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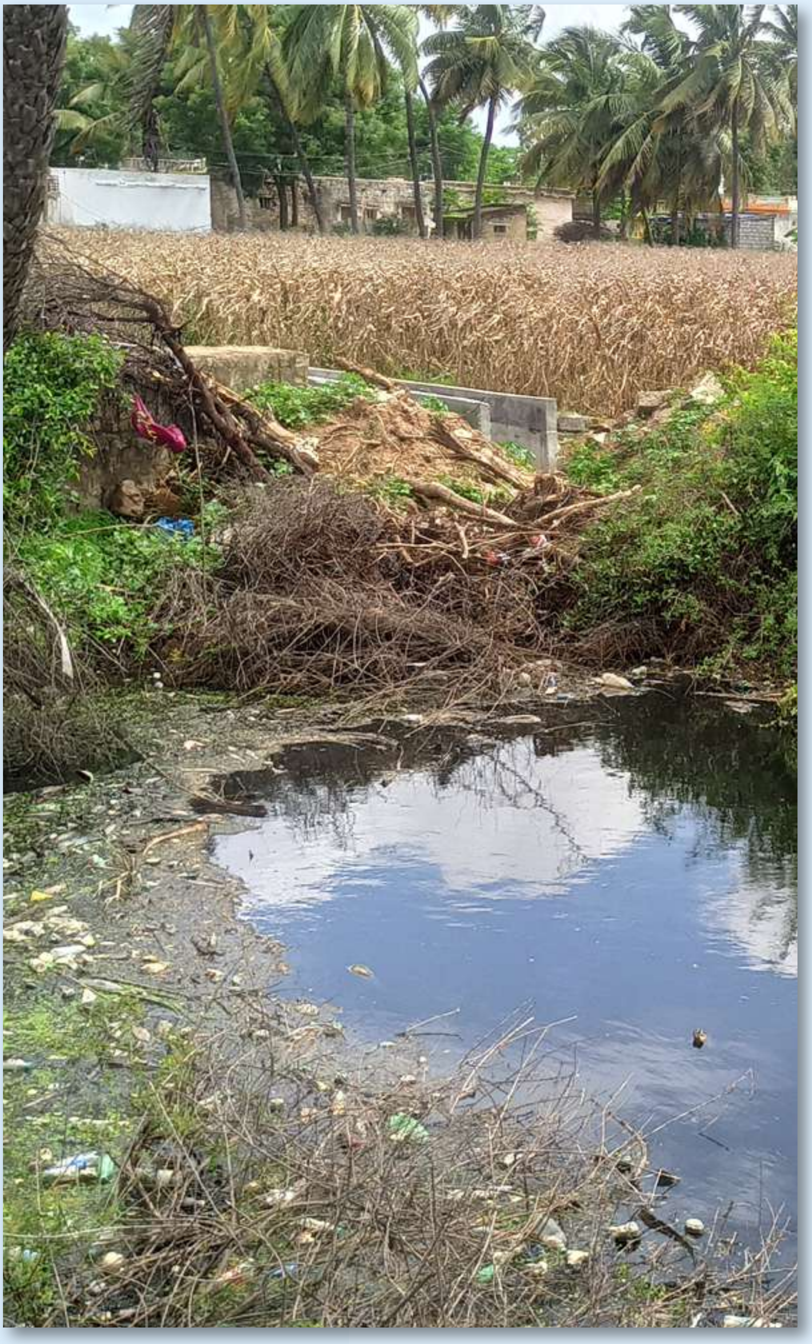

Exploring the Potential of Greywater Management and its Reuse for Irrigation and Groundwater Recharge

A Study Across Five Indian States

2024-25

Study led by
Uzra Sultana

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Application of treated greywater in the Paddy fields, Bhai Bhaktaur Village, Punjab.

Acknowledgement

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Uzra Sultana
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Preface

Greywater management sits at the intersection of water security, sanitation, public health, and environmental sustainability. As India transitions from achieving access-led sanitation outcomes to sustaining and deepening them, the question of how we manage wastewater, especially greywater, has become increasingly critical. With Jal Jeevan Mission (JJM) infrastructure being rolled out in mission mode, the fulfilment of household tap water supply promises to significantly increase the quantum of greywater generated in rural areas, making it imperative to safely channelise, treat, and manage this wastewater to meet appropriate standards for reuse or groundwater recharge. This study, covering five diverse states across India, responds to that emerging challenge by grounding policy and practice in evidence from the field.

At Arghyam, our work has consistently emphasised the importance of source sustainability and systems thinking in water governance. While programmes such as SBM Grameen 2.0 have successfully transformed sanitation outcomes, the next phase demands a sharper focus on what happens after water is used. Greywater, often overlooked, represents both a risk when mismanaged and an opportunity when treated as a resource for groundwater recharge, local reuse and improved environmental health. The findings from this study highlight how context matters deeply: village size, water supply norms, hydrogeology, institutional capacity and financing structures all shape what is feasible and sustainable.

The five-state analysis brings out critical insights on infrastructure gaps, funding constraints, and implementation challenges, particularly in mid-sized villages that fall between household-scale solutions and larger, urban-style systems. A key issue that emerges is the mixing of blackwater with greywater, which alters wastewater characteristics by significantly increasing organic and pathogen loads, effectively converting greywater into blackwater; this substantially raises treatment requirements and therefore becomes a critical point of investigation when greywater planning and system design are initiated. The study also surfaces promising practices and pathways, especially where community-scale systems, programme convergence and local innovation have begun to address these gaps. The study highlights the need to move away from one-size-fits-all norms and instead adopt approaches that are tailored to local conditions, including the amount and quality of wastewater generated, site-specific environmental factors and the ability of local institutions to operate and maintain systems over the long term.

The study also highlights the gap in having the potential of digitally enabled tools to support scientific planning, implementation and O&M. Such tools can integrate inlet and outlet water quality indicators with real-time or periodic estimates of greywater quantities available for reuse and recharge on a single platform, enabling more informed decision-making and scalable programme outcomes.

This report is intended to support policymakers, line departments, implementing practitioners and civil society organisations working to strengthen rural sanitation and water security. We hope it contributes to more informed programme design, sharper investment decisions and better alignment between sanitation goals and water sustainability outcomes. Greywater management is no longer a peripheral concern; it is central to building resilient rural water systems and this study is a step toward that larger goal.

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Executive Summary

The rapid expansion of rural tap-water access under the Jal Jeevan Mission (JJM) from 16.7% (3.2 Cr households) in 2019 to over 81% (15.7 Cr households) by October 2025 has significantly improved hygiene and public health outcomes in rural India. However, this has also led to a substantial increase in greywater generation, ranging from 24 to 30 billion litres per day. Greywater forms 70 to 90% of household wastewater, yet a large proportion of rural habitations lack adequate systems for safe collection, treatment and reuse, causing wastewater to stagnate in drains or infiltrate untreated into shallow aquifers. In states like Punjab, Gujarat and Haryana, water supply levels exceed the 55 lpcd design norm, hence increasing the wastewater volumes.

Despite SBM-G 2.0 creating nearly 2.8 crore liquid waste management assets nationwide, gaps in end-to-end drainage connectivity, variability in design and construction quality and inadequate O&M frameworks continue to limit system functionality and treatment efficiency. According to Mission Antyodaya data analysis, about 97% of India's villages have a population of less than 5,000, underscoring the critical need for decentralised, village-scale greywater solutions tailored to hydrogeological and land-use patterns. This study examines greywater management practices across five states Punjab, Haryana, Rajasthan, Gujarat and Karnataka, visiting over 20 villages, to identify gaps in treatment and reuse, strengthening convergence funding and informing sustainable and scalable recommendations.


Maturation Pond of the DEWATS in Patia Village, Anjar Block, Kutch District, Gujarat.

Primary data from the surveyed villages reveals an uneven system performance despite substantial capital investments. In Haryana, 3-pond systems and constructed wetlands are operational, but treatment capacity remains at only 20%, mainly because systems were designed for 55 lpcd norms, while actual supply reaches more than 150 to 200 lpcd in some villages. Rajasthan shows high household coverage of individual and community soak pits, but almost no water-quality monitoring, creating risks because most greywater directly infiltrates into groundwater in a region already stressed by salinity and low recharge potential. Gujarat demonstrated older DEWATS units in Kutch, achieving 100% coverage, with no blackwater mixing and agricultural reuse. In contrast, newer systems in Banaskantha village reuse treated water primarily for sludge-based revenue generation and groundwater recharge. Karnataka villages exhibit mixed technologies like Inline treatment systems and DEWATS with 50 to 90% household coverage, but stormwater diversion, desludging issues, garbage dumping and limited reuse remain persistent challenges. Treated greywater has supported irrigation of about 50–100 acres in Haryana and Punjab and enabled revenue generation in Gujarat, the greywater is still let into ponds, canals or open land, indicating limited adoption of planned reuse interventions.

Secondary data from State departments reveals structural gaps like:

1. Lack of functional drainage networks,
2. High groundwater tables or saline aquifers affecting technology suitability,
3. Inconsistent O&M financing,
4. Low compliance with water-quality testing and
5. Minimal agricultural reuse except in selected villages.

Untreated greywater let into an open space in Kurubadoddi village in Baidoddi GP in Raichur District, Karnataka.

Strengthening rural greywater management requires a shift from infrastructure-focused construction to BOD content, hydrogeology-based and demand-based planning. Systems must be designed based on the organic load, using actual village supply to avoid under-sizing, while technologies should be matched to site conditions: lined systems in high water table or saline zones and infiltration-based systems where safe. Preventing blackwater mixing through segregated drains and improved toilet containment is essential to maintain system performance. Stronger VWSCs and GP governance, supported by dedicated O&M budgets critical to sustaining infrastructure. Regular quality testing should be institutionalized, with guidelines for safe irrigation and recharge. Reuse infrastructure pipelines, storage and solar-powered pumping can be explored and scaled to enhance productive use of treated water. Finally, coordinated district-level planning and convergence of SBM-G, MGNREGS and Finance Commission (FC) funds is necessary to scale sustainable, village-level greywater management across India.

1. Introduction

Water security is an escalating concern in India. In semi-arid states such as Karnataka, Gujarat and Rajasthan, the challenge is more of water scarcity and in water-stressed regions like Punjab and Haryana faces over-exploitation of groundwater with rising concerns about water contamination. Despite significant improvements in rural water supply and sanitation through national missions like SBM-G 2.0 and JJM[1], greywater management, the wastewater generated from households excluding toilet discharge, remains limited. Untreated greywater poses risks to environmental and public health, but with effective management, it presents an opportunity for improving groundwater recharge, making water available for agriculture and reducing freshwater drawdowns.

SBM-G 2.0 guidelines[2] estimate that approximately 65–70% of potable water used in rural households, about 36 litres per capita per day, is converted into greywater. The mission promotes the “3Rs” principle: Reduce, Reuse and Recharge, primarily through on-site and cost-effective treatment methods such as kitchen gardens, soak pits, leach pits and magic pits. For larger villages where simple solutions are not feasible, decentralized technologies like constructed wetlands, Phytorid systems and DEWATS are recommended. To accelerate the adoption and implementation of greywater management, SBM-G 2.0 rolled out the Sujlam campaigns between 2021 and 2023, mobilising participation across all states and union territories. These campaigns supported the construction of approximately 5.1 million soak pits at community locations and greywater discharge points, contributing to villages achieving LWM and ODF Plus milestones. As per the SBM-G 2.0 dashboard[3] (Oct 2025), around 91.5% of villages report achievement of greywater management targets, with focused interventions underway in the remaining villages. However, reported coverage does not always reflect effective on-ground performance; villages declaring high LWM coverage may still face gaps in access, functionality, and sustained use. An assessment of service quality, completeness of drainage networks and operational performance is therefore critical, rather than reliance on infrastructure counts alone. With nearly 19.36 crore rural households nationally, only about 4% are currently served through soak, leach, or magic pits, and roughly 8% through kitchen gardens as greywater management solutions. This limited uptake is influenced by dispersed settlement patterns and partial household inclusion, underscoring the need for a mixed, context-specific approach to system selection based on local topography, land-use patterns and hydrogeological conditions.

The Department of Drinking Water and Sanitation (DDWS) is promoting the reuse of treated greywater as part of a broader circular economy approach, particularly in kitchen gardens and agricultural lands. Funding convergence across schemes like SBM-G 2.0, the 15th Finance Commission and MGNREGS is enabling states to plan and implement greywater treatment infrastructure, often tailored to local needs.

[1] *Refer to the JJM operating guidelines here.*

[2] *Refer to SBM-Grameen Technical Greywater Management Manual here.*

[3] *Refer to SBM-G dashboard here.*

Black water mixing with greywater in the drain leading to open pond in Bhai Bhucho Khurd, Nathana Block, Bathinda District, Punjab.

The challenge and the opportunity: Why Greywater Management is critical to rural India

The rapid expansion of household water connections under the JJM has created a massive, yet often overlooked, challenge: unmanaged greywater. We are facing an estimated 24–30 billion litres of greywater generated daily across rural India. This unmanaged liquid waste, which comprises 70-90% of household wastewater, creates serious health risks by stagnating in drains and serving as a breeding ground for water and vector-borne diseases. Crucially, however, this "waste" presents a potent solution for water security. By properly treating and reusing this water for non-potable needs like irrigation, villages can reduce their net freshwater demand by an estimated 20-30%.

Our research, "*Exploring the Potential of Greywater Management and its Reuse*," assesses these challenges and opportunities across five diverse states, examining treatment solutions, financing models, capacity of village institutions and implementation challenges. Our findings, based on extensive field visits, interviews and data analysis, underscore a critical reality, while greywater reuse is being practised in many areas, the long-term success of the national mandate hinges on strengthening treatment infrastructure and water quality monitoring. This study provides the necessary evidence and state-specific models to advocate for integrated policy frameworks, community-led initiatives and scalable solutions essential for sustainable greywater reuse.

1.1
Context - Greywater landscape and practice in India

At the time of the JJM's[4] launch in August 2019, only about 3.2 crore rural households (16.7%) had access to tap water connections, which is a 5× increase in household-level greywater generation since the launch of the mission. Efforts are ongoing to connect the remaining 3.6 crore households catering to 913 million rural population. About 70–80% of supplied water becomes greywater, translating to over 24 billion litres per day across connected rural households. Effective management of this ever-increasing greywater is critical. As of October 2025, under the SBM-G 2.0, out of approximately 5.94 lakh villages, about 5.38 lakh villages have liquid waste management systems in place; still, about 49,673 villages remain without waste management systems. This highlights the need to cover greywater management, considering the increased water supply from JJM is matched by effective systems for its reuse and safe disposal.

Figure 1: Tap connection coverage under JJM.

No. of Assets in India (as of Oct 2025)	**Estimated Coverage**
At Individual level - 2,56,18,407 (Soak pits, leach pits and kitchen gardens)	1 household per system reaching ~2.6 crores
At Community level - 22,21,813 (Soak pits, leach pits and magic pits)	Serve clusters of about 1.1 lakh (average 20 household per system[5])
At Village level - 2,20,974 (Phytorid, DEWATS, Constructed Wetlands and Waste Stabilization Pond)	*Households connected to all the villages data unavailable*

**Analysis for estimation purpose only*

Table 1: Total number of liquid waste management assets and the households covered from the SBM-G dashboard

[4] *Refer to JJM dashboard here.*

[5] *SBM-G 2.0 technical manual for liquid waste management, 2020 and CPHEEO manual on sewerage and treatment, 2013.*

1.1.1 Evolution of the SBM: From ODF to sustainable greywater management

The Swachh Bharat Mission launched in 2014 focused primarily on achieving ODF status in providing access to toilets and large-scale behaviour change. While this phase successfully addressed access and usage, it also revealed emerging challenges related to wastewater disposal, environmental hygiene and the sustainability of sanitation outcomes. In response, SBM-G 2.0 consolidated ODF gains and explicitly addressed solid and liquid waste management. Building on this transition,

- The **ODF Plus** framework focuses on sustaining ODF outcomes while tackling the next generation of sanitation challenges, including solid and liquid waste management, and visible cleanliness through the elimination of litter and stagnant wastewater. An **ODF Plus village** is required to demonstrate functional waste management systems.

- An **ODF Plus Model village** goes further by ensuring comprehensive SWM and LWM, clean public spaces and the active use of IEC measures to reinforce sanitation behaviours.

- **ODF Plus Aspiring** is a progressive stage, where at least one waste stream is managed

- **ODF Plus Rising**, where both SWM and LWM systems are in place, providing a structured pathway for incremental improvement.

1.2
Mapping unsafe sanitation practices & public health disparities in India

Unsafe water, sanitation and handwashing were among India's top health risk factors in 1990, ranking second nationally, but by 2016 their contribution declined to about 4.6–5% of the disease burden, mainly from diarrhoeal diseases. However, the burden remains highest in Empowered Action Group (EAG[6]) states and Assam, with slower improvement and greater impact on women due to sanitation-related vulnerabilities.

According to the NHSRC's *Health Dossier 2021*[7], published by the National Health Systems Resource Centre (NHSRC) of different States - the ranking of several water and sanitation-related diseases declined between 1990 and 2019. This downward trend in disease burden may be attributed to improved sanitation infrastructure in rural areas, including better management of greywater and safe sanitation practices. This reduction in overall community pathogen load and the elimination of vector-breeding grounds through stagnant water directly translated into additional health gains, evidenced by the sharp decline in infectious conditions like meningitis.

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[6] *Empowered Action Group (eag) states are eight socio-economically backward states of India, including Bihar, Chattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, Uttarakhand and Uttar Pradesh.*

[7] *Refer to all the States report of National Health Systems Resource Centre here.*

Parameters	India		Punjab		Haryana		Gujarat		Rajasthan		Karnataka	
	1990	2016	1990	2019	1990	2019	1990	2019	1990	2019	1990	2019
Diarrhoea	1	3	1	5	1	5	1	7	2	6	1	6
Typhoid fever	No Data	No Data	9	31	11	21	16	35	9	12	No Data	No Data
Meningitis	18	27	13	76	13	49	12	39	13	39	No Data	No Data
Unsafe water sources	No Data	No Data	3	16	4	13	5	13	5	12	5	12
Unsafe sanitation	No Data	No Data	7	29	5	22	7	25	7	15	6	18
Lack of access to handwashing facilities	2	7	12	35	9	31	11	30	9	25	10	33

Table 2: status of rank in different water-borne diseases and unsafe sanitation progressed from 1990 to 2016.

While India's overall exposure to unsafe water and sanitation reduced during this period by 44% for unsafe sanitation and 17% for unsafe water, the reduction was far less in high-burden states. The Disability-Adjusted Life Years (DALY) rates attributable to unsafe water and sanitation remained highest in Jharkhand, Bihar and Odisha, highlighting the need for sustained investments and targeted interventions. Currently, the continued efforts under SBM and similar programmes, with an urgent focus on improving sanitation systems, ensuring treatment of liquid waste management, are strengthening sanitation infrastructure in lagging regions and designing gender-sensitive approaches in addressing the persistent health risks, particularly in women and children.

Greywater generation from household activity in Kolimpalli village, Kothakote GP, Bagepalli taluk, Chikkaballapur district.

2. Methodology

While water security is an escalating national concern, particularly in the semi-arid states of Karnataka, Gujarat and Rajasthan and the critically water-stressed agricultural belts of Punjab and Haryana, the source sustainability challenges are highly nuanced and state-specific. The states were selected based on criteria such as arid and semi-arid conditions, where there is water scarcity, groundwater over-exploitation in high water table regions, shifting the problem to contamination and prevalence of water-intensive crops.

Figure 2: 5 states selected for the study

FGDs with the Gram Panchayat members and the Community representatives of Bhucho Khurd Village Punjab.

The study adopted a mixed-method approach to evaluate greywater management practices, reuse potential and recharge strategies in the five states. The research framework included field observations, structured interviews, stakeholder consultations and an in-depth analysis of secondary data as given in the details below.

