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Making the Invisible Visible – Technologies for Groundwater Management

04 AUGUST 2026

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WEBINAR INFORMATION – HOUSEKEEPING RULES

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WEBINAR INFORMATION – HOUSEKEEPING RULES

- **'Chat' box**: please use this for general requests and for interactive activities.
- **'Q&A' box**: please use this to send questions to the panelists. (We will answer these during the discussions)

Please Note: *Attendees' microphones are muted. We cannot respond to 'Raise Hand'.*

AGENDA

- **Welcome and Introduction to the webinar**
  Afia Siddiqui, Learn and Knowledge Officer, IWA

- **Speaker Presentation 1**
  Prof. Elango Lakshmanan, Visiting Faculty, IIT Madras, India

- **Speaker Presentation 2**
  Rahul Bakare, CEO & Founder, Urdhvam Environmental Technologies Pvt ltd, India

- **Panel Discussion and Audience Q&A**
  Speaker and Moderator

- **Closing Remarks**
  Afia Siddiqui, Learn and Knowledge Officer, IWA

INTRODUCTION

- The proposed webinar series 'Groundwater - The Invisible Lifeline' seeks to shift how **groundwater is perceived—from an unseen, extractive resource to a dynamic, living system** embedded within the hydrological cycle, ecosystems, and society.

- The third session will focus on the technologies and innovations that are transforming groundwater assessment, monitoring, and decision-making. The webinar will also examine the challenges of data integration, interpretation, and accessibility, highlighting how technology can strengthen policy, planning, and community action.

SPEAKERS PROFILE

Prof. Elango Lakshmanan, *Visiting Faculty, IIT Madras, India*

Prof. Elango Lakshmanan has over 38 years of experience in hydrogeology. He is currently a full-time Visiting Faculty member with the Hydraulics and Water Resources Engineering Group, Department of Civil Engineering, Indian Institute of Technology Madras, Chennai. Prof. Lakshmanan served as Vice-President of the International Association of Hydrological Sciences (IAHS) from 2015 to 2019 and as President of the IAHS International Commission on Water Quality from 2020 to 2024.

Rahul Bakare, CEO & Founder, Urdhvam Environmental Technologies Pvt ltd, India

Rahul Bakare is a Founder & CEO of a Groundwater Sustainability Startup based out of Pune called, Urdhvam Environmental Technologies Pvt. Ltd. By education he has done his MS in Mechanical Engineering from Michigan State University in 1995 and has done IIM Calcutta Executive Program in Business Management. He has worked for 14 years in Software & IT in US and India and has in-depth experience in Project, Program, Product & People Management in Telecom, ERP, CRM, Online Gaming, Financial Transactions, etc.

Making the invisible visible –
Technologies for Groundwater Management

Elango Lakshmanan
Hydraulics and Water Resources Engineering Group
Department of Civil Engineering
Indian Institute of Technology Madras
elango.net.in

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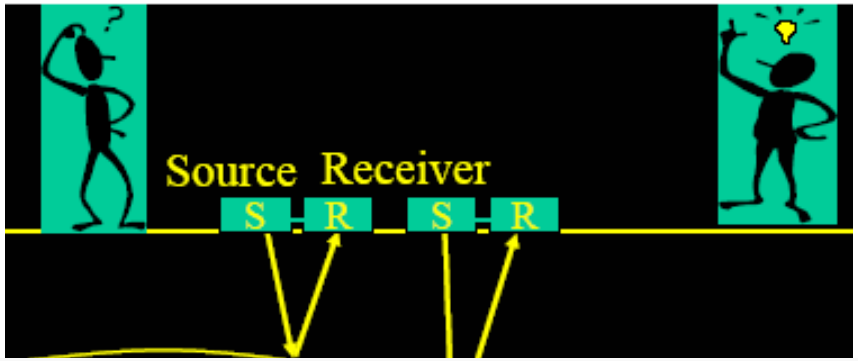
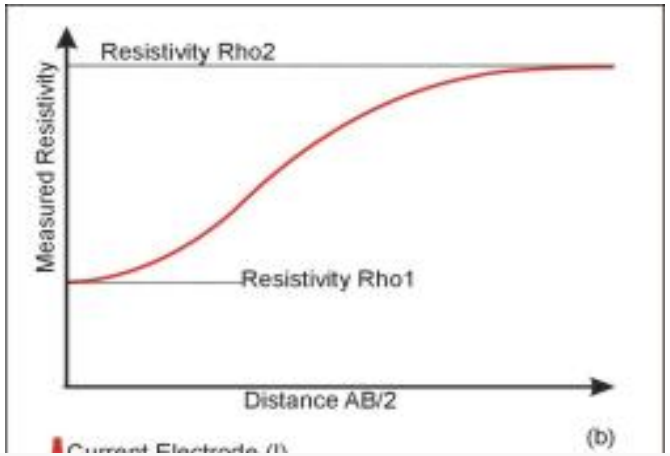
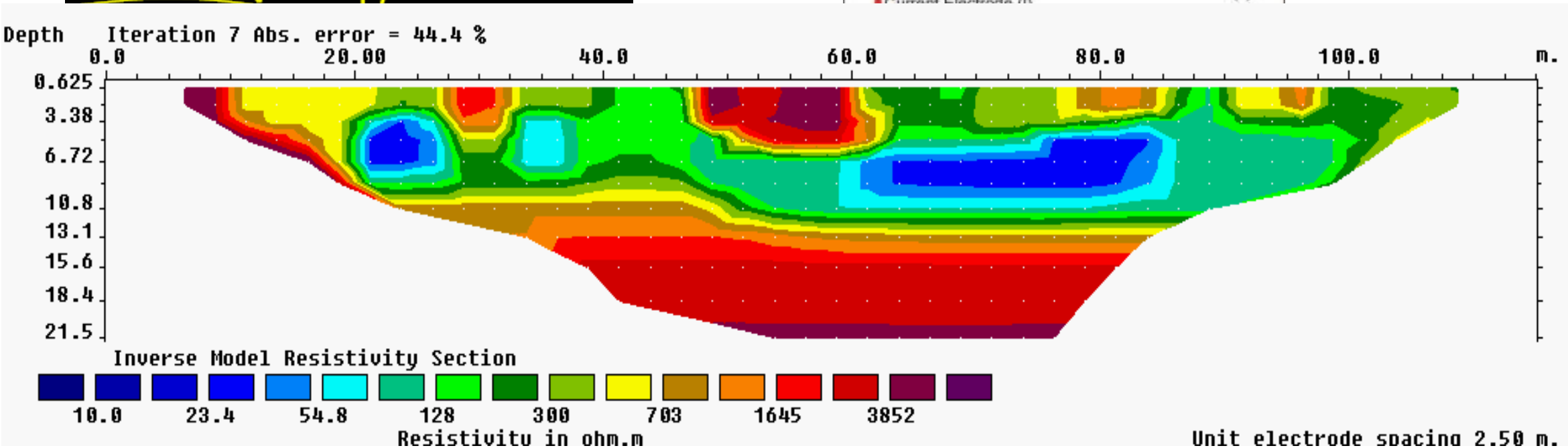
MAKING THE INVISIBLE VISIBLE

- Electrical Resistivity Methods

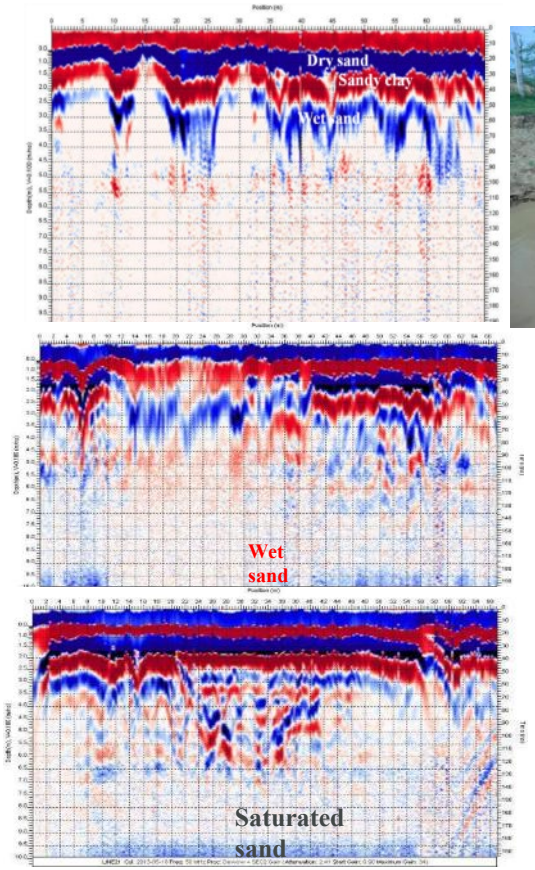






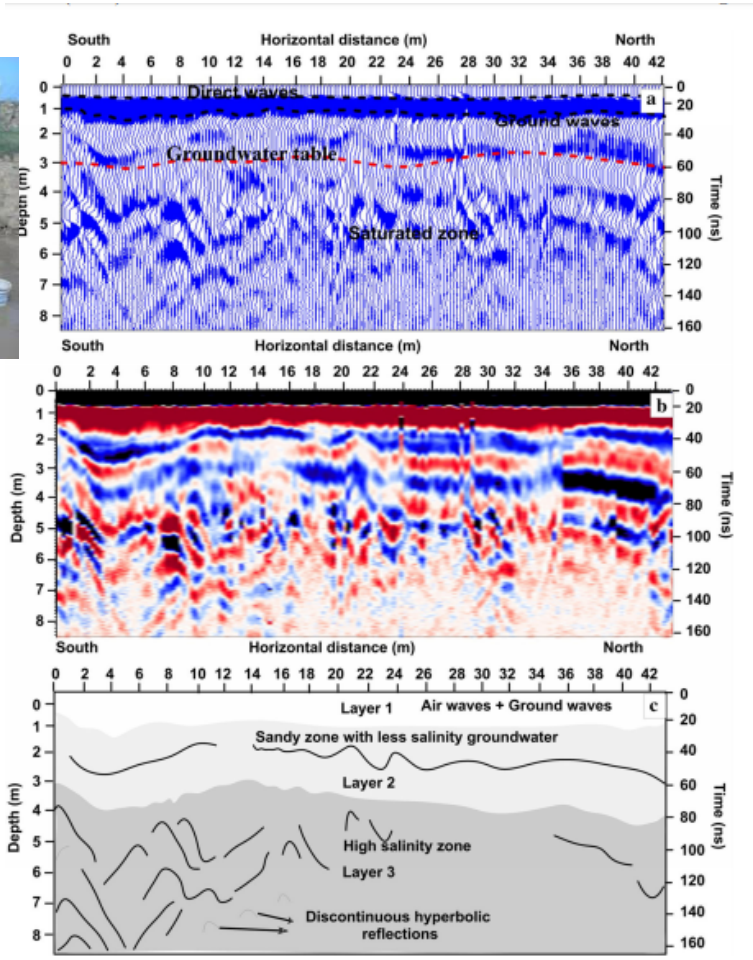
GROUND PENETRATING RADAR

Check dam



Parimala (2014)

Percolation pond



Raicy and Elango (2016)

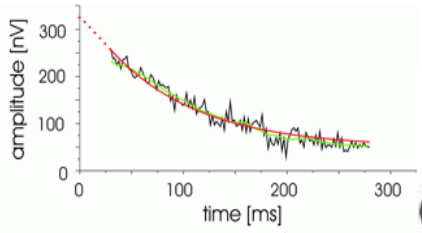
SURFACE NUCLEAR MAGNETIC RESONANCE (SNMR)

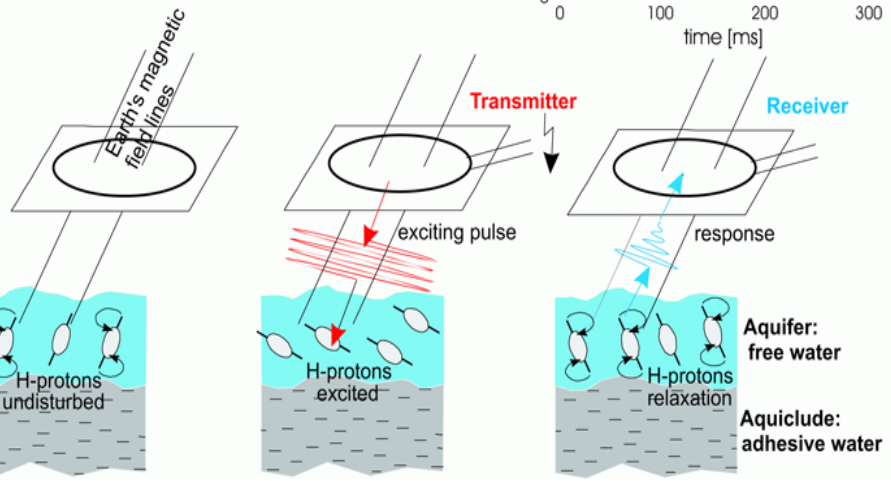
the international water association

pulse moment q ~ penetration depth

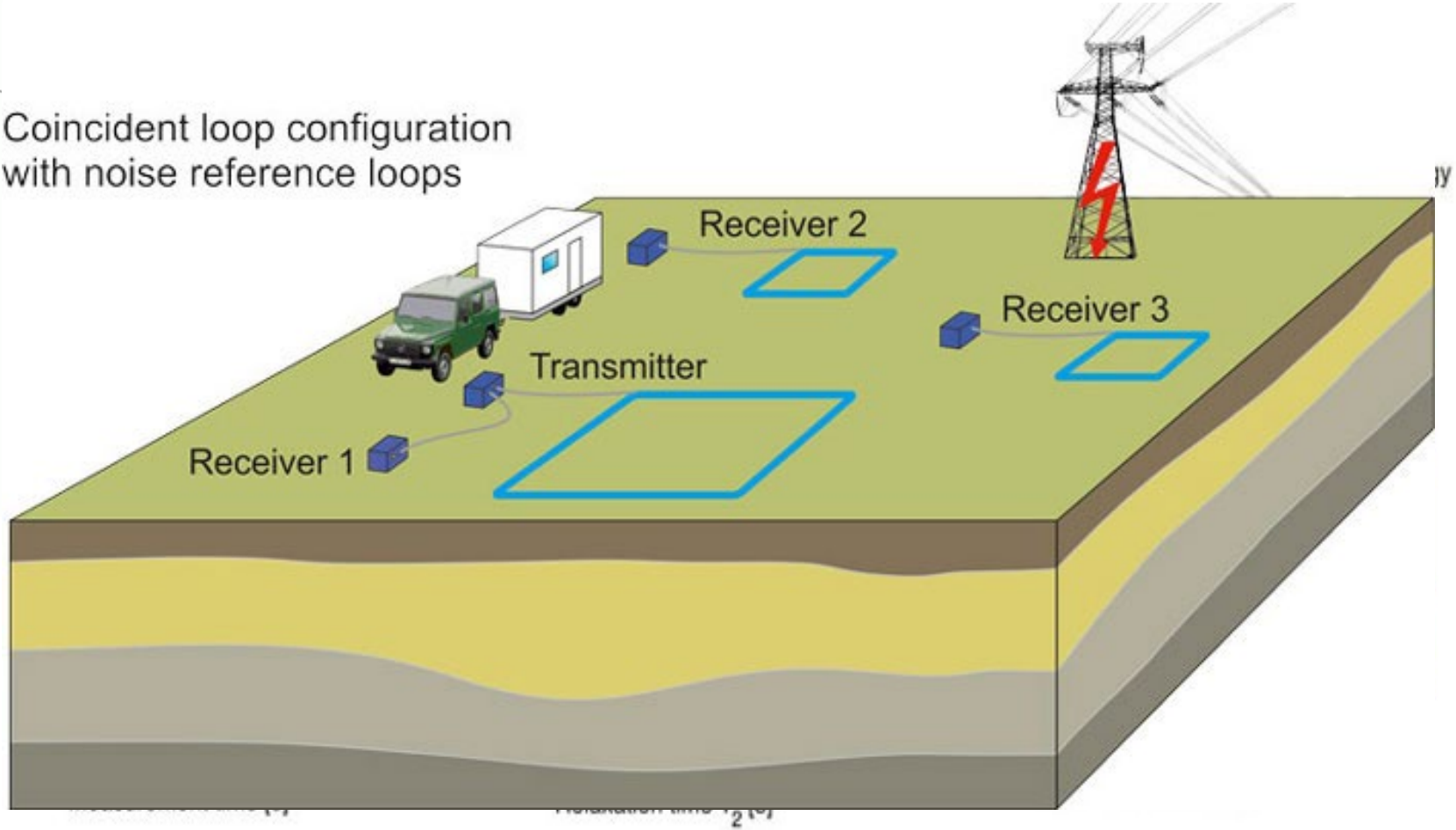
initial amplitude E_0 ~ water content

decay time T_2^*~ pore size





Coincident loop configuration with noise reference loops



www.bgr.bund.de

GRACE-FO

Gravity Recovery and Climate Experiment Follow-On

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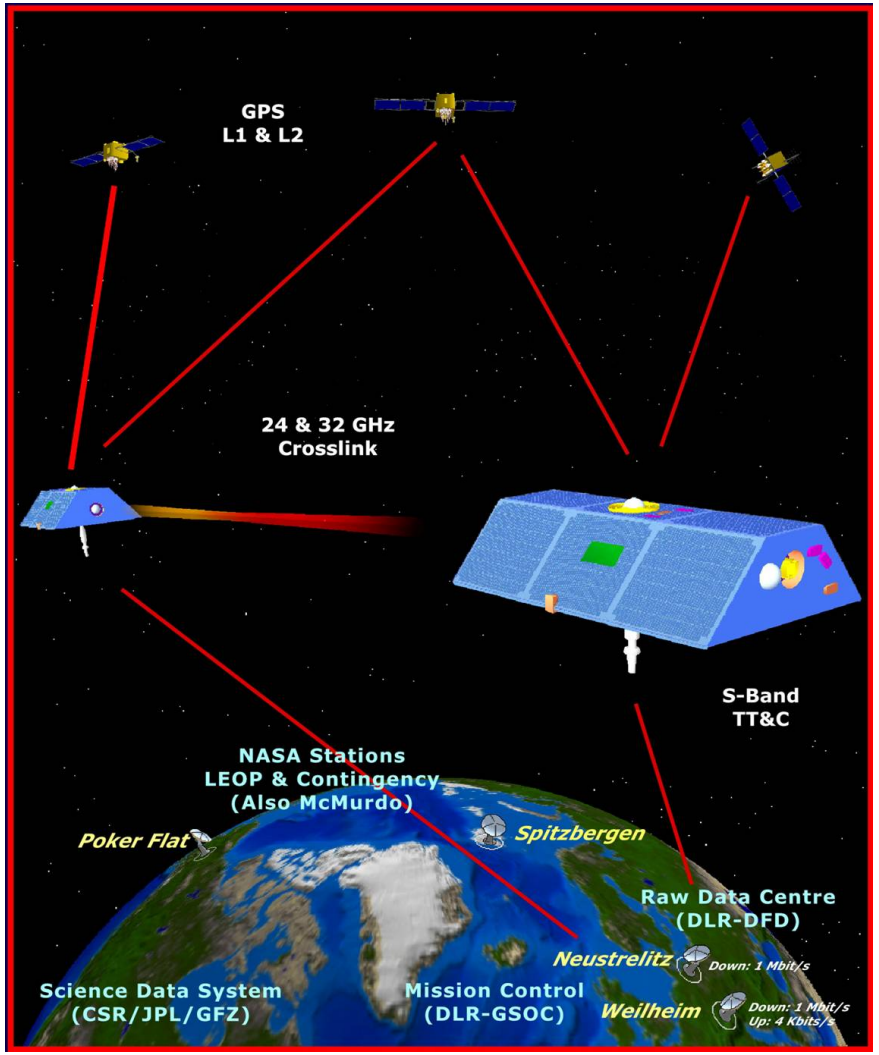
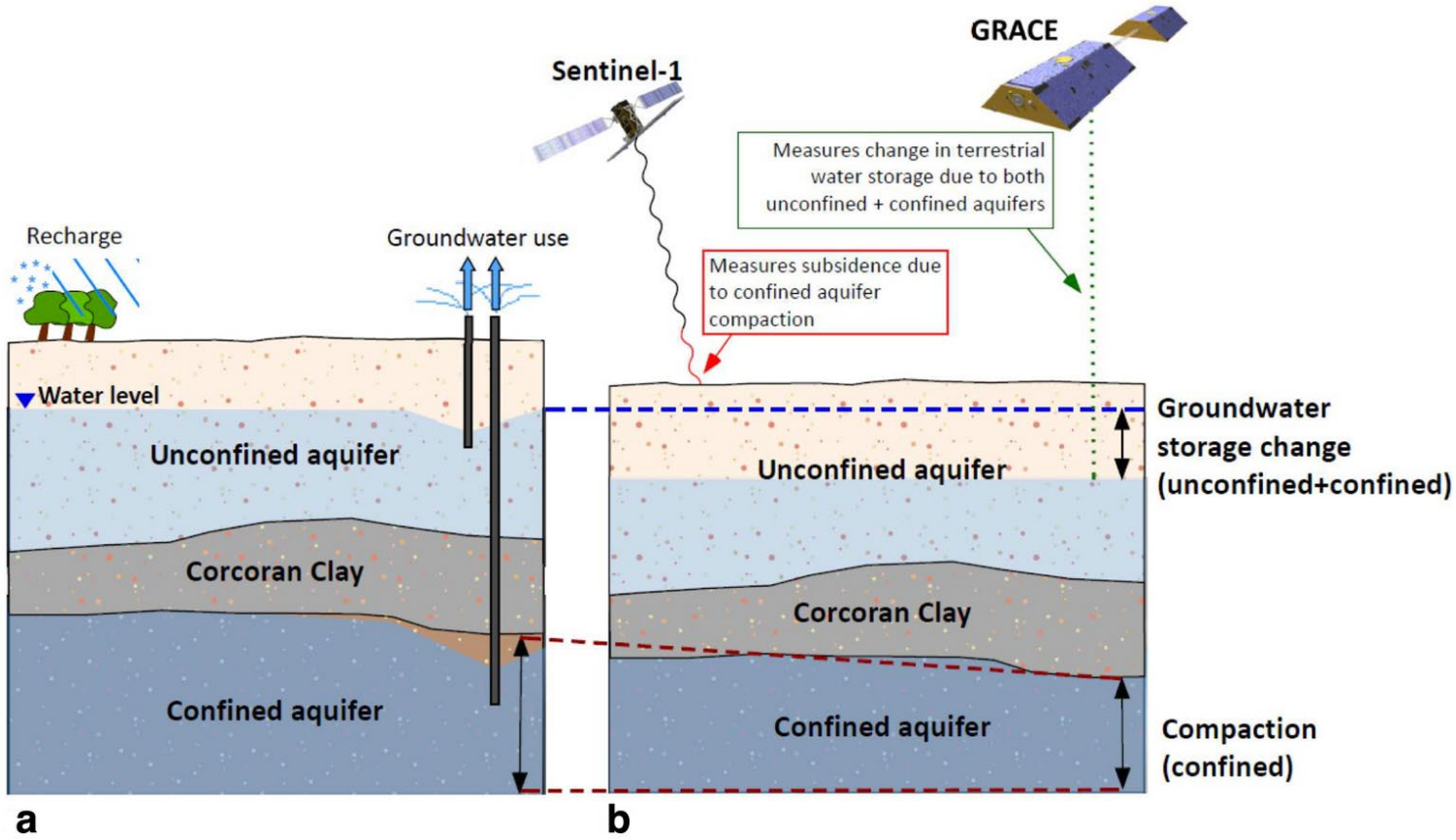
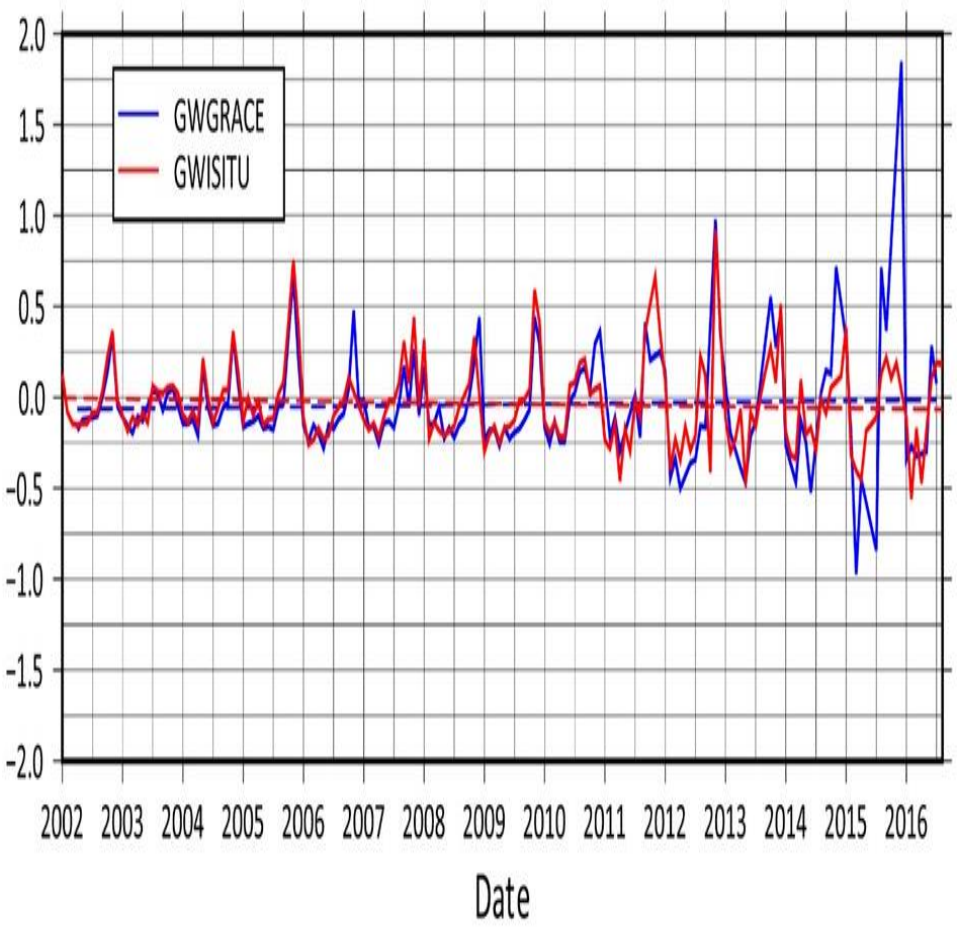


