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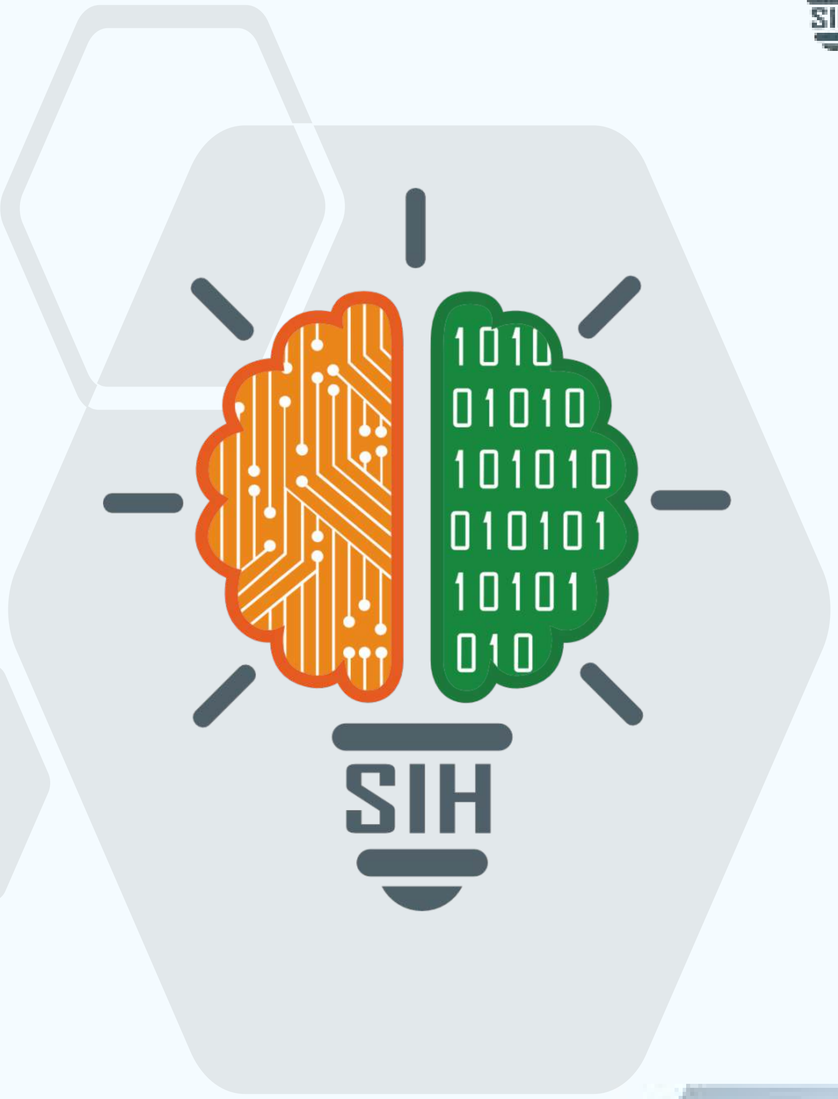
- **Problem Statement ID –** SIH25068
- **Problem Statement Title-**
  Real time Groundwater resource evaluation using DWLR data
- **Theme-** Miscellaneous
- **PS Category-** Software
- **Team ID -** 86211
- **Team Name -** Placeholder



PLACE HOLDER

PREDICTIVE MOBILE BASED GROUNDWATER FORECAST

Develop a mobile app that integrates real-time DWLR data, recharge estimates, and usability checks to enable informed, sustainable decision-making

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PROBLEM IDENTIFICATION

SOCIAL →

TECHNICAL ↓

Population–Resource Mismatch: India: 16% of world's population but only 4% of freshwater

