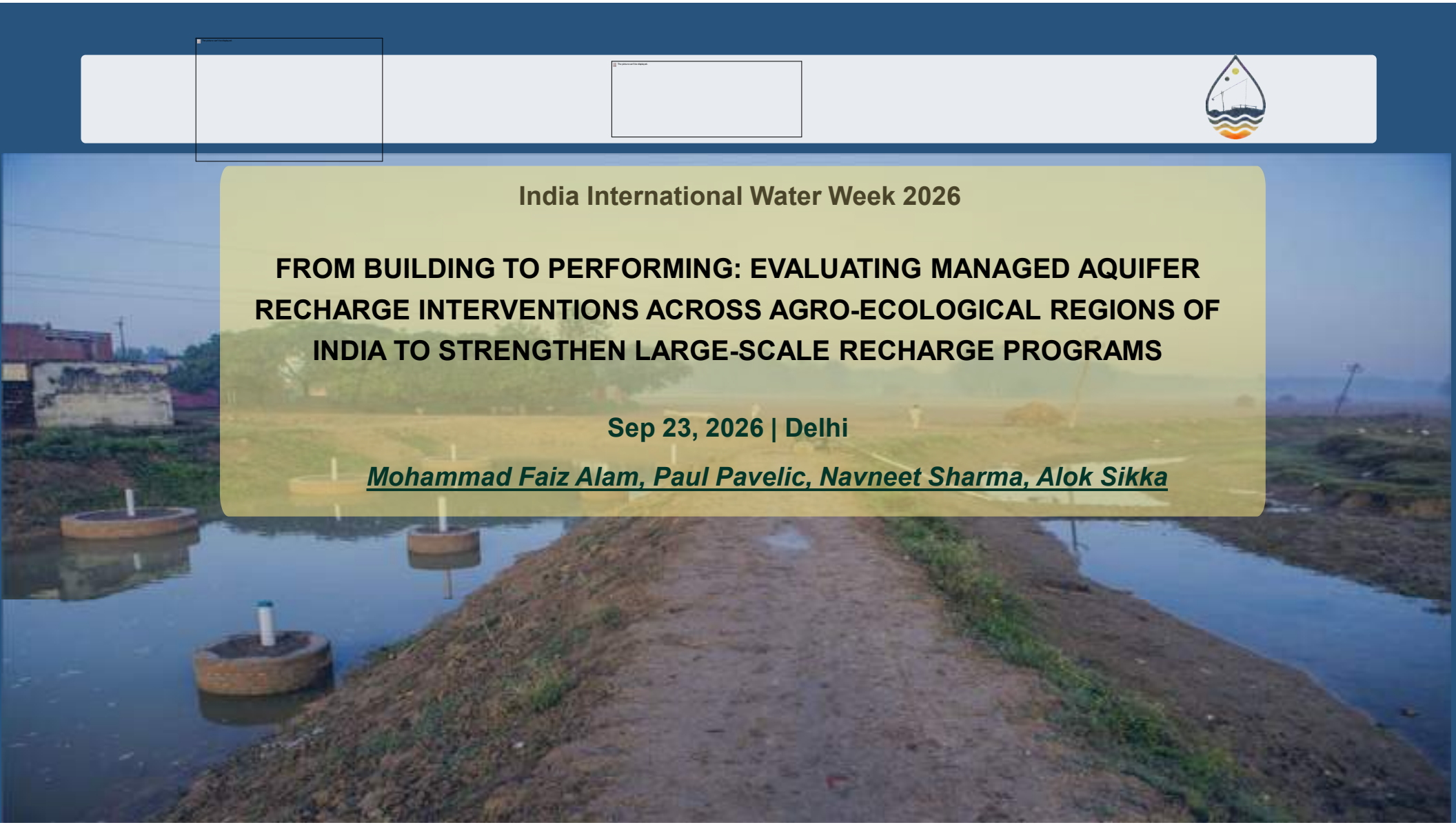


India International Water Week 2026

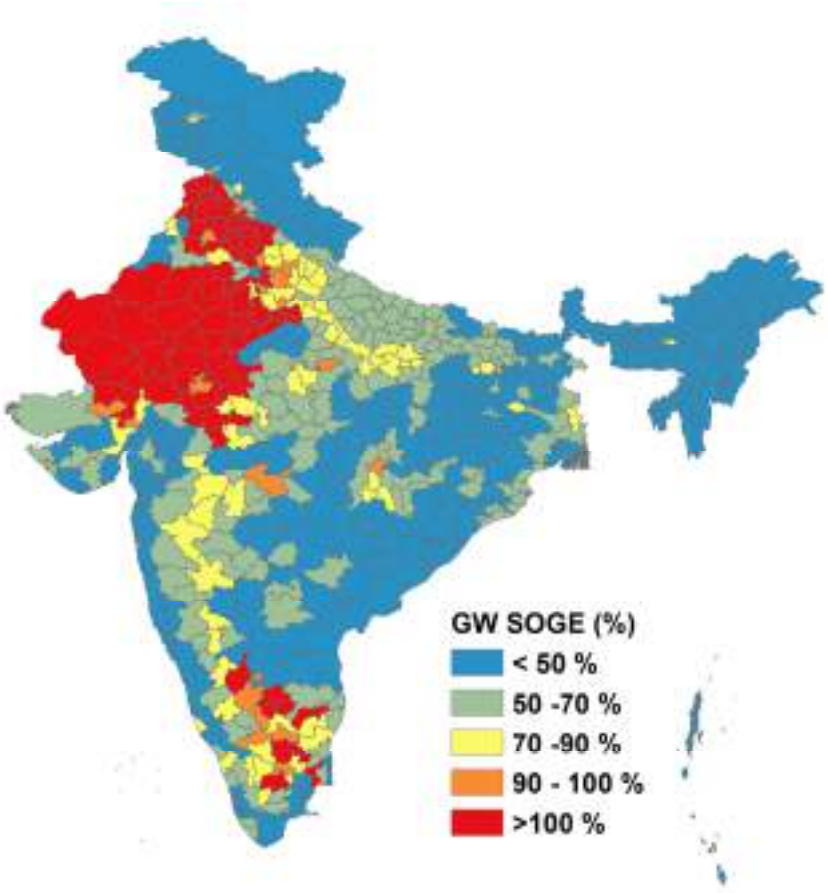
FROM BUILDING TO PERFORMING: EVALUATING MANAGED AQUIFER RECHARGE INTERVENTIONS ACROSS AGRO-ECOLOGICAL REGIONS OF INDIA TO STRENGTHEN LARGE-SCALE RECHARGE PROGRAMS

Sep 23, 2026 | Delhi

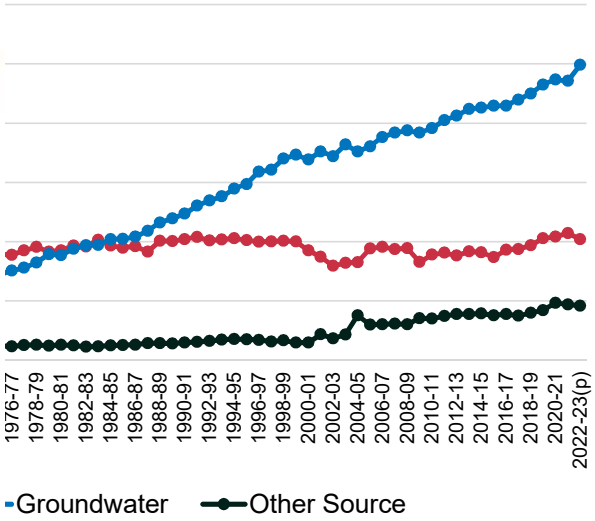
Mohammad Faiz Alam, Paul Pavelic, Navneet Sharma, Alok Sikka

GW contribution to irrigated area increased over years

- Net irrigated area increased from n
  to about ~ 50 % in recent times
- Groundwater contribution from 28 %
  2022-23
  - ~ 21.9 million pumps (MI Cen
- Instrumental in the success of the G
- Central to domestic water security v
  water needs, 45% of urban water c
- ~ 25 % of assessment units overex



on Source ('000 ha)



Groundwater is central to adaptation and building resilience

Nearly 80% of annual rainfall falls in a ~100-day monsoon window, followed by a long dry season; both extremes are intensifying, and groundwater recharge is the critical buffer.