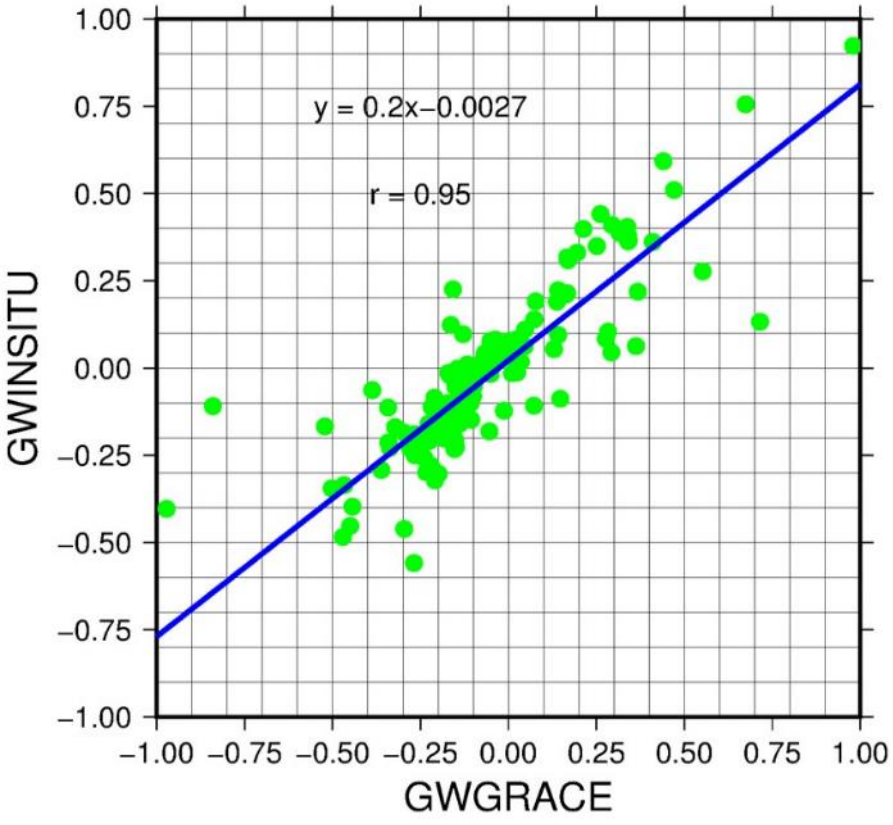


Vasco et al 2022

OBSERVED AND GRACE DERIVED GROUNDWATER LEVEL



Correlation between observed and GRACE derived groundwater level



J. Earth Syst. Sci. (2020)129 215
https://doi.org/10.1007/s12040-020-01465-2

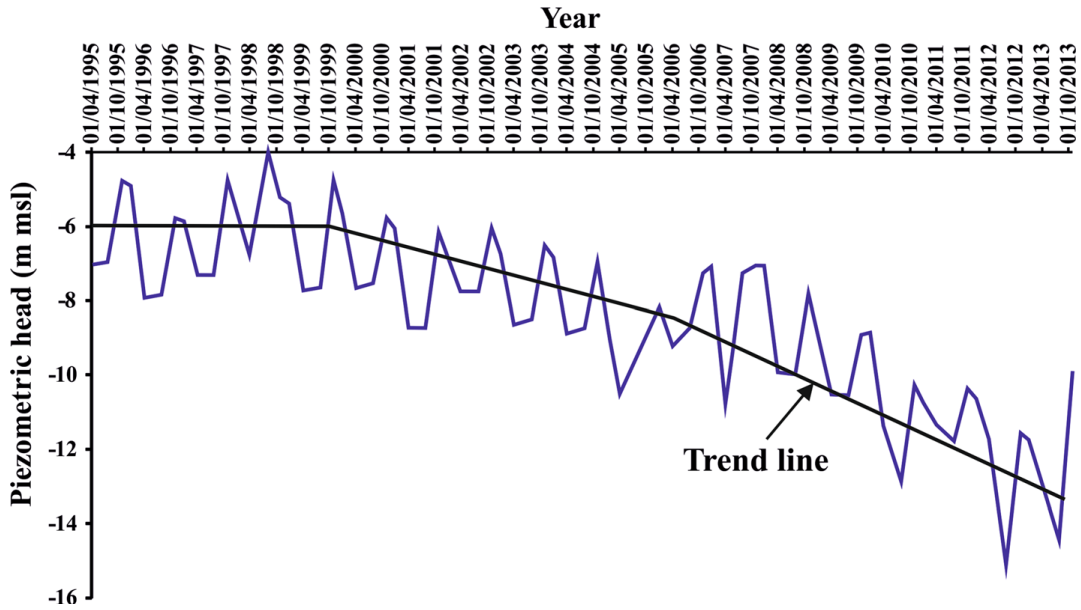
Use of GRACE time-series data for estimating groundwater storage at small scale

Ch Samurembi Chanu[1], Harika Munagapati[2,*], V M Tiwari[2], Arvind Kumar[3] and L Elango[1]

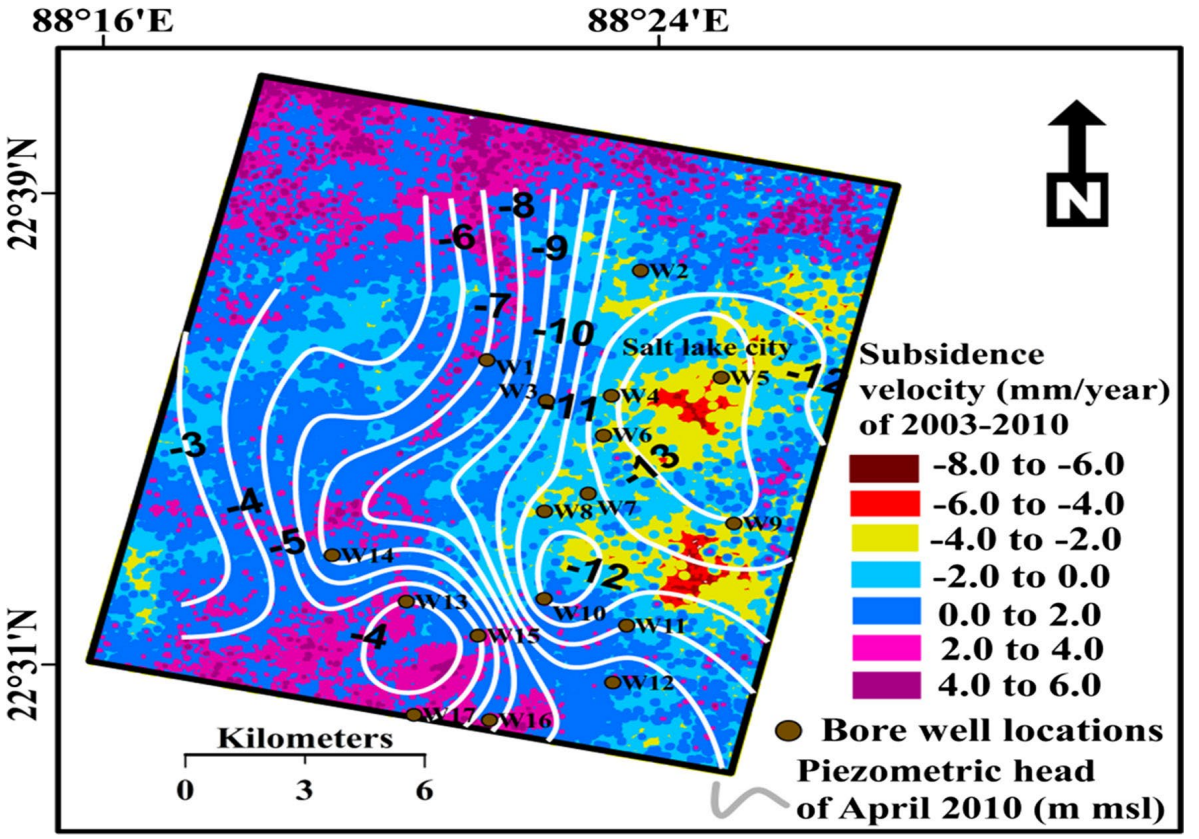
[1]*Department of Geology, Anna University, Chennai, Tamil Nadu, India.*
[2]*National Geophysical Research Institute, CSIR, Hyderabad, India.*
[3]*International Co-operation Division, Department of Science and Technology, New Delhi, India.*

Department of Science and Technology, New Delhi
(Grant No. DST.CCP/NCC&CV/135/2017 (G))

SYNTHETIC APERTURE RADAR IMAGE
LAND SUBSIDENCE IN PARTS OF KOLKATA



SARscape



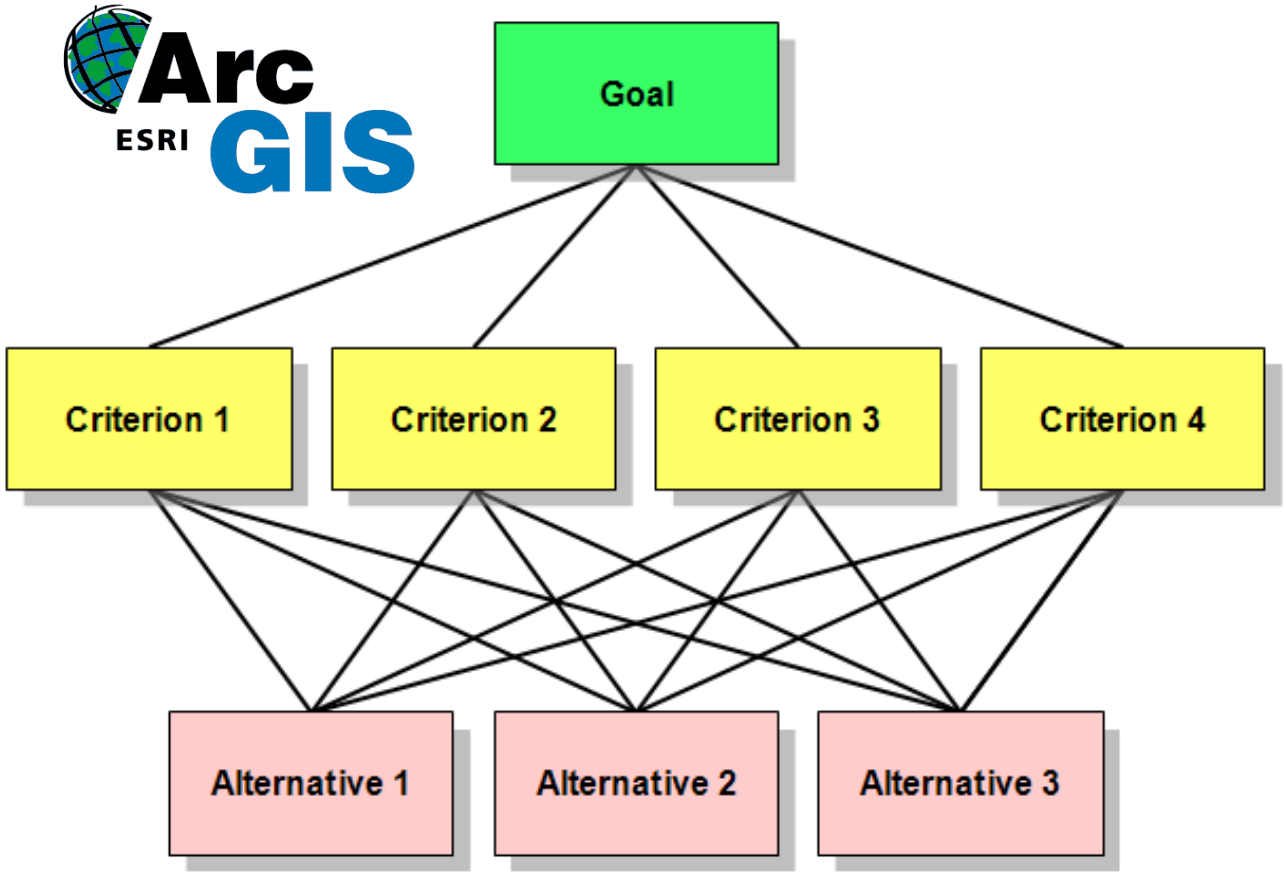
J. Earth Syst. Sci. (2020)129 46
https://doi.org/10.1007/s12040-019-1298-z

Estimation of groundwater abstraction induced land subsidence by SBAS technique

S Suganthi[1] and L Elango[2,*]

[1]*Public Works Department, State Ground and Surface Water Resources Data Centre, Chennai 600 113, India.*
[2]*Department of Geology, Anna University, Chennai 600 025, India.*
*Corresponding author. e-mail: elango34@hotmail.com

AHP (ANALYTIC HIERARCHY PROCESS) – MULTI-CRITERIA DECISION-MAKING (MCDM)



Contents lists available at ScienceDirect

Physics and Chemistry of the Earth

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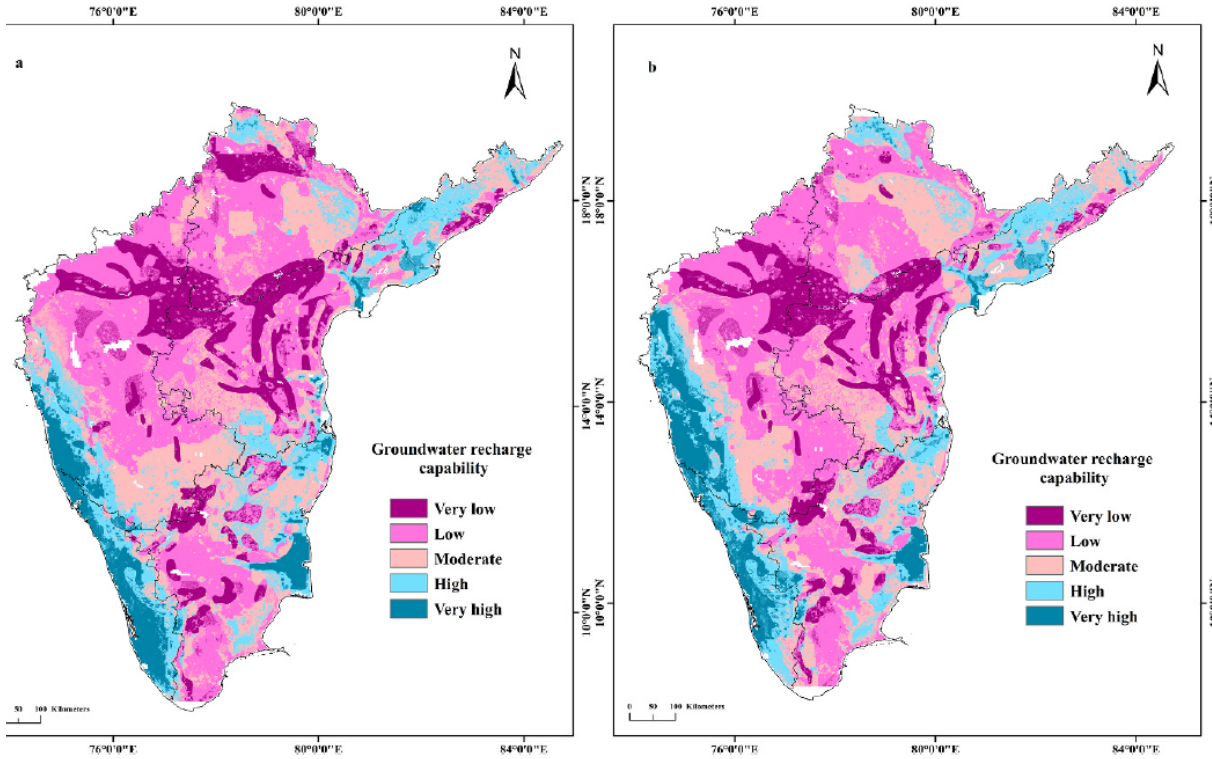
An integrated multicriteria decision framework for spatiotemporal mapping of groundwater sustainability

Srijita Ghosh, Subbarao Pichuka, Lakshmanan Elango

Hydraulics and Water Resources Engineering, Department of Civil Engineering, IIT, Madras, Chennai, India

Groundwater recharge zonation, a. 2017, b. 2024.



AHP (ANALYTIC HIERARCHY PROCESS) – MULTI-CRITERIA DECISION-MAKING (MCDM) LOCATING RECHARGE WELLS IN BENGALURU

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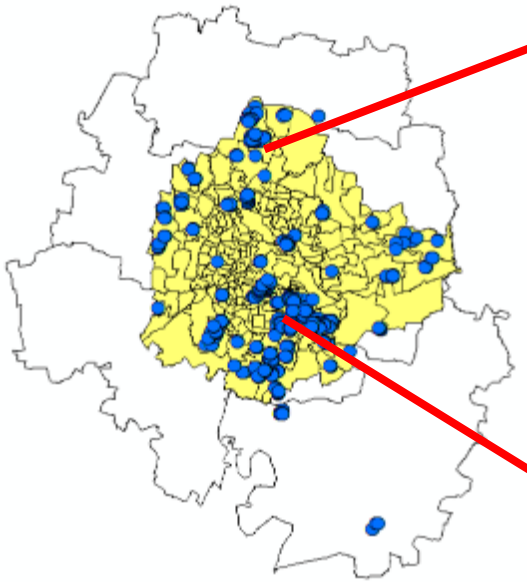
One Billion Drops Initiative