1. Data collection and sampling

The selection of study locations was based on variability in water availability, Policy/Schemes implementation status and presence of decentralized treatment infrastructure. A total of 20 villages were surveyed, covering a population range of 550 to 12,000.

2. Stakeholder consultations

Interactions with 12 subject-matter experts, hydrogeologists and members from Rural WASH Partners' Forum (RWPF) were carried out to evaluate the technical feasibility of various treatment models and to identify challenges in their adoption. Within each village, Gram Panchayats, Village Water & Sanitation Committee, local implementing agencies and representatives from the community were interviewed to assess water usage patterns, treatment infrastructure and financial models. The block, districts and state officials were consulted to understand the challenges and management aspects at different levels.

3. Field surveys/interviews and observations

The study involved on-site assessments of existing greywater treatment infrastructure such as soak pits, leach fields, constructed wetlands and DEWATS systems. It included visual documentation of greywater discharge and reuse patterns in agricultural fields and groundwater recharge structures. Structured interviews were conducted with Sarpanch and members of the GP, village water committees, implementing NGOs and local government officials to understand policy implementation and financing models.

4. Secondary data analysis

The analysis included reviewing financial allocations from JJM, SBM-G2, MGNREGS and the 15th FC to understand budgetary constraints and funding patterns. State-specific greywater management guidelines, policy documents and scientific studies were also examined to contextualize the findings. Additionally, water quality reports were reviewed to assess the efficiency of greywater treatment and its potential for reuse. Village data from Mission Antodaya has helped in analysing and building scenarios.

5. Data analysis and interpretation

The collected data were processed using a comparative analysis to understand the key factors affecting infrastructure adequacy (percentage of population with access to treatment systems); Financial sustainability (CapEx and OpEx requirements, revenue generation models); Community adoption (level of participation in greywater management and reuse) and Technology performance (efficiency of soak pits, constructed wetlands, and DEWATS).

3. Greywater situation in the selected 5 States for the study

This study provides a ground-level assessment of greywater management and reuse practices across five climatically and agriculturally diverse Indian states: **Rajasthan, Karnataka, Gujarat, Punjab and Haryana**. These states were strategically selected to represent major regional challenges, including the arid/semi-arid zones of Rajasthan, Gujarat and Karnataka and the water-intensive crop growing states of Punjab and Haryana, which face severe groundwater depletion. The states were also chosen based on the varying levels of progress achieved in implementing LWM and JJM.

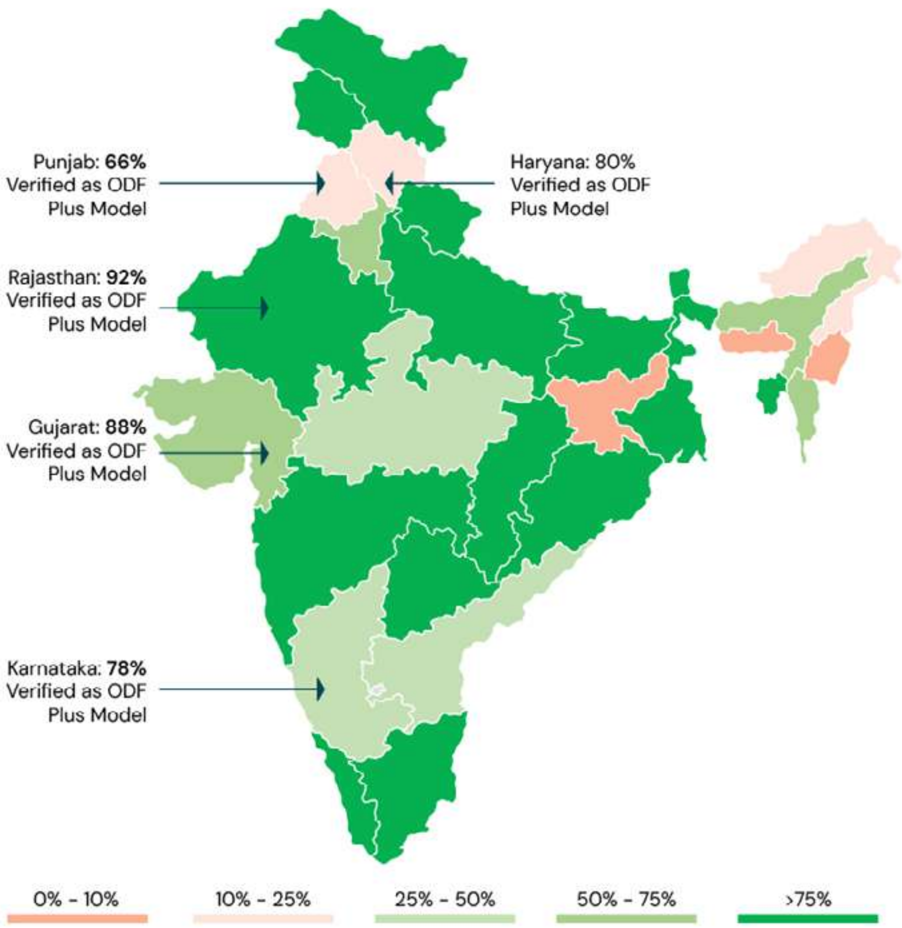

Figure 3: ODF Plus Model 1st verification villages, as on 27 Oct 2025.

Category	Gujarat	Haryana	Karnataka	Punjab	Rajasthan
Overview					
Total geographic area inv sq kms	1,96,244	44,212	1,91,791	50,362	3,42,239
Total population in Crores	7.04	2.53	6.87	2.77	8.2
Rural population in Crores	3.47	1.85	4.45	1.82	5.8
Rural households in Lakhs	91	30.41	101	34.26	107
Number of Districts	33	22	31	23	48
Number of Blocks	248	143	234	154	370
Number of GPs	13,980	5,956	5,952	13,228	11,300
Number of villages	18,023	7,356	26,484	12,729	43,463
Jal Jeevan Mission status as on Oct, 2025					
FHTC coverage	100%	100%	86%	100%	57%
SBM-G Status and Grey water management status as on Oct, 2025					
Villages with ODF Plus status	17,842 (99%)	6,518 (98.5%)	26,402 (99.6%)	11,783	42,417 (97.5%)
Villages with ODF Model status	13,697 (76%)	4194 (64%)	8,696 (32.8%)	2,295	42,140 (96%)
Villages with some form of liquid waste management	16,990 (94.5%)	5,952 (90%)	9,373 (35%)	10,013(84%)	42,815 (98.5%)
Villages without any treatment facility	1,033 (5.7%)	666 (10%)	17,788 (67%)	1,964 (16%)	646 (<2%)
Status of assessment units as per Dynamic Groundwater Report, 2023					
Over-exploited	23 (9.13%)	88 (61.5%)	44 (18.8%)	117 (76.4%)	216 (71.5%)
Critical	8 (3%)	11 (7.7%)	12 (5.1%)	3 (2%)	23 (7.6%)
Semi-Critical	20 (7.94%)	9 (6.3%)	32 (13.7%)	13 (8.5%)	22 (7.2%)
Safe	189 (75%)	35 (24.5%)	146 (62.3%)	20 (13%)	38 (12.5%)

Table 3: Salient features of demographic, JJM, SBM-G and groundwater status of five States.

Financial landscape across 5 study states: Mission Antyodaya village-level data from the 2019–20 survey cycle (with updates reflected in the 2022–23 release) show that between 84% (Haryana) to 97% (Punjab) of villages have populations below 5,000, making them eligible for the lowest per-capita allocation of ₹280 for greywater management. Within this, the 1,000–4,999 population category emerges as the most critical segment for greywater management, accounting for a substantial share of villages, ranging from 38% (Karnatzaka) to 61% (Haryana), yet continuing to receive the same minimum per-capita funding as much smaller villages. This highlights the need to recalibrate funding norms by systematically factoring in population size, risks of wastewater quality and local topography and hydrogeological conditions.

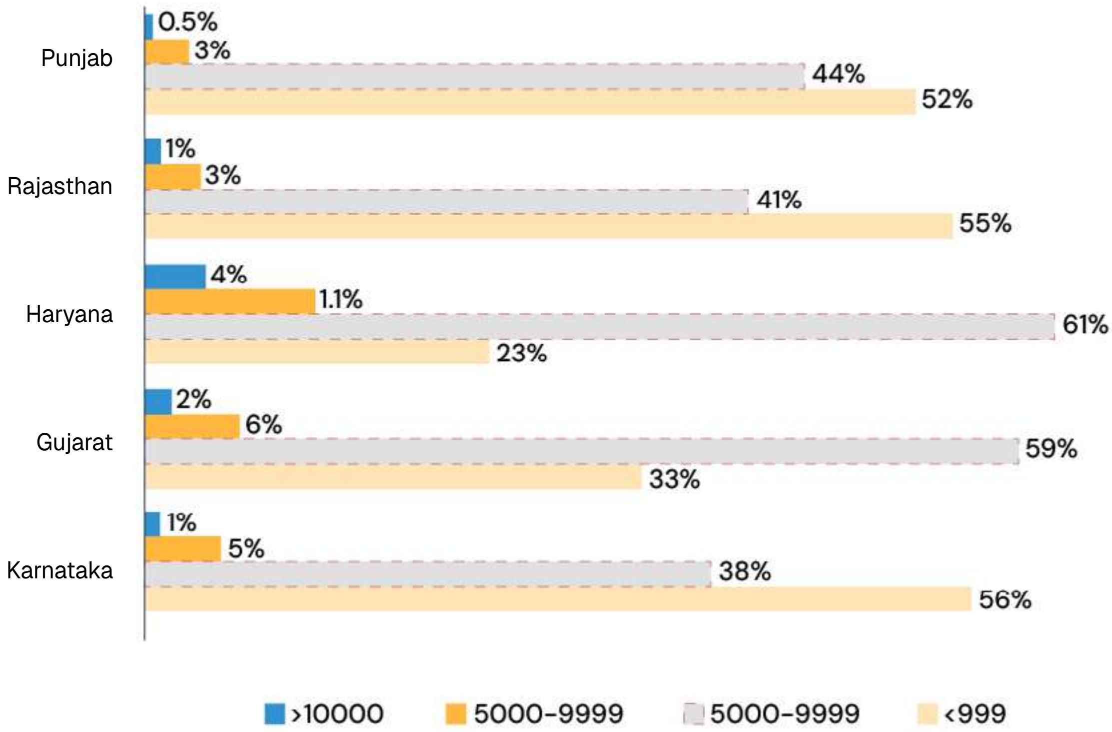

Figure 4: Breakup of Village sizes based on population of the five States.

In contrast, only a small proportion of villages fall in the higher population category. Around 3% of the remaining villages, with populations above 5,000 are eligible for a higher per-capita allocation of ₹660 for greywater management. While this funding level is relatively more adequate to support larger-scale treatment and conveyance systems, the limited number of such villages means that this higher allocation benefits only a small fraction of the rural landscape. As per the field observations, even in these higher-population villages, the increased allocation does not necessarily translate into 100% village coverage, as system design, land availability and local implementation constraints continue to limit universal service provision.

Implementing Departments of SBM-Grameen in the five states: The implementation is led by designated nodal agencies, with varying roles and responsibilities. The effective implementation depends on coordination between the nodal agency and other departments to enable infrastructure creation and on-ground execution.

Gujarat	Haryana	Karnataka	Punjab	Rajasthan
The Commissionerate of Rural Development (CRD), Gujarat under the Department of Rural Development & Panchayats oversees the rural sanitation programme, including Solid and Liquid Waste Management (SLWM). The Gujarat Water Supply and Sewerage Board (GWSSB) provides technical guidance on greywater and drainage solutions under rural sanitation programmes. Village-level institutions: GPs and Pani Samithis support in planning and implementing greywater solutions, with handholding from CRD and technical capacity-building programmes from state agencies and partner organisations.	Haryana Pond and Waste Water Management Authority (HPWWMA): Statutory body responsible for ponds and wastewater management. Promotes treated wastewater reuse for irrigation. Irrigation and Water Resources Department & Panchayats Department implements pond restoration and village-level liquid waste management infrastructure, often working in coordination with the GPs. The Public Health Engineering Department contributes to technical planning of water supply, sanitation and wastewater management schemes. GPs: Responsible for the construction, O&M of the village-level systems.	Rural Drinking Water and Sanitation Department (RDWSD) ensures water infrastructure is aligned with SBM-G 2.0 goals, establishment of treatment systems and subsequent handover to the Panchayat Raj Commissionerate for monitoring and O&M. The Panchayat Raj Commissionerate, through District Water Supply and Sanitation Committees, plays a key role in planning, convergence funding, execution, IEC activities and monitoring of treatment systems. Currently, in-situ treatment measures such as individual and community soak pits and kitchen gardens are supported through MNREGA funds.	Department of Water Supply & Sanitation (DWSS) oversees rural water supply, sanitation services and management of piped water to rural households. Also manages the construction of toilets and liquid waste management. The Rural Development Department implements village sanitation schemes involving panchayats and community participation through MNREGS funding.	Department of Drinking Water and Sanitation (DDWS) at the state level, headed by the State Mission Director. At the district level, the District Collector/ Magistrate chairs the District-level Sanitation and Drinking Water Committee. Block-level implementation is overseen by the Block Development Officer (BDO) or Block Sanitation Officer (BSO). Village-level implementation relies on the Panchayat Secretary and Swachhagrahis.

Table 4: Nodal agencies and other Departments involved in executing liquid waste management in the five States.

3.1 Gujarat

3.1.1 Status of greywater management and reuse potential scenario

Assuming a water supply of 55 lpcd, each household of 5 people generates approximately 185 litres of greywater per day, deriving from 91 lakhs rural households. With a total rural water supply of about 2,406 MLD in the state, nearly 70% of which (1,684 MLD) of greywater is estimated to be available for treatment. As of October 2025, under SBM-G 2.0, Gujarat has created a large number of greywater management structures at the household level assets (with ~184 MLD potential for reuse/recharge) and Community-level systems (with ~904 MLD for recharge/reuse). Taken together, these systems represent an estimated reuse and recharge potential of around 1,087 MLD across the state. Additional factors such as higher water supply levels (around 100 lpcd as per field observations), open wells, borewells and tubewells, blackwater mixing and rainfall can further increase the volume of greywater that requires management.

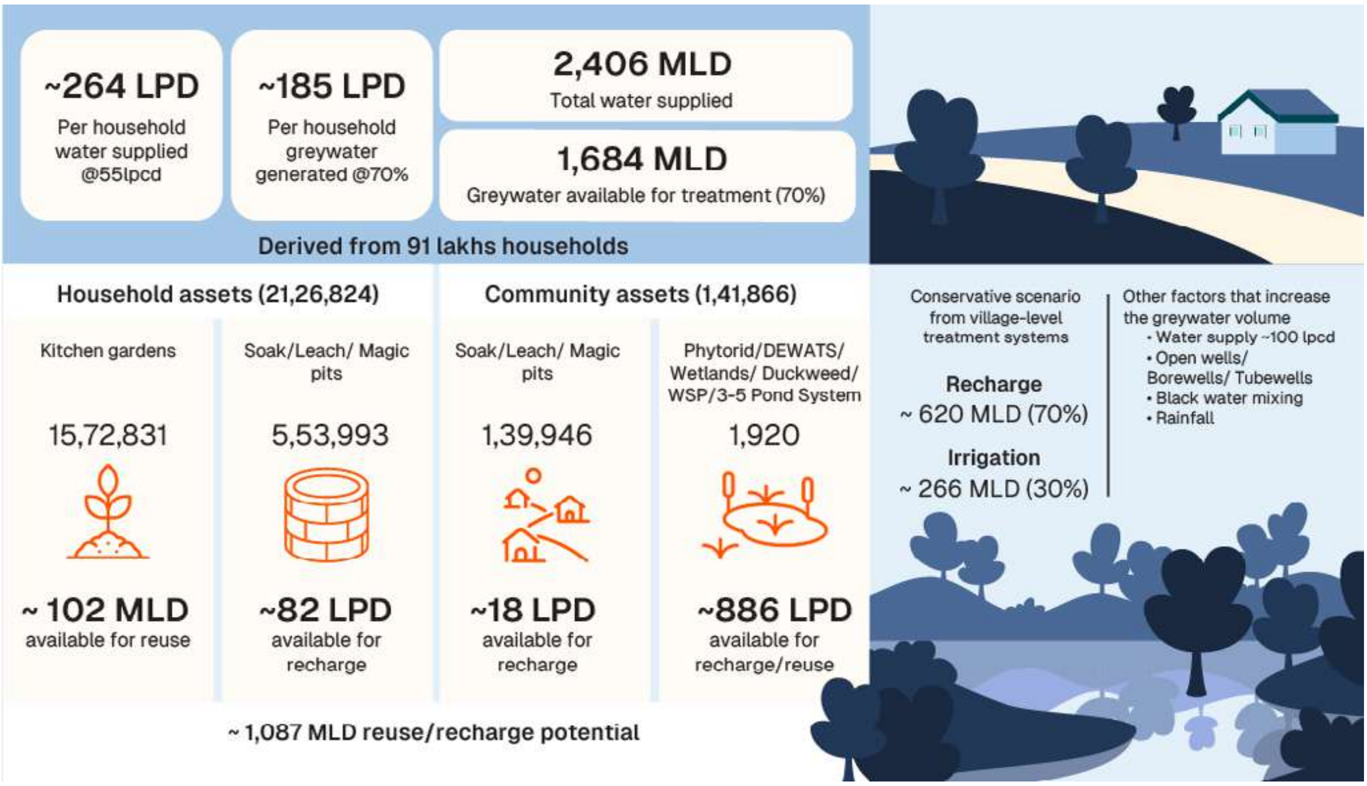

Figure 5: Estimated scenario of greywater generation and its reuse/recharge potential in Gujarat derived from SBM-G 2.0 data and assumptions (Refer to the Annexure 8.3) for assumptions).

Gujarat is hydrogeologically diverse, with nearly 60% of the state underlain by hard rock formations such as basalt and granite, and the rest comprising alluvial and coastal aquifers along major river basins and the Arabian Sea. The hard rock regions of Saurashtra and North Gujarat have limited groundwater storage and poor infiltration, reducing the effectiveness of soak pits and similar systems, while the alluvial plains of Central and South Gujarat offer better recharge potential but face risks of aquifer contamination from untreated greywater. Coastal districts experience salinity intrusion, necessitating lined or non-infiltration systems such as wetlands or DEWATS. Groundwater depth ranges from 2–5 meters in coastal and alluvial areas to 8–20 meters in hard rock zones, making infiltration systems unsuitable in shallow water table areas (2–3 meters) due to contamination and waterlogging risks.

In some areas, toilets are directly connected to open drains due to poor containment, causing blackwater to mix with greywater, with animal washing further increasing the organic load, an issue that was also observed during village visits. Untimely rainfall events further complicate collection and treatment processes. GPs face persistent challenges in maintaining dysfunctional treatment systems due to limited technical capacity and funds for O&M. Additionally, space constraints in several villages highlight the need for compact and locally adaptable treatment solutions.

3.1.2 Innovations

1. Case Study, Vedancha model

The greywater management in Vedancha village showcases a successful example of decentralized wastewater treatment and reuse. Located in Palanpur taluk, Banaskantha district, with 8,500 population. The system treats greywater from approximately 30% of households using a multi-media process that includes moon charcoal, carbon, alum and sand filtration. The treated water is reused for agricultural irrigation, in addition the system generates organic manure, generating a monthly revenue of about ₹45,000–50,000. This revenue generating model addresses wastewater management, also contributes to livelihood generation and stands out as a replicable model for other rural areas in Gujarat and beyond.

2. Community-based Pani Samithis

One of the most notable institutions in rural greywater management in Gujarat is the establishment of *Pani Samitis*, community-based village water and sanitation committees formed within Gram Panchayats.