1 **Seasonal concentration**

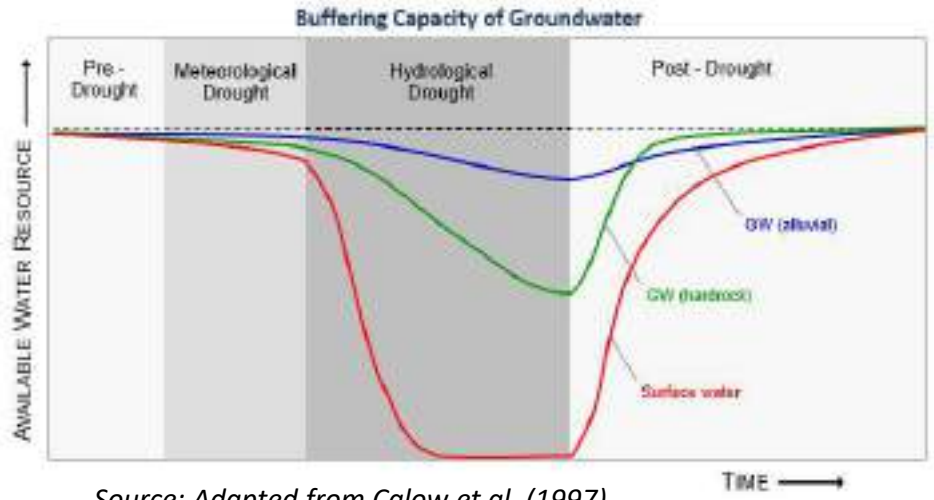
Roughly 75–80% of India's annual rainfall arrives in a single ~100–120 day monsoon window (June–September), followed by an eight-plus month dry season. Storage between the two seasons is the central challenge.

2 **Rising variability and intensity**

Climate change means rainfall into fewer, more intense bursts - more flood-triggering downpours, and longer dry spells between them. Drought and flood risk are both intensifying, sometimes in the same district within one season.

3 **Groundwater: the buffer that is running down**

India relies on aquifers to bridge the dry season, but abstraction now outpaces natural recharge across much of the north and peninsula.



Source: Adapted from Calow et al. (1997)

Managed Aquifer Recharge (MAR) - capturing monsoon surplus and flood flow to actively refill aquifers, turning seasonal flood water into dry-season resilience.

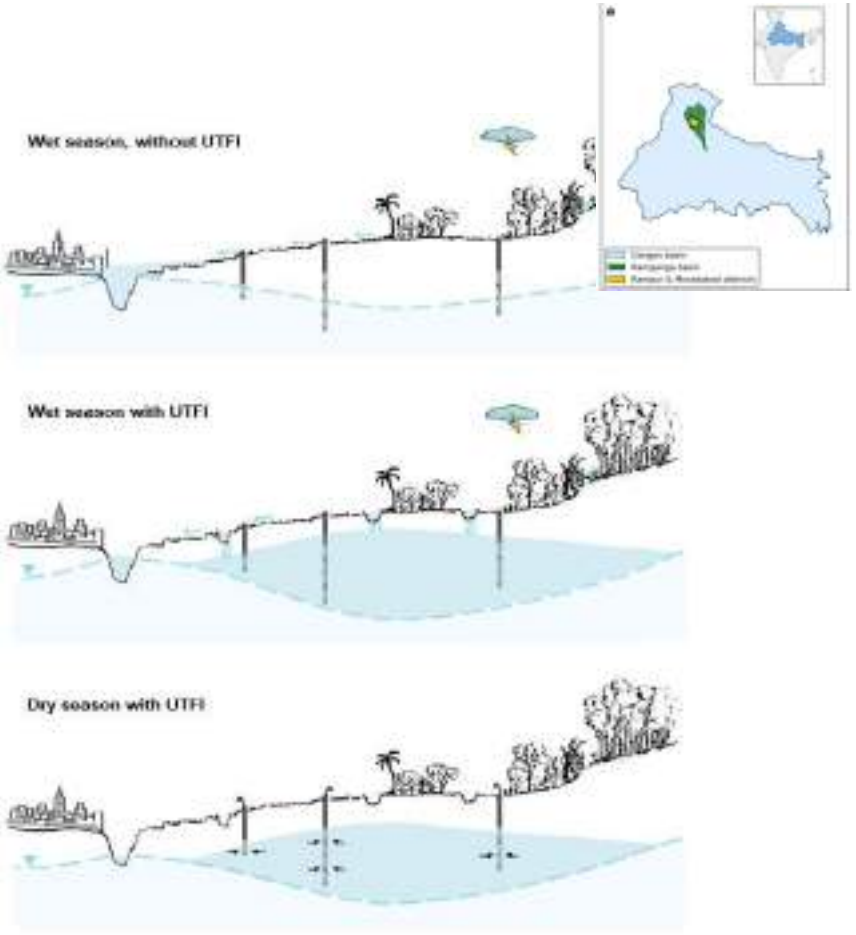
Underground Transfer of Floods for Irrigation (UTFI)