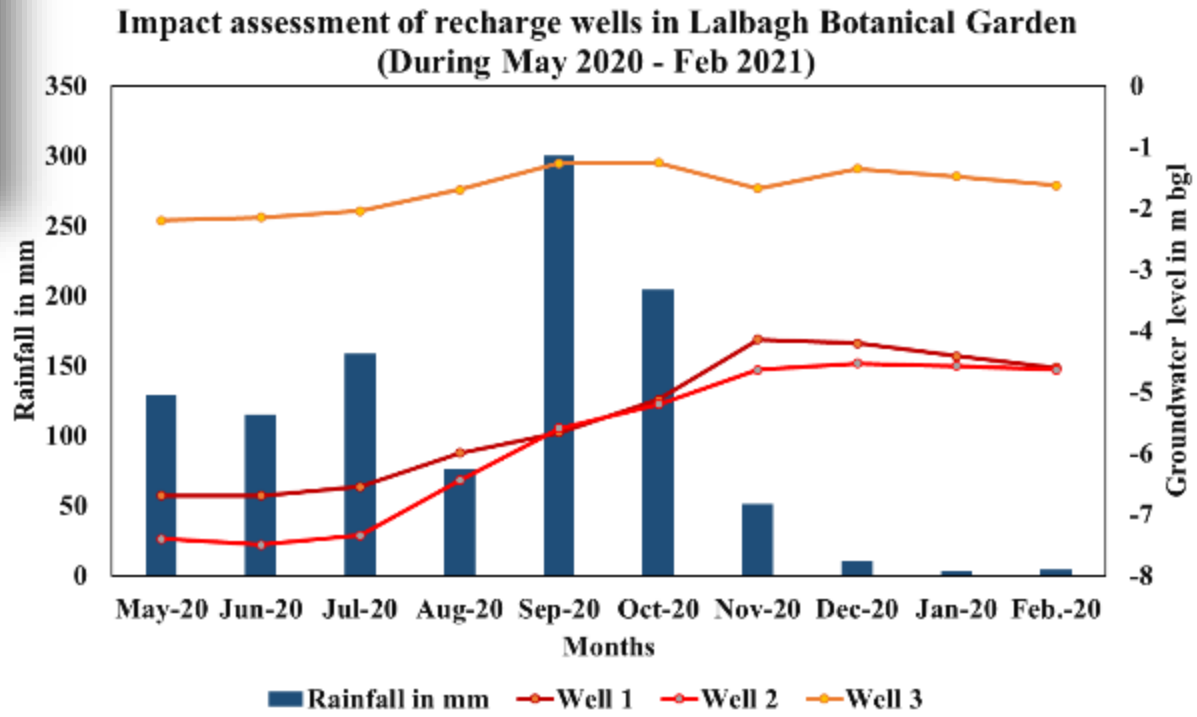
Park in Yelahanka



Lalbagh Botanical Garden

Percolation wells
Bengaluru urban district
BBMP wards

Impact assessment of recharge structures

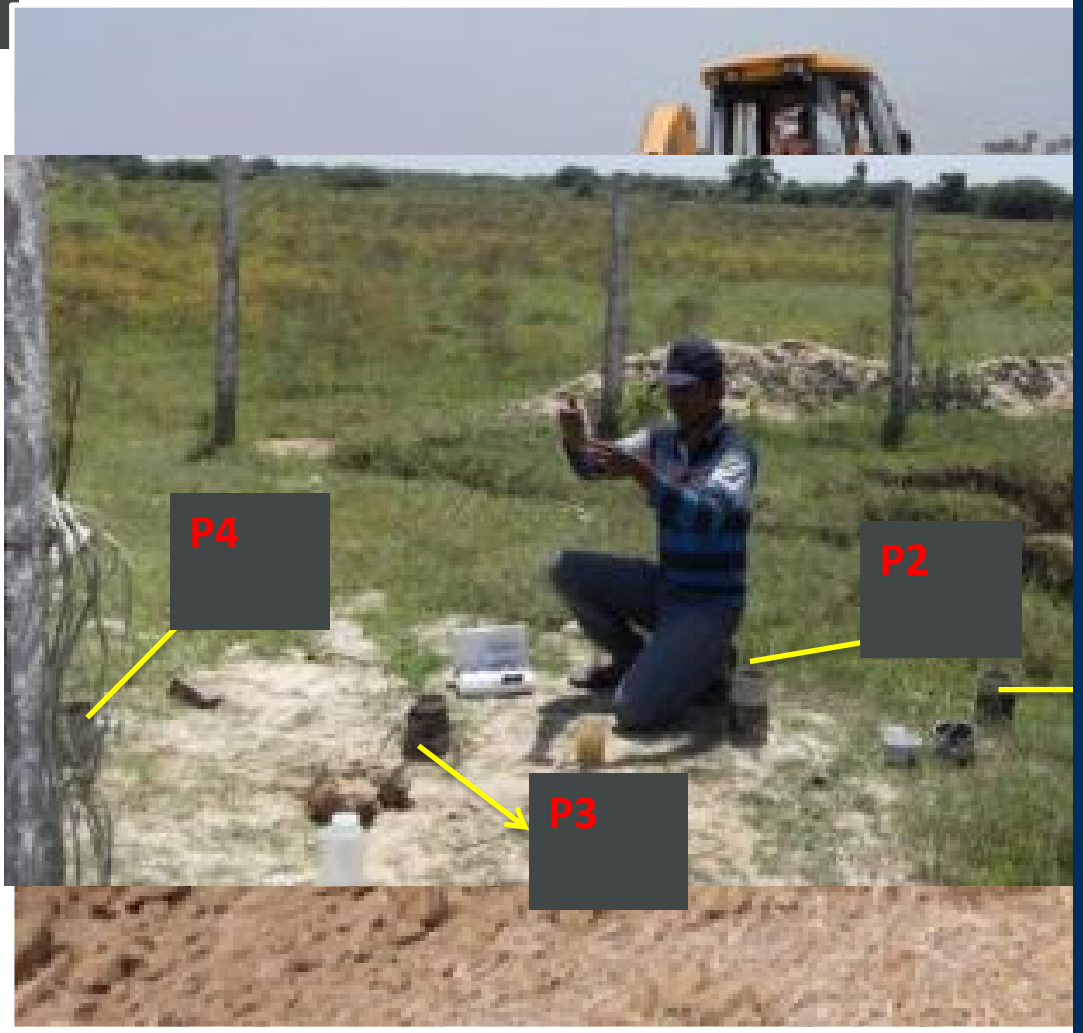


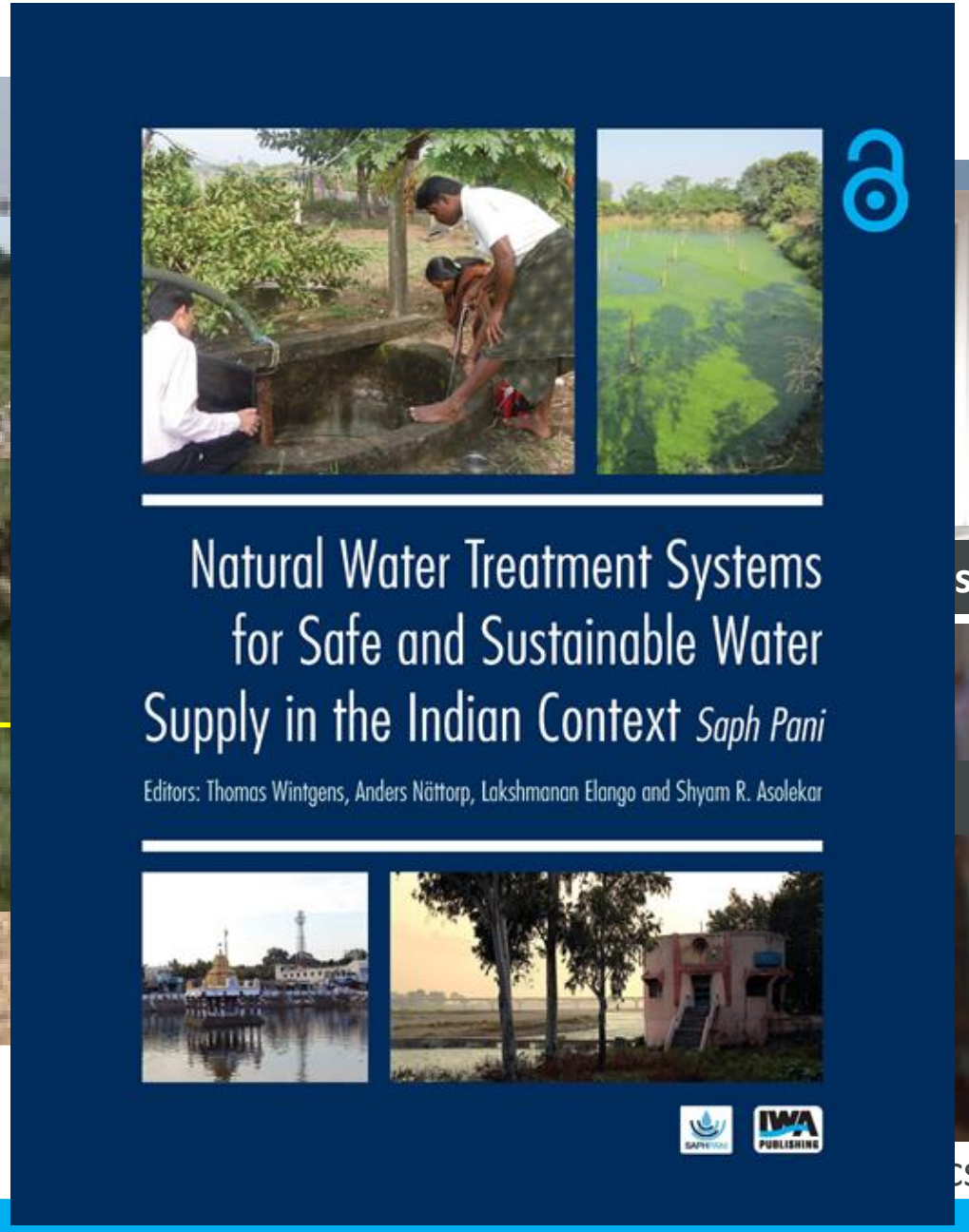
United Way Bengaluru

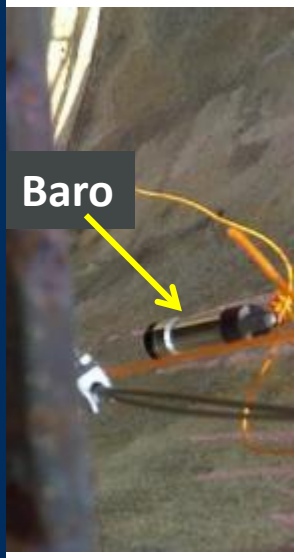
AquaMAP

Data Source : United Way Bengaluru

TOOLS FOR MONITORING



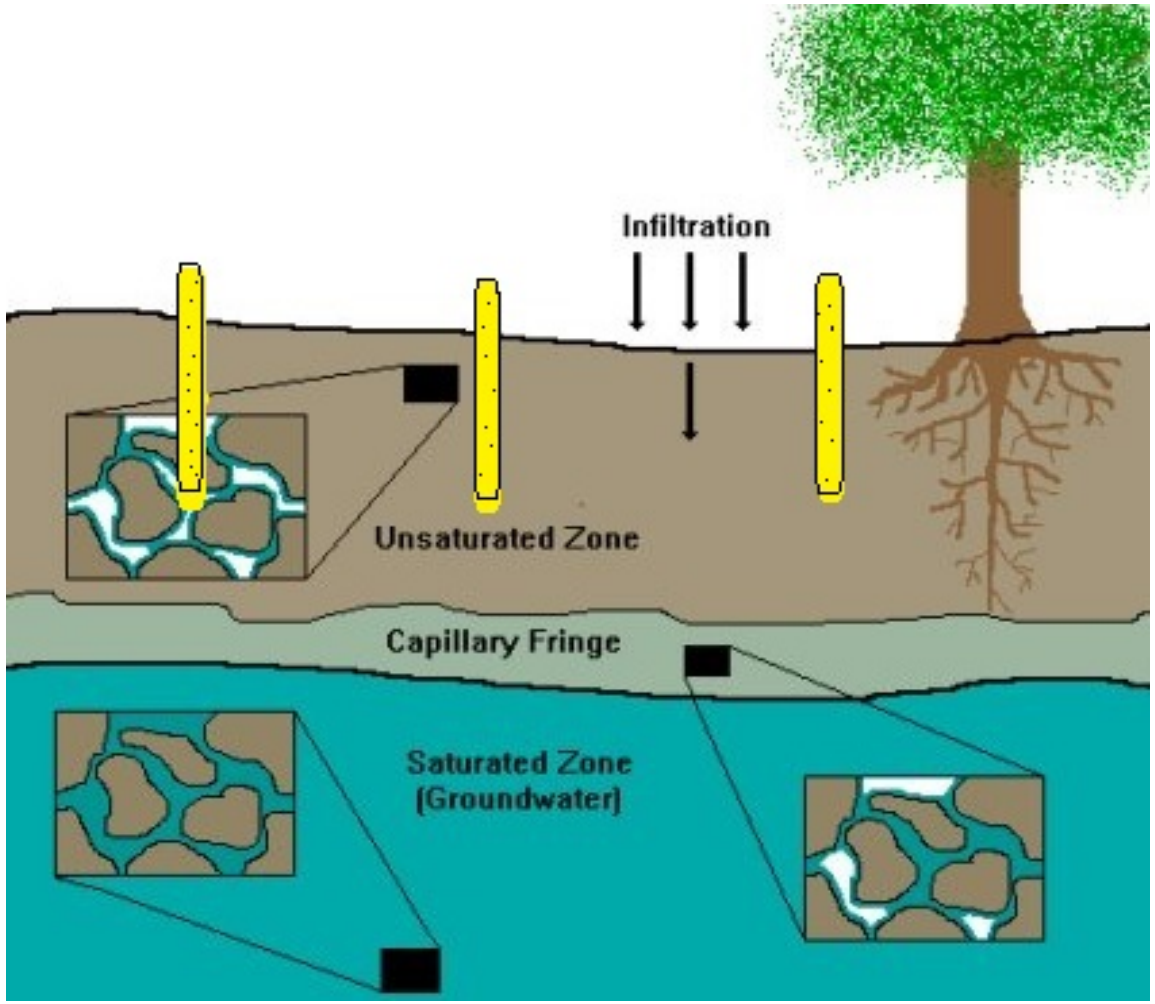


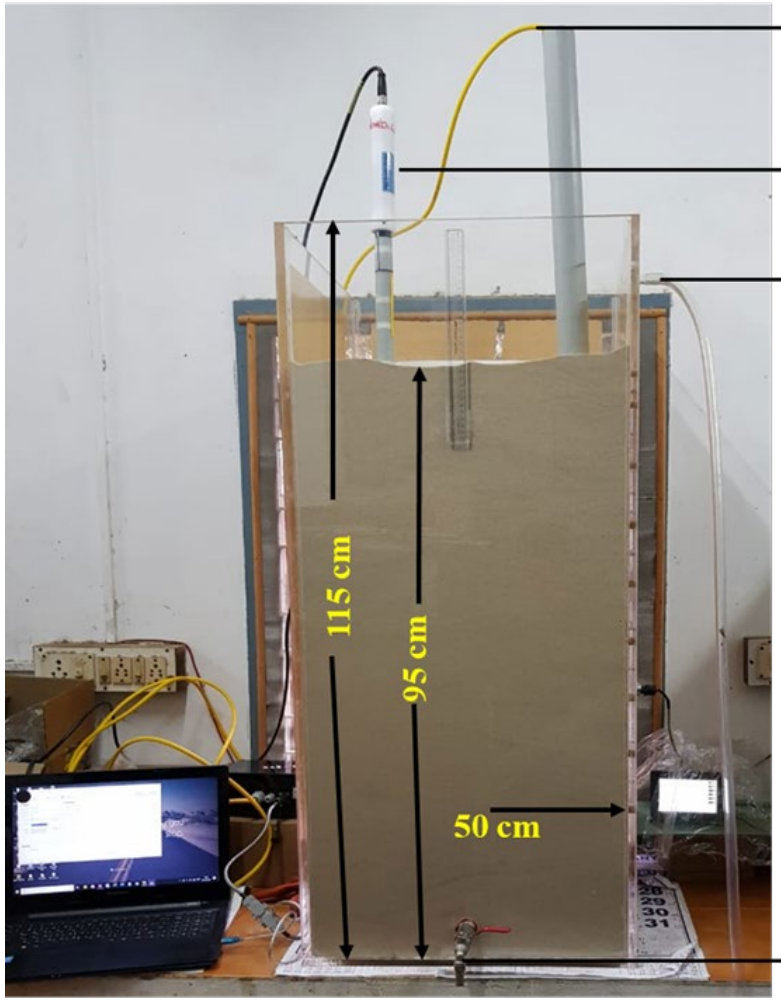


cs: Raicy

EC FP7 Project 'Saphpani'

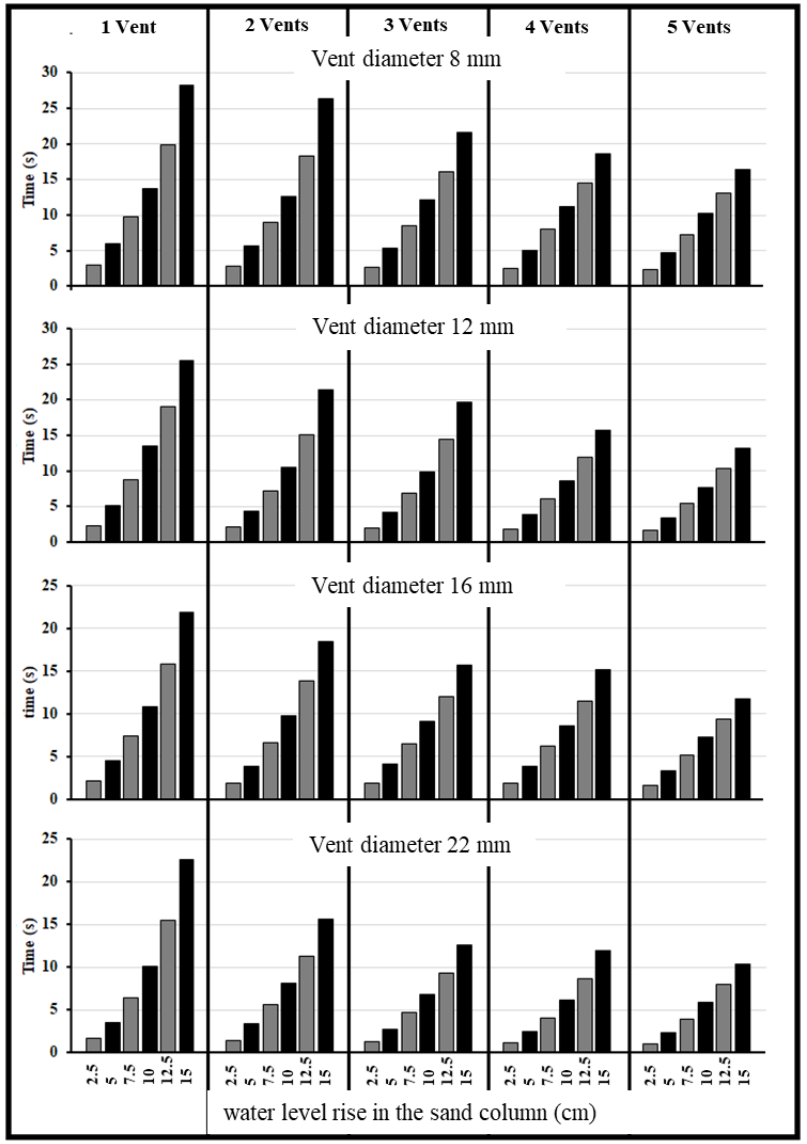
ENHANCING RECHARGE BY VENTILATION

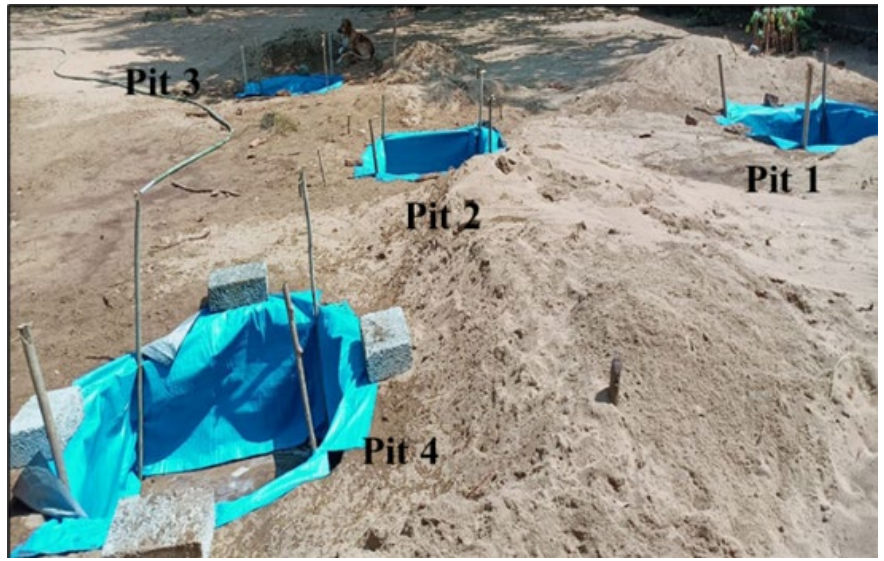




Pics: Haritha

ENHANCING RECHARGE BY VENTILATION





Pics: Haritha

Improving groundwater recharge by ventilation of unsaturated zone

V. K. Haritha and L. Elango*
Department of Geology, Anna University, Chennai 600 025, India

*For correspondence. (e-mail: elango34@hotmail.com)

APPLICATIONS OF AI/ML IN GROUNDWATER MANAGEMENT

Predictive Modelling

Groundwater Level Forecasting

LSTM and Recurrent Neural Network (RNN) models predict future water table fluctuations with 85-95% accuracy

Water Quality Assessment

Ensemble models predict contamination spread, identifying at-risk areas

Recharge Estimation

RF and SVM algorithms model complex precipitation-recharge relationships

Key Algorithm: Deep Learning Neural Networks (LSTM, CNN) achieve highest prediction accuracy in temporal modeling

Haggerty, R., Sun, J., Yu, H., & Li, Y. (2023). Application of machine learning in groundwater quality modeling - A comprehensive review. Water Research, 233, 119745. https://doi.org/10.1016/j.watres.2023.119745

Feng, F., Ghorbani, H., & Radwan, A. E. (2024). Predicting groundwater level using traditional and deep machine learning algorithms. Frontiers in Environmental Science, 12, 1291327. https://doi.org/10.3389/fenvs.2024.1291327

EXAMPLE 1:ML FOR GROUNDWATER FORECASTING

Study Area

Predicting groundwater levels in the Upper Rhine Graben (Germany) using LSTM/CNN/NARX models

Methodology

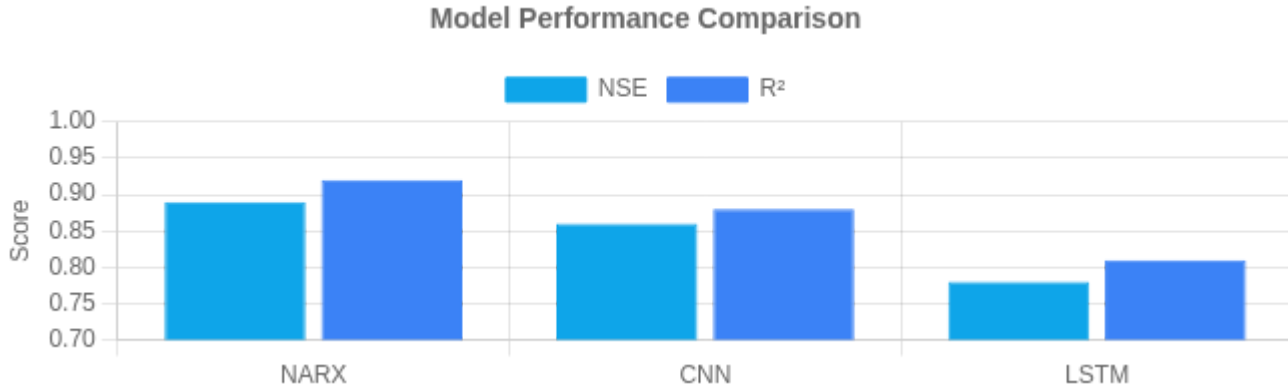
- **Data from 17 monitoring wells (1967-2015)**
- **Input: precipitation, temperature, humidity**
- **Model comparison: NARX vs LSTM vs CNN 4-year validation period (2012-2016)**

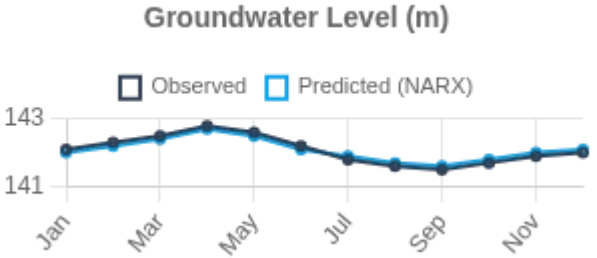
Key Findings

NARX models performed best for seq2val forecasting

CNNs showed comparable accuracy with faster computation

LSTMs demonstrated greater robustness against initialization effects





Model Performance

Model	NSE	RMSE (m)	R^2
NARX	0.89	0.11	0.92
CNN	0.86	0.14	0.88
LSTM	0.78	0.23	0.81

Wunsch, A., Liesch, T., and Broda, S.(2021)Groundwater level forecasting with artificial neural networks: a comparison of long short-term memory (LSTM), convolutional neural networks (CNNs), and non-linear autoregressive networks with exogenous input (NARX), Hydrol. Earth Syst. Sci., 25, 1671–1687, https://doi.org/10.5194/hess-25-1671-2021 CC BY 4.0

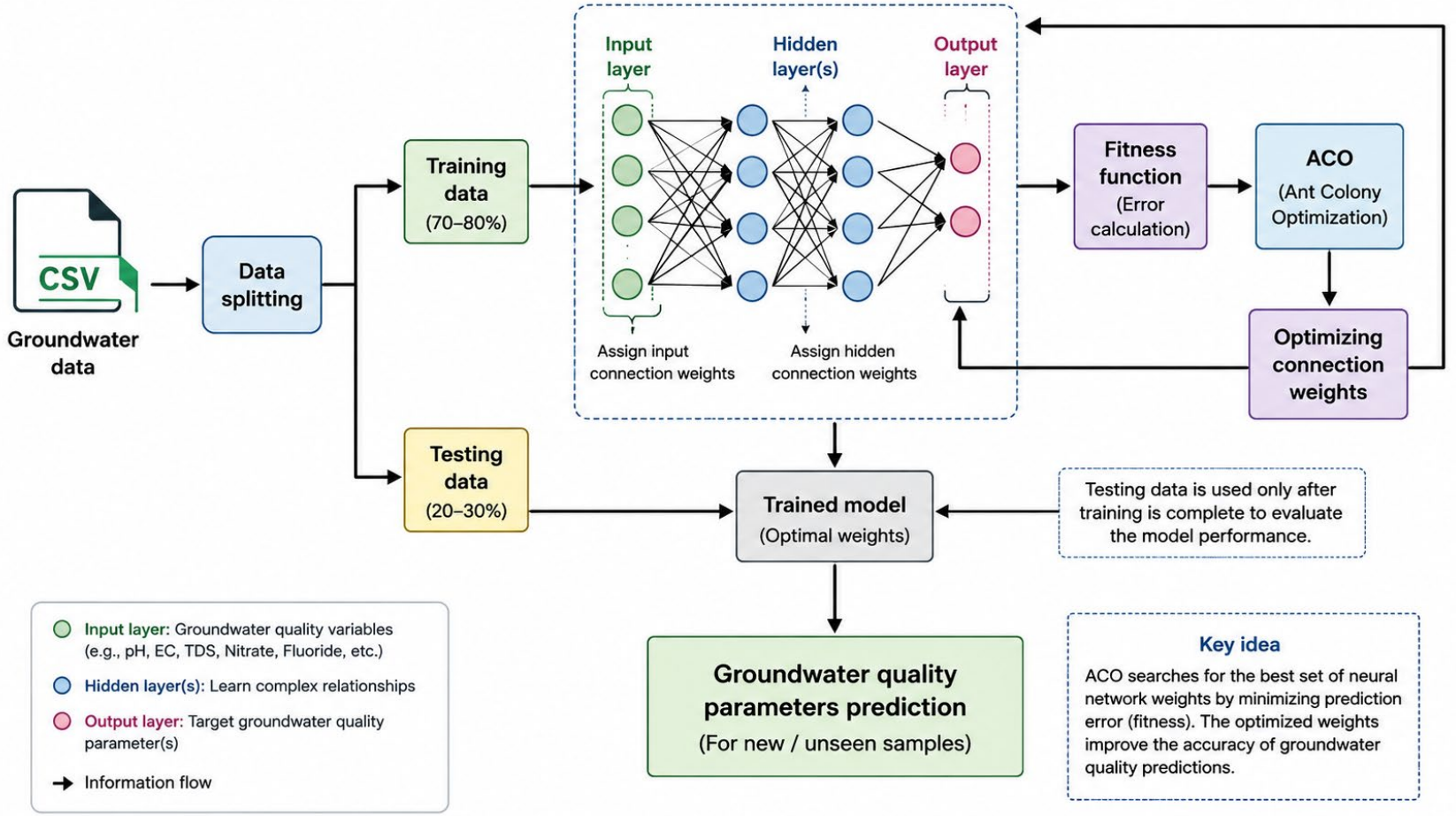
EXAMPLE 2: ML BASED ANT COLONY ALGORITHM FOR PREDICTING GROUNDWATER QUALITY

Study Area

Yadgir District, Karnataka, India

Methodology

- Once in 3 months collection and chemical analysis of groundwater from 50 wells
- ACO optimisation for prediction
- Metrics such as
- (i) R^2,
- (ii) the root mean squared error (RMSE),
- (iii) Nash–Sutcliffe efficiencies (NSE) and
- (iv) Mean Absolute Error (MAE) were used.