These Samitis function as decentralized management units responsible for planning, implementing, and maintaining local water and sanitation systems, including greywater treatment infrastructure.

Constituted as standing committees under the Panchayati Raj framework and reconstituted every two years or after Panchayat elections, Pani Samitis play a crucial role in ensuring local participation and ownership. They are trained to plan and oversee system design, operation and maintenance of greywater management structures such as drains, soak pits, and decentralized treatment units. The Samitis also coordinate with District Rural Development Agencies, NGOs and other departments to mobilize resources from government schemes like MGNREGS and the 15th FC, promoting convergence and sustainability in rural wastewater management.

DEWATS in Patia Village, Anjar Block, Kutch District, Gujarat.

3.1.3 Challenges specific to Gujarat

Field observations across Gujarat highlight a set of interrelated challenges that affect the effective implementation of greywater management systems. Despite the policy and financial support available under the SBM-G 2.0 and other schemes, several contextual and operational issues persist.

1. Limited infrastructure in smaller villages
Rural communities fall below the population threshold for higher funding, leaving them without properly designed drainage lines, soak pits, or decentralized treatment systems. In several villages, greywater is directly discharged into open drains or nearby streams.

2. Site variability and design mismatches
Gujarat's diverse hydrogeological settings, ranging from saline coastal belts to rocky or low-permeability soils complicate standardized system design. Generic templates that ignore local soil and terrain conditions often result in poor system performance.

3. Land availability constraints
GPs struggle to identify and allocate suitable land for treatment systems. Encroachment, unclear ownership and lengthy approval procedures delay project implementation and limit scalability.

4. Demand management
A major challenge in Gujarat is the heavy reliance of agriculture on groundwater, driven by water-intensive crops such as paddy, wheat and sugarcane. High irrigation demand, supported by subsidised electricity, has led to rapid groundwater depletion in many areas. Shifting to less water-intensive crops and reusing treated greywater for irrigation are critical to easing this pressure and improving long-term water sustainability.

5. Use of untreated greywater
Farmers reuse untreated greywater for irrigation, even when it contains high BOD and COD levels, leading to risks for soil health, groundwater quality and public health. Mixing of greywater and blackwater adds complexity to treatment and reduces reuse options.

6. Financial and operational limitations
Although SBM-G, MGNREGS and 15th FC grants support liquid waste management, available funds are often insufficient for technically sound or large-scale systems. Convergence between these schemes should be strengthened and the fund flow should be mapped based on the requirements.

7. Operation and maintenance challenges
GPs lack trained personnel, maintain budgets, and monitoring systems. Handed over systems require regular upkeep and technical know-how.

8. Uncertainty in technology selection
Local decision-makers often lack technical guidance to select suitable treatment options for high BOD wastewater, leading to underperforming or poorly designed systems that fail to meet reuse or discharge standards.

9. Urban expansion and administrative overlaps
As large villages expand and merge with nearby towns, jurisdictional ambiguities arise. These areas often fall between rural and urban governance structures, creating confusion over administrative responsibilities.

10. Leadership and institutional continuity
Successful projects often lose momentum when new Panchayat leadership takes office and fails to prioritize maintenance or training. The absence of institutional mechanisms for continuity weakens long-term sustainability.

11. Limited and generalized capacity building
Trainings led by the State Institute of Rural Development have improved awareness, but remain largely conceptual and not tailored to Gujarat's varied conditions. Arid zones require focus on reuse and water-efficient systems, while coastal regions need training on non-infiltration technologies.

3.1.4 Field observations from Gujarat

The survey of four villages across Kutch and Banaskantha districts reveals critical insights into greywater management performance and gaps in Gujarat. While Patia and Shinay operate a DEWATS, Vedancha demonstrates the system with the addition of moon charcoal, carbon, alum and sand. The analysis shows that actual greywater generation far exceeds the designed treatment capacities, primarily because the systems were sized using the 55 lpcd norm rather than the actual supply levels of 100 lpcd or higher.

• As a result, even fully covered villages treat less than 20% of their actual wastewater load, leading to persistent waterlogging and hygiene issues.

• Villages with blackwater and greywater mixing, such as in Shinay and Akesan villages, face contamination risks that undermine both treatment efficiency and the potential for safe reuse.

• Vedancha village demonstrates a revenue-focused treatment system, including groundwater table recovery of 30–40 ft through recharge and revenue generation from sludge reuse.

• Lack of sustainable O&M financing and older systems rely on deferred maintenance.

The findings point to the need for a realistic design in Gujarat that should be based on:

• Actual water use.

• Complete drainage networks.

• Segregation of wastewater streams.

• Structured reuse planning aligned with local hydrogeology and agriculture.

• Establishing O&M financing mechanisms.

Reusing treated greywater to irrigate Pomogranate plantations in Patia Village, Anjar Block, Kutch District, Gujarat.

DEWATS system in Vedancha Village, Palanpur Block, Banaskantha District, Gujarat.

Untreated greywater being pumped for irrigation in Akesan Village, Palanpur Block, Banaskantha District, Gujarat.

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[8] *Central Ground Water Board, Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India Groundwater year book of Haryana state, 2021-2022*

3.2 Haryana

3.2.1 Status of greywater management and reuse potential scenario

With 100% FHTC under JJM, many villages in Haryana face challenges due to high greywater generation from water supply exceeding the 55 lpcd norm. Driven by extensive agricultural activity and widespread groundwater pumping, water use often surpasses norms, generating larger volumes of greywater. This hydraulic load is further compounded by Haryana's average annual rainfall of ~536 mm, with seasonal peak flows from stormwater entering village drainage networks.

Existing drainage infrastructure often leads to greywater infiltration into the ground, posing risks of groundwater contamination. Traditional structures such as johads capture about 50% of wastewater, historically used for bathing animals. The mixing of blackwater, greywater, and animal waste through complex drainage systems makes it difficult to implement appropriate treatment technologies.

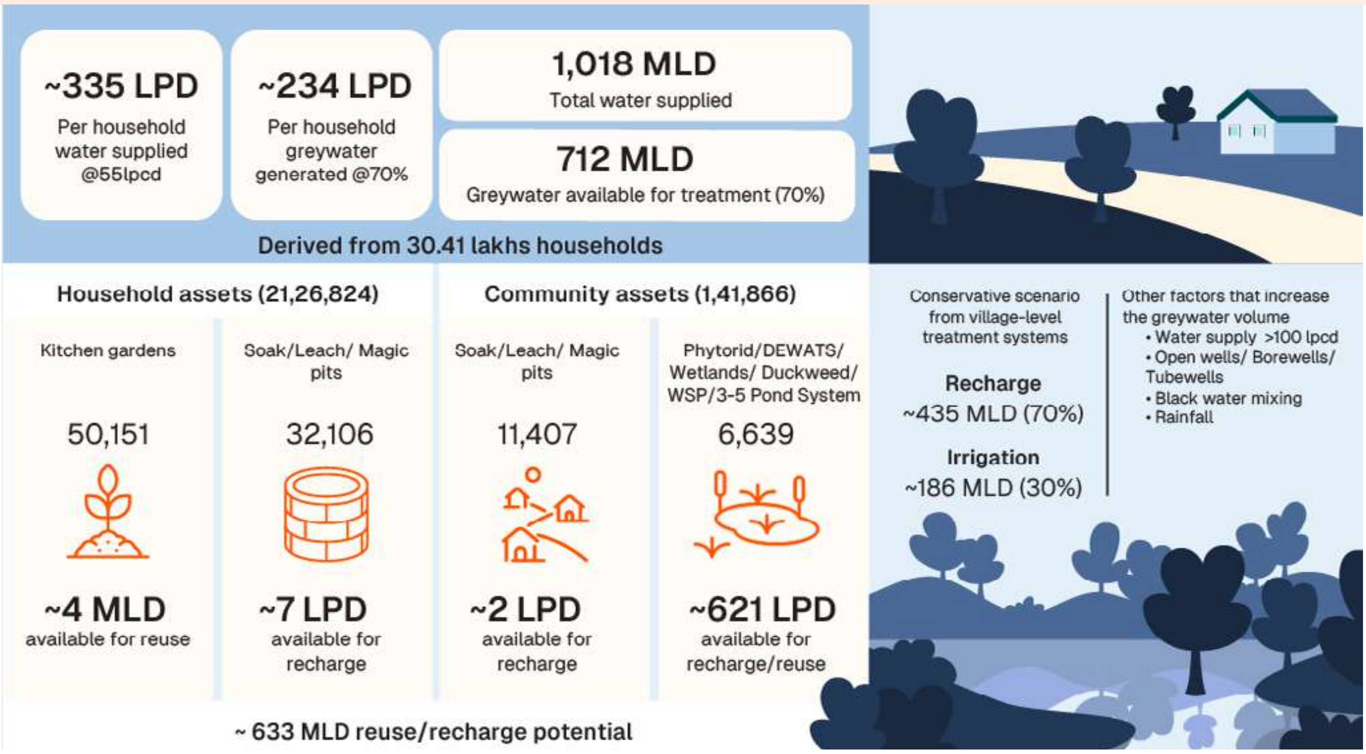


Figure 6: Estimated scenario of greywater generation and its reuse/recharge potential in Haryana derived from SBM-G 2.0 data and assumptions (Refer to the Annexure 8.3 for assumptions).

Assuming a supply of 55 lpcd, each household of 5.5 persons generates ~234 litres of greywater per day across 30.41 lakh rural households. With a total rural water supply of ~1,018 MLD, nearly 70% (712 MLD) is greywater. As of October 2025, under SBM-G 2.0, household-level assets (~11 MLD) and community systems (~623 MLD) together provide ~633 MLD reuse/recharge potential. However, higher actual supply levels (>100 lpcd), along with groundwater sources, blackwater mixing, and rainfall, can further increase greywater volumes requiring management.

Haryana largely comprises alluvial plains with a semi-arid climate and intensive wheat–paddy cultivation. In districts such as Karnal, Kurukshetra, and Panipat, shallow water tables (<2 m) reduce infiltration efficiency due to low hydraulic gradients and limited unsaturated zones, constraining safe absorption and treatment.

Predominantly, Haryana lies on alluvial plains with a semi-arid climate; shallow water table in parts; intensive agriculture with wheat and paddy crops grown in rotation. In Haryana, parts of districts like Karnal, Kurukshetra, and Panipat have shallow water tables (often <2 m)[8], and infiltration efficiency may drop sharply, even in permeable soil. The hydraulic load difference is too low to drive percolation, and the unsaturated zone is too thin for safe absorption and treatment.

3.2.2 Innovations

In Haryana, the “Nehveen” model of greywater management has been adopted under SBM-G to reduce freshwater use, recharge groundwater, and treat community greywater locally. Piloted in Jitanwas, Kairu Block of Bhiwani district, the system, built at a cost of about ₹1.49 lakh for ~200 households, proved effective as a low-cost and low-maintenance treatment option. The innovative approach increased groundwater levels by 2 feet, prompting the district administration to extend it to 84 more villages. In Bhiwani district, this initiative has helped manage about 2,19,000 kilo-litres of greywater. The technical design of the Nehveen model combines a soak pit and a leach pit following a five-step filtration process, ensuring safe disposal of wastewater and maintaining long-term functionality. The model also integrates rainwater management, making it a holistic and sustainable solution for rural areas.

Based on the official government evaluation conducted by the “Water Cell, Bhiwani,” a government institute: A total of 22 project evaluations were performed by the government agency across GPs in Bhiwani District.

3.2.3 Challenges specific to Haryana

1. Financial challenges
A decentralized treatment system in smaller villages requires more than ₹280/- per capita funding for Capex. The lack of recognition and minimal incentives for local innovation in small villages, reduces motivation among officials and GP members to sustain or scale up successful practices. Despite progress made in several villages, the availability of O&M funds remains a critical issue. The lack of sustained funding and convergence between Capex and Opex weakens long-term system functionality.

2. Water quality testing challenges
The state maintains a good standard of water quality testing, with samples sent to central locations like Chandigarh for mandatory testing before reuse of treated greywater, primarily managed by the Haryana Pond and Waste Water Management Authority. However, inconsistencies exist, with some villages neglecting testing procedures.

3. Technical challenges
Most sites continue to face the problem of greywater and blackwater mixing with high pathogenic or organic load. This calls for an appropriate treatment technology selection before reuse. Missing or incomplete conveyance structures, such as silt traps, screens and distribution pipelines, also restrict effective reuse. Regular desludging and system maintenance are often delayed, leading to performance deterioration.

4. Institutional & Governance challenges
O&M responsibilities are gradually being transferred from contractors to Gram Panchayats, but the transition is uneven. Many Panchayats and VWSCs lack the technical capacity to manage these facilities independently. Weak monitoring mechanisms and limited data on system performance further reduce accountability and system optimization.

5. Socio-cultural challenges

Cultural perceptions and local practices also influence system performance. In some villages, the pond (Johads) holds religious significance, being considered sacred, which complicates its use for wastewater treatment.

6. Land and space constraints

Encroachment on GP land has limited the availability of space for constructing or expanding treatment systems. In dense rural areas, identifying suitable land parcels for pond systems or wetlands remains a persistent challenge.

3.2.4 Proposed initiatives for Haryana

The analytical finding highlights that the rigid, population-based financial norm of SBM-G 2.0 is a structural barrier to achieving universal Liquid Waste Management in Haryana. The solution requires a shift from reliance on a single funding stream to a model of "Financial Convergence" and "Innovative Resource Mobilization."

What?	How
Mandate program convergence - Addressing the funding gap	
Formally mandate the integration of funds from the 15th FC grants and MGNREGS into every GPs LWM project plan of a Village Action Plan.	Formally mandate the integration of funds from the 15th FC grants and MGNREGS into every GPs LWM project plan of a Village Action Plan.
Shift to a hybrid Capex model - Optimizing investment	
For the 84% of villages (with population <5,000), shift the focus from solely individual decentralized systems to a Hybrid Decentralized-Cluster Model.	Encourage GPs to build small-scale, cluster-level units (e.g., community leach pits/Phytorid systems for 5-10 households) where land permits. The funding for the common facility should be prioritized for convergence from all available sources, ensuring that the ₹280/- per capita allocation is used as a starter fund rather than a ceiling.
Incentivize GP revenue generation - Sustainability solution	
Implement a state-level policy (e.g., through the Haryana Pond and Wastewater Management Authority) that provides a Performance-Linked Incentives to GPs that successfully convert their treated greywater into a revenue stream.	Incentivize the lease of maturation ponds for pisciculture or the sale of treated water for irrigation. This generates a local recurring revenue base that covers the crucial gap of O&M costs, to ensure long-term sustainability.
Treated greywater quality testing - Safety measures	
Ensure uniform compliance and accountability, a new regulatory mandate is required to enforce periodic testing and publicly display the results on a State/National level dashboard.	HPWWMA to enforce a specific frequency and set of parameters for greywater testing by villages, with penalties for non-compliance. By integrating real-time digital data to the existing dashboard, enabling easy monitoring and accountability by both regulatory bodies and the public.

Table 5: Proposed initiatives for Haryana.

3.2.5 Field observation from Haryana

• Yamuna Nagar district and Karnal district lie within the fertile Indo-Gangetic alluvial plains, characterized by flat terrain and unconfined aquifers with high groundwater potential. Yamuna Nagar receives nearly 890 mm and Karnal around 830 mm of rain annually.

• Baindi, Barani Khalsa and Samana Bahu villages have adopted centralised systems, such as the 3-Ponds System and a modern Constructed Wetland.

• Despite significant capital investments ranging from ₹33 lakh to ₹87 lakh, largely financed through State Funds, SBM-G and the 14th/15th FC, these systems are severely underutilized.

• The Constructed Wetland at Barani Khalsa currently operates at 6% of its design capacity, while the 3-Ponds System in Samana Bahu operates at 13%, even though the actual household water supply far exceeds the 55 lpcd norm used for system design.

• Design norms must be recalibrated by shifting from 55 lpcd to reflect actual consumption patterns (borewells, blackwater mixing, storm water, etc).

• Across all locations, blackwater mixing remains a pervasive challenge, further weakening treatment outcomes.

• Additional governance constraints include insufficient O&M funds in Baindi and Khajuri, the non-functioning of MGNREGS for two years and low SBM-G allocations that restrict the use of convergence funds.

Field observations reveal a clear contrast between villages with established wastewater treatment systems and those without. Khajuri village, which lacks any treatment facility, illustrates the consequences of unmanaged greywater: severely polluted ponds, high siltation, hyacinth growth and frequent monsoon overflows. Villages with operational systems show socio-environmental gains. Baindi, Barani Khalsa and Samana Bahu are all reusing treated greywater, supporting 50–100 acres of irrigation. Based on interactions with farmers, a reduction in chemical fertiliser use has been reported alongside improvements in agricultural productivity. This is likely attributable to the higher nutrient and organic content resulting from the mixing of blackwater, which may be enhancing soil fertility. The integration of solar-powered pumping, as observed in Samana Bahu village, presents a scalable model for low-carbon irrigation with treated greywater and low-cost O&M.

Facultative pond of the 3-pond treatment system in Baindi Village, Radaur Block, Yamuna Nagar District, Haryana.

Stabilization Pond along with Vetiveria Zizanoides plantation as part of a treatment in a constructed wetland in Barani Khalsa Village, Nilokheri Block, Karnal District, Haryana.

Community walking path along side of the constructed wetland in Barani Khalsa Village, Nilokheri Block, Karnal District, Haryana.

Solar powered pumping of treated greywater in Samana Bahu Village, Nilokheri Block, Karnal District, Haryana.

3.3 Karnataka

3.3.1 Status of greywater management and reuse potential

Assuming a water supply of 55 lpcd, each household of 5 people generates approximately 169 litres of greywater per day, deriving from 1.01 crore rural households. With a total rural water supply of about 2,452 MLD in Karnataka, nearly 70% of which (1,716 MLD) of greywater is estimated to be available for treatment. As of October 2025, under SBM-G 2.0, the State has created a large number of greywater management structures at the household level assets (with ~92 MLD potential for reuse/recharge) and Community-level systems (with ~1,207 MLD for recharge/reuse). Taken together, these systems represent an estimated reuse and recharge potential of around 1,299 MLD across the state. Additional factors such as water drawn from open wells, borewells and tubewells, blackwater mixing and rainfall can further increase the volume of greywater that requires management.

