GROUNDWATER ASSESSMENT AND WATER RESOURCE DEVELOPMENT OF CHITTUR BLOCK OF PALAKKAD DISTRICT

by

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ABSTRACT

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ABSTRACT

Groundwater serves as a vital natural resource, supporting the needs of domestic, agricultural, and industrial sectors, particularly in water-scarce regions. The present study, "Groundwater Assessment and Water Resource Development of Chittur Block, Palakkad District," aimed to evaluate the spatio-temporal variations in groundwater levels, delineate potential and recharge zones, and formulate a sustainable groundwater resources development plan through integrated GIS and numerical modelling approaches. Long-term groundwater data (1994–2022) from nine observation wells were analysed using the Mann–Kendall test and Sen's slope estimator to determine temporal trends. Thematic layers on geology, geomorphology, slope, drainage density, land use/land cover, and lineaments were integrated in ArcGIS to identify groundwater potential zones and artificial recharge potential zones through Weighted Index Overlay Analysis (WIOA). A three-dimensional transient groundwater flow model was developed using Visual MODFLOW 2.8.1, calibrated (1998–2017), and validated (2018–2022) to simulate groundwater dynamics under varying recharge and pumping scenarios.

The results revealed a significant declining trend in groundwater levels, particularly in wells PKD S-6, PKD S-8, and 141, reflecting over-extraction and inadequate recharge. Hydrogeomorphological analysis indicated that valley floors, floodplains, and lineament intersections are favourable for groundwater occurrence, while pediment zones offer scope for artificial recharge. The WIOA classified the area into excellent, good, moderate, and poor groundwater potential and recharge zones, with Vadakarapathy, Nallepilly, and Chittur Municipality identified as the most promising regions. The study also identified potential sites and structures for artificial recharge by integrating thematic layers with guidelines from the Integrated Mission for Sustainable Development (IMSD) and the Central Ground Water Board (CGWB). The most suitable areas for artificial recharge sites and different structures viz. percolation pond (10 No.), Checkdam (5 No.), Recharge wells (30 No.) and sub-surface dyke (4 No.) were proposed for the study area. Visual MODFLOW model calibration and validation produced excellent performance metrics with R^2 values 0.986 and 0.997, NSE values 0.976 and 0.997, normalised RM MSE values

3.76% and 2.77% respectively. The model simulations demonstrated that increasing recharge by 5%, 10%, and 15% could raise the groundwater table by 1–5 m in the next 10 years (2023-2032), mainly in the southern and western parts of the block. Sensitivity analysis indicated that recharge and pumping were the most influential parameters governing groundwater dynamics. Among the five management scenarios evaluated, those combining enhanced recharge and regulated pumping (Scenarios 2 and 4) were found sustainable, yielding optimal water balance with minimal mass balance error.

Implementation of the proposed groundwater resource development plan is expected to contribute approximately 0.815 MCM of additional recharge annually based on its unit capacity, aiding the gradual transition from the over-exploited to the critical category and then gradually to a safe condition. The integrated GIS and MODFLOW-based approach provided valuable insights into groundwater behaviour, confirming that excessive abstraction and limited natural recharge have caused a progressive decline in groundwater levels. However, the study found that targeted artificial recharge interventions, water conservation measures, and regulated extraction can significantly improve groundwater sustainability in the Chittur block.