Bhavya, R., Sivaraj, K., & Elango, L. (2023). Ant Colony Based Artificial Neural Network for Predicting Spatial and Temporal Variation in Groundwater Quality. *Water*, *15* (12), 2222. https://doi.org/10.3390/w15122222

ML BASED ANT COLONY ALGORITHM FOR PREDICTING GROUNDWATER QUALITY

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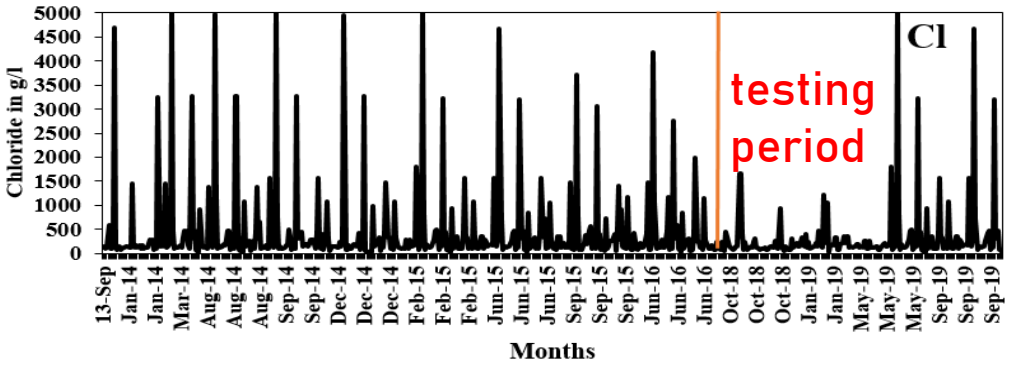
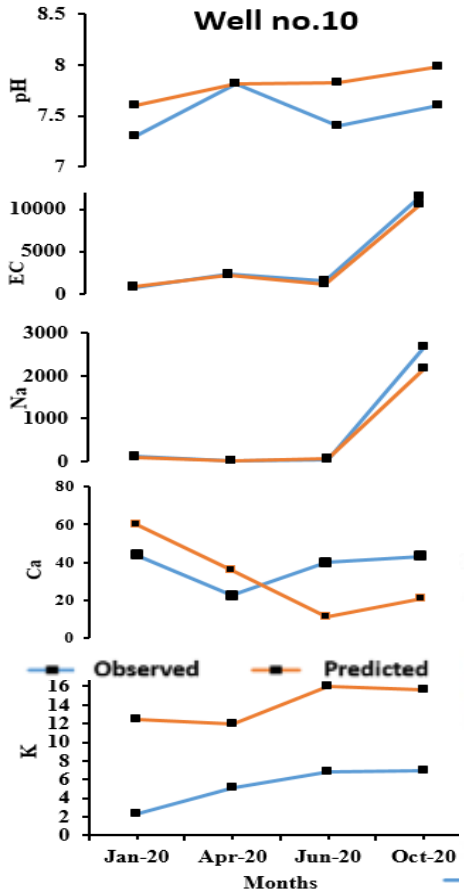
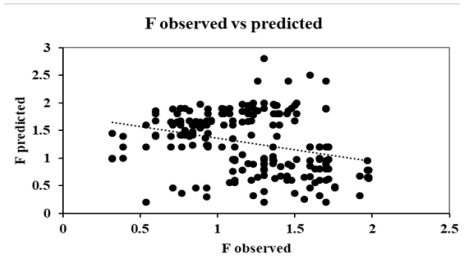
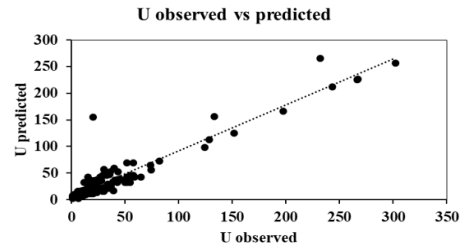
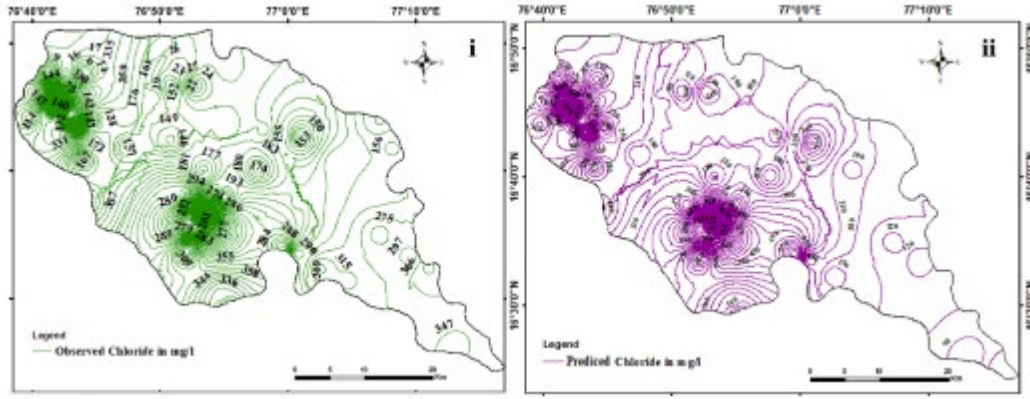


Model Performance









Key Impacts

- Efficient prediction of groundwater quality for complex datasets
- Better performance than conventional neural networks
- Adaptable to various regions and groundwater studies.

Bhavya, R., Sivaraj, K., & Elango, L. (2023). Ant Colony Based Artificial Neural Network for Predicting Spatial and Temporal Variation in Groundwater Quality. *Water*, *15* (12), 2222. https://doi.org/10.3390/w15122222

DIGITAL TOOLS – URBAN WATER MANAGEMENT

Water Evaluation And Planning WEAP

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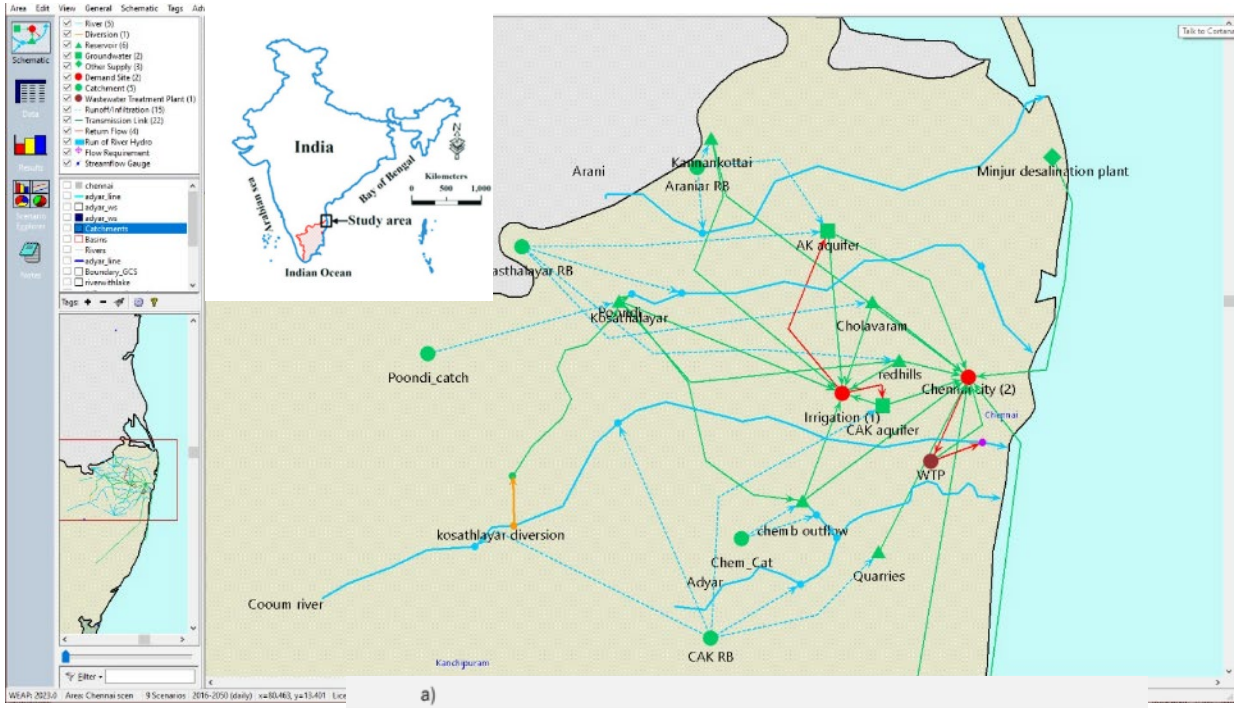

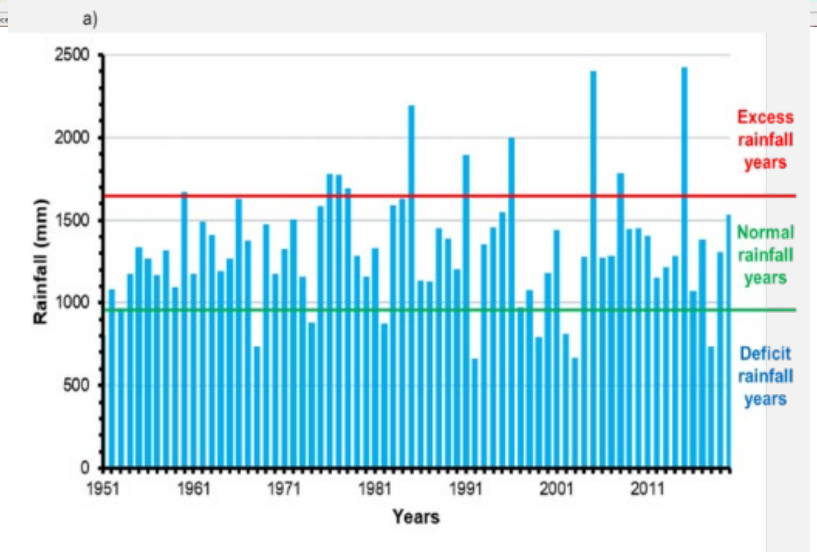

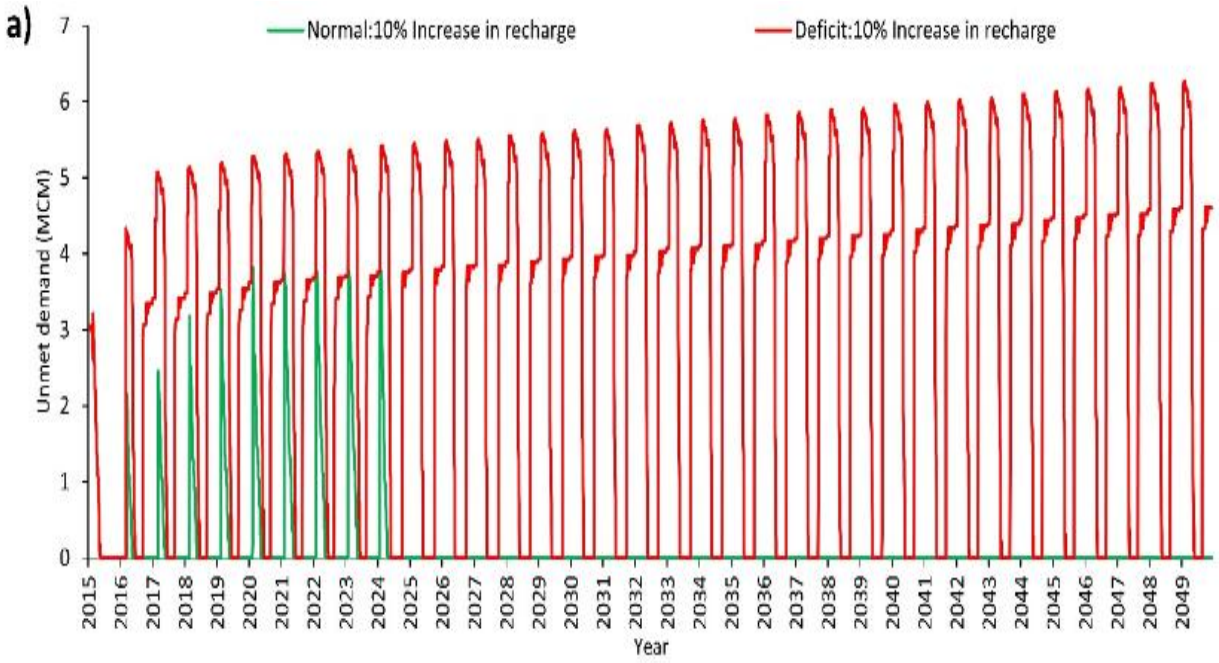

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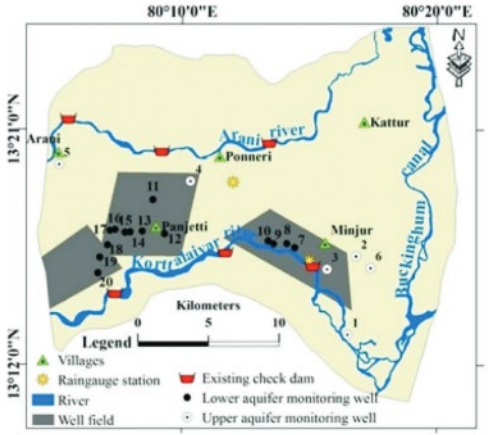
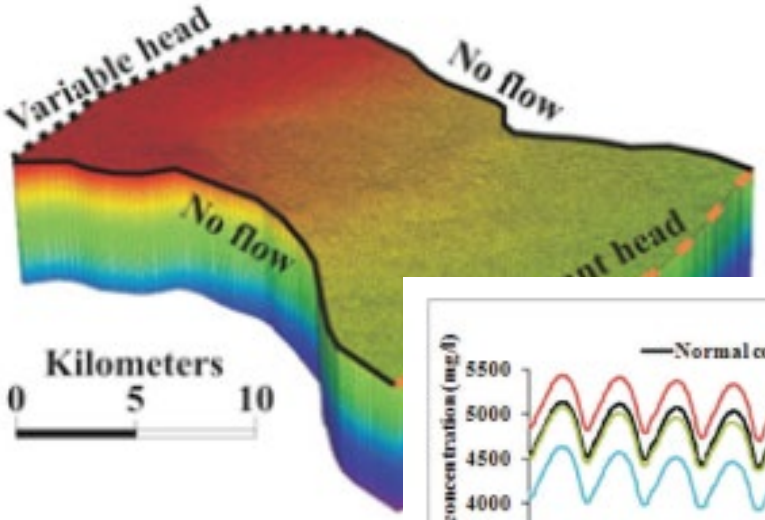
AQUA — Water Infrastructure, Ecosystems and Society Vol 00 No 0, 1 doi: 10.2166/aqua.2023.144

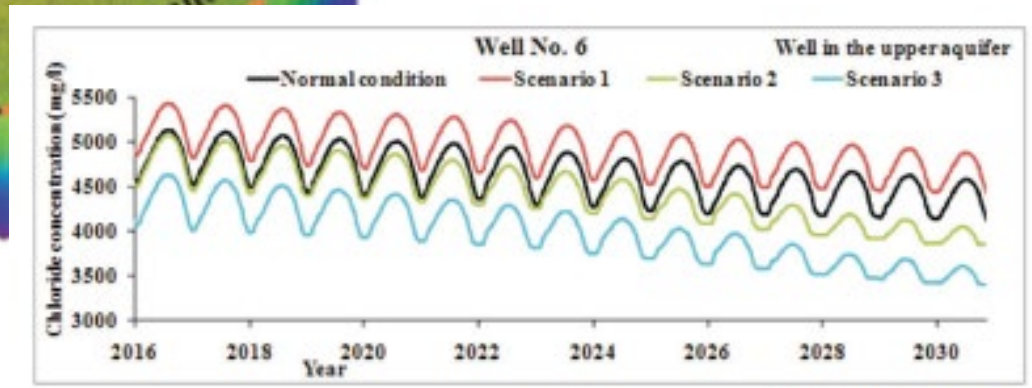
WEAP Model Based Evaluation of Future Scenarios and Strategies for Sustainable Water Management in the Chennai Basin, India

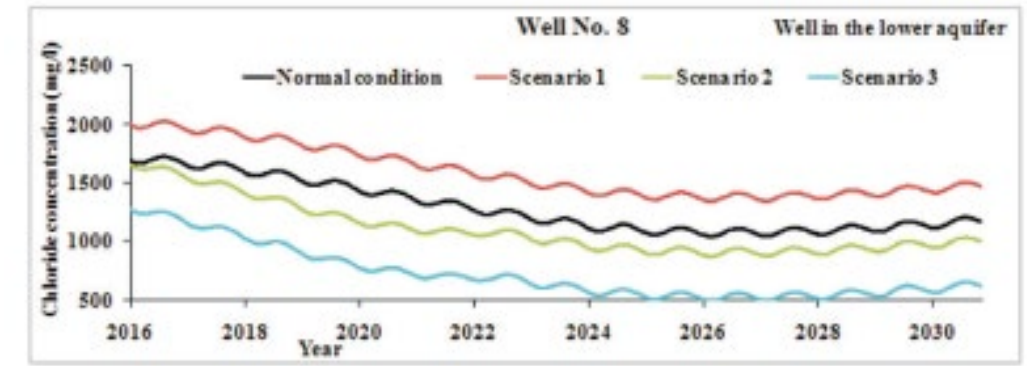
Puthan Veettil RaziSadath [a], Mariappan RinishaKartheeshwari [a] and Lakshmanan Elango [b,*]
[a] Department of Geology, Anna University, Chennai, Tamil Nadu 600025, India
[b] Hydraulics and Water Resources Engineering Group, Department of Civil Engineering, Indian Institute of Technology-Madras, Chennai, Tamil Nadu 600036, India
*Corresponding author. E-mail: elango34@hotmail.com
PVR, 0000-0002-8663-3639; MR, 0000-0003-1132-8928; LE, 0000-0002-6692-5773

MODELS TO PREDICT AND PLAN ENGINEERING SOLUTIONS









DHI

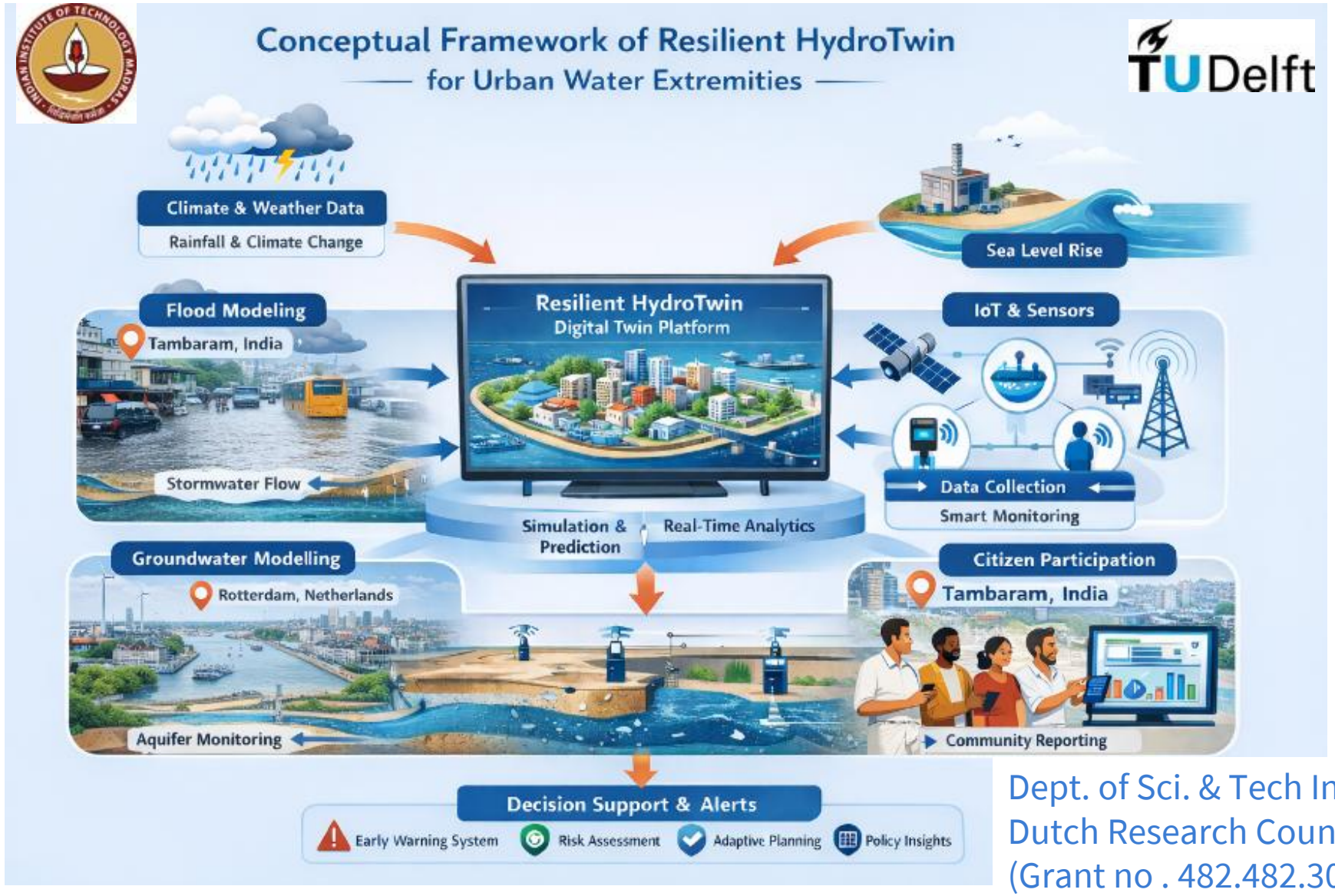
SUBSURFACE FLOW & TRANSPORT MODELLING

FEFLOW

DIGITAL TWINS

RESILIENT HYDROTWIN
FLOOD RESILIENCE
Through participatory Digital Twins

the international



6. HYDROLOGICAL & HYDRAULIC MODELS

Simulation of water cycle and flood behaviour

Hydrological Models

- Rainfall–Runoff
- Water resources & demand
- Land use change

HEC HMS | SWAT+

Hydraulic / Flood Models

- Urban drainage & sewer flow
- River flow routing
- Flood inundation & depth

HEC RAS | MIKE FLOOD

Other Supporting Models

- Reservoir operation
- Water quality (when required)
- Groundwater (as needed)

MODFLOW | Delft3D D-Flow

* Specific models can be selected based on city data and application needs.