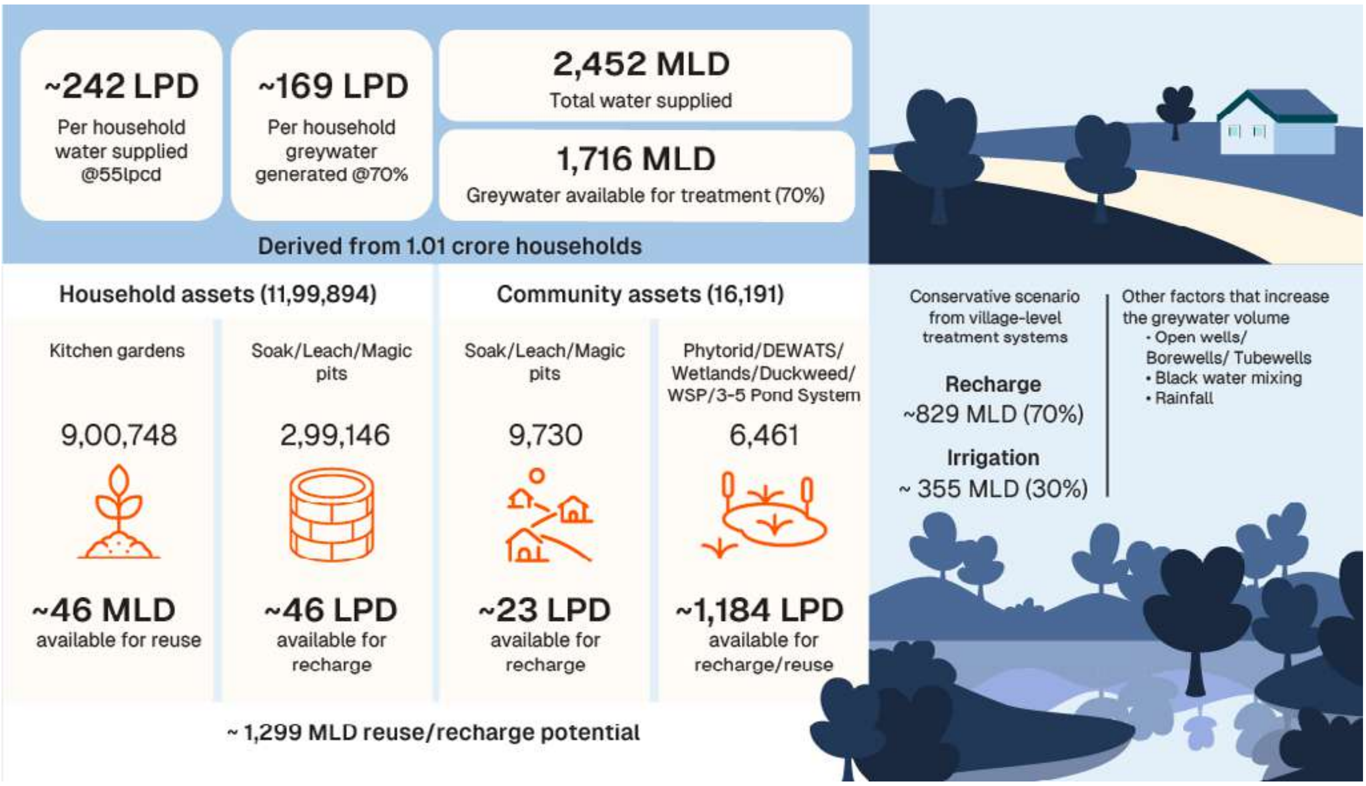


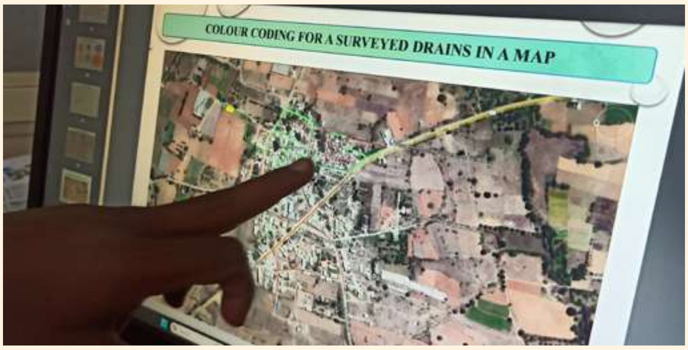
Figure 7: Estimated scenario of greywater generation and its reuse/recharge potential in Karnataka derived from SBM-G 2.0 data and assumptions (Refer to the Annexure 8.3 for assumptions)

DEWATs using Canna Indica plants in Muthur Village, Sidlaghatta Taluk, Chikkaballapur District, Karnataka.

3.3.2 Innovations

1. The Inline treatment system and constructed wetlands have been identified as scalable technologies for rural greywater management in Karnataka. This system integrates horizontal, vertical, and sub-surface flow channels supported by Canna Indica plantations, which enhance treatment efficiency and natural filtration.

2. Karnataka has initiated the systematic collection of greywater by strengthening village drainage networks to include all households, a critical prerequisite for implementing treatment systems and ensuring hygienic conditions across the village.



Block Engineer in Chikkabalapur District showing the GIS based planning of drainage network.

3. Training, convergence and local ownership have emerged as key priorities for sustaining greywater management systems. Cluster-level capacity-building workshops build technical understanding among district and block staff of the RDPR and MGNREGA implementing departments. In addition, Zilla Panchayats are expected to play a larger role in facilitating O&M training, monitoring and knowledge exchange. Eventually, O&M responsibilities will be vested in the GPs, necessitating human resources and funding support for long-term sustainability.

4. Innovations under the New Gandhi Sakshi Kayaka (NGSK) programme are strengthening the monitoring and accountability of greywater management initiatives in Karnataka. The programme uses digital tools such as geotagging of assets and digital payment systems to ensure transparency and real-time progress tracking.

Separate diversion channels of stormwater and greywater in Muthur Village, Sidlaghatta Taluk, Chikkaballapur District, Karnataka.

5. Muthur village in Chikkaballapur district features a constructed wetland designed using DEWATS technology, with a stormwater drain separation system to prevent overflows during heavy rains. The Muthur initiative was implemented through a partnership involving Gramantara Trust, IIT Madras, the Rural Development Department under MGNREGA and the Rural Water Supply and Sanitation Department. The Muthur model exemplifies the benefits of a multi-stakeholder approach that combines scientific expertise with local participation and government support. While such models provide direction for future interventions, scaling them up across the state remains a challenge due to high costs (Rs 29 lakhs for capital cost alone), the need for continuous capacity building and limited convergence between funding streams.

• Several GPs have demonstrated innovative and replicable approaches to greywater management, as seen in Bedawatti in Koppal district and Kodiyal in Haveri district showcasing effective inline treatment systems. These examples illustrate how convergence between scientific design, community ownership, and institutional collaboration can deliver sustainable solutions in rural wastewater management.

3.3.3 Challenges specific to Karnataka

Greywater management in Karnataka faces a complex set of challenges spanning institutional, financial, technical and behavioural dimensions as given below:

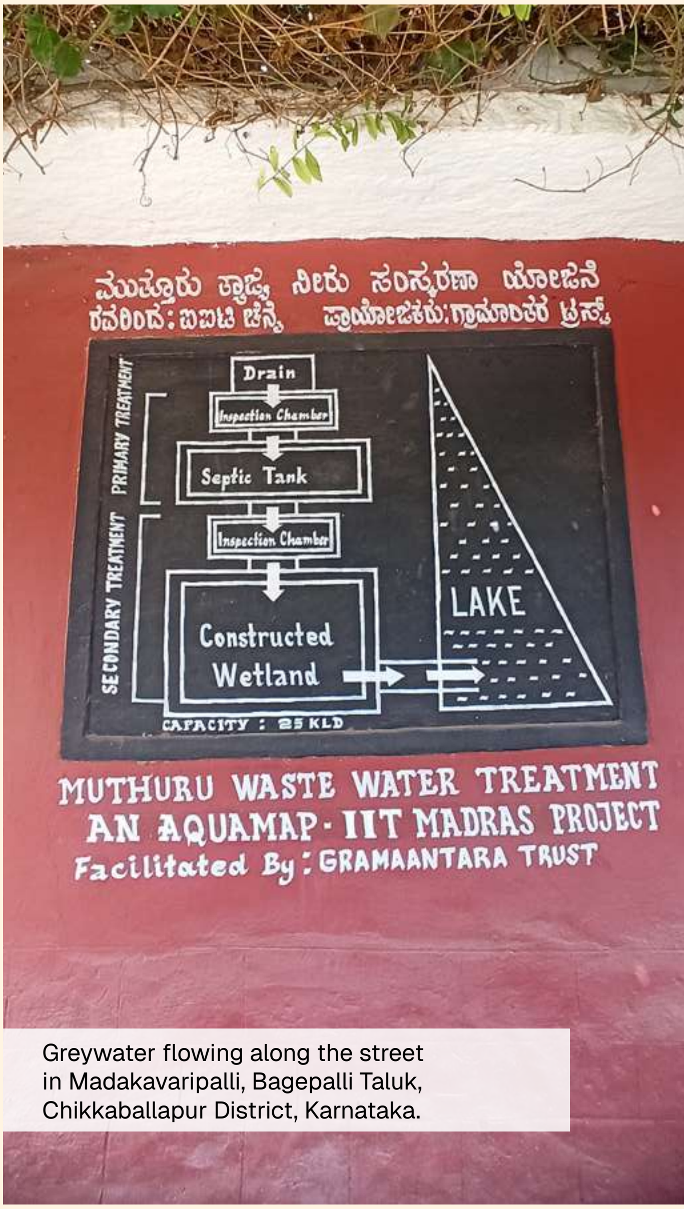
1. Financial challenges

Greywater management in Karnataka is constrained by systemic financing and implementation challenges. Nearly 94% of villages fall below the 5,000 population threshold, limiting allocations to ₹280 per capita is inadequate for community-scale treatment systems, while MGNREGA's 60:40 labour–material ratio further restricts the construction of technically robust infrastructure. Although GPs have estimated annual budgets of ₹10–30 crore, delays in fund release significantly slow project execution, and 15th FC grants, despite earmarking 30% for WASH, are largely confined to O&M.

Funding for greywater management relies primarily on SBM-G 2.0 and MGNREGA. Under MGNREGA, around 500 GPs were covered in Phase 1, with another 500 planned in Phase 2; however, progress remains slow due to financial constraints and delayed fund flows. As a result, inline treatment systems currently cover only about 10–15% of drainage networks, and land constraints limit the construction of community soak pits. At the household level, greywater reuse through kitchen gardens and individual soak pits supported by MGNREGA at ₹5,000 per unit is common, particularly in the coastal and Malnad regions, following intensive IEC efforts. However, the absence of extended drainage networks and the lack of full coverage for drainage construction under SBM-G 2.0 leave village-level treatment systems fragmented and incomplete, underscoring the need for stronger programme convergence and innovative financing mechanisms to bridge the funding gap.

2. Technical challenges

From a technical standpoint, incomplete drainage networks and limited land availability undermine the performance of community systems. Inline systems cover only a small portion of drainage lines, and soak pits often fail in areas with impermeable soils or high groundwater tables. Since SBM guidelines do not support full-length drainage systems, the current fund allocation remains inadequate to set up functional community treatment solutions. Systematic water quality testing and monitoring are rare, and there is little awareness about the reuse potential of treated greywater.



Greywater flowing along the street in Madakavaripalli, Bagepalli Taluk, Chikkaballapur District, Karnataka.

3. Social challenges

Behavioural and social challenges add another layer of complexity. Private landowners are often reluctant to allow drains to cross their property, and existing road networks disrupt the natural flow of wastewater. At the local level, awareness and engagement remain limited, and dedicated staff for O&M are rarely available; at least 1-2 people are required for managing and cleaning. There is currently no awareness around the reuse of treated greywater. Reducing BOD is the primary technical concern, yet no systematic testing of treated greywater is planned. O&M responsibilities will eventually be transferred to GPs once training is provided.

Only around 4,000 villages have prepared liquid waste management plans, reflecting the gap between planning and implementation readiness. Overall, the combination of weak institutional integration, low funding and technical limitations continues to restrict the scalability of greywater management solutions in the State.


Greywater treatment system in Muthur Village, Sidlaghatta Taluk, Chikkaballapur District, Karnataka.

3.3.4 Proposed initiative

Karnataka must move towards integrated, data-driven and resource-efficient systems. Strengthening convergence across SBM-G 2.0, JJM, MGNREGA and FC grants is essential to overcome fragmented funding streams. Developing district-level convergence plans that map out financial contributions and shared responsibilities can ensure that infrastructure, O&M and reuse planning are funded cohesively.

Institutional strengthening is another priority. Establishing dedicated technical support units at the district level for planning, design vetting and capacity building will help maintain quality and consistency. GPs should be supported in preparing Village Liquid Waste Management Plans, which align local priorities with available resources and emphasize reuse pathways such as groundwater recharge, irrigation or horticultural use.

The state can further enhance transparency and accountability by leveraging digital platforms for asset mapping, monitoring and water quality testing. Integration of greywater asset data with the SBM-G dashboard or New Gandhi Sakshi Kayaka (NGSK) portal can enable real-time performance tracking and flag non-functional systems for timely rectification.

Finally, the way forward requires a shift from viewing greywater as waste to seeing it as a recoverable water resource. Promoting decentralized reuse models, such as linking treated greywater to kitchen gardens, green belts, or farm ponds, will not only close the water loop but also build local resilience to water stress. With its strong Panchayati Raj system, robust technical ecosystem, and demonstrated pilots, Karnataka is well-positioned to lead the next generation of scalable, climate-responsive rural greywater management solutions in India.

3.3.5 Field observations from Karnataka

Field observations across four villages in Raichur, Koppal, Chikkaballapur and Tumkur reveal significant variation in greywater system performance driven by differences in coverage, design and the extent of blackwater mixing. Inline systems in Tungabhadra Camp, Bedavatti and Banavara operate with 50–90% household coverage, but their effectiveness is reduced by blackwater inflows and stormwater intrusion, especially during the monsoon. Muthur stands out with a constructed wetland–based DEWATS system covering 70% of households, no blackwater mixing and regular water-quality monitoring supported by IIT Madras, indicating a technical foundation. Villages with no treatment face issues such as lake pollution, hyacinth growth and open-drain stagnation. Reuse practices also vary widely, from limited irrigation with blended freshwater (Raichur) to groundwater recharge (Chikkaballapur) and direct farm irrigation (Tumkur), yet none of the villages have revenue-linked reuse models or strong VWSC-led governance structures.

To strengthen rural greywater management across these regions, systems must be redesigned with segregated drainage networks to prevent blackwater and stormwater mixing. Treatment performance can be significantly improved through intermediate chambers, upgraded conveyance lines and dedicated stormwater bypasses. O&M sustainability requires standardized budgets, revival of MGNREGA support for routine maintenance and cluster-based contractor models to ensure consistent operation. Enhancing greywater reuse with fodder or crops with appropriate blending can expand irrigation benefits, particularly in water-scarce districts. Strengthening VWSCs and water-quality testing will further improve systems and environmental outcomes.

Inline Treatment System, a Nature-based Technology in Bedavatti village, Shirur GP, Koppal District, Karnataka.

3.4 Punjab

3.4.1 Status of greywater management and reuse potential scenario

Assuming a water supply of 55 lpcd, each household of 5 people generates approximately 205 litres of greywater per day, deriving from 34.2 lakhs rural households. With a total rural water supply of about 1,003 MLD in the state, nearly 70% of which (702 MLD) of greywater is estimated to be available for treatment. This is crucial given the state's severe water stress: over 75% of Punjab's blocks are classified as "over-exploited" and groundwater extraction stands at 157%, the highest rate in India. Such figures underscore the urgent need for regulated, standardized water supply to relieve burdened treatment systems, optimize reuse potential and safeguard rural water sustainability.

As of October 2025, under SBM-G 2.0, the State has created a large number of greywater management structures at the household level assets (with ~1 MLD potential for reuse/recharge) and Community-level systems (with ~560 MLD for recharge/reuse). Taken together, these systems represent an estimated reuse and recharge potential of around 561 MLD across the state. Additional factors such as higher water supply levels (more than 150 lpcd as per field observations), open wells, borewells and tubewells, blackwater mixing and rainfall can further increase the volume of greywater that requires management.

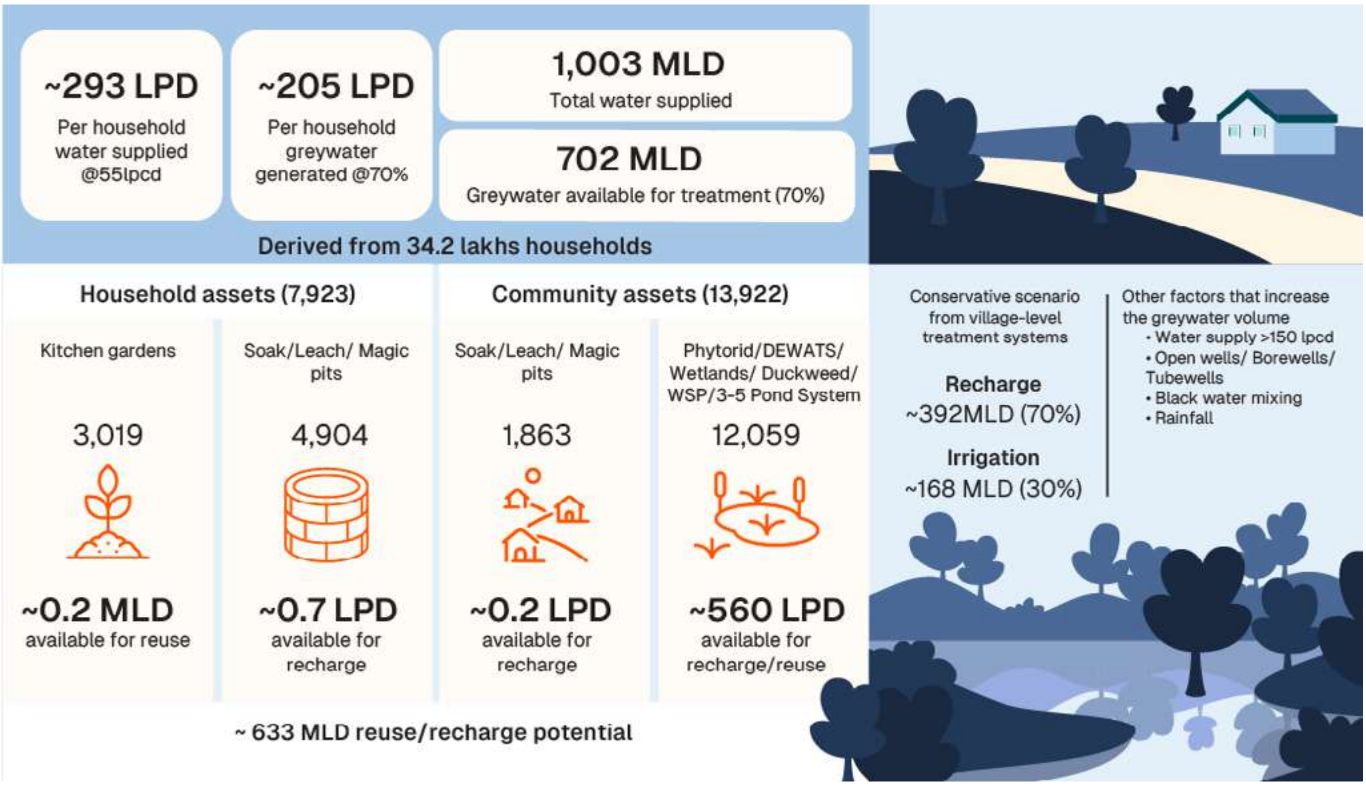


Figure 8: Estimated scenario of greywater generation and its reuse/recharge potential in Punjab derived from SBM-G 2.0 data and assumptions (Refer to the Annexure 8.3 for assumptions).

3.4.2 Innovations

The Seechewal Model and the Thapar Model represent two distinct approaches to low-cost, decentralized greywater management widely adopted in rural Punjab. The Seechewal Model, pioneered by Sant Balbir Singh Seechewal, is a community-led, indigenous system centered on a gravity-based network. It collects grey water from the village into a series of three or four wells/chambers: the first for screening of solid debris, the subsequent ones for sedimentation and oil/grease removal. The partially treated water is then typically pumped out for direct use in agricultural irrigation, effectively reducing the pollution of village ponds and river bodies, such as the Kali Bein and promoting groundwater recharge. Its success relies heavily on strong community participation for regular maintenance and cleaning of the chambers.

Thapar Model is generally seen as a technically refined, engineered version that often integrates the primary treatment of the Seechewal system with a subsequent nature-based technology. While also using the initial screening and multi-chamber sedimentation process, the Thapar Model frequently incorporates Constructed Wetlands (Reedbed Technology). These wetlands utilize specific aquatic plants (like phragmites or typha) to biologically filter and purify the water, removing residual nutrients and pathogens to a much greater extent before it is used for irrigation or allowed to recharge the groundwater. The Thapar Model aims to achieve higher water quality standards through this added biological step, though it may require greater initial investment and more specialized technical oversight compared to the simplicity of the original Seechewal method.

Figure 9: Schematic flow of steps involved in Waste Stabilization Pond (Thapar Model) treatment system.

