



GUJARAT TECHNOLOGICAL UNIVERSITY

(Established by Government of Gujarat under Gujarat Act No. : 20 of 2007)

ગુજરાત ટેકનોલોજીકલ યુનિવર્સિટી

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

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Abstract of the Thesis



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Faculty: Engineering

Discipline/Branch: Civil Engineering

Title of the Thesis: An Integrated Geo-Hydrological Approach Towards Water Resource Development Plan for the Isolated Islands in The Great Rann of Kachchh, Gujarat, Western India

ABSTRACT

The Great Rann of Kachchh (GRK), India, is a hyper-arid salt desert with isolated inhabited islands (bets) dependent solely on groundwater. Khadir Island (~315 km², ~17,000 people, ten villages, UNESCO site Dholavira) faces acute water scarcity due to aquifer salinity, over-extraction, and seawater intrusion. This study develops an integrated geo-hydrological framework combining remote sensing, GIS, multi-criteria decision analysis, numerical modelling (MODFLOW-6, SWI2), hydrogeochemical validation, and socio-economic assessment.

Groundwater Potential Zones (GWPZ) were delineated using the Multi-Influencing Factor (MIF) method with eight thematic layers. Drainage density (22.6%) and LULC (19.4%) were the highest-weighted factors. The island was classified into Good (8.45%), Moderate (90.45%), and Poor (1.10%) zones, validated by hydrochemical data showing the Poor zone has 66% higher TDS and 330% higher chloride than the Good zone. A transient MODFLOW-6 model (2001–2020, RMSE 1.24 m, mass balance error <0.5%) showed recharge (2.45×10^7 m³) balanced by evapotranspiration (48.2%) and coastal outflow (45.7%), with abstraction only 6.5%. Despite this, abstraction exceeds sustainable yield due to recharge variability (CV=61%), required coastal outflow, and seasonal mismatch. SWI2 modelling revealed seawater intrusion advanced from 0 to



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6.3 km inland by 2020, accelerating from 0.20 to 0.48 km/yr, with a critical threshold at 2.4 km (2010). Projections indicate 7.95–9.60 km intrusion by 2025 without intervention.

A Managed Aquifer Recharge (MAR) strategy with 23 structures (7 recharge shafts, 6 percolation tanks, 5 check dams, 5 bandharas) was proposed. Water demand (2001–2041) is dominated by agriculture (>99%), with total demand reaching 292.65 MCM by 2041. Water Stress Index for 2026–2030 ranges from 0.65 (moderate) to 1.05 (critical), highlighting drought vulnerability. A five-phase, 10-year Integrated Water Resource Development Plan (2026–2035) targets 27% demand reduction and 60 MLY additional supply via MAR.

This study provides the first integrated geo-hydrological assessment and management framework for Khadir Island and the isolated bays of the GRK. Its principal scientific contribution lies in coupling RS-GIS-MIF groundwater potential mapping, transient MODFLOW-6 flow modelling, SWI2 seawater intrusion simulation, and hydrogeochemical validation to quantify the recharge–abstraction–intrusion nexus and identify a critical intrusion threshold for timely intervention in a data-scarce, hyper-arid island aquifer. Practically, the findings translate into a phased, community-centred water resource development plan that integrates managed aquifer recharge, demand-side efficiency, and salinity-control measures, offering a replicable blueprint for sustainable water security in similar arid island and coastal aquifer systems globally.

Keywords: Groundwater potential zoning, Managed Aquifer Recharge, Seawater intrusion, MODFLOW, SWI2, Khadir Island, Great Rann of Kachchh, Remote sensing, GIS, MIF, Water Stress Index, Hydro geochemistry



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Application:

This PhD Thesis will help in Integrated assessment, planning and sustainable management of groundwater and water resources in arid and coastal island environments.

List of Publication:

1. Fluid Dynamics of a Stressed Freshwater Lens: Integrated Flow Modeling and Pathways for Material-Centric Interventions in Khadir Island, Gujarat by Sagar Vinodray Nimavat and Dr. Mahendrasinh S. Gadhavi in *Journal of Polymer & Composites*, Vol. 14, Issue 02, 2026, ISSN No.: 2394-7799 (Print), 2394-7802 (Online), Web of Science Indexed, DOI: <https://doi.org/10.37591/JOPC.v14i02.238343>.
2. Integrated Water Balance and Water Stress Index–Based Sustainability Assessment of a Semi-Arid Island Ecosystem by Sagar Vinodray Nimavat and Dr. Mahendrasinh S. Gadhavi in *Journal of Water Pollution & Purification Research*, Vol. 13, Issue 01, 2026, ISSN No.: 2394-7306, DOI: <https://doi.org/10.37591/JoWPPR.v13i01.238470>.
3. Buried Rivers, Thirsty Island Belt: A Review of Water Challenges in the Great Rann of Kachchh by Sagar Vinodray Nimavat and Dr. Mahendrasinh S. Gadhavi in *International Journal of Environmental Chemistry*, Vol. 12, Issue 01, 2026, ISSN No.: 2456-5245, DOI: <https://doi.org/10.37628/ijec.v12i01.24655>