Dept. of Sci. & Tech India (DST)
Dutch Research Council (NOW) Cooperation|
(Grant no . 482.482.302)

THANK YOU

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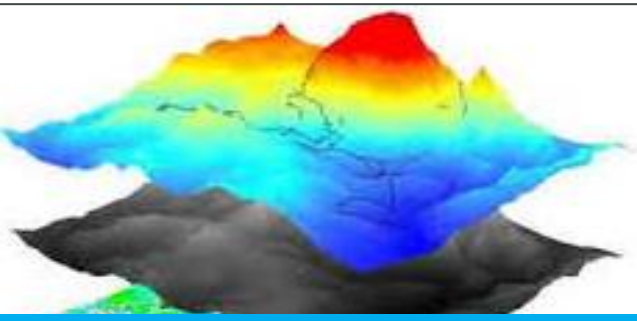

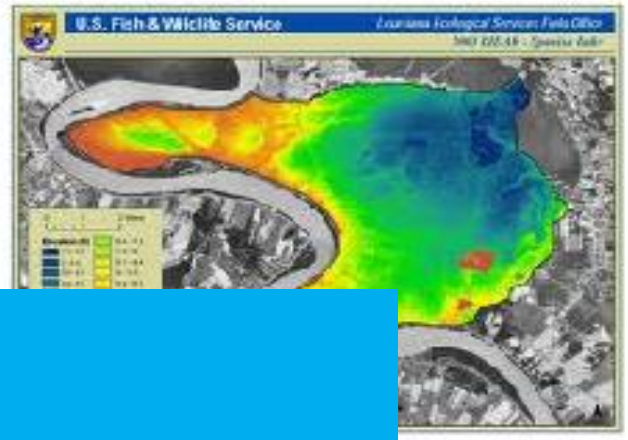

Making the Invisible Visible – Technologies for Groundwater Management

Urdhvam Environmental Technologies Pvt. Ltd.
- A Groundwater Sustainability, Technology & Products Company

Rahul Bakare
Founder & CEO

inspiring change

URDHVAM

PROBLEM : GROUNDWATER DEPLETION & DRYING UP WELLS

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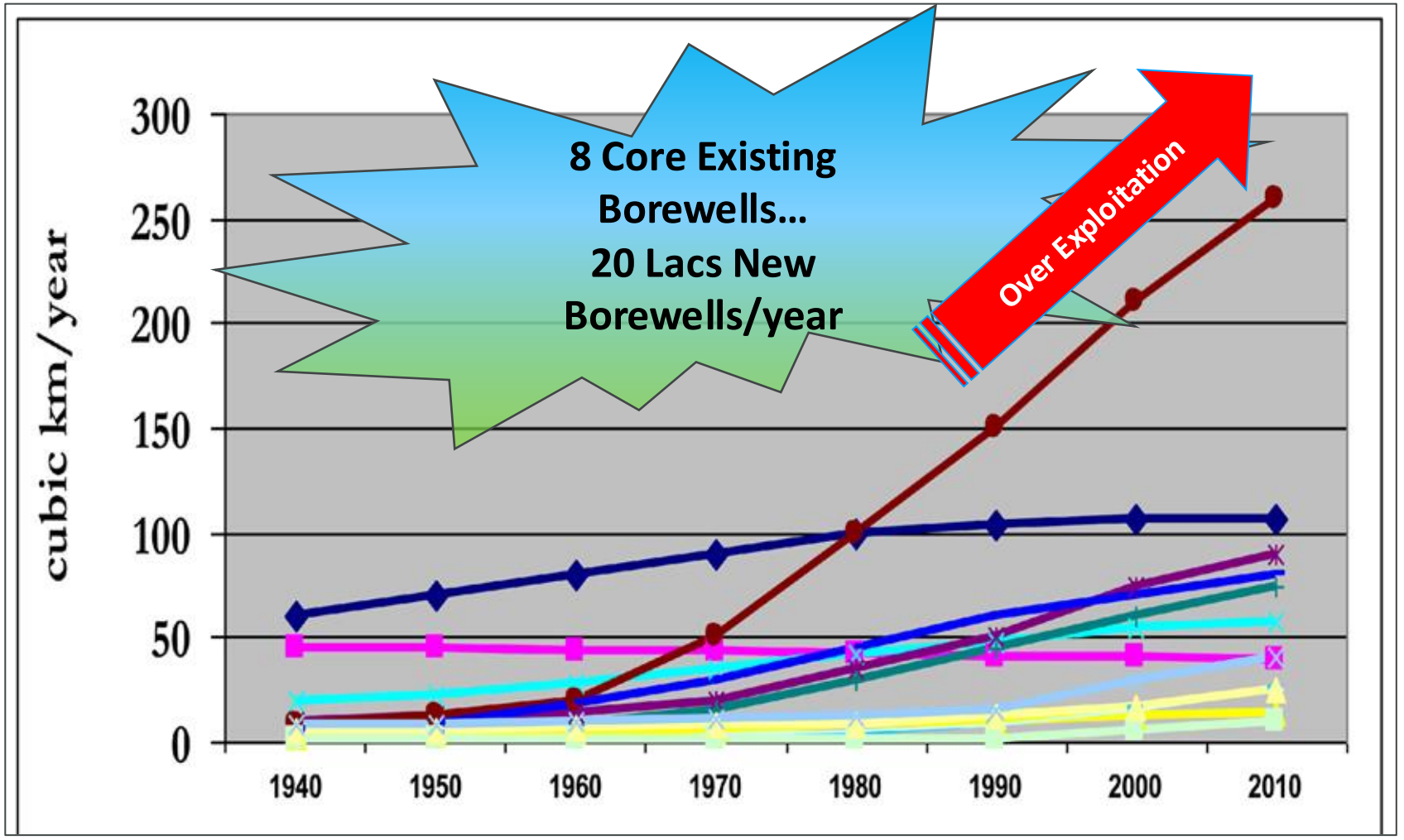

ADVERSE SOCIO – ECONOMIC IMPACTS OF DRY BOREWELLS

MARKET MAP & GAP ANALYSIS

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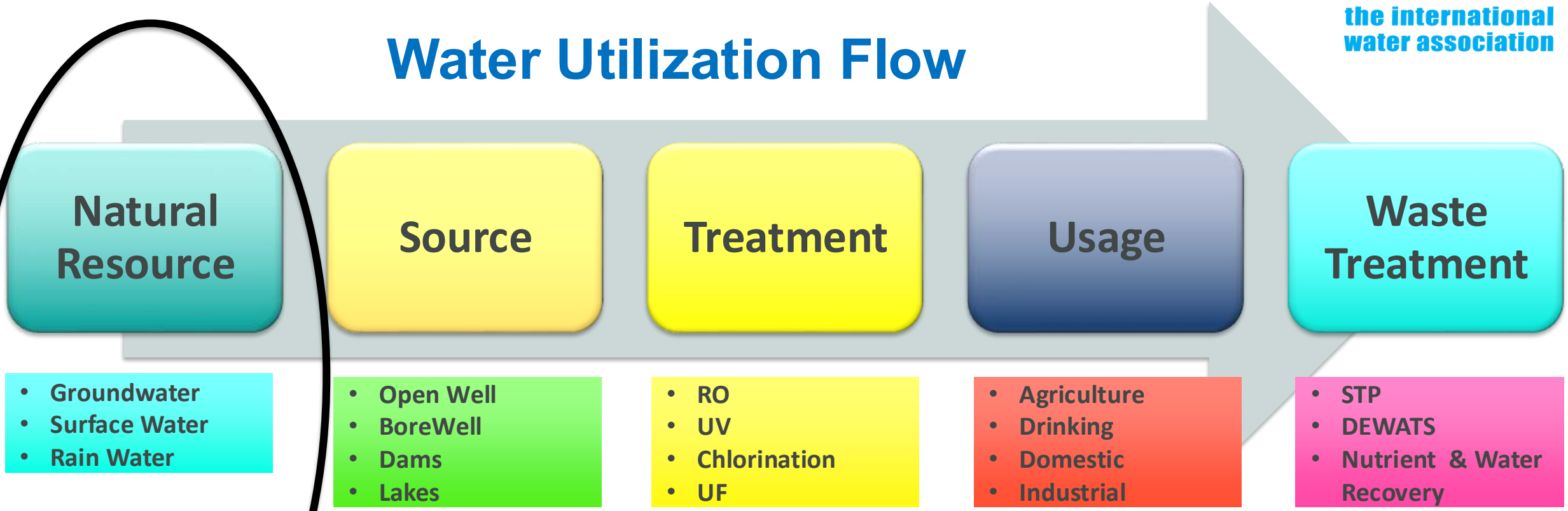
Water Utilization Flow



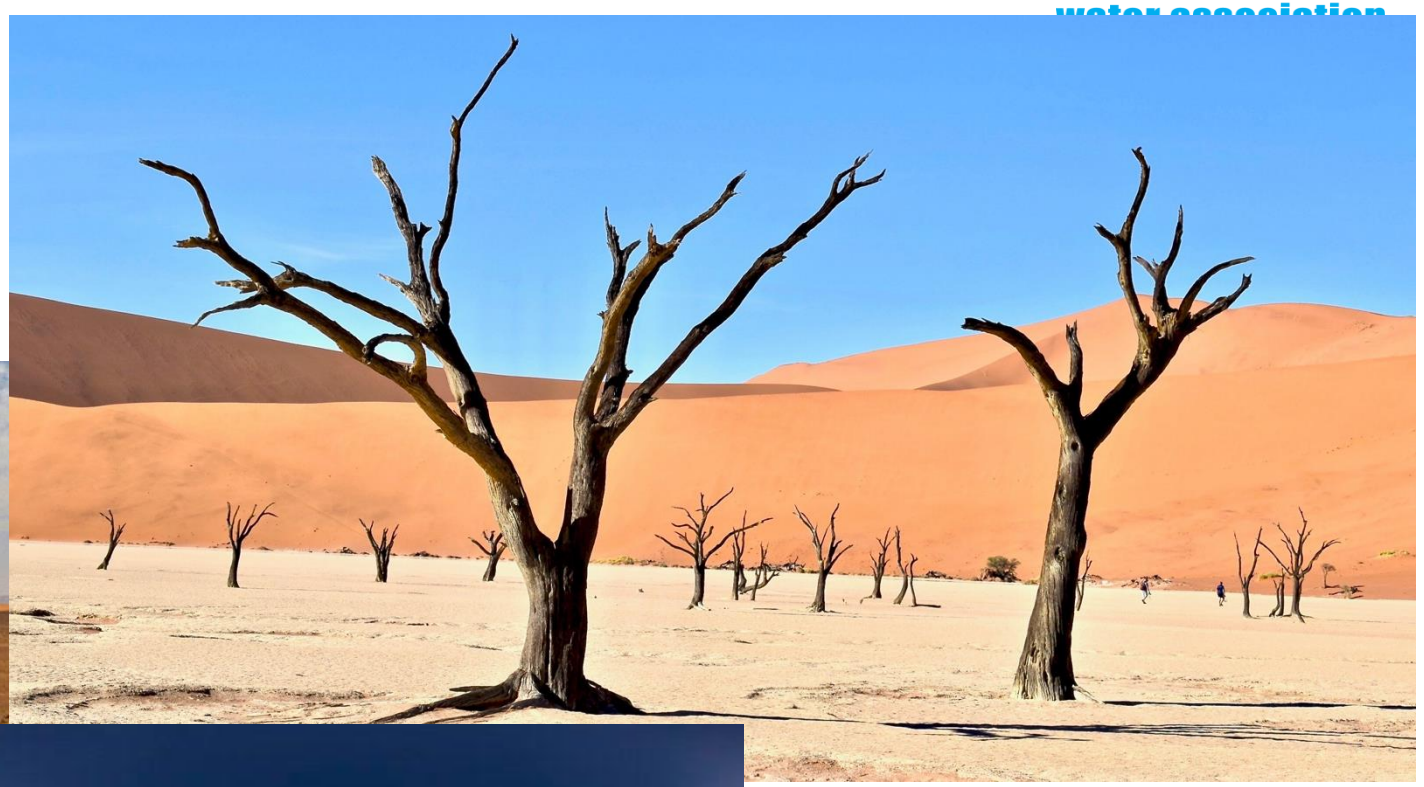
Urdhvam's Offerings

IT, IoT, Robotics, Mobile, Technology

Crowded Engineering Products Space

WHY GROUNDWATER ???

WATER AS A PROBLEM – DROUGHTS & DESERTIFICATION



GROUNDWATER & AFFORESTATION

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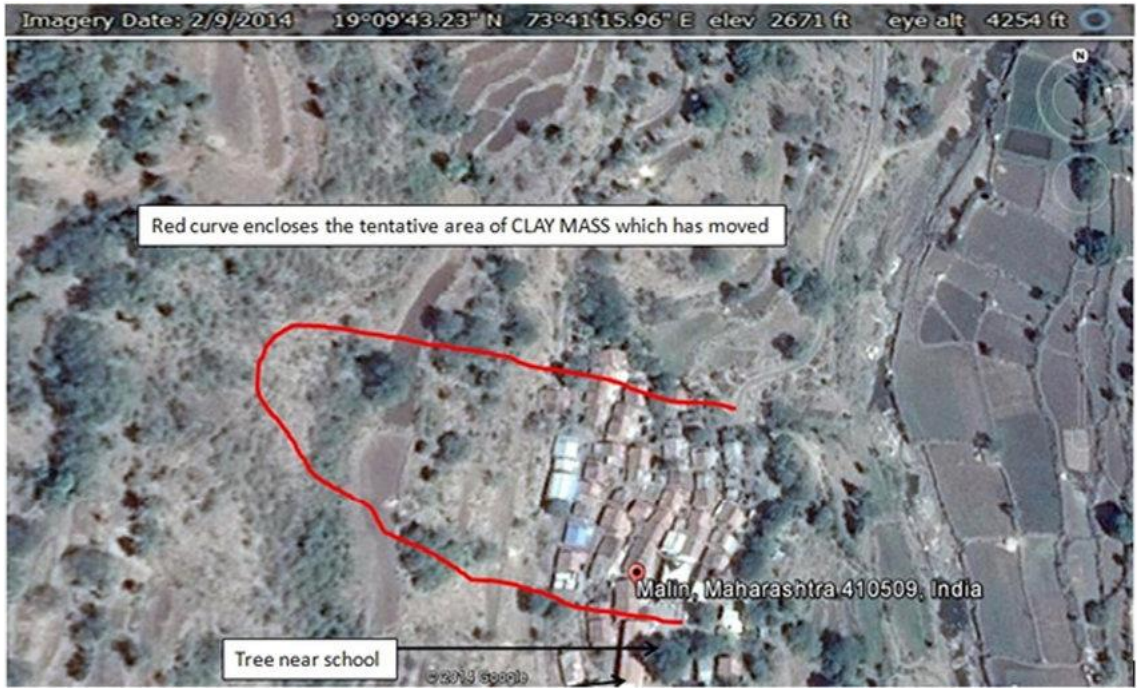
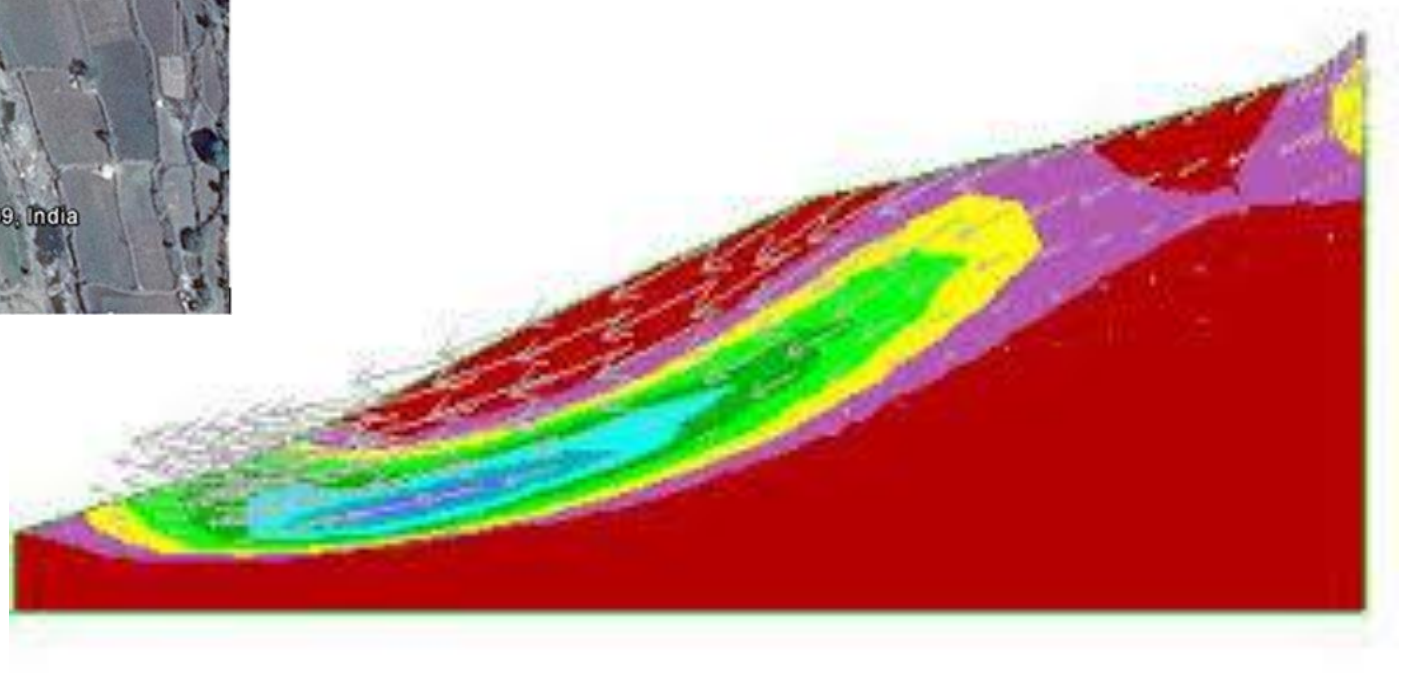
DRIED UP RIVERS

WATER AS A PROBLEM – CONSTRUCTION - ROADS

MALIN LANDSLIDE NEAR PUNE

MALIN LANDSLIDE NEAR PUNE





WATER AS A PROBLEM – CONSTRUCTION – SINK HOLES

WATER AS A PROBLEM – CONSTRUCTION – FOUNDATION

WATER AS A PROBLEM – SUBSIDENCE

WATER AS A PROBLEM – CONSTRUCTION – FOUNDATION

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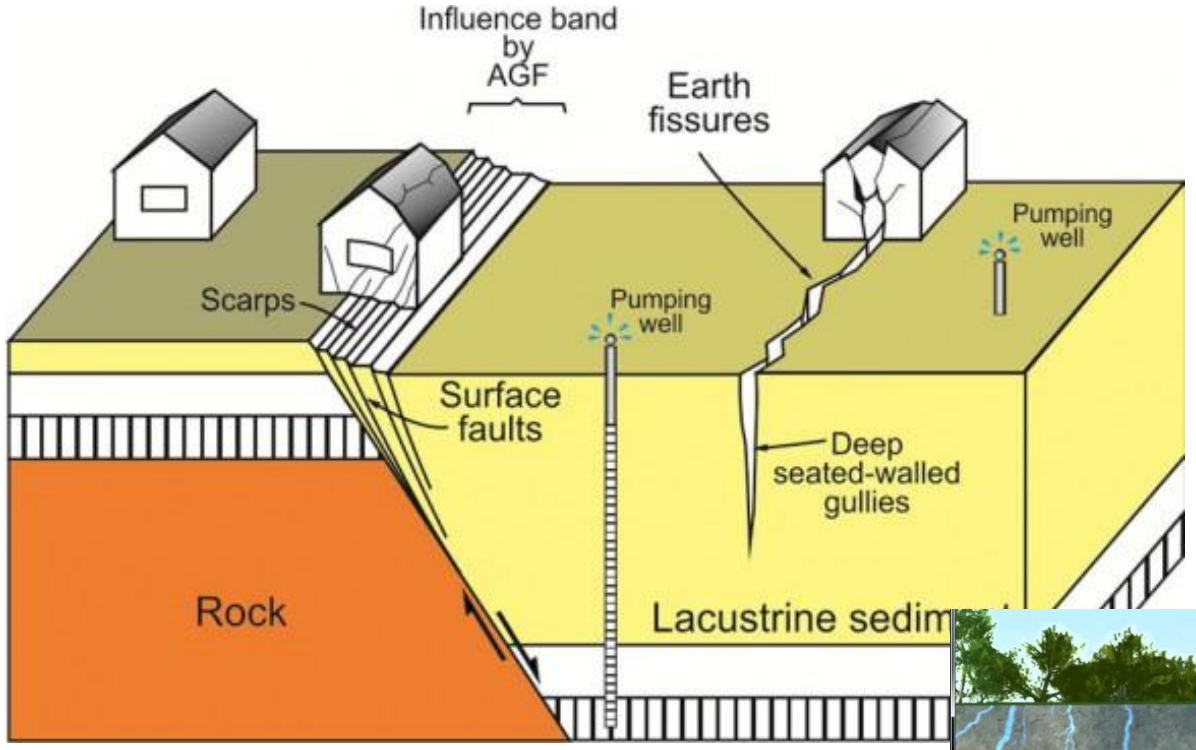
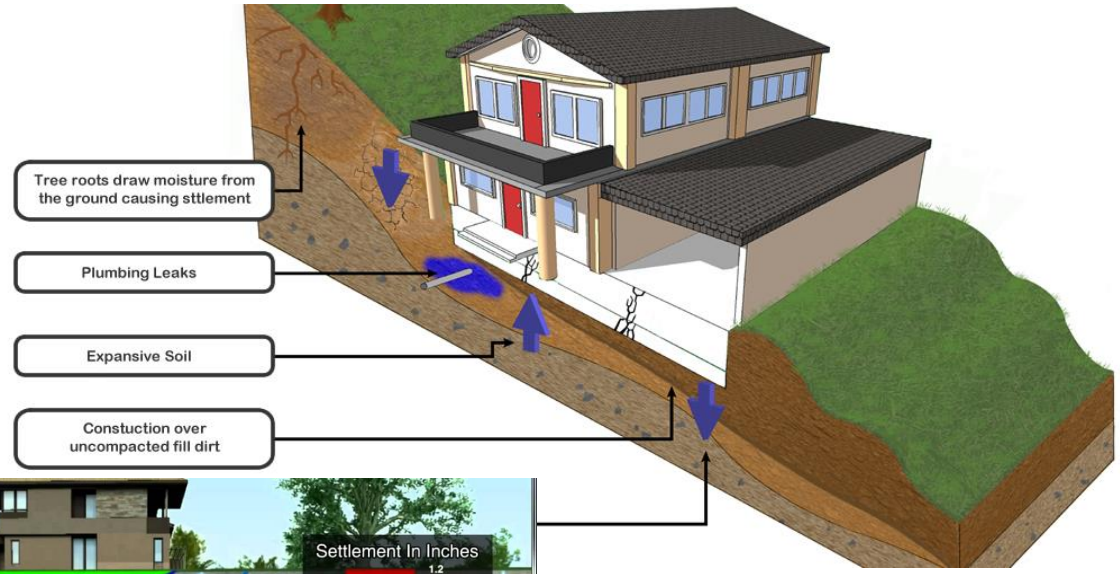
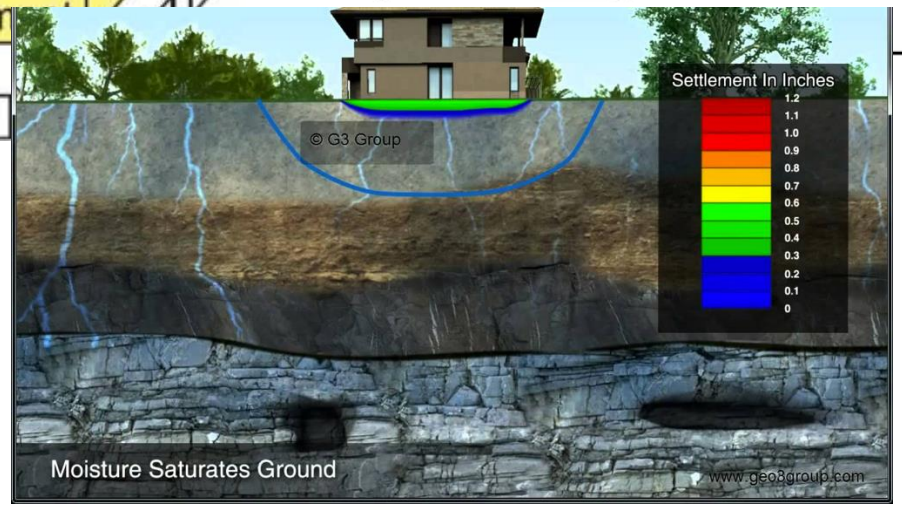
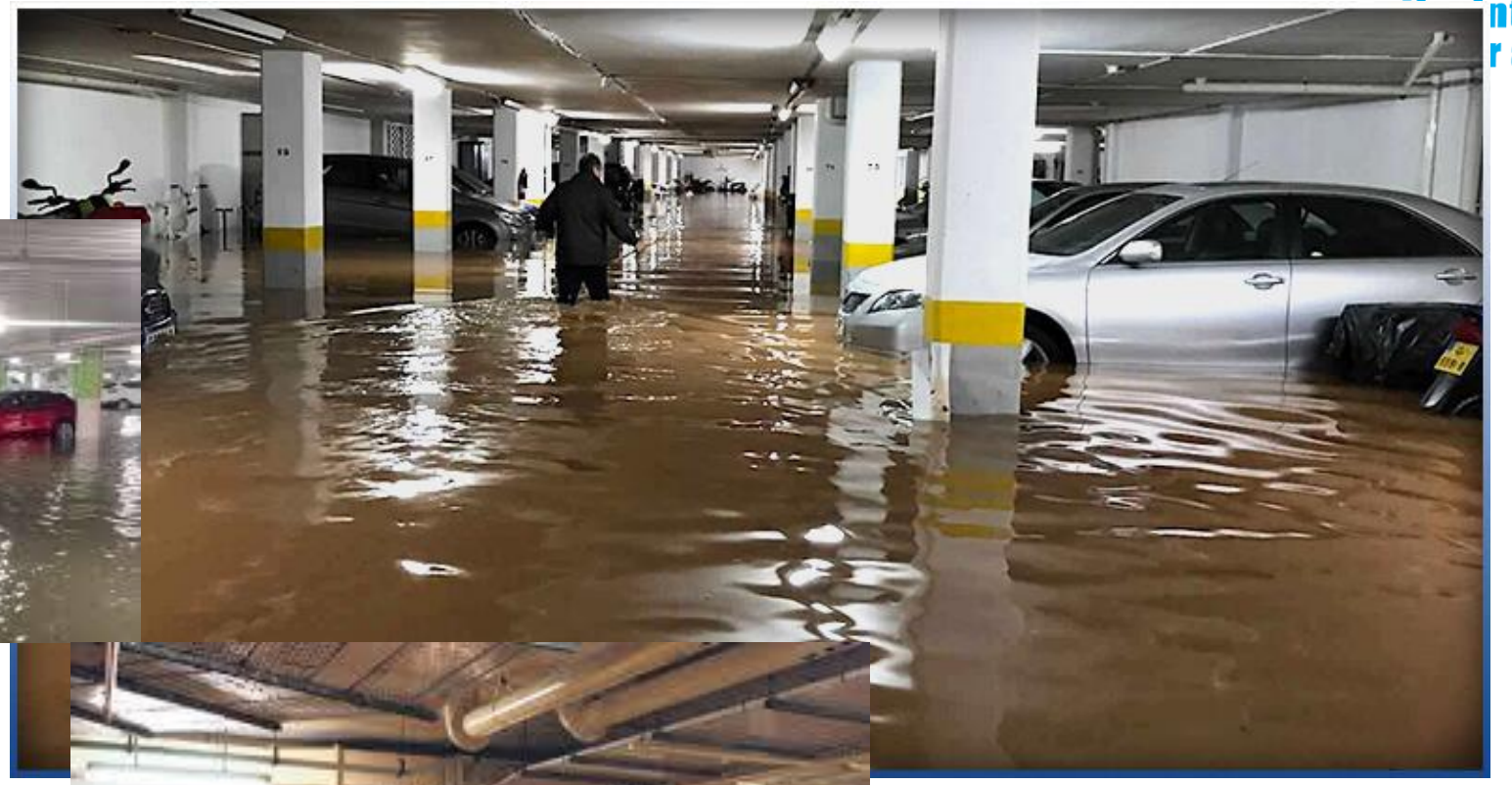