- Involves recharging aquifers at the basin or catchment scale with excess wet season flows
  - Mitigates potential flood risks downstream
  - Increasing water availability during dry periods
  - Climate change adaptation

- Pilot and testing of UTFI (2016-2018) in Jiwai Jadid village of Milak block, Rampur district. From one unused village pond,
  - Average of ~ 44000 m3 recharged,
  - enough for 13 ha rabi wheat
  - 6.7 – 13.7 times the storage capacity of pond
  - ~ 25000 such structures to capture 20 %







Connecting the Dots

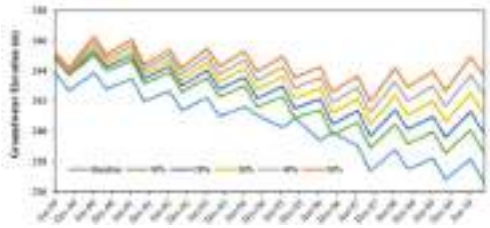


Suitability
Ramganga suitable: Need + Conditions met

Pilot
One site 6.7 – 13.7 times the storage capacity of pond [~ 221 mm/day (164-295)]

MAR programs
~ 12000 structures, many more from other ~ 60 million USD NREGA alone

Modeling
1156 MCM ~ 20 % excess flows capture stabilizes groundwater levels



Required
~ 409 Million USD
~ 5000 ha land, ~ 25000 such sites



India’s National recharge plan

- Revised national plan (2021) prepared by CGWB, updating the 2002 and 2013 plan
- Identified 11.23 lakh sq. km area suitable for artificial recharge interventions.
- Estimated 537.3 BCM sub-surface storage potential, with 185 BCM of surplus water available for recharge
  - Restricted by available water
- Targets construction of 14.2 million rainwater harvesting and recharge structures nationwide.
- Total estimated cost: ₹1.33 lakh crore (~ 15 billion USD).


MASTER PLAN FOR ARTIFICIAL RECHARGE TO GROUNDWATER IN INDIA – 2020

CENTRAL GROUND WATER BOARD
DEPARTMENT OF WATER RESOURCES, RD & GR
MINISTRY OF JAL SHAKTI
GOVERNMNET OF INDIA

APRIL 2021

https://cgwb.gov.in/cgwbpnm/public/uploads/documents/16861332625 1844776file.pdf

Scale of Investment in Small Scale MAR

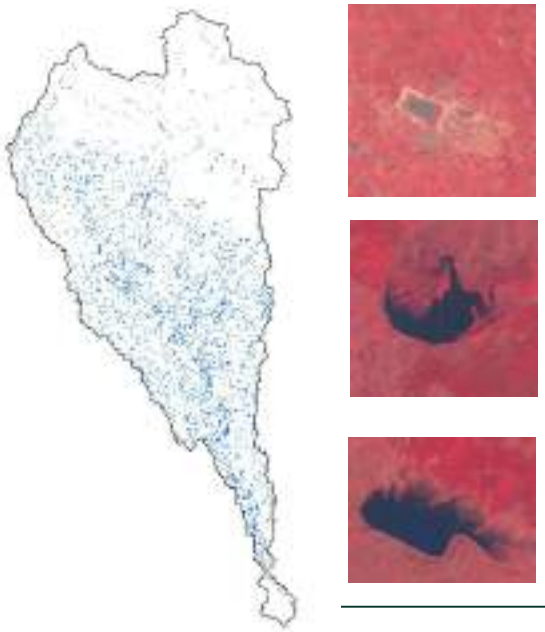
- MGNREGA – Rural Employment Scheme – Main driver with state, CSOs, Corporates
- MGNREGA total expenditure last decade ~ 55 billion > 25 billion USD on water related works
- Water conservation, watershed management – a good part on recharge structures
- Groundwater recharge from INR 286 crore in 2014-15 to INR 1,440 crore (1.6 billion USD) in 2023-24, a 5.0-fold real increase.
- Acceleration post 2020, coinciding with COVID