Overexploitation & Stress: Many aquifers: critical or over-exploited

Uneven Recharge: Seasonal & regional variability

Fragmented Platforms: DWLR, IN-GRES, and lab datasets: not integrated

No Real-Time Access: periodic (yearbooks, bulletins), not continuous

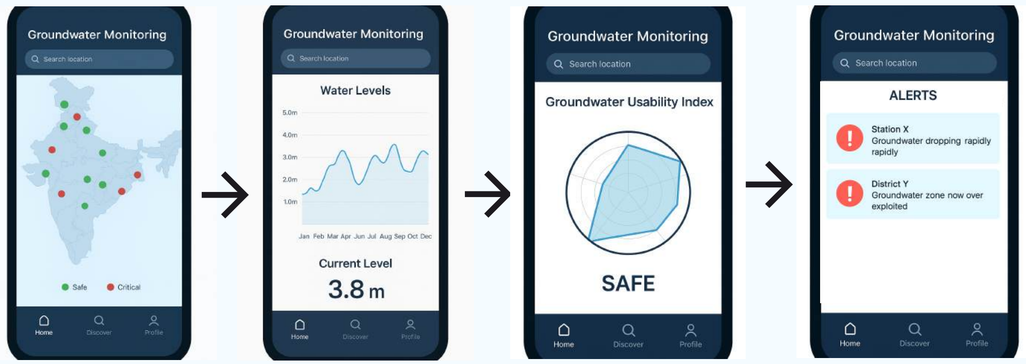
No Forecasting Capability: No predictions of near-term fluctuations

No Mobile-First Solution: Lack of unified, easy-to-use app

CORE IDEA

- Develop an **application** that integrates 5,260 DWLR station datasets
- **One platform** combining real-time availability + long-term recharge + quality indicators
- Provide **real-time groundwater level** fluctuations and recharge patterns
- Use **SARIMAX models** for short-term **forecasting** of groundwater levels.
- Incorporate **qualitative assessment** (natural minerals & weather conditions) for **usability**

APP WIREFRAMES



INNOVATION AND UNIQUENESS

- First-of-its-kind unified platform
- Predictive intelligence (SARIMAX model)
- Usability-centric approach (GUI simplification)
- Accessibility & reach
- Scalable & modular

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TECHNICAL APPROACH

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SARIMAX Forecasting Approach

3-Tier Architecture
The project is built on a **3-tiered model** (Individual, Regional, National), scaling from micro to macro-level insights

Exogenous Variables
The use of exogenous variables (like weather data) improves forecasting accuracy by **accounting for external factors**.

Station-Level Models:
Each of the **5,260** stations has its **own SARIMAX model**, generating **up to 30 day** forecast using historical and local weather data.

Regional Aggregation:
36 regional models combine station forecasts for state-level insights, identifying trends and supporting policy recommendations

National Overview:
A single national model provides a **pan-India groundwater status**, serving as a national early warning system.

App: Technical Architecture

Database (PostgreSQL + PostGIS):
- **Store** station metadata, time-series, and forecast outputs.
- Use **spatial queries** for fast geographic filtering.

Backend API (FastAPI, Python):
- RESTful endpoints
- Integrates **SARIMAX forecasting**
- Handles CSV uploads, authentication etc

Visualization:
- Charts via Flutter libraries or **Chart.js**.
- Color-coded maps
- **Quality indicators** via tables, gauges, or radar charts

Frontend (Flutter):
- App with **Mapbox SDK** for station map visualization
- Station details show time-series chart and water quality metrics

Forecasting Pipeline:
- Daily batch updates trigger SARIMAX
- Results written back to DB for frontend display

PIPELINE

1. Data Collection
Nationwide groundwater, rainfall, and climate data integrated from **WRIS** (5,260 stations), **IMD**, and **NASA POWER.**

2. Data Storage
Scalable **PostgreSQL database** supports historical records and real-time groundwater updates.

3. SARIMAX Modeling
Hierarchical **time series forecasting** at station, regional, and national levels for **early warnings.**

4. Mobile Application
Real-time dashboards: groundwater status, predictive insights, user alerts, and personalized recommendations.

5. Expected Impact
Pan-India coverage, >85% forecast accuracy, and proactive **crisis prevention** via actionable warnings.