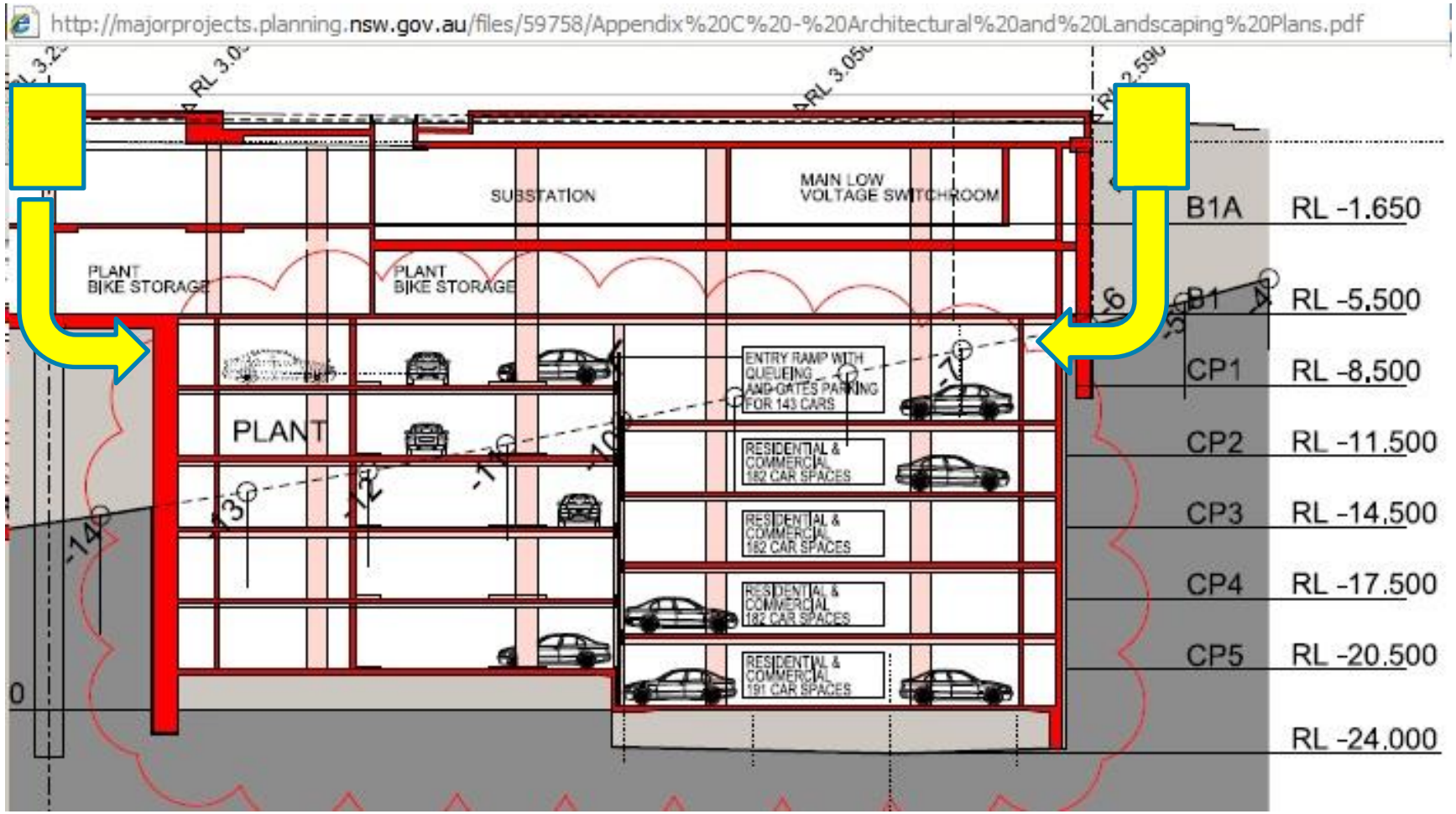




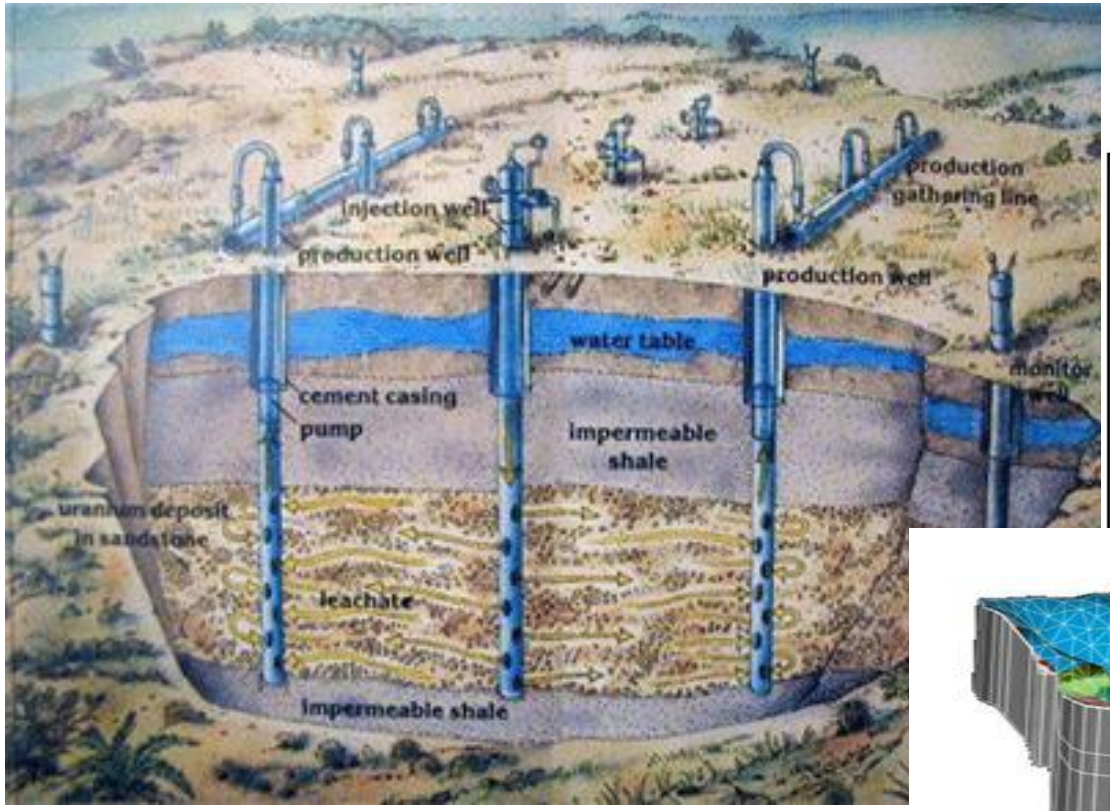
WATER AS A PROBLEM – CONSTRUCTION – BASEMENTS

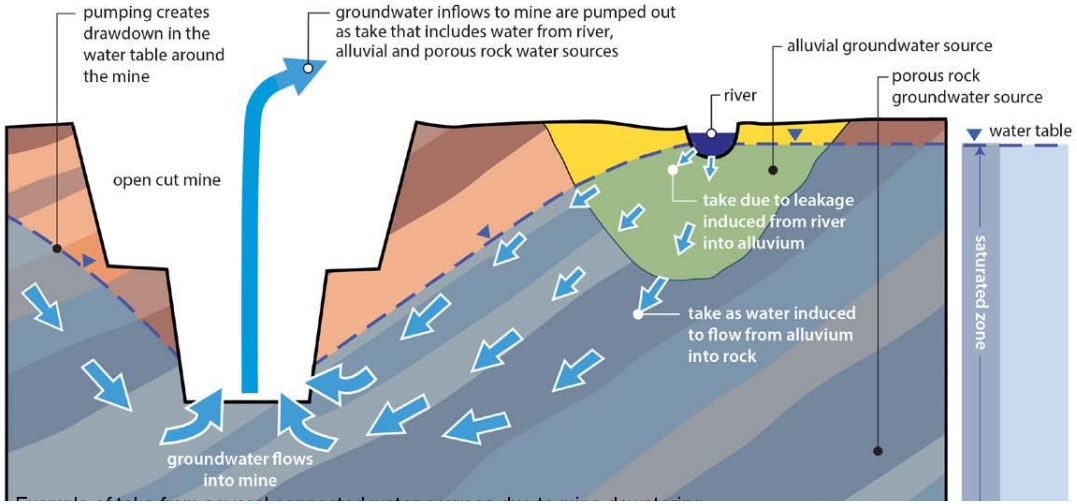


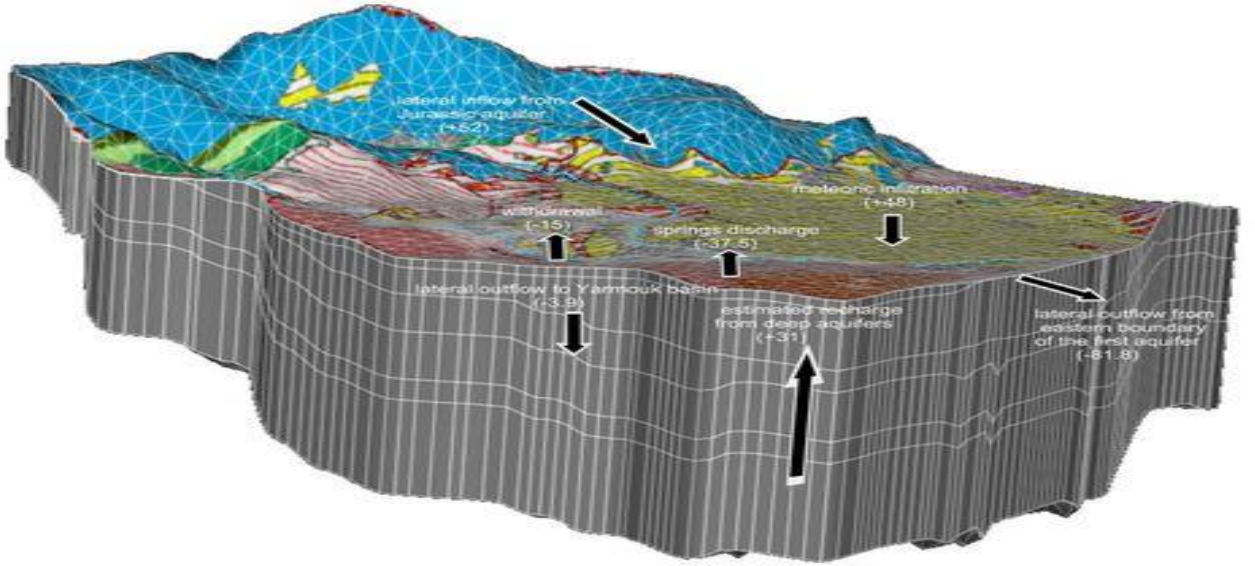
WATER AS A PROBLEM – CONSTRUCTION – BASEMENTS



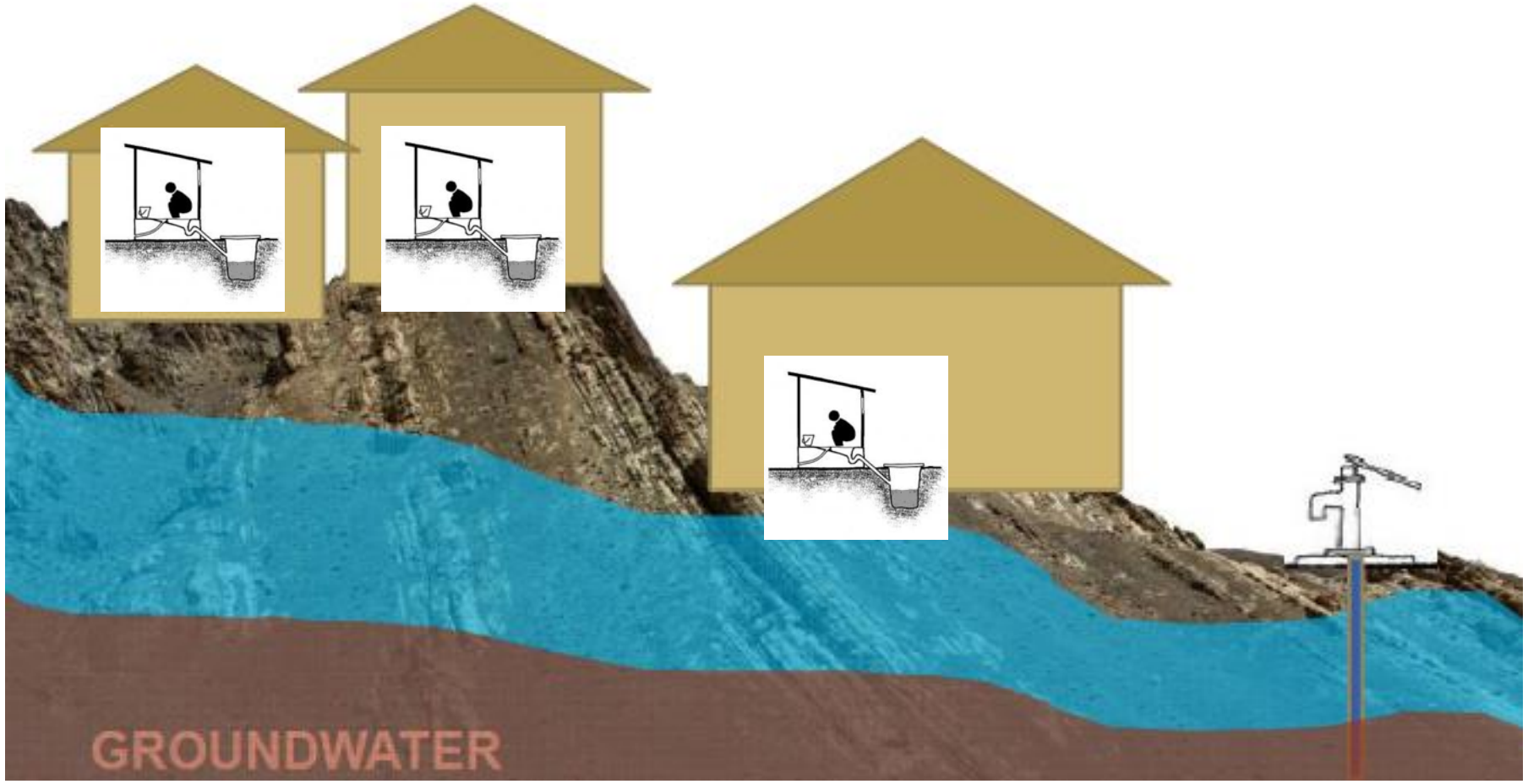
WATER AS A PROBLEM – MINING



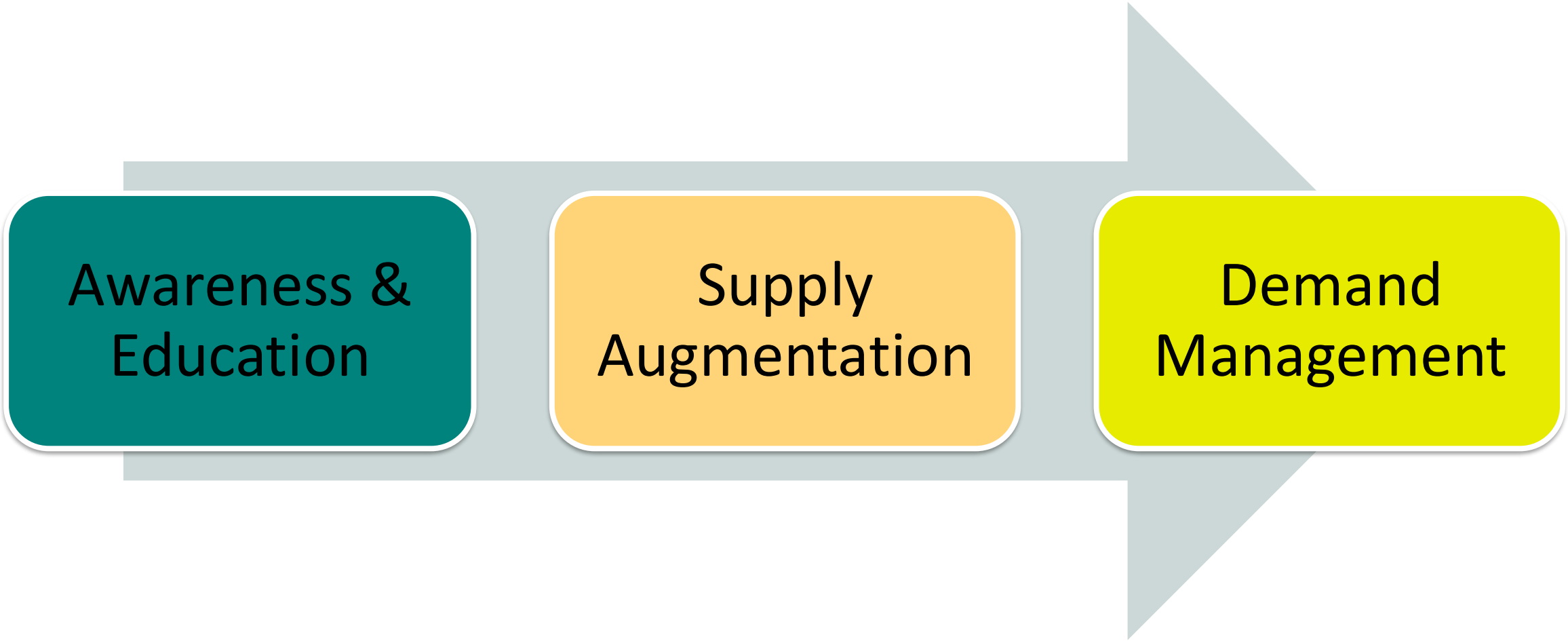




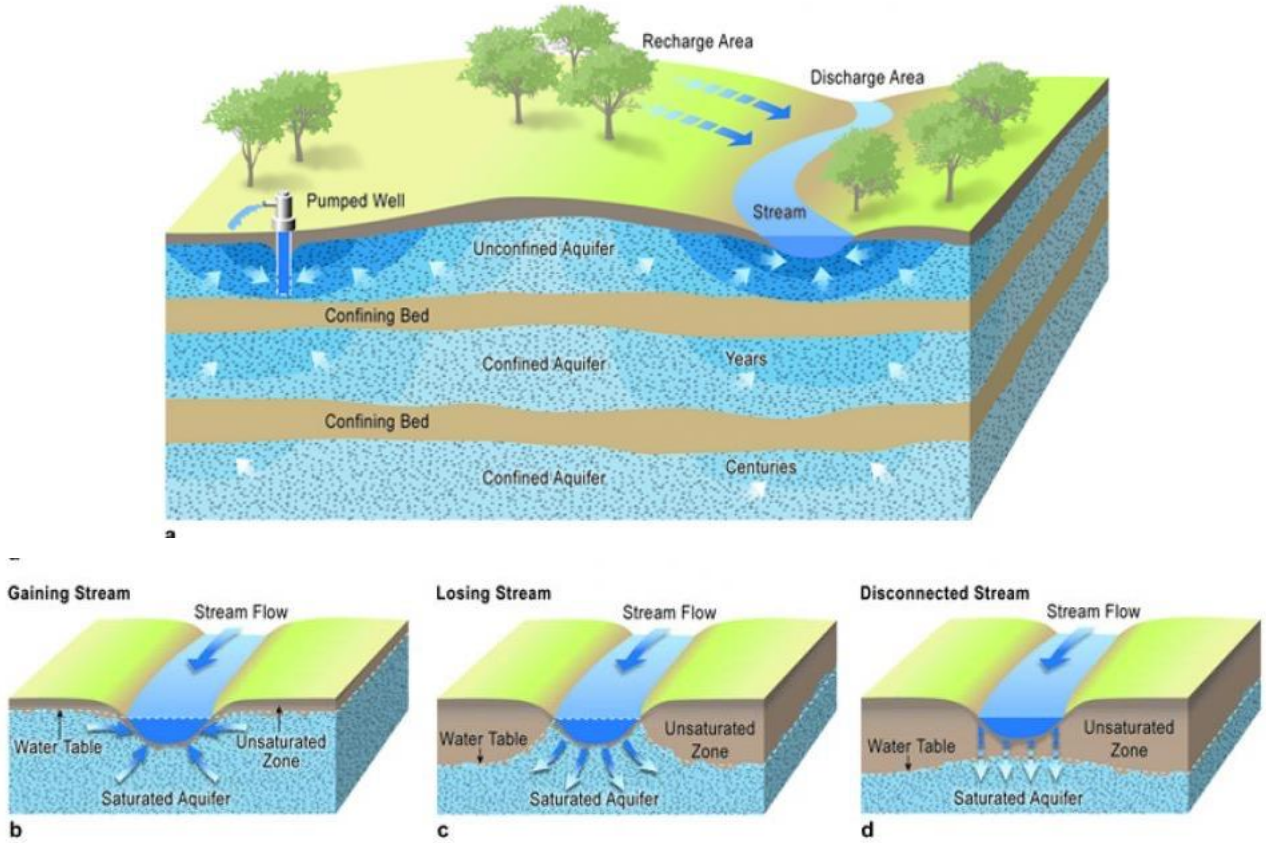
Groundwater & Sanitation - Aquifer Typology & Toilet Design



GAPS IN GROUNDWATER DOMAIN



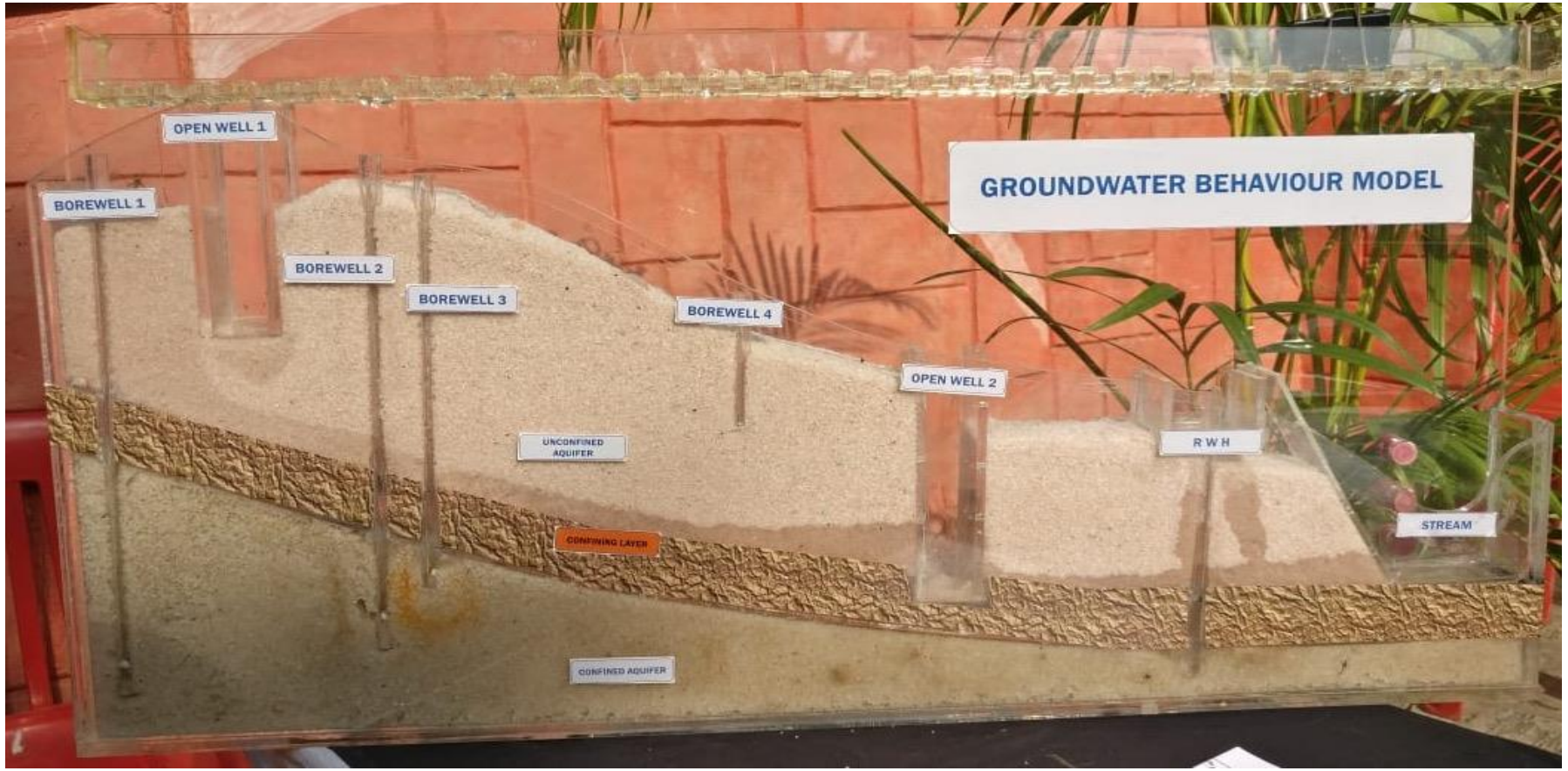
AWARENESS & EDUCATION



Gamified Visualization for Education & Awareness Generation on Groundwater Behavior