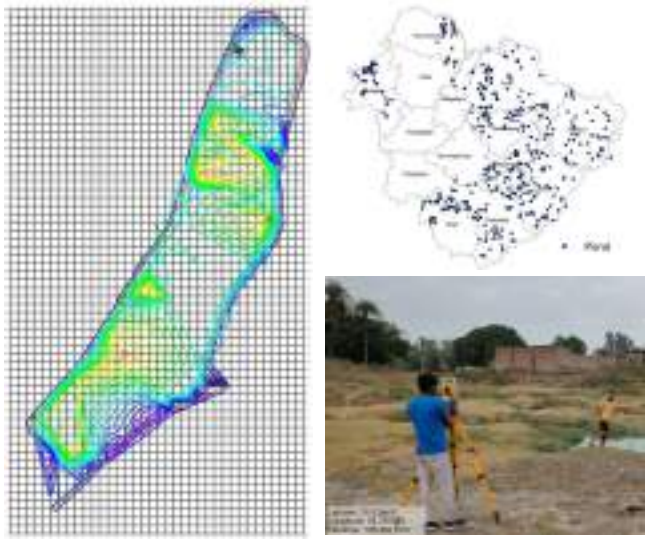
National Water Mission – 15.5 million structures

(Potential) Recharge performance of ~ 25 representative sites over 3 years

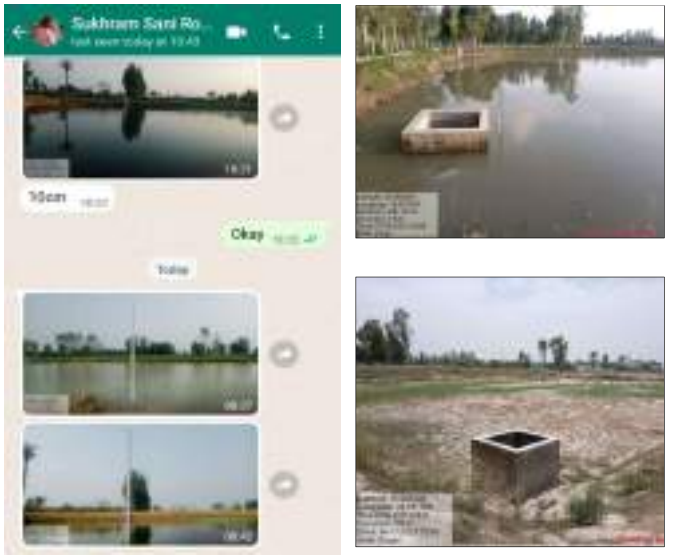
Remote sensing-based assessment and census of water bodies



Field visits and data collection of recharge performance assessment



Participatory monitoring with citizens and stakeholder discussions



a)



b)



c)

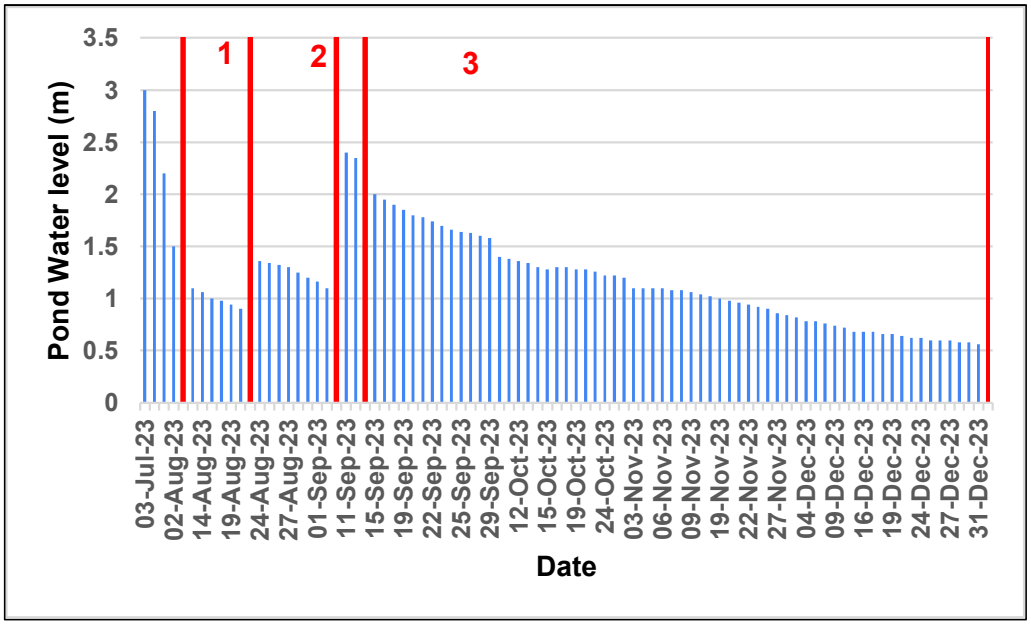


d)