3.4.3 Challenges and proposed initiatives specific to Punjab

Challenges	Proposed initiatives
Overload due to rainfall and contamination - Punjab has a moderate, highly variable average annual rainfall of about 649 mm, concentrated in the monsoon season. Northern regions, like Pathankot, receive higher amounts (>1,000 mm), while southwestern districts, such as Bathinda, are significantly drier. Effective greywater systems must integrate stormwater and roof-runoff. Failure to do so can cause a hydraulic overload of soak/leach/magic pits during heavy rain causing groundwater contamination, as it forces partially treated wastewater into the shallow water table.	The need for source segregation: Since Punjab is severely groundwater-stressed due to intensive agriculture, the reuse potential of greywater (for non-potable purposes like agriculture) and the potential for stormwater harvesting (for groundwater recharge) are high. Effective parallel systems are essential to maximize both goals.
Increased volume of greywater due to subsidized electricity leading to overexploitation of groundwater extraction - Punjab reports the highest level of electricity subsidy per hectare of groundwater irrigated area (Rs. 12194/ ha; Without subsidy ~Rs. 1.62 per m^3 and with subsidy ~Rs. 0.38 per m^3).	Subsidies for agriculture should be linked to groundwater status and incentivize farmers to adopt water-saving practices and reuse treated greywater for irrigation. Such alignment of energy and water policies would help curb uncontrolled groundwater extraction and promote sustainable water management.
Weak institutional convergence and limited funding - Overlaps between SBM-G, MGNREGA, and Finance Commission allocations delay implementation, while most funds are restricted to O&M.	Strengthen convergence across schemes through joint planning and fund pooling and establish district-level technical coordination cells for implementation support.
Perceived risks on water quality testing - The farmers apply the treated greywater without testing to their agricultural lands. Some farmers have also experienced loss of crop due to excess nutrient content.	Conduct awareness and demonstration campaigns, introduce routine greywater quality testing to ensure safety assurance
Blackwater mixing is one of the failures for the popular Seechewal and Thapar Models. Even minor sewage contamination introduces high pathogenic loads like *E. coli*, Nitrogen and Phosphorus into the greywater. This instantly overloads the natural treatment capacity of the systems and requires the village to invest in advanced and costly mechanical treatment plants that are difficult to maintain in a rural setting.	Ensure all blackwater is directed exclusively into twin-pit latrines or septic tanks. The local Village Water and Sanitation Committee must be empowered with the authority and resources (funded by the GP and SBM-G) to conduct regular inspections on mixing blackwater into the greywater or stormwater drains and ensure the segregated systems are in order.
Many systems fail due to the absence of dedicated O&M staff and inadequate maintenance budgets.	Build local capacity through training of GP functionaries and masons, create clear O&M protocols and allocate regular budgets for upkeep.

3.4.4 Field observations from Punjab

The study visited four villages across two districts: Heron Kalan and Khiwa Khurd in Mansa and Bhai Bhaktaur and Bhucho Khurd in Bathinda. These areas lie in the semi-arid, flat plains of Punjab, with high groundwater extraction for agriculture. The data highlights a strong regional preference for the Thapar Model technology, which is fully operational and covers between 58 - 81% of households in Heron Kalan, Khiwa Khurd and Bhai Bhaktaur villages. The capital expenditure for these systems ranged from ₹18 - ₹28 lakhs, funded primarily through a blend of 15th FC, SBM and MGNREGS. All the four villages, including the village with no treatment facility in Bhucho Khurd, report blackwater and greywater. None of the treated villages has conducted inlet or outlet water quality testing, underscoring a critical gap in monitoring and regulatory compliance.

A significant finding across the treated villages is the severe mismatch between plant capacity and actual greywater generation. While the actual water supply is high (ranging from 140 to 160 lpcd, far exceeding the 55 lpcd norm), two villages show major capacity issues: Heron Kalan is running at 408% of its design capacity and Bhai Bhaktaur at 156%. This overload leads to operational challenges such as maturation tank overflow and rainwater bypass, as observed in Khiwa Khurd. Furthermore, the sustainability of these systems is questioned by low community engagement; two VWSCs are noted as “not active” with limited women representation. The high volume of free electricity for borewells acts as a major disincentive for farmers to reuse treated greywater, forcing the state to compete with subsidised freshwater, thereby limiting the full environmental and financial returns on the multi-lakh rupee investment.

Greywater management in Punjab is supported through a convergent funding model under SBM-G 2.0, combining allocations from multiple government sources to enable infrastructure creation and maintenance. The funding structure is as follows:

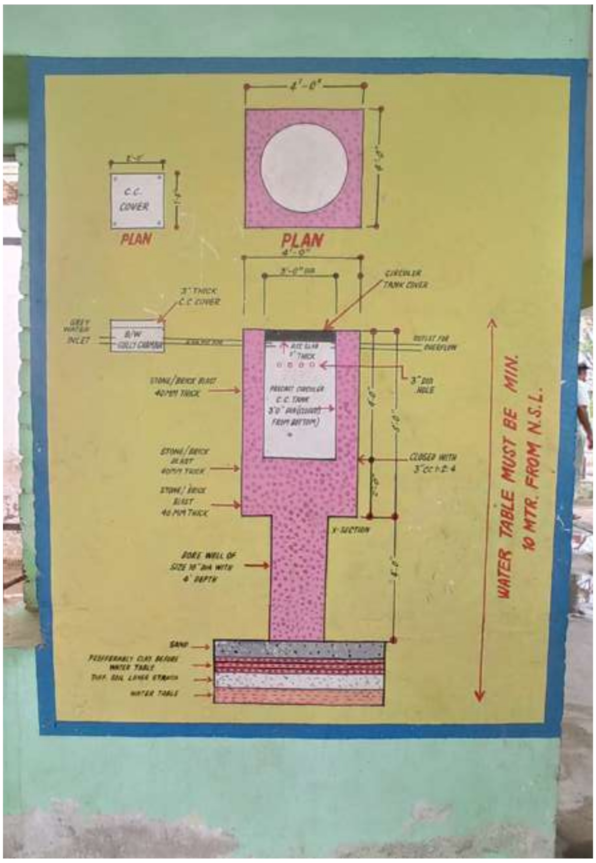
Untreated greywater let into the village pond in Bhucho Khurd Village, Nathana Block, Bathinda District, Punjab.

• *SBM Grameen 2.0*: Funds primarily support the construction of drainage networks, soak pits, and community treatment systems.

• *14th & 15th* FCs: Approximately 60% of tied grants are allocated for WASH activities, including sanitation, ODF maintenance and greywater recycling.

• MGNREGS complements SBM by financing labour-intensive works, such as the excavation of drains, ponds, and soak pits, ensuring infrastructure affordability for GPs.

• *State Funding*: Department of Water Supply and Sanitation (DWSS) – for project design and monitoring; and Punjab Rural Development Fund (RDF Act) – for supplementary financing and convergence activities. *For example in Khiwa Khurd GP, Mansa District, Punjab, the funds converged from 14th FC (39%), 15th FC (19%), SBM-G (20%) and MGNREGA (22%), highlighting how multi-source financing enables rural local bodies in Punjab to implement and maintain effective greywater management systems.*



Schematic diagram of Soak Pit in a school in Punjab


Community Soak Pit in Sevaki Khurd Village, Baori Block, Jodhpur District, Rajasthan.

3.5 Rajasthan

3.5.1 Status of greywater management and reuse potential

Assuming a water supply of 55 lpcd, each household of 5.5 people on average generates approximately 208 litres of greywater per day, deriving from 1.07 crore rural households. With a total rural water supply of about 3,206 MLD in the state, nearly 70% of which (2,244 MLD) of greywater is estimated to be available for treatment. As of October 2025, under SBM-G 2.0, the State has created a large number of greywater management structures at the household level assets (with ~19 MLD potential for reuse/recharge) and Community-level systems (with ~1091 MLD for recharge/reuse). Taken together, these systems represent an estimated reuse and recharge potential of around 1,110 MLD across the state. Additional factors such as open wells, borewells and tubewells and blackwater mixing can further increase the volume of greywater that requires management.

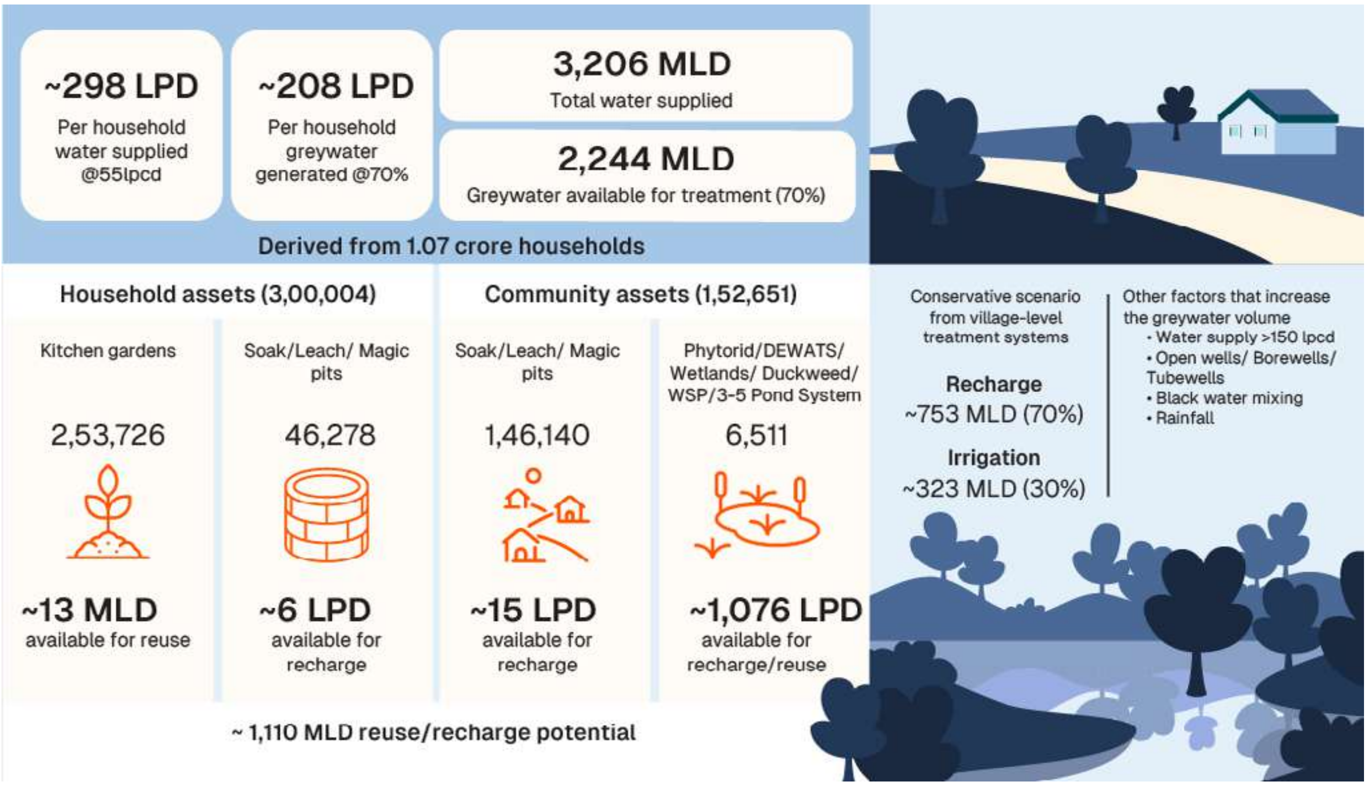


Figure 10: Estimated scenario of greywater generation and its reuse/recharge potential in Rajasthan derived from SBM-G 2.0 data and assumptions (Refer to the Annexure 8.3 for assumptions).

In Rajasthan, greywater reuse and recharge potential is constrained by acute water scarcity and limited service levels. Most villages receive less than 35 lpcd, often only once or twice a week, resulting in low greywater generation, while reliance on wells and local waterbodies further fragments wastewater flows. High evaporation in the arid climate reduces volumes further, limiting the effectiveness of open systems. These conditions necessitate covered greywater systems that minimise losses and support groundwater recharge. Other influencing factors include:

• The greywater volume could be higher in reality due to open wells, borewells or tube wells supplementing household water use beyond the official supply

• Mixing of greywater with blackwater in drains is another factor that increases the total wastewater load, further complicating the treatment efficiency.

3.5.2 Innovations

1. Cluster-based greywater treatment systems[9]
In arid districts such as Bhilwara, Udaipur and Rajsamand, village clusters (3–5 villages) share a single treatment unit such as a constructed wetland or DEWATS system, reducing infrastructure cost and land requirement. Governance is strengthened via Joint Village Sanitation Committees that span multiple GPs and jointly manage the O&M.

2. MGNREGS-Converged greywater ponds for reuse and recharge[10]
Villages in Barmer, Jodhpur and Nagaur are using MGNREGS funds to build lined greywater collection and treatment ponds integrated with plantation and recharge trenches. This financial model converges MGNREGS labour support with grants from the 15th FC and involves village SHGs and Panchayats in operation. Treated water is used for village plantations and fodder crops and Panchayats in operation. Treated water is used for village plantations and fodder crops.

3.5.3 Challenges specific to Rajasthan

Rajasthan's arid climate, fragile hydrogeology and chronic funding constraints pose unique challenges for greywater management. Addressing these issues will require region-specific system designs, contingency financing for O&M and enhanced capacity-building at the GP level to ensure resilient and sustainable wastewater solutions.

1. Water scarcity limits greywater generation
Many villages in Rajasthan receive a piped water supply once a week and in some areas on alternate days less than 55 lpcd resulting in low volume of greywater generation, making it difficult to design and sustain treatment systems. In arid districts like Jaisalmer, Barmer and Jodhpur, household greywater is often reused directly in kitchen gardens, community soak pits or livestock, leaving little residual wastewater for centralized collection or treatment. The gap of 42% FHTCs once achieved, will likely increase the total volume of greywater generation.

2. High evaporation constrains reuse potential
Rajasthan's hot and dry climate, with evaporation rates often exceeding 2,000 mm/year (CGWB, 2023), significantly reduces the scope for using treated greywater for irrigation or groundwater recharge. Open ponds and wetlands lose significant volumes of water through evaporation, leading to reduced efficiency of treatment and reuse systems.

3. Damage and lack of O&M funding
O&M remain a major bottleneck across rural greywater systems. In one reported case, the treatment plant in Bhatinda Village, Jodhpur District was damaged due to heavy rainfall, but the GP lacked funds for repair and has since left the plant repaired. Most GPs have no dedicated O&M budget or staff, making systems vulnerable to neglect and eventual failure.

4. Design unsuitability for local hydrogeology
Much of Rajasthan is underlain by hard rock or saline formations with poor infiltration capacity. Soak pits or infiltration-based systems are therefore ineffective or even hazardous, as they may cause contamination of shallow aquifers.

5. Low technical capacity and convergence gaps
Panchayats often lack trained personnel to oversee construction, O&M. *The villages visited in Jodhpur district had SBM-G 2.0 (70%) and 15th FC (30%) funding.* Coordination between SBM-G, MGNREGS and FC funds remains weak, leading to delays due to insufficient funds for implementation.

[9] *SBM-G 2.0 progress report 2023, Department of Rural Development, Rajasthan.*

[10] *UNDP India - Greywater management through convergence models in Rajasthan, 2023.*

3.5.4 Field observations from Rajasthan

The assessment of greywater management across Sevaki Khurd, Sevaki Kallan, Bhatinda and Daikara villages shows that rural Jodhpur has achieved relatively high household coverage through low-cost, decentralized systems such as magic pits, leach pits, soak pits and WSPs. Coverage ranges from 64-94%, with no blackwater mixing reported due to the arrangement of separate twin pits for toilets, indicating good containment practices. Since most households rely on individual or community soak pits, ensuring the quality of pit construction and regular monitoring of greywater quality becomes essential. With a large share of greywater infiltrating directly into the ground, maintaining structural standards is critical to safeguard groundwater for a water-scarce and groundwater-dependent state like Rajasthan. Reuse potential remains largely unrealized due to low and irregular water supply at 35 lpcd once in a week. Consequently, greywater volumes range from 34,800 to 149,400 litres/day and most of it infiltrates due to high soil permeability. Systems are functioning more as recharge structures than reuse assets. The O&M of WSP-based systems require desilting every three years, while household-level systems pose minimal maintenance. Water-quality testing across all villages is required before reuse. For example, in Bhatinda village, farmers previously experienced soil hardness when untreated greywater was applied. Following solutions would strengthen long-term sustainability:

- Villages with intermittent water supply require coordination with PHED to stabilise the supply, as higher, more regular inflows improve treatment performance and reuse reliability.

- Villages with WSPs, introducing controlled reuse pilots for horticulture or fodder crops, can convert treated water into productive irrigation support.

- The recurring infiltration requires a storage option, such as lined reuse ponds or elevated tanks, especially in high-infiltration areas.

- Villages need regular greywater quality testing to establish safety benchmarks and unlock reuse opportunities, especially since recharge alone provides limited community benefits.

Treated greywater evaporated and/or infiltrated into the ground in Daikara Village, Mandor Block, Jodhpur District, Rajasthan.

Waste Stabilization Pond in Sevaki Khurd Village, Baori Block, Jodhpur District, Rajasthan.

Treated greywater doesn’t reach the Maturation Pond due to high evaporation rates in Sevaki Khurd village, Baori Block, Jodhpur District, Rajasthan.

A portion of treatment system damaged due to heavy rains in Bhatinda Village, Luni Block, Jodhpur District, Rajasthan.

WSP showing little greywater collected in Daikara Village, Mandor Block, Jodhpur District, Rajasthan.

4. Analysis from the field visits

4.1 Greywater treatment coverage: How many connections exist?

Under the JJM, villages are expected to receive an average of 55 lpcd of water, resulting in an estimated 34,000 million litres of greywater generated daily from rural India. In the studied villages, which have populations ranging from 530 to 12,000, the water supply varies widely between 35 and 200 lpcd.

Approximately 65% of households in these villages are covered under greywater treatment initiatives, with the coverage of greywater management ranging between 50% and 100% across different locations.

Untreated greywater being collected in the downstreams of Kurubadoddi village in Baidoddi GP in Raichur District, Karnataka.

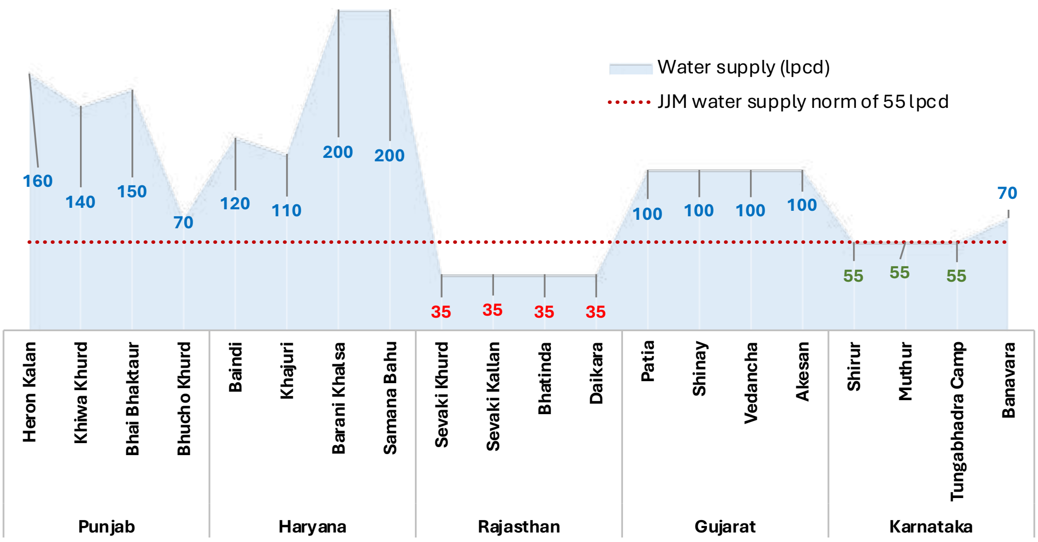


Figure 11: Water supply spanning from 35 - 200 lpcd across surveyed villages.