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FEASIBILITY AND VIABILITY

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Current Solutions & Limitations

Current Solution

- **CGWB WIMS/WRIS:** No mobile access or user-friendly analytics.
- **Aaxis Nano App:** Private and subscription-based.
- **Bhoojal Survey DWLR:** Commercial and not a public platform.
- **India Observatory GMT:** Requires manual data entry; no automation.
- **Research Prototypes:** Not scalable or publicly available.

Limitations

- Slow Training
- Unreliable Data Ingestion
- Model Drift
- Linearity Constraints
- No Offline Mode
- Delayed Anomaly Detection

Scalability, Viability and Feasibility of our solutions

Technical Scalability:

- **Scalable Architecture:** Centralized **PostgreSQL** database streamlines data and ensures **consistency**.
- **Parallelized ML Models:** Separate models for each of the 5,260 stations enables **parallel processing**
- **Decoupled Services:** ML models deployed as an **independent microservice** ensures scalability as needed to handle high demand without impacting the system.

Economic & Social Viability:

- **Cost-Effective:** Built on an **open-source stack**: minimizes costs for national-scale
- **Tiered Insights:** 3-tier architecture: **customized data** to different **users** (detailed forecasts for farmers to high-level dashboards for policymakers)

Feasibility Of Our Solution

- **Technical**: Proven SARIMAX models provide lightweight**, interpretable forecasting**. The open-source stack (PostgreSQL, FastAPI, Flutter) is widely adopted and **computationally efficient**.
- **Economic:** We minimize costs by leveraging the **existing ~5,260 DWLR** station **network** and using **open-source tools** to avoid licensing fees.
- **Operational:** An automated daily pipeline efficiently retrains models and updates forecasts, **scaling** easily with **modest hardware**.
- **App Development:** Using a single **Flutter** codebase with an **offline-first** design ensures rapid, affordable, and **reliable** development.

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IMPACT AND BENEFITS

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BENEFICIARIES

Citizens: Access to groundwater availability information for planning

Government: Data-driven policy making and resource allocation

Agriculture: Informed irrigation planning and crop management

Industry: Sustainable water usage and compliance monitoring

Research Community: Enhanced data access for groundwater studies

PESTEL ANALYSIS

Political: Ministries (Jal Shakti) mandate **digital monitoring**; CGWB sets **national standards**; India-WRIS **strengthens** open data; **policies** & subsidies influence adoption pace.

Economic: Demand **grows** with water stress; IoT sensors/analytics need high upfront cost; venture/ government funding **fuels innovation**; industrial & Agri-growth **expands business opportunities**.

Social: Rising public **concern** on scarcity & climate change; community science apps (MyWell, MARVI) engage citizens; **digital adoption** via mobile/web widens access and provides **critical educational awareness**.

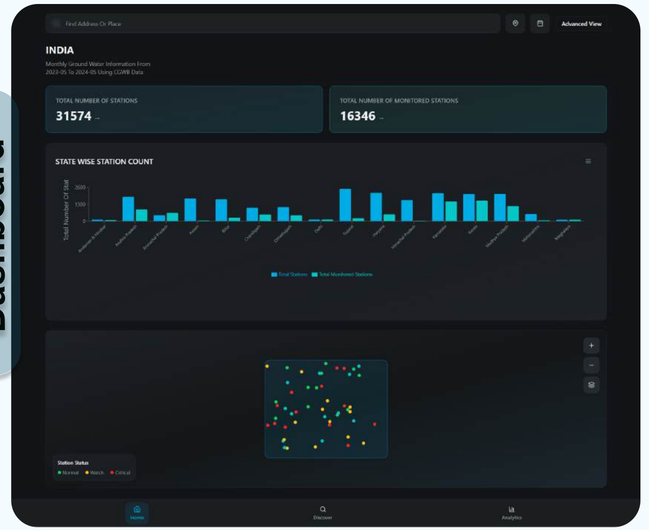
Technological: Real-time **IoT/DWLR sensors** for water level & quality; **AI/ML & GIS** enable anomaly detection & **forecasting**; apps (Bhujal, Waltr) make data visible; reliant on **robust telecom** for remote data.