Recharge events

- Recharge events delineated in the season based on continuous water level receding
- Total ~ 250 recharge events



Suboptimal performance when compared with pilot

23

monitored ponds

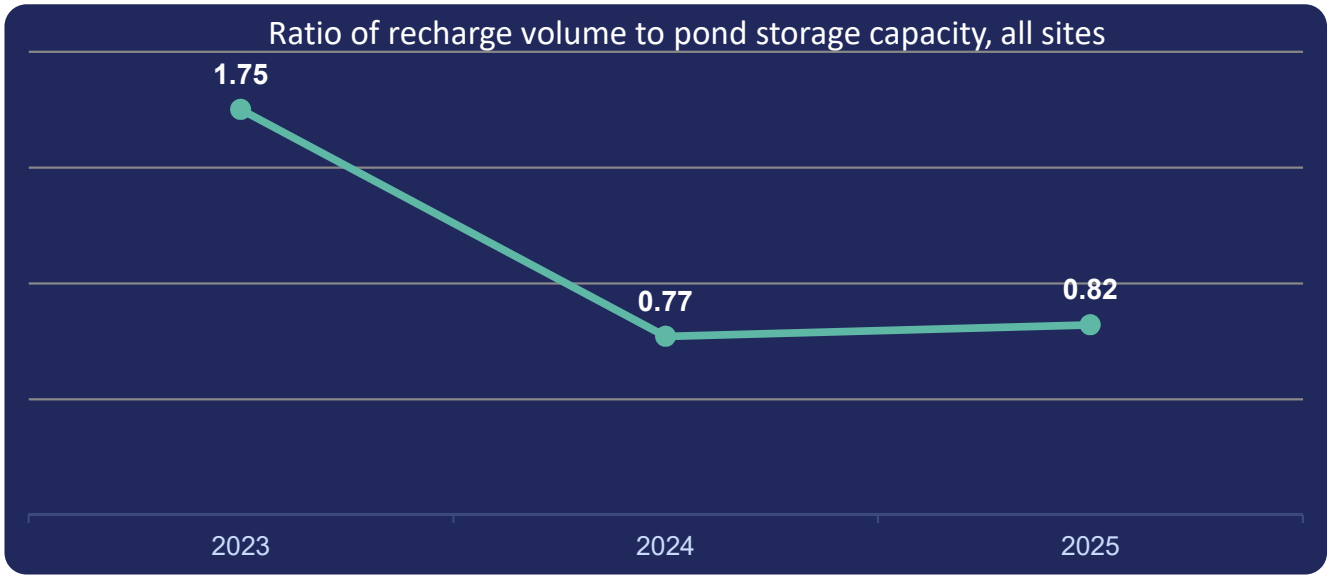
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recharge spells recorded

