater conservation and irrigation planning. Regions with increasing October rainfall may require enhanced drainage systems. Long-term water supply strategies must integrate these trends to ensure sustainable resource allocation, particularly where declining rainfall threatens drinking water availability.

While statistical significance confirms trends, real-world impacts must also be assessed. For example, an increase of 4.66 mm/year may be negligible in high-rainfall regions but crucial in arid zones. Further research is needed to evaluate the practical implications of these trends for agriculture, water management, and climate resilience. Policymakers must integrate these findings to enhance climate resilience in water and agricultural management.

Keywords: Rainfall trends, Mann-Kendall test, Sen's slope, water resource management,, climate resilience,, climate resilience, precipitation variability,flood mitigation