GROUNDWATER SIMULATOR

- **Features :** 17 Scenarios, Gamified Education, Enhanced Understanding, Reusable
- **Benefits to Customers : Farmers, Schools & Colleges, Gram Panchayats, Government Departments**
  - Improved Understanding of Groundwater Behavior
  - Science based Decision Making
  - Increased Income



SUPPLY AUGMENTATION

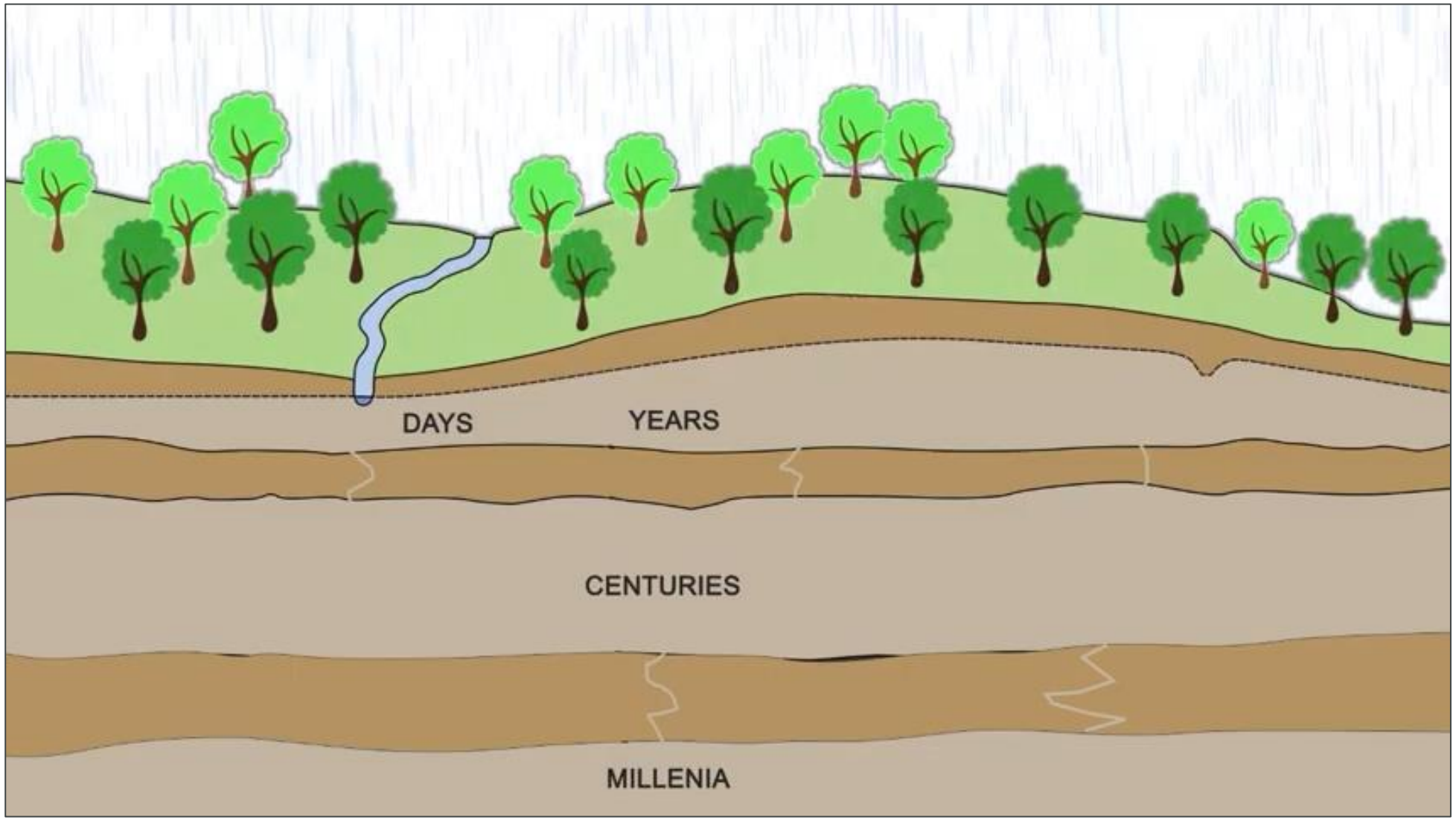
Patented Smart Rain Water Harvesting (RWH) Technique that Recharges & Revives "Existing" Low Yielding or Dry Borewells

www.borecharger.com

BORECHARGER - PATENTED, UNIQUE & SMART RWH

the international water association

Animation Video- https://www.youtube.com/watch?v=vP-HI-gH5qA



Bore++ Charger

BORECHARGER – SUCCESSFUL IMPLEMENTATIONS

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Bore++ Charger

REAL WORLD PROBLEMS FACED & IMPACT OF BORECHARGER

the international water association

Nabi Saab - Farmer

Borewell water level 450 ft >> 150 ft
Pumping of 1 hr/day >> 6 hr/day
Low Agriculture Income >> 85%

Shivaji Suryavanshi - Sarpanch

Pumping of 30 mins/day >> 4 hr/day
Village Water Insecurity >> Security

Rakesh Koti - Urbanite

Pumping of 15 min/day >> 3.5 hr/day
Borewells 3 Dry >> Started Yielding
Purchase Tanker Water >> Saved Rs 6 L/yr

Bore++ Charger

Audio Visual References and Testimonials

Video Links:

- BoreCharger YouTube Channel https://www.youtube.com/channel/UC13cTbjVsapVAFsK7bx5N0A
- How BoreCharger Works ? Animation Video- https://www.youtube.com/watch?v=vP-HI-gH5qA
- BoreCharger For Farmers: https://www.youtube.com/watch?v=_nBMgkd8Axk
- BoreCharger for Industries, Townships: https://www.youtube.com/watch?v=FDqTxbNHHMc&t=103s
- Evidence of BoreCharger Impact: https://drive.google.com/open?id=14970GSDKpsVMCPQCTH940lYAYm5pKMBL

Testimonial Video Links:

- Mr. Nabi Testimonial with Video (Hindi)- https://www.youtube.com/watch?v=7JFXTgpya8k&t=5s
- Organo Naandi Testimonial with Video (English)- https://www.youtube.com/watch?v=NiWYZoPTWtE&t=4s
- Mr. Suryawanshi Testimonial with Video (Marathi)- https://www.youtube.com/watch?v=hovytiTdhqM
- Mr. Veera Reddy Testimonial with Video (Kannada)- https://www.youtube.com/watch?v=bFsXmib8er8&t=14s
- BoreCharger Testimonial (All Merged)- https://www.youtube.com/watch?v=giRO6F0z6JA

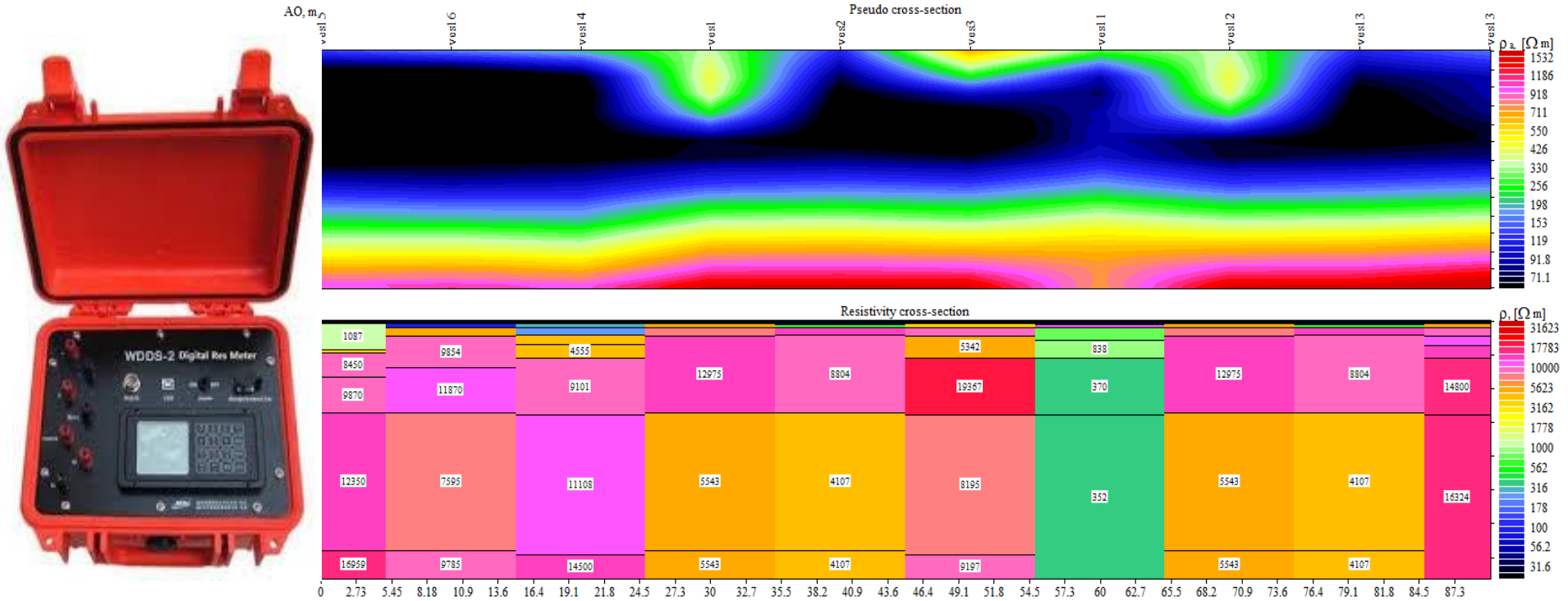
SOCIO-ECONOMIC-ECOLOGICAL IMPACT OF BORECHARGER:

the international water association

- Increases recharge of borewells **4 to 20 times** that of natural recharge
- Depending upon the hydrogeology of the location BoreCharger induces artificial injection recharge of between **2 Lac to 80 Lac Litres** of rainwater in the borewell/year
- Increase in duration of water supply by **Additional 1 to 6 more months**
- Improved irrigation & drinking water **Quantity & Quality**
- **95% success rate** in revival of failed and low yielding borewells
- **Lesser vulnerability of farmers** due to weather shocks
- **Reduced pumping energy costs** and competition for water
- **Improved farm output** productivity, production and farm income
- **Reduced cost of tanker water** supply and water treatment for urban population

Bore++ Charger

SOURCE IDENTIFICATION & AQUIFER MAPPING



Scientific Groundwater Mapping

GROUNDWATER SCANNING SERVICES – VES

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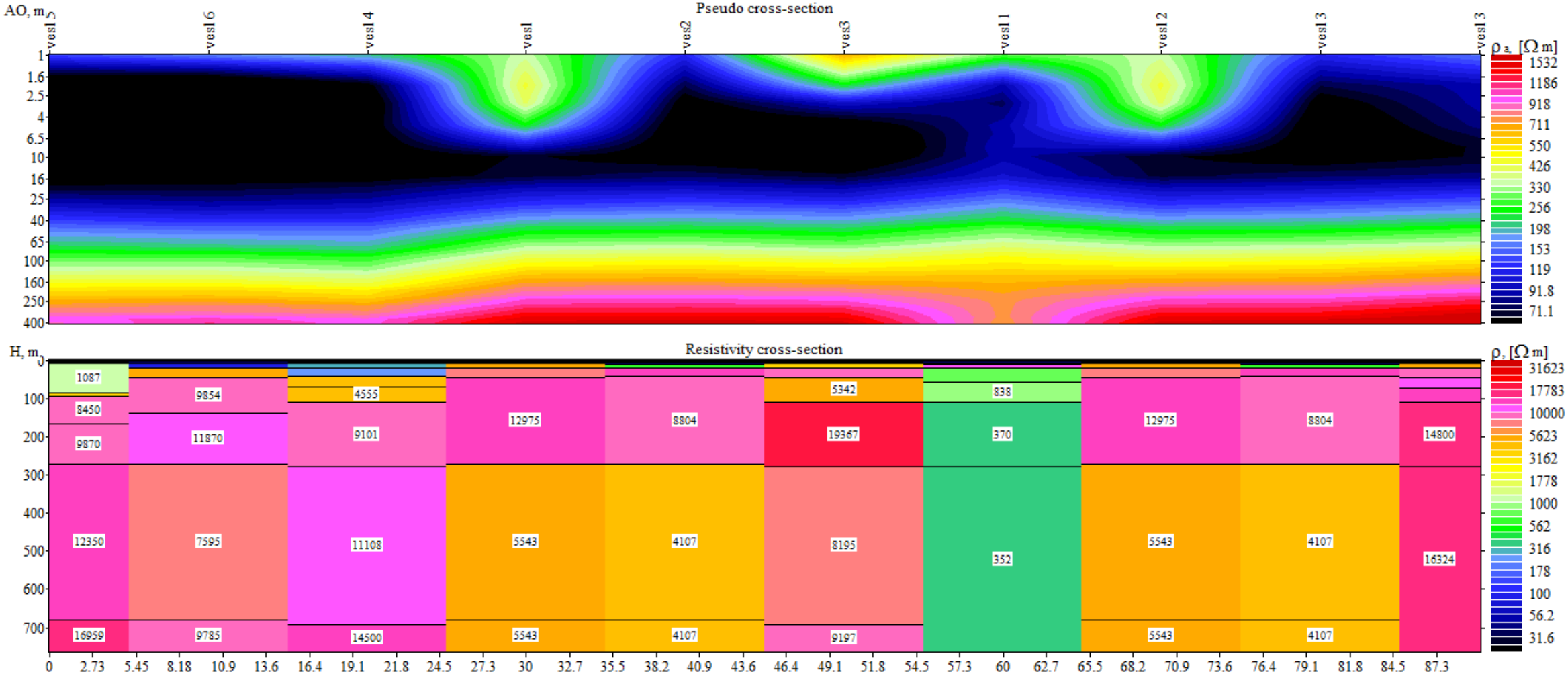

Bore++ Charger

SUGGESTED INTERVENTIONS AT HYDROGEOLOGICALLY APPROPRIATE LOCATIONS

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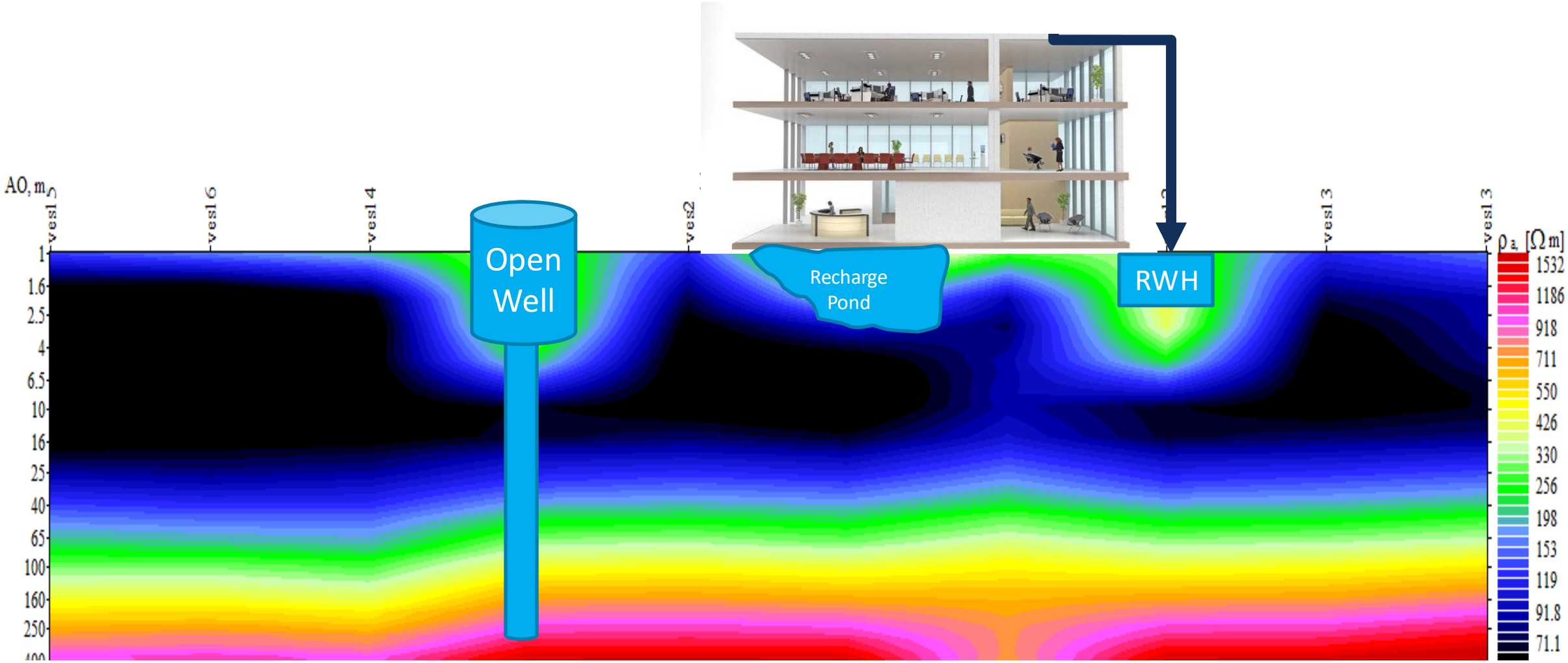

GROUNDWATER SCANNING SERVICES – GEOMAGNETIC TECHNOLOGY

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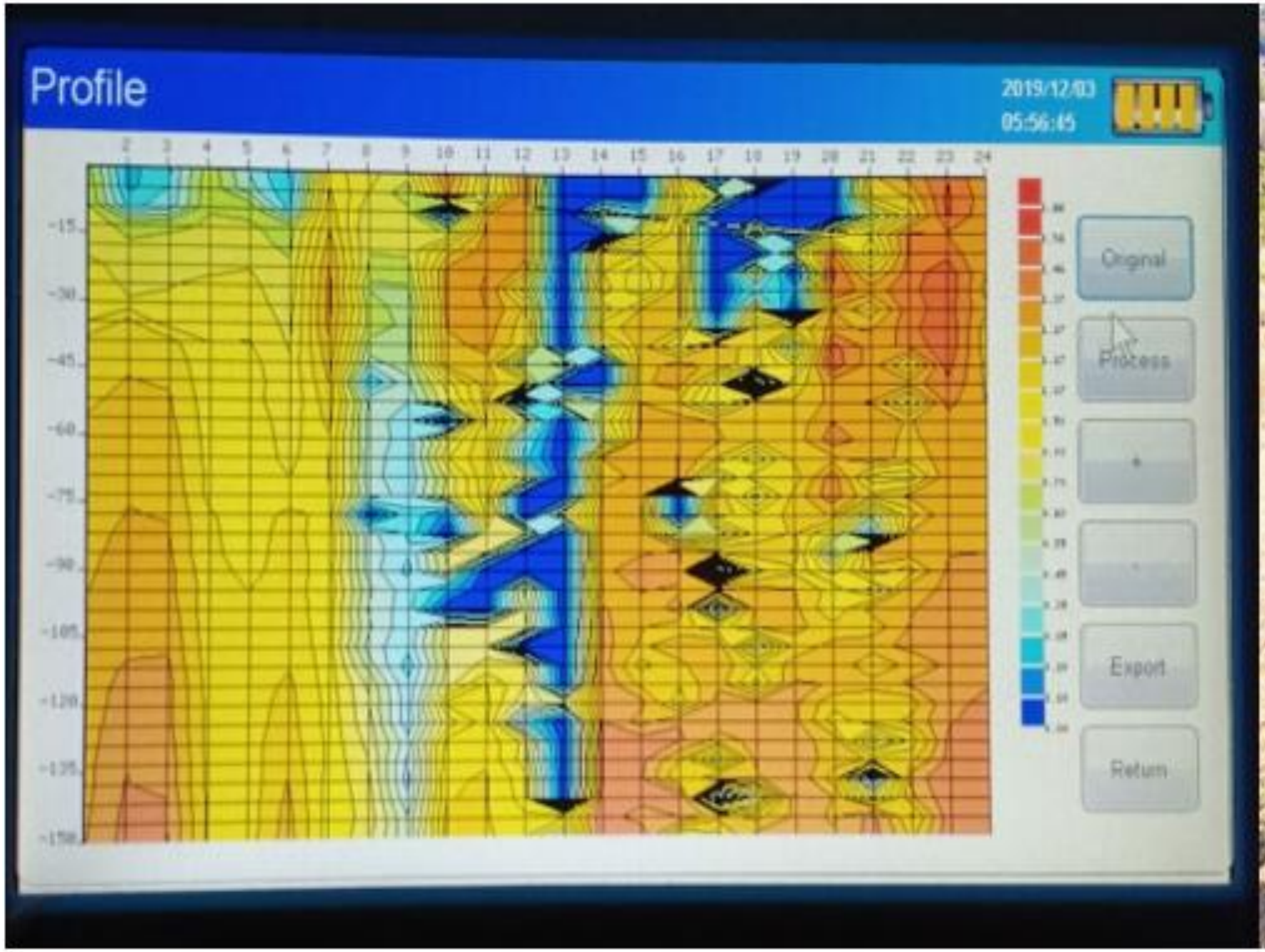