3 yrs

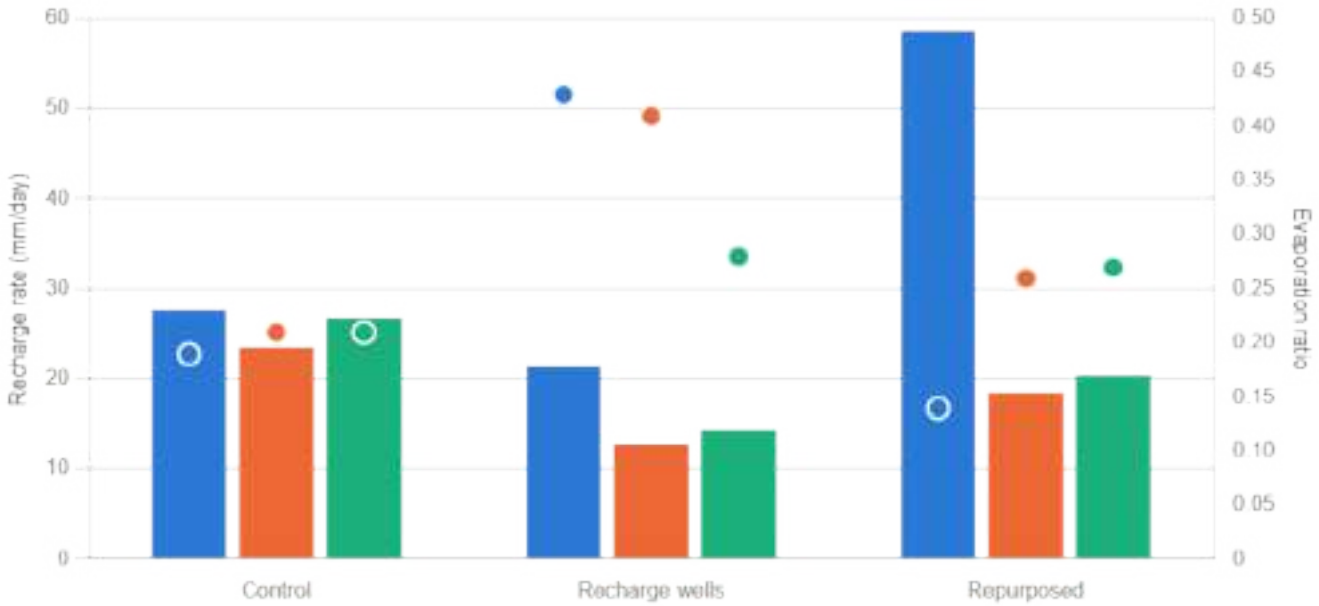
of continuous monitoring (2023–25)

- On average 20-40 mm/day, UTFI pilot > 6 -11 times
- No clear difference between control and repurposed sites
- Overall recharge efficiency declined sharply after the first monsoon season



Recharge rate declines over years and no clear difference between sites

Mean recharge rate by site type and season (mm/day), 2023–2025



Sub-optimal recharge well sites

Pre-monsoon groundwater levels averaged 4.7 m below ground at recharge-well sites — far shallower than control (15.0 m) or repurposed sites (14.7 m), leaving little available storage or hydraulic head.

Two drivers

(1) Shallow water tables reduce the hydraulic gradient as the season progresses.
(2) Progressive siltation of the pond bed reduces infiltration capacity over successive monsoons — together explaining the consistent early-to-late decline across all site types.

Factors influencing recharge rates: Maintenance

- No major differences in basic infiltration (basic) rates
  - Control (40.9 mm day^{-1}) vs recharge well (47.6 mm day^{-1}) vs repurposed ponds (42.7 mm day^{-1})
- Decline over years -> High siltation
  - high sediment loads from agri-runoff
  - Control ponds relatively stable -> not rejuvenated
- Deposition ~ 2 cm, though the thickness varied across ponds





Monitoring Water Quality Risks in MAR

As MAR scales up under Amrit Sarovar, Jal Shakti Abhiyan and state programmes, need for tracking whether recharge water is safe, not just how much water is captured.

Pond and groundwater samples were collected over two monsoon seasons and tested by an accredited lab against India's drinking water standard (IS 10500:2012).



General chemistry & nutrients

pH, dissolved solids, major ions, nitrate, ammonia

Trace metals

Arsenic, lead, chromium, nickel, mercury

Pesticide residues

Screened against a comprehensive residue panel

Microbial indicators

Turbidity and faecal coliform counts

Chemically Safe But Turbidity & Microbial Risk Need Attention

Risk is strongly shaped by what surrounds the pond

3 mg/L
avg. nitrate
vs. 45 mg/L national standard

>5 NTU
turbidity
exceeded in most ponds

11→53
faecal coliform (MPN/100mL)
2024 → 2025 average

~6
MPN/100mL in groundwater
natural filtration reduces risk

RISK DEPENDS ON CATCHMENT LAND USE

LOW RISK

Agricultural catchments

Cropland-dominated ponds show mainly turbidity, with minimal chemical or microbial concern.

