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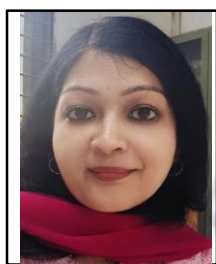
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ગુજરાત ટેકનોલોજીકલ યુનિવર્સિટી

(ગુજરાત સરકારના ગુજરાત અધિનિયમ ક્રમાંક : ૨૦/૨૦૦૭ દ્વારા સ્થાપિત)

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Abstract of the Thesis



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Enrollment No.: 189999912033

Faculty: Engineering

Discipline/Branch: Civil Engineering

Title of the Thesis: IMPACT ASSESSMENT OF URBANISATION ON THE GROUNDWATER RECHARGE OF AHMEDABAD DISTRICT USING GEOSPATIAL TECHNIQUES AND HYDROLOGICAL MODELLING

Abstract

This study provides insight into urban groundwater recharge of the Ahmedabad district, which happens to be one of the most urbanised cities of India. Urbanization, a dominant global trend of the 21st century, reshapes hydrological dynamics and directly influences groundwater recharge rates. Groundwater is essential to the social and economic well-being of urban populations of the developing world. According to the Central Ground Water Board, India is the world's largest groundwater extractor, with 45–50% of urban water supply dependent on groundwater. Ahmedabad is extracting an enormous amount of available groundwater recharge. Groundwater recharge is one of the most significant hydrological processes that needs thorough analysis during urbanisation. The study was carried out with the objectives of assessing the impact of urbanisation on groundwater recharge by performing statistical analysis of existing hydro-meteorological conditions, detecting changes in land use using geospatial techniques, and hydrological modelling. This work integrates multi-temporal and geospatial analysis with the Soil and Water Assessment Tool (SWAT), which is a semi-distributed hydrological model. The required input data, including hydrometeorological data and spatial maps, have been collected from authentic sources like CWC, SWDC, IMD and satellites. The multi-temporal satellite imagery was imported in ArcGIS to prepare land use maps for each decade. After performing land-use change detection, it is found that the built-up area increased consistently across all decades, with the largest expansion of 7.2% between 2011 and 2020.

The analysis was carried out by the non-parametric Mann-Kendall (MK) test, which was used to examine historical temperature and rainfall time series for temporal trends in order to identify statistically significant changes in climatic variables over the period of 1980 to 2020. Following the hydrological modelling, the

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Ph.D. Programme

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analysis part includes the SWAT model, as it is one of the most efficient models in this field. It is made to run using multiple land-use/land-cover scenarios with a Digital Elevation Model (DEM), soil-type data, and climate inputs to simulate hydrological processes. From the existing literature review, it has been observed that out of all the basins available in the study area, Vasna barrage (22.99°N, 72.55°E), located in the heart of the city, is one of the most significant hydraulic structures that contributes to the hydrology of the study area. SWAT model output, i.e., groundwater recharge specifically to the shallow aquifer, was visualized using a tool named “SWAT output viewer,” which is widely used to represent outputs obtained from SWAT runs.

SWAT-CUP and the SUFI-2 algorithm perform the calibration and validation for 2014-2019 and 2020-2024, respectively. Observed streamflow data from the Vasna barrage were used by identifying the sensitive parameters that affect the value of groundwater recharge considerably. During the calibration and validation periods, model predictions performed well, as shown by the coefficient of determination (R^2) and Nash-Sutcliffe efficiency (NSE) values that significantly exceeded 0.70. During the calibration phase, the coefficient of determination value of 0.74 indicates a highly accurate correlation between the simulated and observed daily discharge. The Nash Sutcliffe coefficients obtained were 0.79 and 0.72 for the calibration and validation period, respectively. After the successful validation, the absolute values of sensitive parameters are incorporated in the SWAT model to replicate the watershed, and analyses suggest the marginal increase in groundwater recharge was 0.58% during 1991-2000 and 1.98% increase during 2001-2010 with the baseline period (1981-1990) due to a relatively higher amount of rainfall, and during 2011-2020 groundwater recharge declined by 5.36% relative to the baseline due to rapid urbanisation.

Future projections were carried out after calibration and validation of the SWAT model, where rainfall and temperature projections are derived from the Coupled Model Intercomparison Project Phase 6 (CMIP6) dataset that represents the latest generation of climatic projections. The CMIP6 provides climate projections from a large number of global climate models (GCMs). In this study, EC-Earth3, one of the CMIP6 models, is used for the Indian monsoon region and provides consistent daily climate variables required for hydrological modelling. Daily precipitation, maximum temperature, and minimum temperature data will be used for future periods under the SSP3-7.0. The coefficient of determination (R^2) between observed and simulated values was found to be 0.96, indicating strong agreement in the model. The model was



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subsequently used to generate future climate projections up to the year 2050, which shows annual average groundwater recharge decreases up to 11.79%. This trend indicates that Ahmedabad might face groundwater extraction challenges in the near future.

The study shows the significant decadal variability in groundwater recharge, where recharge exhibited an increasing trend during the first two decades but declined in the most recent decade, where urbanisation is one of the dominant driver, but climatic variability may also have played a secondary role.

The integrated GIS and SWAT modelling approach provides a solid framework to understand how urbanization impacts groundwater dynamics and aids in sustainable water resource management and planning in semi-arid regions like Ahmedabad. By analysing land-use change and its impact on groundwater recharge, the study contributes directly to achieving SDG 6 and SDG 11.

This PhD thesis will help in:

This research will help in assessing the impact of urbanisation and land-use/land-cover changes on groundwater recharge in Ahmedabad District. It will provide a spatial and temporal assessment of changes in groundwater recharge using geospatial techniques and SWAT modelling. The findings will support sustainable groundwater management, artificial recharge planning, and urban water-resource planning. It will also provide scientific inputs for policymakers, planners, and water-resource agencies to develop climate-resilient and sustainable groundwater management strategies.

List of Publication(s):

1. Groundwater Infiltration Trends in the Major Basin of Ahmedabad District, Gujarat, India by Chaitali Bhavsar; Dr. Mahendrasinh S. Gadhave in International Journal of Innovative Science and Research Technology, Volume 10, Issue 11, November – 2025, ISSN No: -2456-2165, <https://doi.org/10.38124/ijisrt/25nov102>
2. Impact Assessment of Land Use Change Detection on the Environment of Ahmedabad District, Gujarat, India using Supervised Classification in GIS By Chaitali Bhavsar, Dr. Mahendrasinh S. Gadhave, Dr. Mohdzuned M. Shaikh, Turkish Journal of Engineering – 2025, 9(4), 823-830, DOI: <https://doi.org/10.31127/tuje.1605134>