Bore++ Charger

DEMAND MANAGEMENT

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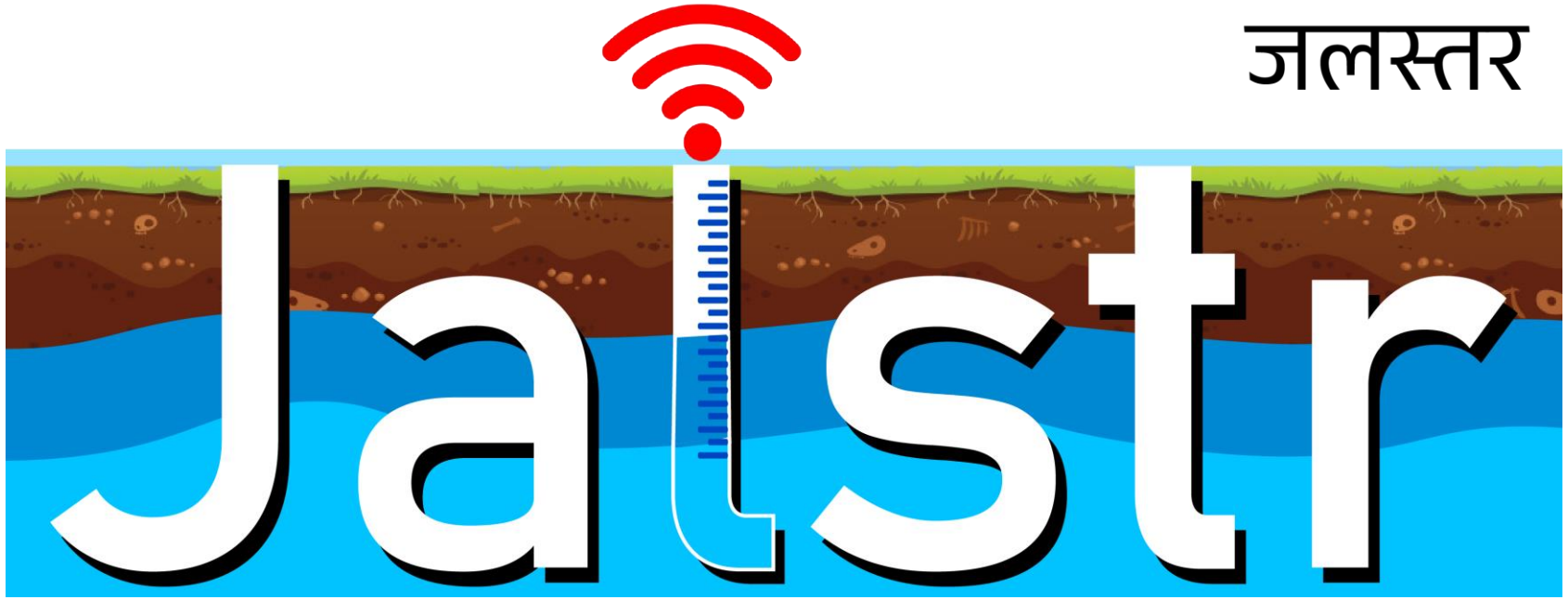


www.jalstr.com

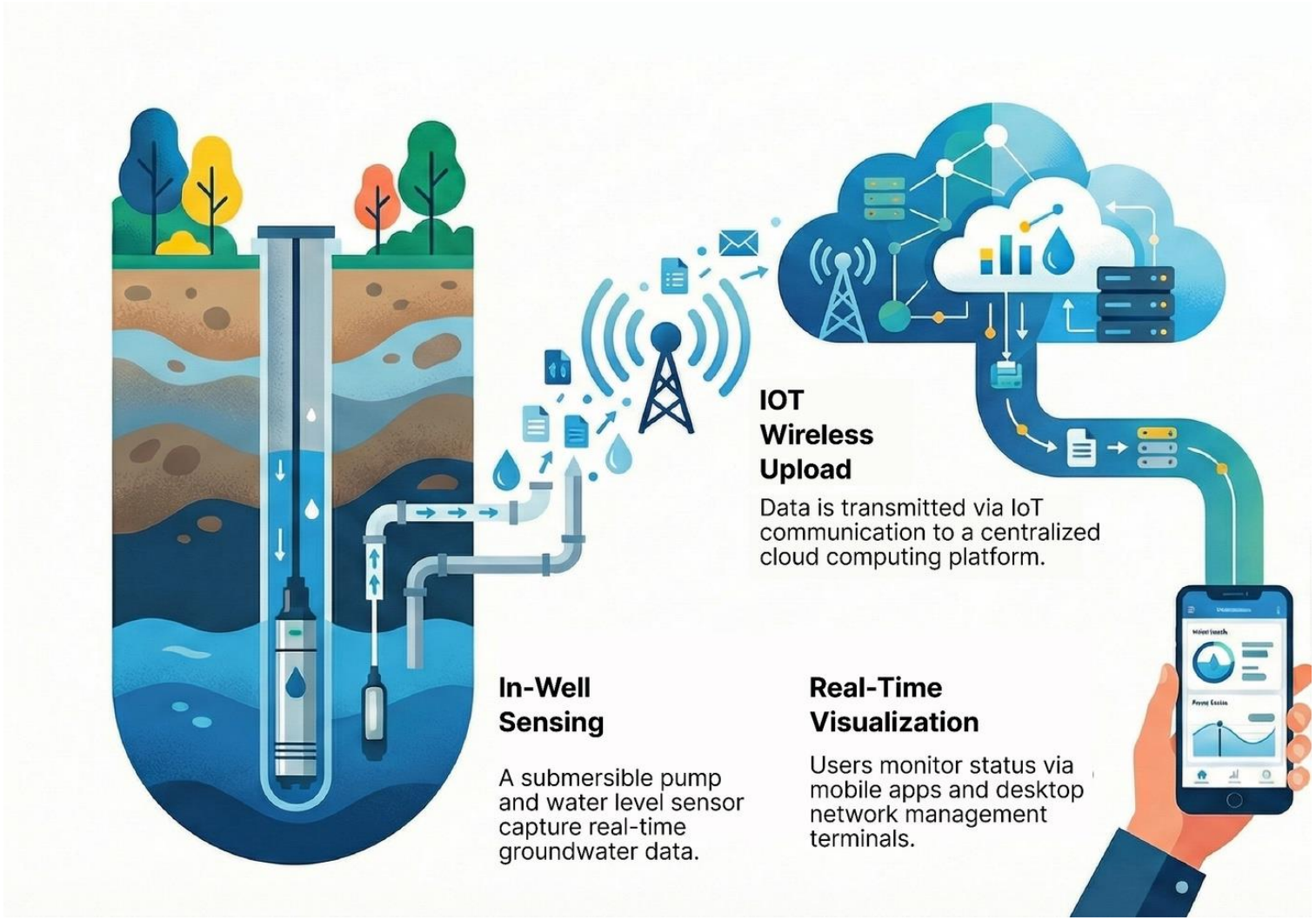
Scientific Groundwater Measurement & Prediction

Jalstr – Digital Water Level Recorder

An IoT based piezometer for Real-time high frequency groundwater data.

Jalstr – Digital Water Level Recorder

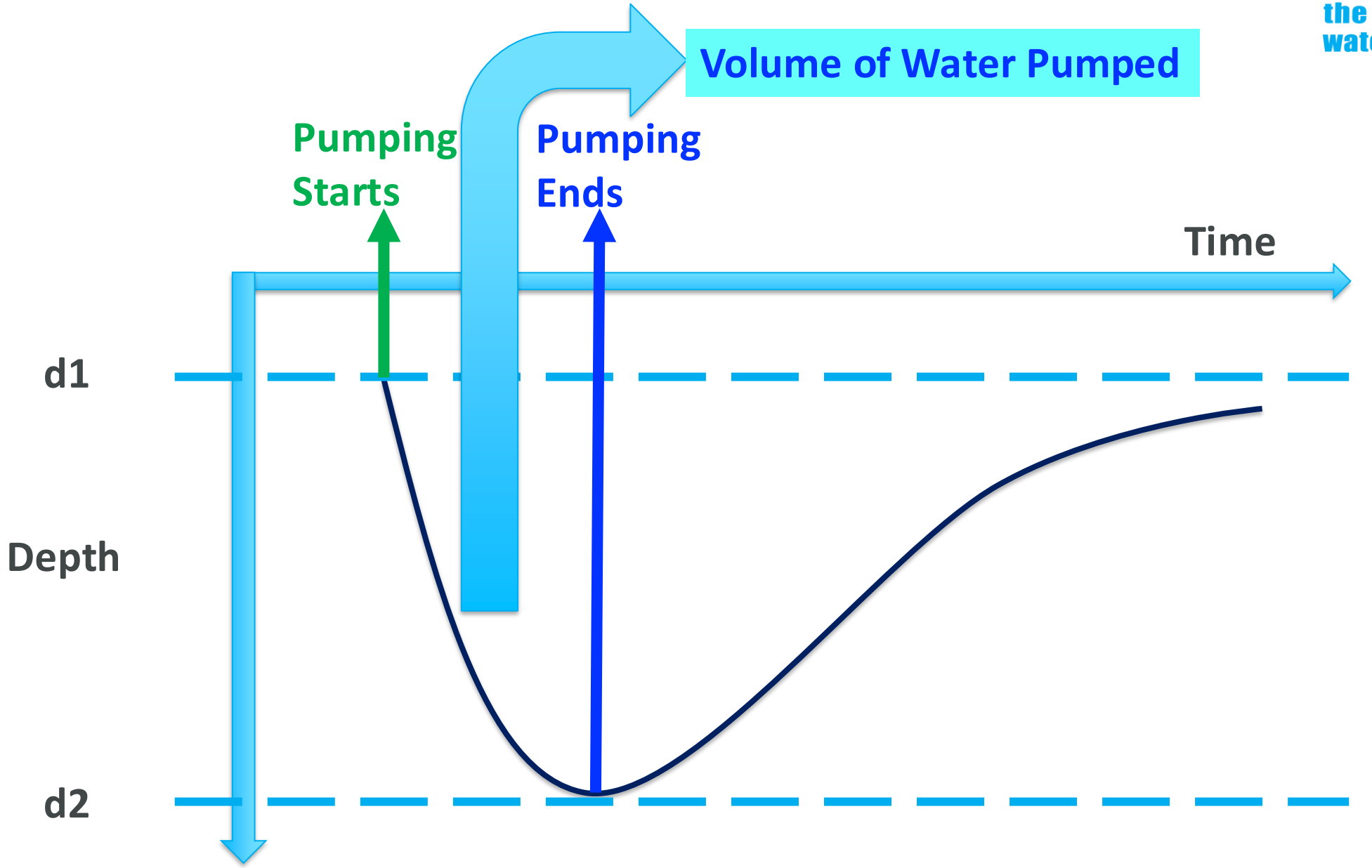
An IoT based piezometer for Real-time high frequency groundwater data.



Jalstr – Digital Water Level Recorder

An IoT based piezometer for Real-time high frequency groundwater data.

INDIVIDUAL FARMER VIEW OF SENSOR DATA



Core Offerings

water association

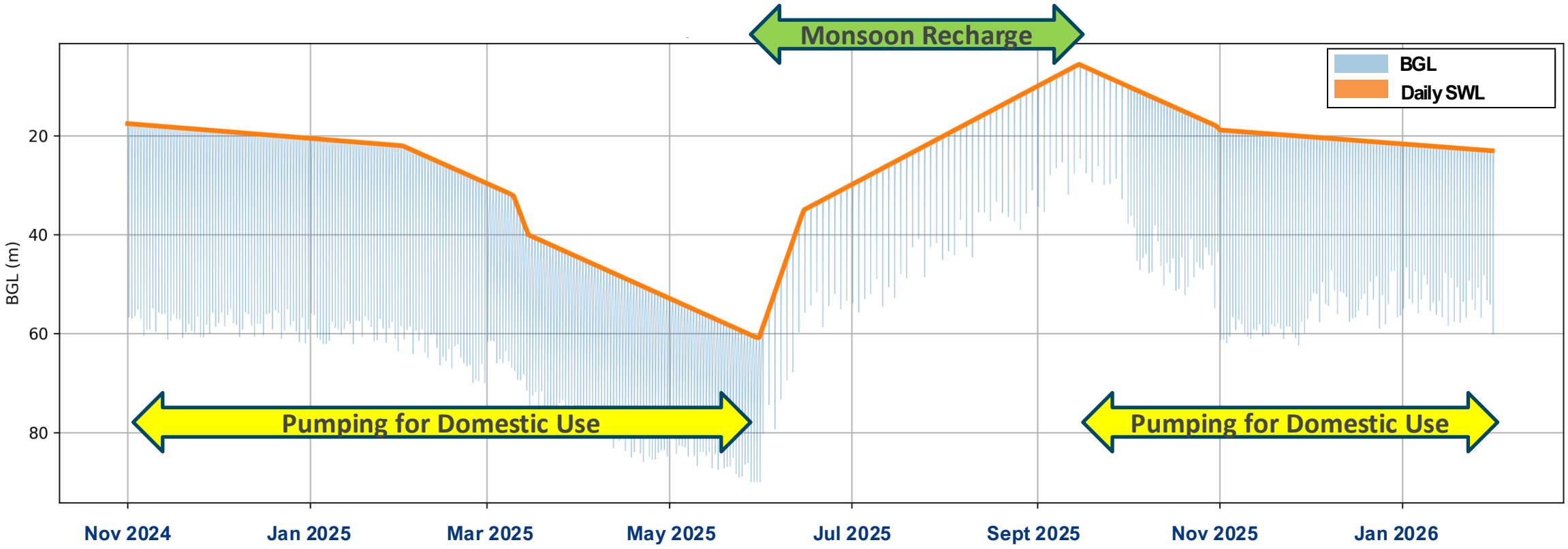
High Frequency Data: 3 mins

Realtime Visualization & Analysis

Advisory based on the Data Analysis & Prediction

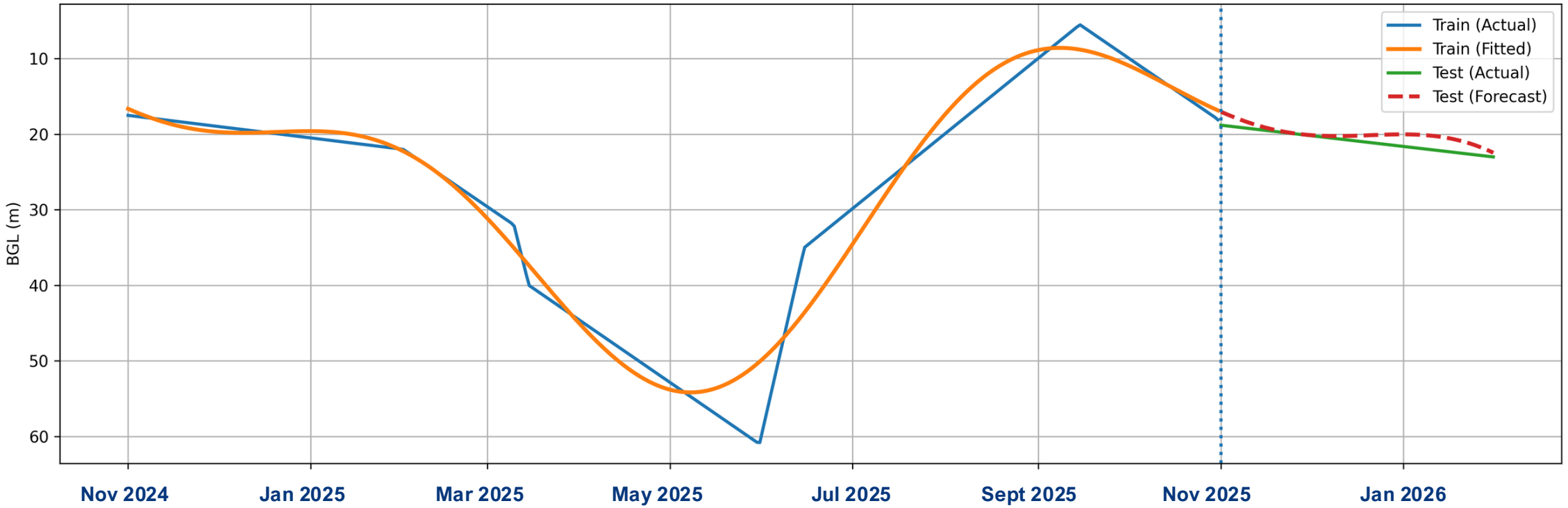
Jalstr – Digital Water Level Recorder

Daily Groundwater Model



Data Analysis, Prediction & Trend Model + Validation

Linear + Fourier Model Validation – Prediction in Nov 2025 Vs Actual in Jan 2026



Advisory

Considering the Water Level is predicted to drop….
The Residential Building needs to implement
Demand Reduction and Recharge Interventions for Future Years

1

Reduce the Water Demand and Control the Borewell Supply.

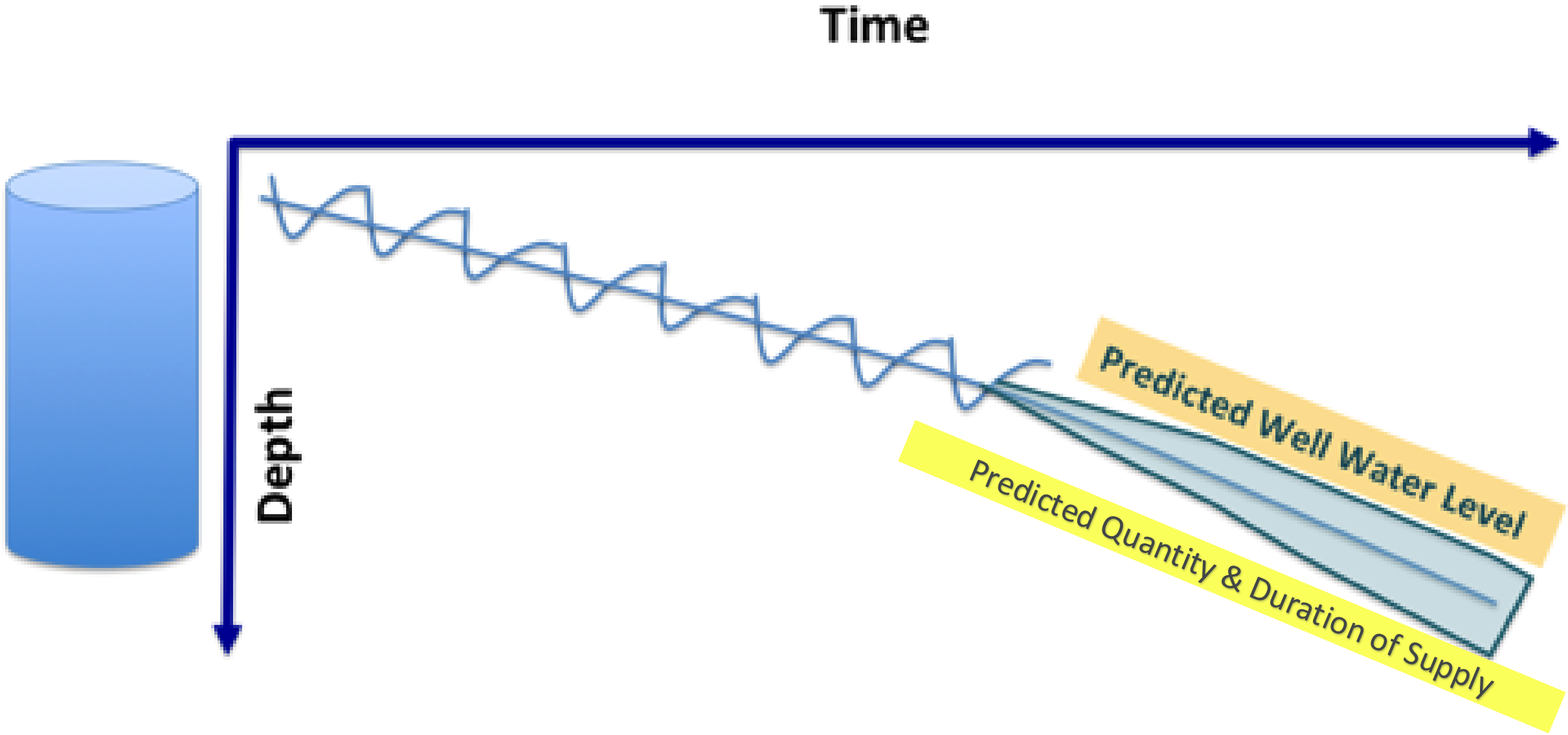
2

Waste Water Recycling to Reduce Demand

3

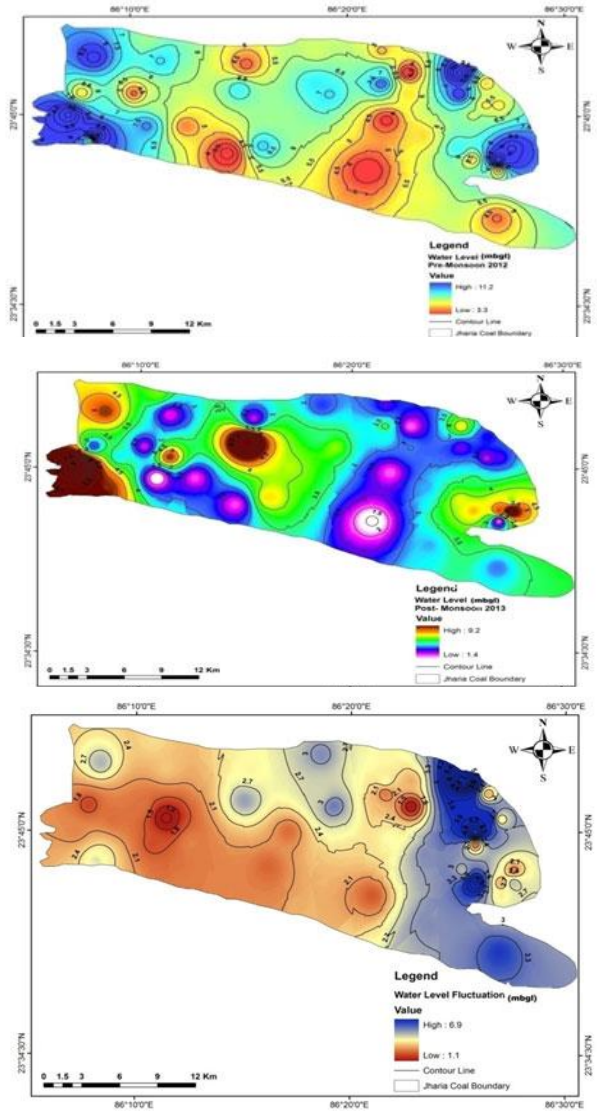
Recharge Implementations like Rooftop Rainwater Harvesting

PREDICTIVE BEHAVIOR ADVISORY ON QUANTITY & DURATION

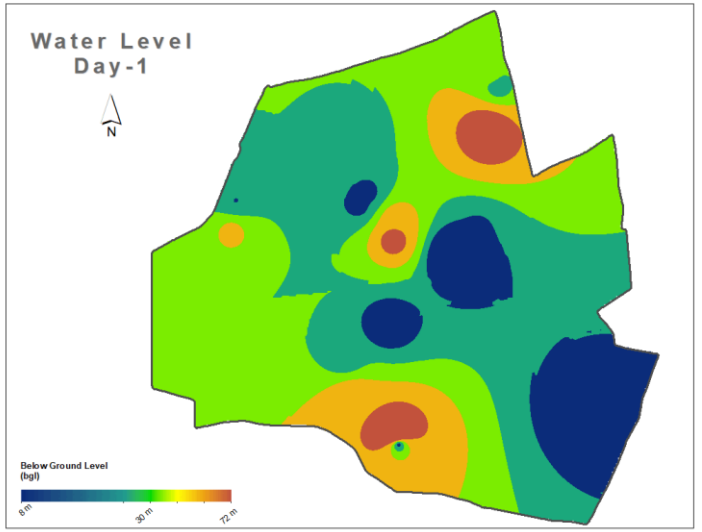


GROUNDWATER INFORMATION SYSTEM & VISUALIZATION AT VILLAGE LEVEL

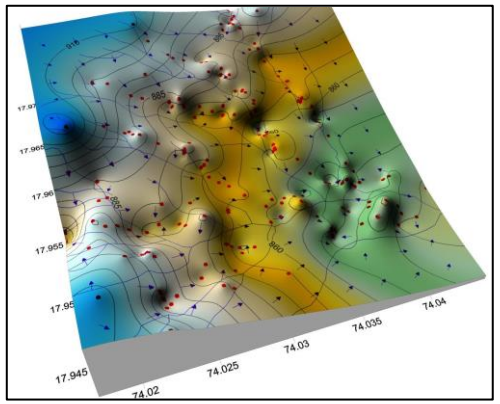
Aquifer Health Status



Animation of Behavior



Aquifer Visualization



BENEFICIARIES AND IMPACT OF JALSTR

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Farmers

- Real-time water level tracking → better irrigation scheduling.
- Prevents over-pumping → longer borewell life.
- Reduces crop loss due to unexpected borewell failure.
- Helps plan for water-saving methods (drip, sprinklers).

Rural Communities & Households

- Reliable water supply for drinking & domestic use.
- Early warnings if borewell levels are falling.
- Reduces dependence on tanker water.

Industries (agro-processing, mining, manufacturing)

- Continuous monitoring of borewells used for industrial processes.
- Compliance with groundwater abstraction regulations.
- Optimizes water use → lowers operational costs.

NGOs & CSR Programs

- Transparent monitoring of water projects.
- Data-driven impact assessment for donors.
- Enhances credibility and accountability in water conservation programs.

Government & Regulators

- Data for groundwater mapping and policy decisions.
- Early detection of stressed aquifers.

CURRENT GTM

Company Owned Company Operated (COCO)

- Head Office Pune
  - Regional Office 1
    - Sales Dealer1
    - Sales Dealer2
  - Regional Office 2
    - Sales Dealer3
    - Sales Dealer4
  - Regional Office 3
    - Sales Dealer5
    - Sales Dealer6
  - Regional Office 4
    - Sales Dealer7
    - Sales Dealer8

SCALE UP - FRANCHISING

Franchisee Owned Company Operated (FOCO)

- Automation Of BoreCharger & Aquifer Mapping
- Para-Hydro Geologists
- Training Of Youth

- Franchisee1
- Franchisee2
- Franchisee3
- Franchisee4
- Franchisee5

Farmers

Industry

Townships

Urdhvam
Environmental Technologies
Private Limited

the international
water association

Let's Recharge, Replenish and
Revive Groundwater For Our Future Generations.....

Jal Hai Toh Kal Hai

Rahul Bakare
CEO
77740 34634
rahul@urdhvam.com

Panel Discussion and Q&A

UPCOMING IWA WEBINARS & EVENTS

Learn more at
https://www.iwa-network.org/learn/guardians-of-water-indigenous-women-as-knowledge-holders-and-stewards

UPCOMING IWA WEBINARS & EVENTS

Learn more at
https://www.iwa-network.org/learn/mainstreaming-water-sensitive-design-and-planning-tools-and-nature-based-solutions-for-resilient-futures

UPCOMING IWA WEBINARS & EVENTS

Learn more at
https://worldwatercongress.org/

UPCOMING IWA WEBINARS & EVENTS

Learn more at
https://digitalwatersummit.org/

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