LOW–MODERATE

Mixed catchments

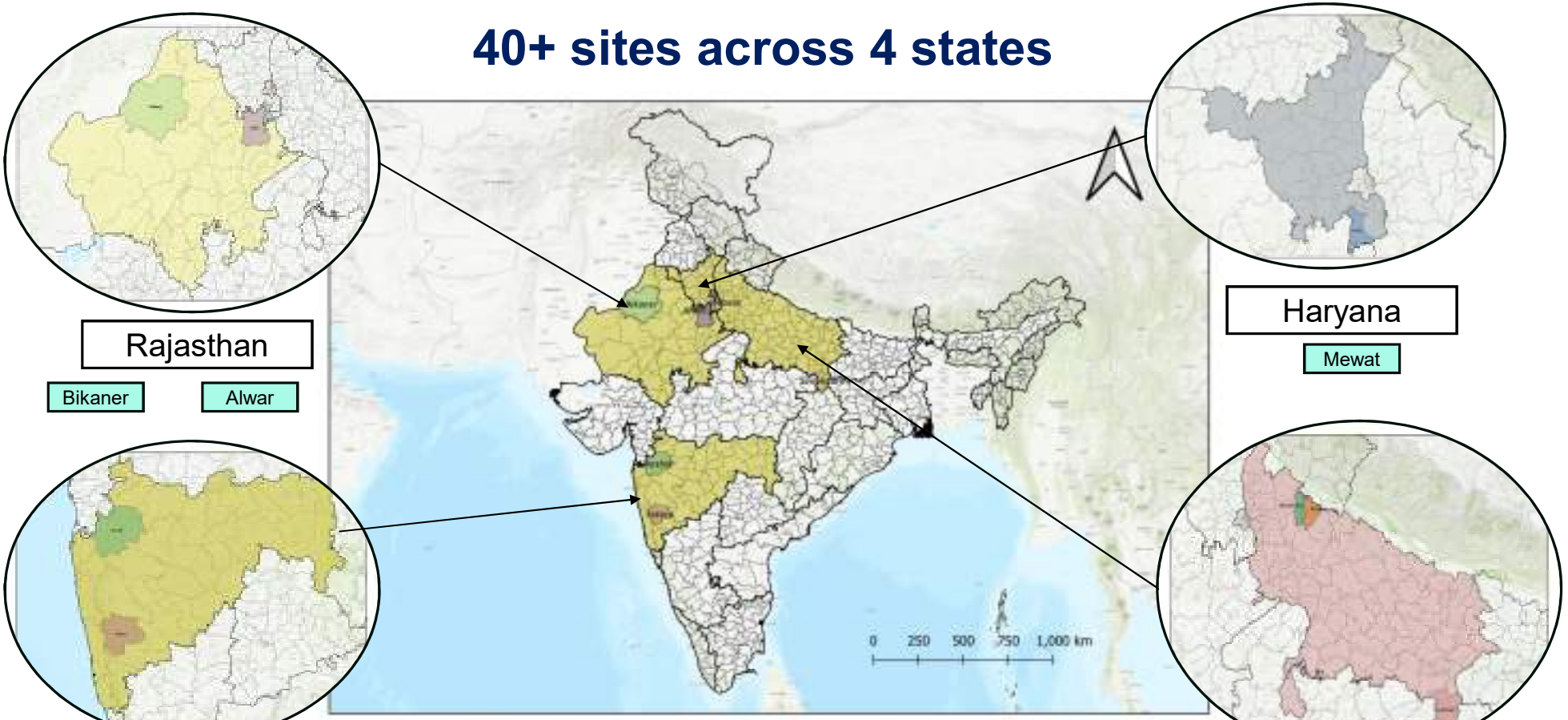
Ponds near settlements show elevated ammonia and faecal coliform from domestic inflows.

MODERATE–HIGH

Industrial-influenced catchments

Upstream industrial discharge can drive trace-metal exceedances — requires separate screening.

40+ sites across 4 states



Rajasthan

Bikaner | Alwar

Haryana

Mewat

Maharashtra

Igatpuri | Satara

Uttar Pradesh

Rampur | Moradabad | Sonbhadra

Deccan Trap Basaltic Aquifers (MH)

Gangetic Alluvial Aquifers (UP)

Semi-Arid Arid Alluvium & Sandstone (RJ & HR)

Recommendations

- Inlet Design and catchment measures
- Regular desilting 3-4 years
- Recharge wells siting, O&M and clusterisation
- Low-cost recharge pits in multiple usage pond
- Participator monitoring and linked incentives







Thanks

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