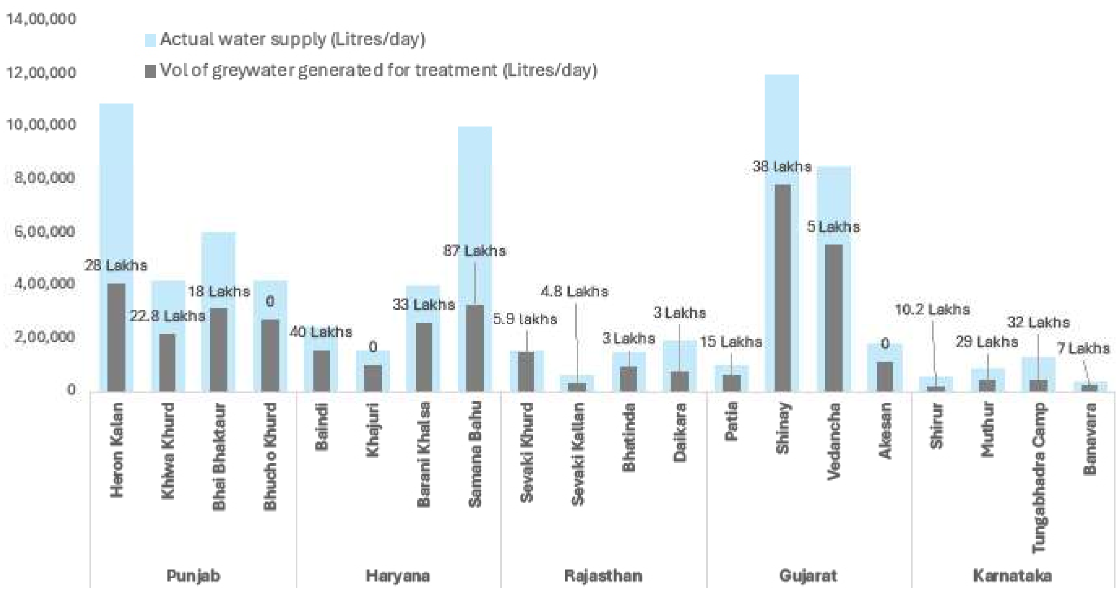


Figure 12: Households covered with greywater treatment system – Only 25% of the 20 surveyed villages were 100% covered.

4.2 Water quality and treatment: Is this tested for safety?

There are frequent instances of untreated black water mixing with greywater, posing significant health and environmental risks. Additionally, water quality parameters such as Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), etc., are not tested before greywater is reused for agriculture or diverted towards groundwater recharge. In the absence of adequate treatment infrastructure, untreated greywater is often discharged directly into nearby water bodies or open lands. Most households rely on rudimentary methods like informal soak pits or direct discharge, indicating minimal investment in structured greywater treatment systems.

4.3 Technology Design and Finance: Is the technology appropriate and financially viable?

Technical interventions such as decentralized treatment units, soak pits, and leach fields have shown promise in enhancing the efficiency of water reuse. Nature-based Solutions (NbS), including constructed wetlands, DEWATS systems, soak pits and kitchen gardens, offer low-maintenance alternatives that require minimal manual intervention. Additionally, strategic design of stormwater drains to divert excess water directly into wetlands can help reduce the burden on existing treatment facilities. The capital expenditure required for greywater treatment systems ranges from ₹18 lakh to ₹87 lakh, with funding typically sourced through a combination of government schemes such as MGNREGS, SBM-G 2.0 and allocations from the 15th FC. In states like Karnataka, Haryana and Punjab, MGNREGS contributes 70–80% of the funding, while in Gujarat and Rajasthan, SBM-G 2.0 supports 20–30% of the total greywater treatment costs. O&M costs vary significantly, ranging from ₹4,000 to ₹30,000 per month, depending on the type of technology deployed.

While the multi-source funding model appears comprehensive, its implementation on the ground reveals several challenges. One of the significant hurdles is the requirement for GPs to maintain an escrow account and deposit 30% of the required funds from sources like the 15th Finance Commission grants or their own funds. Only after this deposit is made are the remaining funds released from schemes like SBM-G. This process, while designed to ensure local commitment and financial discipline, often becomes a bottleneck. Many villages simply lack the resources to make this initial deposit, effectively barring them from accessing the larger pool of funds available for greywater management projects. This requirement of an advance 30% deposit highlights a fundamental tension in the funding model. While it aims to promote local ownership and financial responsibility, it may inadvertently exacerbate existing inequalities. Villages with more resources are better positioned to make the initial deposit and thus access additional funds, potentially leaving behind the communities that are most in need of improved water and sanitation infrastructure.

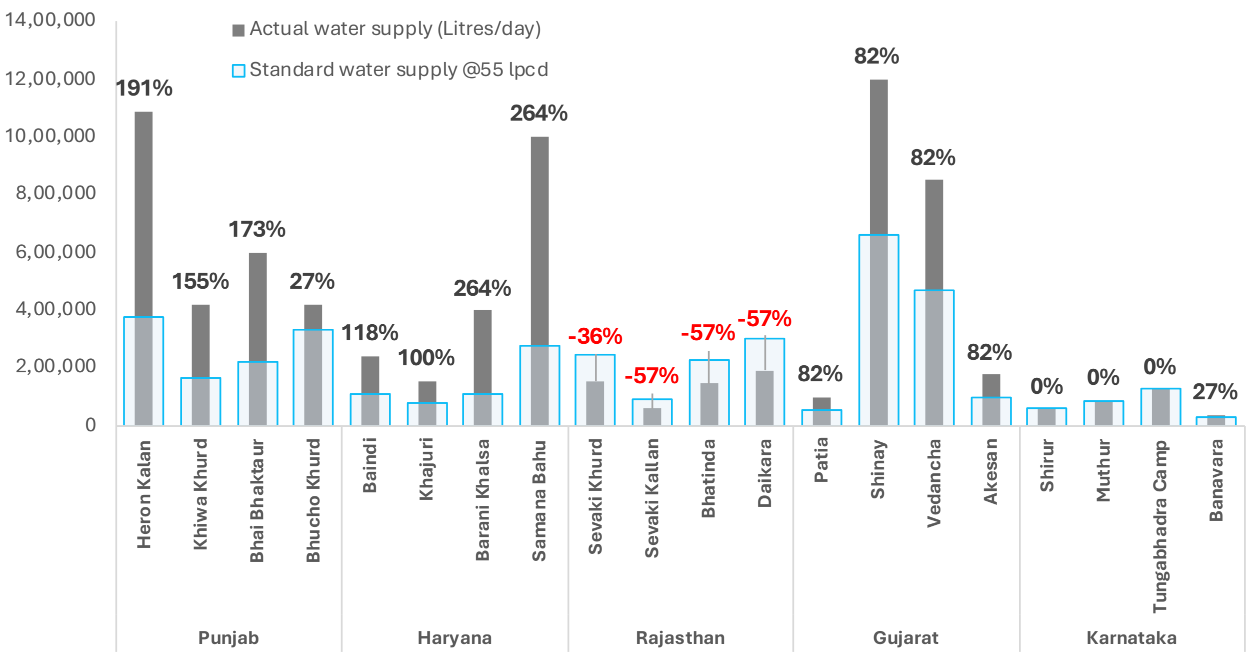


Figure 13: Under capacity of greywater generated.

• The complexity of this multi-source funding model poses significant challenges for local administrators. Many Sarpanches and Panchayat members struggle to navigate the intricacies of various funding streams, each with its own set of guidelines and requirements. This complexity not only leads to inefficiencies in fund utilization but also creates mismanagement or underutilization of available resources.

• The issue is further compounded by delays in fund release, particularly when multiple schemes are involved leading to project implementation setbacks and, in some cases, increased costs.

• The situation is particularly dire when it comes to funds for O&M. While there's often a focus on capital expenditure for building new infrastructure, the allocation for ongoing O&M is frequently insufficient.

As a result, many villages struggle to maintain their greywater management systems effectively, leading to premature deterioration of infrastructure and reduced effectiveness of the interventions.

• The financial landscape is further enriched by state funding. *In Punjab, the Department of Water Supply and Sanitation implements SBM-G, while the Punjab Rural Development Fund (Under the Punjab RDF Act) offers another potential source of financing. Similarly, Haryana has established the Haryana Pond and Wastewater Management Authority, provided funding and offered technical support for greywater management projects.*

Per capita cost: Across the five states, village size and per capita costs vary widely, mainly due to differences in settlement scale and system design. Village populations range from a few hundred to over 12,000, with per capita costs spanning a wide spectrum from very low values in larger or denser settlements (for example, parts of Rajasthan and Gujarat) to significantly higher costs in smaller or dispersed villages, particularly in Haryana and Karnataka. A clear pattern of economies of scale is visible, with larger villages generally showing lower per capita costs as infrastructure costs are spread across more households. Smaller or dispersed villages, especially in Haryana and Karnataka, tend to have higher costs, while Rajasthan shows very low costs, suggesting simpler or shared systems. Overall, the data highlights that settlement size and design strongly shape cost efficiency, calling for context-specific planning rather than uniform cost norms.

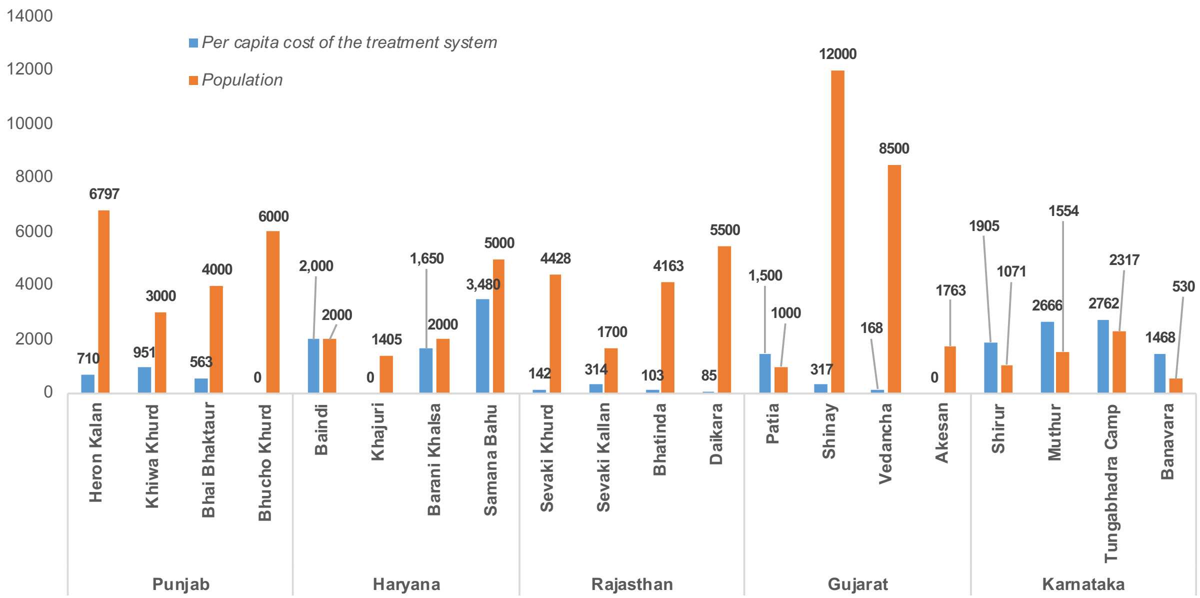


Figure 14: Per capita cost of the treatment system.

4.4 Reuse potential and revenues: Does greywater reuse generate revenue?

Potential reuse of greywater- 60-65% of household total water used; Approximately 55% available for reuse after treatment such as irrigation, groundwater recharge, fishing and manure production.

• In Rajasthan, reuse remains limited due to factors like low water availability, high infiltration, and elevated evaporation rates.

• In Karnataka, NGO-led models utilizing CSR funding have successfully financed complete greywater treatment systems.

• Gujarat showcases innovative revenue-generating activities such as selling manure derived from treated sludge and leasing treated ponds for fishing.

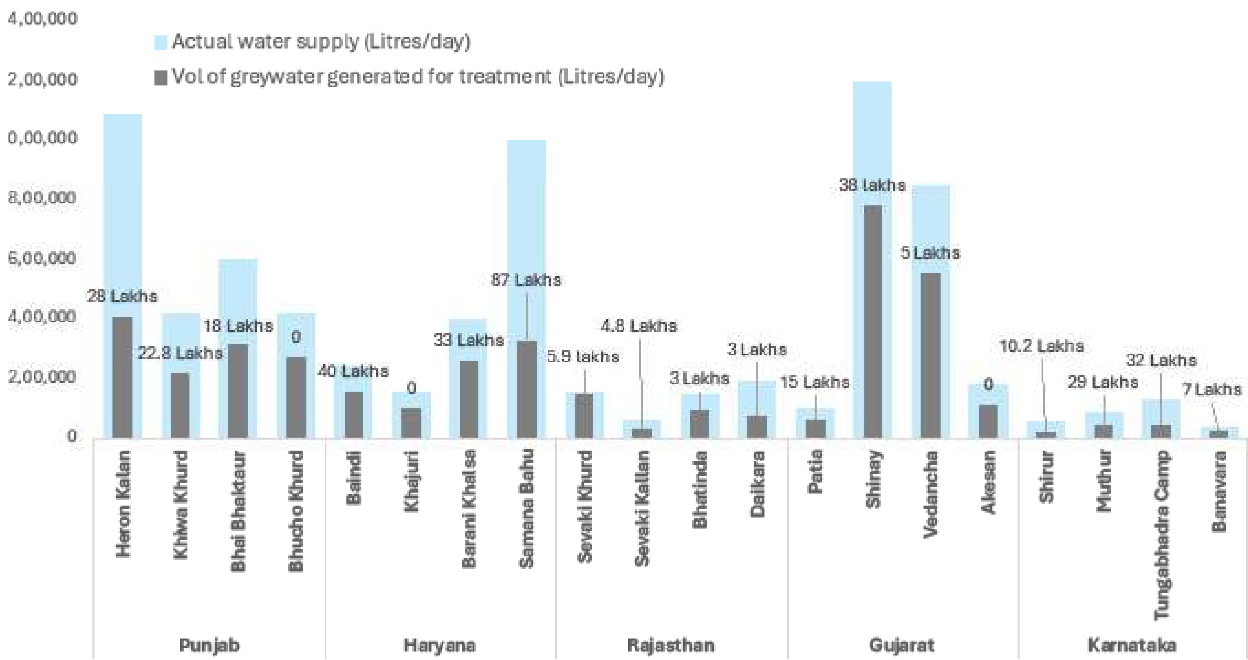


Figure 15: Water supply analysis: Actual vs. JJM supply with a standard of 55 lpcd.

Depending on the scale of operations and the degree of community involvement, annual revenue from greywater reuse ranges from ₹40,000 in Heron Kalan Village, Mansa District, Punjab to ₹4 lakhs in Vedancha Village, Banaskantha District, Gujarat. The GPs utilize the revenue for rural infrastructure and other O&M of existing facilities.

Greywater accumulated in the open drains in Kolimpalli village, Kothakote GP, Bagepalli taluk, Chikkaballapur district.

4.5 Key gaps and on-ground observations

1. Harnessing treated greywater for sustainable agriculture

The urgent need for interventions in greywater management in rural Punjab and Haryana is emphasized by the region's critical groundwater situation and the untapped potential of treated greywater in agriculture. With over 60-70% of blocks in these states facing groundwater overexploitation, utilizing treated greywater for irrigation, along with crop diversification and water saving techniques in agriculture could reduce pressure on depleting aquifers.

Currently, the lack of proper testing of treated greywater hinders its widespread adoption in agriculture. Implementing a robust testing regime would not only ensure safe usage but also build farmer confidence. Though many farmers recognize the nutritional value of treated greywater, noting reduced need for chemical fertilizers and increased crop yields. The fact is that the increased yields are high due to the high organic load that comes with mixing of black water and not greywater alone. *In Samna Bahu village, Haryana, a farmer claimed a 30% increase in crop yield and a 40% reduction in fertilizer use after adopting greywater irrigation.* With sustainable use of treated greywater, the state governments can reduce the strain on groundwater resources, decrease the financial burden of providing free electricity for farm tubewells in Punjab and promote sustainable agricultural practices. Agricultural departments, water supply authorities and research institutions can develop and implement scientifically tested methods for using treated greywater for irrigation by combining pilot projects, farmer training, and regular monitoring.

An interaction with a Farmer and Sarpanch in Samna Bahu Village, Nilokheri Block, Karnal District, Haryana.

2. Strengthening VWSCs

Strengthening VWSCs in rural Punjab and Haryana is crucial due to challenges in maintaining greywater management systems, often affected by village politics. *For example, in Baindi village, Haryana, a change in panchayat leadership led to neglect of the treatment facility, showing the system's vulnerability to political shifts. Similarly, in Bhucho Khurd village, Punjab, opposition from certain groups delayed project implementation. In Karnataka, the VWSC has been formed, but its members are currently not active.*

Empowering and incentivising VWSCs for their active participation and to function as a permanent, apolitical water cadre can ensure continuity in management and reduce the burden on Sarpanches. Sustainable business models like leasing treated water ponds or using treated water for community gardens can provide financial incentives for VWSC members, ensuring better maintenance and creating economic opportunities. Additionally, training VWSC members on solid waste management with community participation can prevent clogging of drains.

The role of VWSCs in managing these systems varied significantly across villages. We observed that the effectiveness of VWSCs often depended heavily on the initiative of the Sarpanch, rather than being driven by the committee itself. In many instances, it was the Sarpanch's husband who led the meetings. This highlights the ongoing challenges of gender representation and empowerment in rural governance structures.

3. Strengthening financial and operational sustainability through innovative Business Models

The long-term success of greywater management systems in rural Punjab and Haryana critically depends on their economic and operational sustainability. Our field observations revealed that while initial funding for infrastructure development is managed, many villages struggle with ongoing O&M costs. *In Baindi village, for instance, it struggles with inadequate funds, in addition, MGNREGA support has not been functional for the last two years, affecting routine upkeep.*

Leasing treated water ponds for fish farming, as considered *in Barani Khalsa village, Haryana, could generate a steady income of 1-1.5 lakhs per year.* Similarly, using treated greywater for high-value crop irrigation or community-managed nurseries could create economic opportunities while ensuring proper system maintenance. The approach goes beyond mere cost recovery; it aims to create a financial incentive for villages to maintain and optimize their greywater treatment facilities. This could include partnerships with local industries for non-potable water needs or developing micro-enterprises around greywater-based products. *In Samna Bahu village of Karnal district, Haryana, the installation of solar pumps to distribute treated greywater for irrigation demonstrates how innovative technologies can be integrated into these business models.*

In Patia village of Anjar block in Kutch, Gujarat, the DEWATS system built at a cost of ₹15 lakhs in 2008–09 by WASMO, has enabled reuse of treated greywater using drip irrigation on 3 acres of GP land, leased on a 10-year tenure. This has significantly boosted agricultural returns, specifically in pomegranate cultivation, where earnings have increased from ₹10,000 to ₹30,000 per acre and yield has doubled from 1.5 tons to 3 tons per year, with improved quality.

Implementing robust M&E systems is essential to demonstrate the effectiveness of these business models for scaling. This intervention has the potential to demonstrate how rural communities view and manage their greywater resources, addressing the critical issue of O&M funding and creating economic incentives for effective greywater management.

4. Lack of greywater treatment systems from the Socio-economic context

One of the pressing issues observed was the impact of improper greywater management on various aspects of rural life. *In Bhucho Khurd village, Punjab, no treatment facility was found and during the monsoon season, the Bagadla Pond gets flooded with wastewater, which also enters a nearby government school.* This forces the school to close, affecting children's education for up to 40 days each year. This anecdote illustrates the consequences of inadequate wastewater management, extending beyond immediate health and environmental concerns to impact the prospects of the younger generation.