Environmental: Tackles **core crisis** of **groundwater depletion**; water quality/pollution monitoring adds value; climate change **intensifies urgency**; solutions **promote sustainable** usage **practices**.

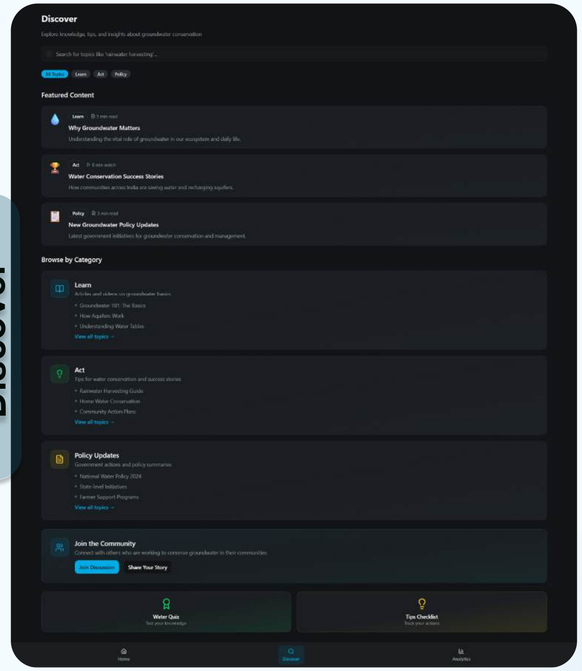
Legal: Must comply with **equipment/data standards**; **ensure privacy** in handling sensitive resource data; **water rights laws** affect deployment; **IP protection** safeguards innovations.

APP PROTOTYPE

Dashboard

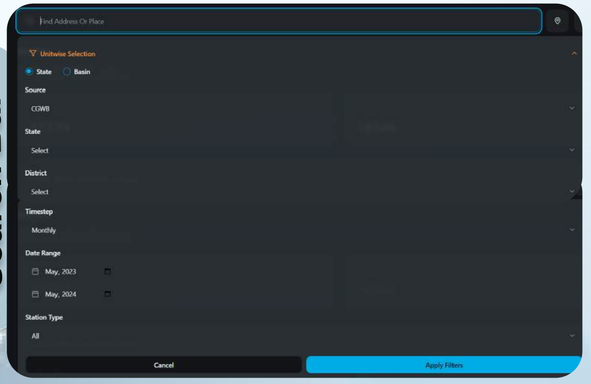


Discover



Analytics

Search Bar



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RESEARCH AND REFERENCES

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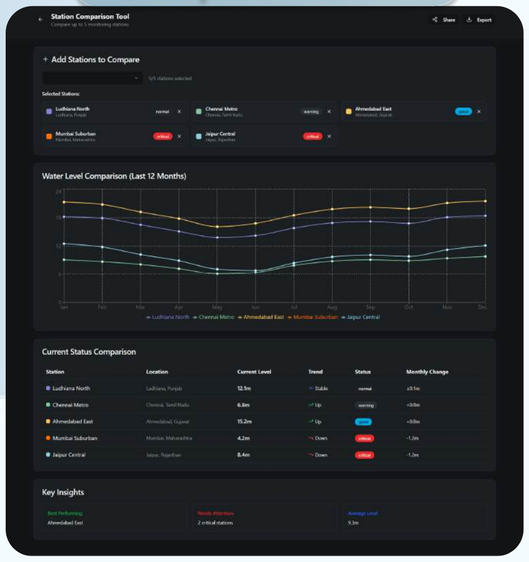
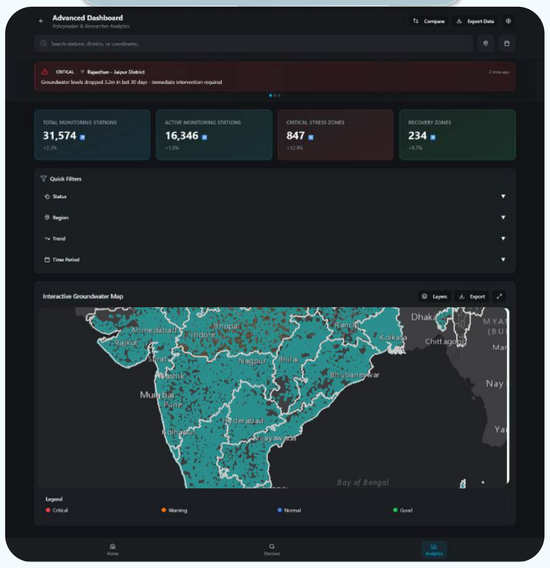
Comparision tool