The health implications of poor greywater management were also evident. In some villages, residents reported a history of skin diseases and other health issues related to exposure to untreated wastewater. For instance, *in Bhai Bhaktaur village, Punjab, farmers using untreated wastewater for irrigation experienced severe skin infections.* These health problems not only affect the quality of life but also lead to increased out-of-pocket healthcare expenditures for rural families, creating a financial burden that could be avoided with proper wastewater management.

Elderly men of the village showing the level of water, along with wastewater accumulates during monsoon in Bucho Khurd Village, Nathana Block, Bathinda District, Punjab.

5. Status of Greywater Management-Excerpts from the Experts

A series of expert interviews was conducted with government officials, Rural WASH Partners Forum (RWPF) practitioners and sector specialists across various states and organizations. The findings given below highlight cross-cutting issues, providing an integrated understanding of systemic strengths, gaps and emerging trends across different contexts.

Waste Stabilization Pond in Khiwa Khurd, Village, Bhika Block, Mansa District, Punjab.

1. Coverage and the functionality challenge

Despite wide coverage of greywater infrastructure on paper, the functionality of these systems remains questionable. As highlighted by *Mr. Biswanath Sinha (WaterAid)*, while approximately 4.7 lakh villages are officially covered under greywater management, only 25% have achieved "model village" status. Even within these, infrastructure such as toilets and treatment systems is often non-functional, indicating a significant gap between reported coverage and ground reality. *Ms. Bhawna Badola (Piramal Foundation)* further emphasized the inconsistency of greywater management even within villages, with partial coverage and uneven performance contributing to stagnation and waterlogging issues.

2. O&M and Institutional gaps

O&M remains a persistent challenge, particularly for community-level structures. Both *Mr Biswanath Sinha (WaterAid)* and *Mr Sujoy Mazumdar (UNICEF)* point to weak community ownership and inadequate institutional support despite the existence of training modules, manuals and national frameworks. *Mr Mazumdar* notes that although capacity building efforts under SBM and JJM include translations and online platforms (watersanitationlearning.gov.in), the actual handover of responsibilities to GPs remains unclear due to lack of financial assurance and defined service roles. *Mr Balinder Kumar, DPM for SBM, Punjab* adds that convergence across departments is poorly understood at the GP level, placing undue burden on block officials.

3. Policy ambiguity and planning gaps

Experts agree on the lack of policy clarity and systemic planning. *Mr Sujoy Mazumdar (UNICEF)* highlights the absence of benchmarking standards and regulatory oversight, which hampers greywater service delivery. *Mr Mahesh (SBM, Karnataka)* also notes funding limitations and fragmented planning across schemes like MGNREGA, JJM and 15th Finance Commission funds. This sentiment is echoed by *Mr Tabrez (Piramal Foundation),* who highlights planning duplication and poor coordination.

Several experts note that greywater is often not prioritized, especially in areas with erratic water supply, despite the increase in greywater volume expected from improved access under JJM.

4. Technology and infrastructure challenges

Inappropriate technology deployment and poor design contribute to greywater misuse. *Mr Sasanka (WASHi)* and *Ms Bhawna Badola (Piramal Foundation)* point to poor drainage planning, design flaws in soak pits and improper integration with toilets and irrigation. In Punjab and Haryana, the combined flow of cattle wash, blackwater and greywater complicates treatment, as noted by *Mr Vivek Awasthi (WASHi)*. *Mr Jeetendra Joshi (SBM, Haryana)* adds that existing collection systems like Johads are outdated and insufficient to manage current wastewater loads. *Mr Amit Talwar (DWSS, Punjab)* notes that funding fragmentation across departments hinders unified infrastructure development.

5. Capacity building

Experts stress the importance of informed personnel in successful greywater management. *Mr Vivek Awasthi (WASHi)* highlights the use of Kobo Collect tool for data-driven, participatory planning in Punjab, including training of Technical Assistants and GP members, noting that the scale-up of 231 pilots demonstrates scalable and context-sensitive solutions digital capacity building. However, *Mr Kamaljeet Singh* and *Mr Gurlal Singh (MGNREGA, Nathana Block, Punjab)* point out that GP members' reluctance and limited knowledge hinders decentralized implementation.

6. Promising models and emerging innovations

Despite systemic gaps, there are best practices and innovations worth noting. *Mr Tabrez (Piramal Foundation)* mentions Gujarat's early adoption of DEWATS systems and pilot successes like in Patia village, where revenue from greywater reuse funds the O&M. Karnataka has piloted the inline treatment systems with Canna Indica plants. Villages like Bedawatti in Koppal and Kodiyal in Haveri, Karnataka, demonstrate effective O&M with

6. Policies and Programmes

The transformation of rural India's water and sanitation landscape over the past decade has been significant. In the context of greywater management, two key trends have emerged. First, traditional water bodies such as lakes and ponds are increasingly falling into disuse. Second, these water bodies are often becoming receptacles for solid & liquid waste from nearby habitations. Recognising these challenges, the Government of India introduced SBM-G 2.0 in 2020, bringing together multiple components, including biogas generation (Gobardhan), solid waste management (including plastic), liquid waste management and O&M of community sanitation assets. However, implementation of SBM-G 2.0 has faced constraints on the ground. As a policy layering initiative, it adds new objectives and instruments onto existing programmes, increasing complexity. This has been particularly challenging at the block level, where limited human resources are expected to manage construction oversight, MIS reporting, subsidy disbursement and IEC activities simultaneously.

Screening chamber of greywater treatment system.

[13] *Refer to the webpage of Mission Antyodaya here. (self-reported by GPs and the data has not yet been audited by the Registrar General).*

6.1 Funding allocations for rural greywater management

The financial structure supporting greywater management in rural India is intricate, weaving together various central and state-level schemes. For LWM, the SBM-G 2.0 prescribed a tiered funding model based on population: Rs. 280 per capita for villages <5000 population and Rs. 660 per capita for villages >5000 population. This approach aims to balance the economies of scale in larger villages with the needs of smaller communities. However, the field visits revealed a concerning reality. Many small villages struggle to implement decentralised systems due to insufficient funds, creating a significant equity gap. *An example from Khajuri village in Radaur Block, Yamunanagar District - With a population of 1,405, the village is eligible to receive limited funding, making it challenging to plan and implement any decentralized greywater treatment system.* Consequently, smaller villages are less prioritised due to limited financial resources, highlighting a significant gap between policy intent and ground-level implementation, particularly for smaller rural communities.

Population size range	2011 Census data		Mission Antyodaya provisional village count 2023-24		Population range	Trend analysis
	No. of villages	%	No. of villages	%		
<1000	4,03,000	62%	3,68,214	58.7%	<5000 – 6,11,748 Receiving INR 280/- per capita	Still dominate, but their share has declined since 2011 due to consolidation during GP boundary rationalisation.
1,000–1,999	1,25,000	19.5%	1,29,982	20.7%		
2,000–4,999	1,09,000	17.3%	1,13,552	18.1%		Steady growth
5,000–9,999	3,961	0.6%	10,024	1.6%	>5000 –15,740 Receiving INR 660/- per capita	Doubled in absolute count due to rural population concentration in larger near-urban settlements.
>10,000	3,961	0.6%	5,716	0.9%		
Total	**6,44,922**	**100%**	**6,27,488**	**100%**		

Table 6: Percentage of villages as per population size: Based on re-tabulation of the latest village-level population by the Ministry of Rural Development on the Mission Antyodaya portal13 (May 2025), compiled for the Gram Panchayat Development Plan (GPDP).

The 15th FC for Rural Local Bodies (RLBs) or Panchayati Raj Institutions (PRIs), spanning for five years until 2025-26, provide 60% funds as tied grants, split equally between sanitation (maintenance of ODF status) and water supply (drinking water provision, rainwater harvesting and water recycling). Further augmenting the financial resources is the MGNREGS, serving a dual purpose in greywater management by providing funding for labour-intensive components of projects (digging ponds, constructing drainage channels, etc) and offering employment opportunities to rural residents, thereby promoting a sense of ownership.

7. Recommendations

Effective greywater reuse and recharge are essential for strengthening rural water security. While SBM-G 2.0 and JJM have established a strong foundation, long-term sustainability depends on integrating decentralised treatment with rural water programmes, linking greywater with stormwater, blackwater and solid waste management, and enabling GPs to sustain systems through modest revenue-generating mechanisms. Ongoing challenges such as funding gaps, limited local capacity and weak monitoring of recharge impacts highlight the need to move beyond asset creation toward an integrated, context-specific and programmatic approach with stronger institutional ownership. The following are the suggestive areas to maximize benefits from effective greywater management:

01 Accurate estimation of greywater generation and quality

Current estimates, which often assume that 70–80% of the 55 lpcd supplied becomes greywater, significantly underrepresent actual generation. Rural households frequently use additional water from groundwater sources, private borewells and handpumps, which is not captured in official supply data. Moreover, animal husbandry, a major livelihood in northern and western India, contributes considerable wastewater from washing and cleaning activities, which is typically unaccounted for.

- Greywater estimation needs to move beyond supply-based calculations. States should undertake realistic assessments of greywater quantity and quality, factoring in all water sources and uses. This forms the essential first step toward appropriate infrastructure design and cost-effective treatment planning.

- Planning for waste management infrastructure often faces significant limitations, including restricted funding and a lack of available space for treatment facilities.

- O&M plans, including cost recovery mechanisms, are rarely integrated at the planning stage and implementation usually responds only to immediate needs rather than long-term strategies.

- It is uncommon for 100% households in a village to be covered, and it is due to scattered households, difficult terrain or newly constructed homes. Inclusion of all households is critical.

- A complete village-level drainage network to channel greywater effectively should be established, which is a prerequisite before introducing any suitable treatment systems.

02 Mapping greywater flow and preparing Village Greywater Management Plans

Understanding where greywater flows, accumulates, or infiltrates is crucial for selecting interventions. In most villages, greywater either collects in open drains leading to ponds/ nearby streams or seeps into the ground through informal soak pits or low-lying areas. Without clear mapping, interventions are often misplaced or ineffective. A Village Greywater Management Plan, integrated into the Village Water & Sanitation Plan, siting of treatment systems and ensure interventions are socially inclusive and environmentally safe and should identify:

- Drains or nallas that lead into streams and agricultural fields,

- Condition and functionality of existing soak pits,

- Status and ownership of village ponds (their storage, inflow–outflow and spatial-social positioning (e.g., proximity to specific settlements or caste groups),

- Vulnerable households and local hotspots for stagnant wastewater.

- A comprehensive approach that integrates greywater, blackwater, stormwater and solid waste management is necessary to enhance efficiency and water security.

03 Treatment system options and design considerations

Field experiences show that soak pits and leach pits, once widely promoted, are now reaching saturation in many areas due to limited infiltration capacity and rising water tables. In denser settlements, community-level systems such as DEWATS, constructed wetlands or pond-based treatment units are being adopted, but with mixed results due to maintenance and land availability challenges. Design principles must be guided by actual BOD and organic loading rather than standard templates. States and GPs need guidance frameworks to choose technically and socially appropriate systems, with scope for:

- The potential of shallow-bore sewers and solid-free sewers must be assessed as scalable options for dense rural settlements transitioning toward peri-urban typologies.

- Locating treatment units on available public or common lands.

- Document and disseminate the success and failure of existing treatment pilots under SBM-G and MGNREGS and lifecycle costs of existing systems to guide scale-up and innovation.

- In areas of black water mixing, bioaugmentation, through the addition of selected microorganisms, can enhance greywater treatment efficiency by accelerating the breakdown of organic pollutants, provided system design, loading and operating conditions are appropriate.

- Primarily designing systems based on BOD load and wastewater quantity; secondly, depending on local climatic and hydrogeology and settlement density, appropriate treatment technology can be chosen.

Figure 16: An example of Gujarat to show how Greywater planning can be done based on hydrogeological parameters of the state – A guide to say 'why one size solution does not fit for all'.

04 GIS based digital planning platform

At present, India lacks a dedicated digital planning tool to guide greywater management decisions based on local topography, hydrogeology and settlement patterns, resulting in ad-hoc system selection and sub-optimal outcomes. Enabling a GIS-based decision-support platform, similar to CLART, can empower GPs and villages to systematically plan, implement and monitor greywater treatment, reuse and recharge options using data on population, water supply, soils, land availability, rainfall and groundwater conditions. Such a tool would improve technology suitability, avoid contamination and stagnation risks, support convergence across schemes, and strengthen evidence-based governance of rural wastewater systems.

05 Financial arrangements

Population-based funding norms remain inadequate for effective greywater management. Although guidelines promote sustainable financing mechanisms such as revenues from treated wastewater reuse or sales of processed sludge as manure, these are seldom operationalised, with most villages limiting efforts to basic treatment infrastructure. At the same time, there are proven examples of systems functioning sustainably for over a decade through income streams such as fisheries, leased treatment ponds and compost sales. Promoting such revenue-generating models, with facilitation from NGOs or implementing partners, can strengthen long-term financial viability. Overall, funding frameworks need to shift from rigid population thresholds to needs-based allocations aligned with hydrogeological context, system design and O&M requirements.

06 Water quality testing

Though the SBM-G 2.0 guidelines mandate periodic testing of greywater for parameters such as BOD and COD, this provision is rarely followed at the village level due to limited technical capacity and laboratory access. Regular testing is essential to:

- Design and operate treatment systems to ensure reused water meets safety standards.
- In practice, most villages lack structured monitoring mechanisms, resulting in the use of untreated or partially treated greywater for irrigation or recharge groundwater. While this water's organic and nutrient content can boost short-term agricultural productivity, it poses long-term risks to soil health and groundwater quality.
- To address this gap, greywater quality monitoring should be institutionalized through district laboratories or mobile testing units, with clear enforcement protocols and linkage to fund disbursements under SBM-G or FC grants.

07 Integrate wastewater reuse

In water-scarce, agriculture-dominated regions of north and western India, treated greywater can be a valuable resource. The way forward is to:

- Promote safe reuse in agriculture through simple irrigation guidelines and farmer awareness,
- Integrate reuse planning with watershed and groundwater management programs,
- Build convergence with agriculture, rural development and water resources departments, ensuring greywater is seen as part of the rural water economy, not waste.

09 Community-driven approaches

Village-level capacity for managing, scaling greywater reuse and generating revenue remains inadequate, capacity building of the community institutions becomes crucial. The GP members familiarizing themselves with the components and indicators of Swachh Survekshan Grameen will help them prioritize SBM activities and stay informed about new funding opportunities. The Government of India launched the Jal Sanchay Jan Bhagidari initiative in September 2024 to strengthen community-led water conservation and recharge. Applied to greywater management, it enables communities to plan, operate and monitor systems, improving accountability and long-term sustainability. This needs to be emphasised to encourage people's participation in greywater governance.

08 Institutional and policy strengthening

Greywater management requires multi-departmental convergence and locally empowered governance and this can be achieved by:

- Defining clear roles for Panchayati Raj Institutions, line departments and state water boards.
- Strengthening technical capacity for design, O&M and monitoring at all levels.
- Building an integrated monitoring framework combining functionality and reuse potential.
- Encouraging state-level innovation funds for piloting low-cost-decentralized reuse models.
- Regulating the quantity of water supply to prevent excessive greywater generation.

10 Research and monitoring

Despite growing emphasis on greywater reuse in rural sanitation and water security programmes, there is no reliable mechanism to measure its contribution to groundwater recharge in rural India. Interventions largely depend on design assumptions rather than direct monitoring, limiting assessment across hydrogeological contexts. Targeted research and policy refinement are needed to develop feasible monitoring frameworks and link evidence to programme design and guidelines.

Digestion, skimming tank in a waste stabilisation pond in Punjab.

8. Annexures

8.1 Greywater Management Study Questionnaire

Focus area	Key aspects covered
Stakeholder: Gram Panchayat	
Planning & technology choice	Site suitability (land, soil, water table); selection of treatment options; capacity estimation; viability of systems; household vs village-level systems; potential for clustering with nearby villages
Coverage & targets	Household coverage under greywater management; SBM-G 2.0 targets; performance-linked indicators
Financing & assets	Capital expenditure sources; schemes utilised (SBM-G, MNREGS, etc); land identification
Operations & maintenance	O&M arrangements; monthly costs; funding sources; role of contractors
Institutional coordination	Engagement with VWSCs, SHGs, Swachagrahis, ASHA; District and Block-level technical support; availability of trained human resources
Monitoring & incentives	Swachh Survekshan recognition; motivation through performance scoring and targets
Stakeholder: Community institutions (VWSCs, Swachagrahis, SHGs, ASHA, etc)	
Capacity building	Training received on greywater management systems
Awareness & messaging	Key messages disseminated; methods of community outreach and engagement
Incentives & verification	Activity-based incentives; use of digital tools for verification; payment timelines
Community response	Community concerns; behaviour change observed
Community mobilisation	Mechanisms to ensure participation and inclusion of households
Local systems & livelihoods	Role of SHGs, youth groups and local entrepreneurs; service and livelihood models linked to greywater management
Challenges & support needs	Operational bottlenecks; capacity and training gaps

Village Name: .... **Block:** ....

District: .... **State:** ....

Focus area	Key aspects covered
Stakeholder: Contractors	
System design	Type of greywater treatment system; design considerations and parameters
Construction & quality	Quality assurance processes; safety standards
Implementation challenges	Site constraints; coordination and implementation issues
Sustainability & handover	O&M training; regulatory compliance; long-term system performance
Stakeholder: Farmers using treated greywater	
Access & use	Access mechanisms for treated greywater; irrigation practices
Agricultural outcomes	Crops cultivated; changes in yield or quality
Water quality & safety	Practices for checking water quality; confidence in treated greywater
Costs & capacity	User charges; any guidance received; perceived benefits and risks

8.2 Primary study details

8.2.1 Gujarat (as of January 2025)

1. Administrative details				
a. Village/ GP	Patia	Shinay	Vedancha	Akesan
b. Block & District	Anjar, Kutch	Anjar, Kutch	Palanpur, Banaskantha	Palanpur, Banaskantha
2. Demographic details				
a. Households	170	2200	1100	700
b. Population	1000	12000	8500	1763
3. Treatment systems				
a. Type of treatment facility	DEWATS	DEWATS	DEWATS	No treatment
b. Percentage of HHs covered	100%	100%	35%	Few community & individual soak pits
c. Blackwater mixing (Yes/No)	No	Yes	No	Yes
d. Year of adoption	2008-09	2010-11	2021, modified in 2024	NA
4. Treatment- Capacity & Finance				
a. Treatment system area (m^2)	200	300	75	NA
b. Capital expenditure	15 Lakhs	38 Lakhs	5 Lakhs	NA
c. Per capita cost	1,500	317	168	NA
d. Schemes utilised for Capex	Earthquake Rehabilitation Fund	Earthquake Rehabilitation Fund	15th FC + MLA Fund	NA
e. Treatment plant capacity (Litres/day)	50,000	1,00,000	2,00,000	NA
f. Percentage of treatment system capacity	100%	100%	35%	0%
g. Total quantity of fresh water supply @ 55 lpcd	55,000	6,60,000	4,67,500	96,965
h. Actual water supply (lpcd)	100	100	100	100
i. Total quantity of actual fresh water supplied @100 lpcd	1,00,000	12,00,000	8,50,000	1,76,300
j. Volume of greywater generated @100 lpcd @65%	65,000	7,80,000	1,93,375	1,14,595
5. Treatment – Greywater quality				
a. Before treatment	277 BOD	80 BOD	Testing by GPCB	NA
b. After treatment	25 BOD	4 BOD	Testing by GPCB	NA

6. Treatment – O&M				
a. Maintenance frequency	Once in 10 yrs	Once in 10 yrs	Every 3 months	NA
b. O&M cost – INR per month	None	None	25,000	NA
c. O&M challenges	None	None	Manpower required	NA
d. Issues without treatment facility faced/facing	Hygiene problem and water logging	Hygiene problem and water logging	Hygiene problem and water logging	Hygiene problem and water logging
7. Community Institutions				
a. No. of VWSC members & women representation	12 (6 women)	12 (6 women)	11 (5 women)	NA
8. Reuse and revenue				
a. Greywater uses	Grows Pomegranate in GP land. Before intervention: 1 acre provided Rs 10,000/- earning with 1.5 tons/year production. Post intervention: 1 acre provides Rs 30,000/- with 3 tons/year production with improved quality	Irrigation purpose. Grows vegetables and grains.	100% treated water is recharged in a well (only 35% HHs covered). 30 - 40 feet level raised due to recharge. Remaining HHs (65%) is let to the other tank untreated	Directly greywater is pumped to the nearby field without treatment
b. Revenue generated (INR / annum)	Land on lease for a 10 years tenure period	No revenue model currently	Revenue from sludge: In summer: 5 tons in 30 days. Winter: 4 tons; Monsoon: 2 tons, due to rainwater flow into the treatment unit. 25 Kg sludge cost is Rs 2,000/- (Monthly revenue generated ranges from ₹1.6 lakh during monsoon to ₹4 lakh during summer)	No revenue
c. Area utilized for irrigation (acres)	3 acres	20-25 acres among 5 farmers		
d. Method of irrigation	Direct pumping using motor No issues	Direct pumping using motor	Direct pumping using motor	Direct pumping using motor
e. Issues in reusing treated greywater for irrigation		Irrigation is done with a 25:75 mix of treated greywater and borewell water, since applying only treated greywater had resulted in crop damage due to its high nutrient content.	No issues	
5. Treatment – Greywater quality				
a. Population after 5 years	1,063	12,756	9,018	1,870
b. Treated greywater available after 5 years (Litres/day)	74,412	8,92,947	6,31,255	1,30,930

8.2.2 Haryana (as of July 2024)

1. Administrative details				
a. Village/ GP	Baindi	Khajuri	Barani Khalsa	Samana Bahu
b. Block & District	Radaur, Yamuna Nagar	Radaur, Yamuna Nagar	Nilokheri, Karnal	Nilokheri, Karnal
2. Demographic details				
a. Households	346	240	311	1,000
b. Population	2,000	1,405	2,000	5,000
3. Treatment systems				
a. Type of treatment facility	3-Ponds System	No treatment	Constructed Wetland	3-Ponds System
b. Percentage of HHs covered	100%	NA	100%	50%
c. Blackwater mixing (Yes/No)	Yes	Yes	Yes	Yes
d. Year of adoption	2016	NA	2022	2022
4. Treatment- Capacity & Finance				
a. Treatment system area (m^2)	8093	NA	20234	12141
b. Capital expenditure (Lakhs)	40 Lakhs	NA	33 Lakhs	87 Lakhs
c. Per capita cost	2,000	NA	1,650	3,480
d. Schemes utilised to fund Capex	State Fund, 14th FC, SBM-G	NA	State fund, SBM-G fund, 15th FC	SBM-G
e. Treatment plant capacity (Litres/day)	2,05,580	NA	41,00,818	24,60,491
f. Percentage of treatment system capacity	76%	NA	6%	13%
g. Total quantity of fresh water supply @ 55 lpcd	1,10,000	77,275	1,10,000	2,75,000
h. Actual water supply (lpcd)	120	110	200	200
i. Total quantity of fresh water supplied (lpcd)	2,40,000	1,54,550	4,00,000	10,00,00
j. Volume of greywater generated as per actual water supply (Litres/ day)	1,56,000	1,00,458	2,60,000	3,25,000
k. Greywater available after treatment (Litres/ day)	1,00,000	NA	1,00,000	2,00,000
5. Treatment – Greywater quality				
a. Before treatment	Contaminated with black water and cattle wash	NA	Contaminated with black water and cattle wash	Greywater with black water mix
b. After treatment	Tested – pH within 6.5 to 8.5 range	NA	Samples tested at Chandigarh	Tested by Haryana Pond Authority

6. Treatment – O&M				
a. Maintenance frequency	Annually	NA	As required	Annually
b. O&M cost per month		NA		
c. Challenges	The O & M fund is less and NREGA has not been working for the last 2 years.	Fund available under SBM-G is so low that District officials classify these villages as Non-Visible villages. GP land has been encroached by villagers, space is another challenge.	No challenges with the O&M cost as this is a new facility. GP funds available, if required.	Currently operated by contractor however later on the facility will be transferred to GP
d. Socio-economic/ Environmental impact	The village was recognised at national level. Agriculture productivity increased as farmers utilise the water with less fertiliser input.	NA	Village GP is trying to bring state and national level recognition to greywater management.	Solar power pump application along with waste water treatment could lead to a sustainable irrigation system with less input cost.
e. Issues faced / facing in absence of treatment facility	Earlier ponds get polluted and dirty water overflow used to occur during monsoon season.	Ponds in the village receive waste water – High siltation, even Hyacinth growth was observed, overflow occurs during monsoon.	Water stagnation was prominent. After SBM Phase-1, more black water mixing in the Johars was observed. Culturally, people consider Johars as the incarnation of God and worship near the pond bank during festivals.	The pond's bad condition with garbage and smell was reduced with health improvement.
7. Community Institutions				
a. No. of VWSC members & women representation	11 (7 women)	14 (8 women)	22 (10 women)	14 (10 women)
8. Reuse and revenue				
a. Greywater uses	Irrigation	NA	Irrigation, Fisheries	Irrigation
b. Revenue generated (Rs/Annum)	0	NA	1,00,000	0
c. Area utilized for irrigation (Acres)	90	NA	50	100
d. Method of irrigation	Fixed pipelines that take water from the maturation pond	Temporary structure for water transfer to the farms, untreated wastewater utilised quite aggressively.	System of fixed pipelines that take water from the maturation pond.	Solar pumps and fixed pipeline
e. Issues in reusing treated greywater for irrigation	No issues faced	NA	No issue faced	No issues faced
9. Future projection				
a. Population after 5 years	2,139	1,502	2,097	5,242
b. Treated greywater available after 5 years (Litres/day)	1,79,650	1,15,687	2,93,555	7,33,888

8.2.3 Karnataka (as of July 2025)

1. Administrative details				
a. Village/ GP	Tungabradra Camp	Bedavatti, Shirur GP	Muthur	Banavara, Doddanaravangala GP
b. Block & District	Gillesagur, Raichur	Kukanoor, Koppal	Sidlaghatta, Chikkaballapur	Tumkur
2. Demographic details				
a. Households	589	214	324	130
b. Population	2317	1071	1554	530
3. Treatment systems				
a. Type of treatment facility	Inline Treatment System	Inline Treatment System	Constructed Wetlands with modified Septic Tank (DEWATS)	Inline Treatment System + 150 m drainage system
b. Percentage of HHs covered	50%	50%	70%	90%
c. Blackwater mixing (Yes/No)	Yes	Yes	No	Yes
d. Year of adoption	2019	2022		2024
4. Treatment- Capacity & Finance				
a. Capital expenditure (In Lakhs)	32 Lakhs	10. 2 Lakhs	29 Lakhs	7 Lakhs
b. Per capita cost	2762	1905	2666	1468
c. Area of the treatment system (in m^2)				Length -55m; Width – 1m; Depth – 0.75 m. (~55 m2)
d. Schemes utilised to fund Capex	MNREGA + SBM + 15th FC	MNREGA + SBM + 15th FC	MNREGA + SBM + 15th FC	MNREGA + SBM + 15th FC
e. Quantity of fresh water supply @ 55 lpcd	1,27,435	58,905	85,470	29150
f. Actual water supply (lpcd)	55	55	55	70
g. Total quantity of actual water supply in lpcd	1,27,435	58,905	85,470	37100
h. Capacity of the treatment plant (Litres/day)				31,766
i. Volume of greywater generated as per actual water supply (Litres/day)	41,416	19,144	38,889	24,115
j. Percentage of treatment system capacity				76%
5. Treatment – Greywater quality				
a. Before treatment	No testing	No testing	IIT Madras conducts testing	No testing
b. After treatment	No testing	No testing	IIT Madras conducts testing	No testing

6. Treatment – O&M				
a. Maintenance frequency	Once in a year			Once in a year
b. O&M cost per month		Rs 30,000 every 3 months using 15th FC and Own resources		2000/month
c. Challenges		Desilting, clearing the bush etc. are the issues with maintenance. High stormwater flows during the rainy days.	Mixing of greywater and storm water has been addressed with a separate bore system and stormwater drain Solid waste dumping and water hyacinth in the lake due to untreated greywater	New treatment system, hence no challenges
d. Issues faced / facing in absence of treatment facility				No issues
7. Community Institutions				
a. VWSC formed and active				No committee formed
b. No. of VWSC members & women representation				NA
8. Reuse and revenue				
a. Greywater uses	Irrigation	Let into the canal	Fills the tank after the treatment, mostly getting recharged into the ground	Open land like a pond; farmers use it for irrigation
b. Revenue generated (Rs/Annum)	No revenue	No revenue	No revenue	No revenue
c. Area utilized for irrigation (Acres)	5-6 farmers	Not used for irrigation	Not used for irrigation	Neighbouring farmers use based on availability
d. Method of irrigation	Gravity flow	Not used for irrigation	Not used for irrigation	Pumping using Motors
e. Issues in reusing treated greywater for irrigation	Treated greywater is mixed with fresh water for irrigation	Use of treated greywater for agricultural purposes is limited. Currently, let into the Hirehalla stream	No issues	No issues
9. Future projection				
a. Population after 5 years	2,490	1,154	1,624	540
b. Treated greywater available after 5 years (Litres/day)	95,862	44,442	62,539	26,441

8.2.4 Punjab (as of July 2024)

1. Administrative details				
a. Village/ GP	Heron Kalan	Khiwa Khurd	Bhai Bhaktaur	Bhucho Khurd
b. Block & District	Bhikhi, Mansa	Bhikhi, Mansa	Maur, Bathinda	Nathana, Bathinda
2. Demographic details				
a. Households	953	513	550	1035
b. Population	6,797	3,000	4,000	6,000
3. Treatment systems				
a. Type of treatment facility	Thapar Model	Thapar Model	Thapar Model	No treatment
b. Percentage of HHs covered	58%	81%	80%	0%
c. Blackwater mixing (Yes/No)	Yes	Yes	Yes	Yes
d. Year of adoption	2021	2020	2022	NA
4. Treatment- Capacity & Finance				
a. Capital expenditure (In Lakhs)	28	22.83	18	NA
b. Per capita cost	710	951	563	NA
c. Area of the treatment system (in m^2)	4,164	38,445	8,093	NA
d. Schemes utilised to fund Capex	15th FC, SBM, MNREGA	14th & 15th FC, SBM, MNREGA	15th FC, SBM, MNREGA	NA
e. Total quantity of fresh water supply @ 55 lpcd	3,73,835	1,65,000	2,20,000	3,30,000
f. Actual water supply (lpcd)	160	140	150	70
g. Total quantity of fresh water supplied (lpcd)	1,087,520 (291%)	4,20,000 (255%)	6,00,000 (273%)	4,20,000 (127%)
h. Capacity of the treatment plant (Litres/day)	1,00,000	2,50,000	2,00,000	NA
i. Volume of greywater generated as per actual water supply (Litres/ day)	4,07,874	2,18,400	3,12,000	2,73,000
j. Greywater available after treatment (Litres/ day)	1,00,000	2,00,000	1,50,000	NA
k. Percentage of treatment system capacity	408%	87%	156%	NA
5. Treatment – Greywater quality				
a. Before treatment	No testing	No testing	No testing	NA
b. After treatment	No testing	No testing	No testing	NA

6. Treatment – O&M				
a. Maintenance frequency (in months)	6	8	12	NA
b. O&M cost per month	4,000	No data	No data	NA
c. Challenges	Blocked drains & insufficient funds	Rainwater causes to bypass the 3 tank system, No testing	Maturation tank overflow due to less capacity, water exit points are blocked.	Water logging at collection pond, silt have not been cleaned since last 3 decades
d. Socio-economic/ Environmental impact	Reduced litter, reduced stagnant water, better health	Better visual space, earlier eating food and working in the field was not possible.	Clean neighbourhood, less odour, less water borne/ mosquito caused diseases	NA
e. Issues faced / facing in absence of treatment facility	Water stagnation earlier	Odour issue was solved	Water stagnation earlier. People using untreated greywater for irrigation caused skin diseases	School remains closed for a month during monsoon as water gets inside the primary school
7. Community Institutions				
a. VWSC formed and active	Yes (not active)	Yes	Yes (not active)	Not formed
b. No. of VWSC members & women representation	11 (0 women)	21 (10 women)	21 (5 women)	NA
8. Reuse and revenue				
a. Greywater uses	Irrigation, Fisheries	Irrigation, Fisheries	Irrigation	NA
b. Revenue generated (Rs/Annum)	40,000	1,50,000	0	NA
c. Area utilized for irrigation (Acres)	10-15	15	20	NA
d. Method of irrigation	Direct pumping	Direct pumping	Direct pumping	Underground pipes laid
e. Issues in reusing treated greywater for irrigation	Limited to nearby farms; other fields lack access	Free electricity supplied for farm tubewell, making treated greywater less relevant	Excessive application causes overgrowth & hazards	NA
9. Future projection and capacity assessment				
a. Population after 5 years	7,172	3,166	4,326	6,489
b. Treated greywater available after 5 years (Litres/day)	8,03,270	3,10,223	4,54,245	3,17,972

8.2.5 **Rajasthan** (as of February 2025)

1. Administrative details				
a. Village/ GP	Sevaki Khurd	Sevaki Kallan	Bhatinda	Daikara
b. Block & District	Baori, Jodhpur	Baori, Jodhpur	Luni, Jodhpur	Mandor, Jodhpur
2. Demographic details				
a. Households	447	425	854	1,100
b. Population	4,428	1,700	4,163	5,500 Treatment systems
3. Treatment systems				
a. Type of treatment facility	Magic Pit, Leach Pit, Soak Pit, Kitchen Gardens	WSP + Magic Pit, Leach Pit, Soak Pit, Kitchen Gardens	WSP + Soak Pits	WSP + Community Soak Pits
b. Percentage of HHs covered	94%	90%	70%	64%
c. Blackwater mixing (Yes/No)	No	No	No	No
d. Year of adoption	2021	2021	2022	2022
4. Treatment- Capacity & Finance				
a. Area of the treatment system (m^2)	NA	50/50 30/30 Height 1.3 meter	1,161 m2 (125*100 ft)	1,858 m2 (200*100 ft)
b. Capital expenditure	5.9 Lakhs	4.8 Lakhs	3 Lakhs	3 Lakhs
c. Per capita cost	142	314	103	85
d. Schemes utilised to fund Capex	SBM (70%) + FFC (30%)	SBM (70%) + FFC (30%)	SBM (70%) +FFC (30%)	SBM (70%) +FFC (30%)
e. Treatment plant capacity (Litres/day)	NA		Approx 5,00,000	
f. Percentage of treatment system capacity	NA			
g. Total quantity of fresh water supply @ 55 lpcd	2,43,540	93,500	2,28,965	3,02,500
h. Total quantity actually supplied (@35 lpcd)	1,54,980	59,500	1,45,705	1,92,500
i. Total quantity of fresh water supplied (lpcd)	35	35	Once in a week water is supplied. 2 distribution points. In Summer, tanker water is supplied due to scarcity. 10-15 feet water is available, but it is salty water leading to crop loss during monsoon.	Once in a week water is supplied. 2 distribution points. PHED draws water from Kailana Lake.
j. Volume of greywater generated as per actual water supply (Litres/ day)	1,49,447	34,808	94,708	75,075
5. Treatment – Greywater quality				
a. Before treatment	No testing done	No testing done	No testing done	No testing done
b. After treatment	No testing done	No testing done	No testing done	No testing done

6. Treatment – O&M				
a. Maintenance frequency	Maintenance at household level		Once in 2-3 years	
b. O&M cost – INR per month	No O&M for now		Approx 6,000 annually	
c. O&M Challenges	High infiltration rate, no immediate requirement on O&M	WSP: GP funds are used for cleaning the silt and other waste deposits in the WSP once in 3 years. 30-50K for the O&M in 3 years.	WSP is just 2 years old, hence no O&M so far	Greywater collected is accumulated in an underground sewer lines that carries it till the WSP
d. Issues faced / facing in absence of treatment facility	No major issues	No major issues	No major issues	No major issues
7. Community Institutions				
a. No. of VWSC members & women representation	15 (6 women)	14 (6 women)	No	7 (3 women)
8. Reuse and revenue				
a. Greywater uses	Groundwater recharge	Infiltration and Groundwater recharge. No reusing for agricultural purpose	Flows into the open spaces. Mostly gets recharged underground. Before WSP, farmers tried using untreated greywater for irrigation, they experienced soil hardness. Post treatment no such attempt was made.	The temple uses treated water by pumping using a motor and carrying it in a tanker. The water is reused for plantations of horticulture use within the temple premises.
b. Revenue generated (Rs/Annum)	No revenue	No revenue	No revenue	No revenue
c. Area utilized for irrigation (Acres)	NA	Not used for irrigation	Not used for irrigation	Irrigation around the premises
d. Method of irrigation	No reuse	No reuse	No reuse	Pumping
e. Issues in reusing treated greywater for irrigation	NA	No issues	Soil hardness	No issues
9. Future projection and capacity assessment				
a. Population after 5 years	4,656	1,788	4,378	5,783
b. Treated greywater available after 5 years (Litres/day)	1,79,263	68,823	1,68,535	2,22,662

8.3 Assumptions of greywater infiltration, reuse and system loss across the study states

System / Source type & Rationale	Gujarat	Haryana	Karnataka	Punjab	Rajasthan
Individual pits	~80% infiltration Sandy loam soils with good percolation; reduced efficiency in saline/ compacted areas	~90% infiltration Indo-Gangetic alluvial plains with high infiltration; reduced where groundwater <2m	~90% infiltration Permeable red loamy/ lateritic soils; lower in hard rock & black cotton soils	~70% infiltration Shallow water tables and low-permeability soils cause waterlogging	~60% infiltration Hard, rocky, compact soils; seasonal clogging; low percolation
Community pits	~70% infiltration Occasional clogging and overloading; works well with good drains and desludging	~60% infiltration High loading rates; soil type and maintenance may affect performance	~70% infiltration Effective but prone to clogging if desludging is irregular	~60% infiltration Clayey soils and shallow groundwater may restrict percolation	~50% infiltration Overloading (>20 HHs), high evaporation, limited maintenance
Kitchen gardens	~35% reuse Small-scale reuse; losses due to evaporation and plant uptake	~30% infiltration Partial reuse; majority lost to evapotranspiration	~30% percolation Evaporation and crop uptake limits recharge	~40% percolation Higher plant uptake; semi-arid climate	~25% percolation Very high evapotranspiration; surface irrigation dominates
Treatment systems	~70% recharge and/ or irrigation Treated water reused for irrigation with some storage and evaporation losses	~90% recharge and/ or irrigation Focus on recharge due to groundwater depletion; reuse + recharge mix	~80% recharge and/or irrigation Effective in moderate-depth aquifers; reused for community irrigation	~80% recharge and/or irrigation Preference for lined systems due to infiltration risks	~50% reuse and/or recharge Arid climate and hard rock geology limit infiltration; reuse recommended

Arghyam is an Indian philanthropic organisation working on water security and sustainable water management. It supports initiatives across the water lifecycle, from source sustainability and water quality to service delivery and governance through research, partnerships and technology-enabled solutions. Arghyam works closely with governments, communities and civil society organisations to strengthen water systems and enable safe, sustainable access to water for all.

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