Advanced view



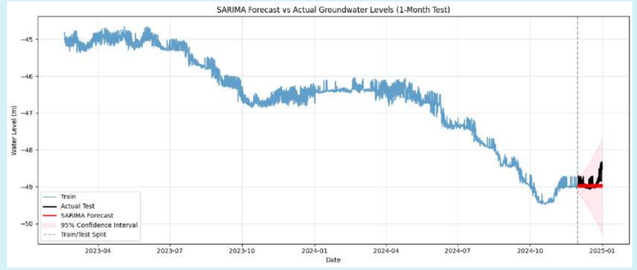
Mock study

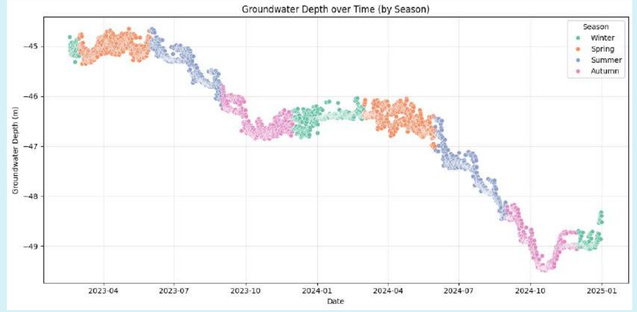
Location:- Barnala, Punjab

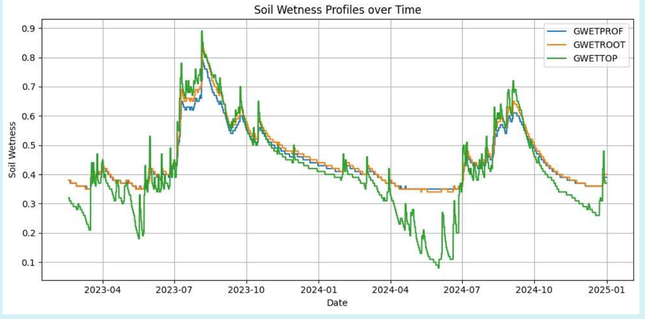
Groundwater level data from Barnala DWLR station was analyzed along with relative humidity, temperature, and soil moisture to demonstrate real-time monitoring and forecasting.

Our Analysis

- Groundwater levels are on a steady decline, with mean values falling over 7.6% across the dataset period.
- Recent daily averages hover near historic lows, pointing to sustained depletion.
- Steep seasonal declines during dry months show only partial, short-lived recoveries, insufficient for aquifer restoration.
- Chronic stress indicators: 38.5% of observations fall below the long-term mean.
- Rapid dips in daily/weekly averages suggest over-extraction spikes, likely tied to agriculture or policy gaps







References

Datasets / Government Sources

Central Ground Water Board (CGWB), Groundwater Data Portal, Govt. of India
NASA- POWER
IMD – Rainfall & Climate Data Portal

Research Papers & Studies

Exploring AI approaches for predicting groundwater levels in coastal agro-climatic zones: case study, Cuttack, Odisha
-Discover Geoscience (2024)

Long-term groundwater recharge rates across India by in situ measurements
-Bhanja, S. N. et al., Hydrology & Earth System Sciences, 2019

Link:

India WRIS *Research Paper 1*

CGWB *Github* *YT Channel*