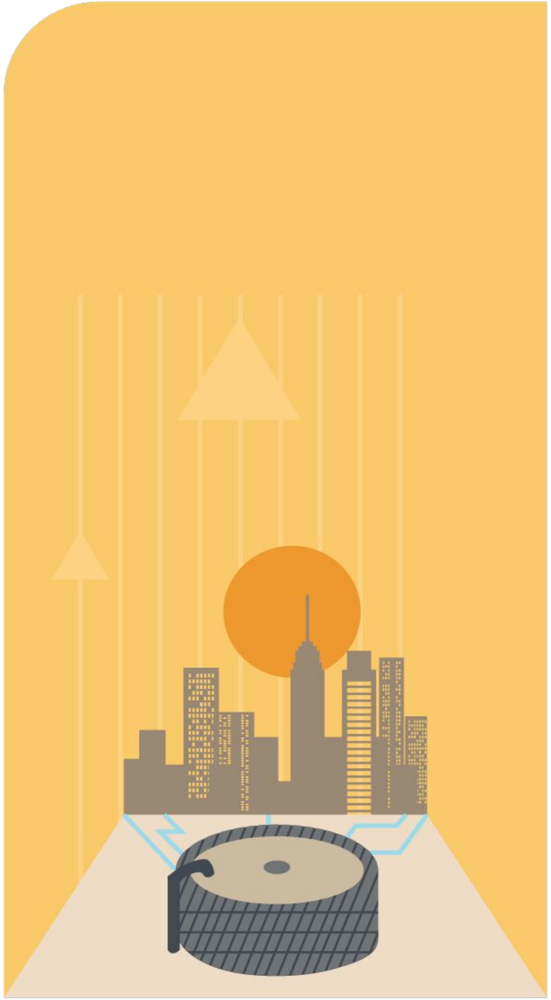

Challenges and opportunities in the residential decentralised wastewater treatment and reuse sector in Bengaluru

By Shreya Nath, Sneha Singh and Sahana Balasubramanian

CENTRE FOR SOCIAL & ENVIRONMENTAL INNOVATION

atree

February 2022

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The Centre's focus is to empower the 'first mile' — in their role as citizens, producers or consumers. Our goal is to enable a transition to a more sustainable and fair system.

Contributors

Shreya Nath and Sneha Singh prepared the systems map, designed the questionnaire for the quantitative survey, conducted the site visit, contributed to all the insights and the entire research brief .

Shreya Nath prepared the stakeholder journey mapping. She also conducted telephonic interviews with STP operators and MEP consultants.

Sneha Singh worked on insight 4. She also conducted telephonic interviews with builders and RWAs.

Sahana Balasubramanian prepared the questionnaire for builders, MEP consultants and STP operators. She also conducted telephonic interviews with STP operators and RWAs. She worked mostly on insights 5 and 6.

Arjun and Sakshi prepared the questionnaire for RWAs and conducted telephonic interviews with RWAs.

Sarayu Neelakantan designed all the icons and graphics for the entire research brief.

Dr. Veena Srinivasan guided the overall research and reviewed the brief.

Acknowledgments

We would like to thank all the RWAs, builders, MEP consultants and STP operators and experts who agreed to participate in the telephonic interviews and give us their time. Each one of them generously shared their motivations and challenges, which helped us understand their STP selection journey.

We would also like to thank the STP operators and RWAs for giving us permission to visit the STP in their apartment, taking us through the site and sharing their concerns.

We thank all those who took time to participate in our surveys. They helped us gain a better perspective of the existing reality among residents in the city towards treating and reusing wastewater.

Our research brief has a summary of insights which we learned during the process of interviewing the stakeholders involved in STPs.

List of acronyms and abbreviations

BBMP	Bruhat Bengaluru Mahanagara Palike
BWSSB	Bengaluru Water Supply and Sewerage Board
CPCB	Central Pollution Control Board
EIA	Environmental Impact Assessment
KLD	Kilo Litres per Day
KSPCB	Karnataka State Pollution Control Board
MLD	Million Litres per Day
RWA	Resident Welfare Association
STP	Sewage Treatment Plant
WW	Wastewater
GW & BW	Greywater and Blackwater

Definitions

Decentralised wastewater treatment system	Decentralised wastewater treatment systems are those which treat, reuse or dispose the effluent in relatively close vicinity to its source of generation.
Sewage treatment	Sewage treatment is a type of wastewater treatment that aims to remove contaminants from sewage to produce an effluent that is suitable for discharge to the surrounding environment or an intended reuse application.
Third-party certifications	Third-party certification is the assessment and approval by an (accredited) party on an established standard.
Zero Liquid Discharge	Zero Liquid Discharge (ZLD) is a wastewater management strategy used to remove liquid waste and maximise water reuse efficiency.

List of icons to represent various stakeholders involved at various stages of WW treatment and reuse cycle

INFLUENCER

- Media outlets
- Academia
- CSOs
- STP operators & STP vendors
- Companies enabling monitoring & reuse
- MEP/STP consultants

DECISION MAKER

- End users (RWAs/home buyers)
- Builders

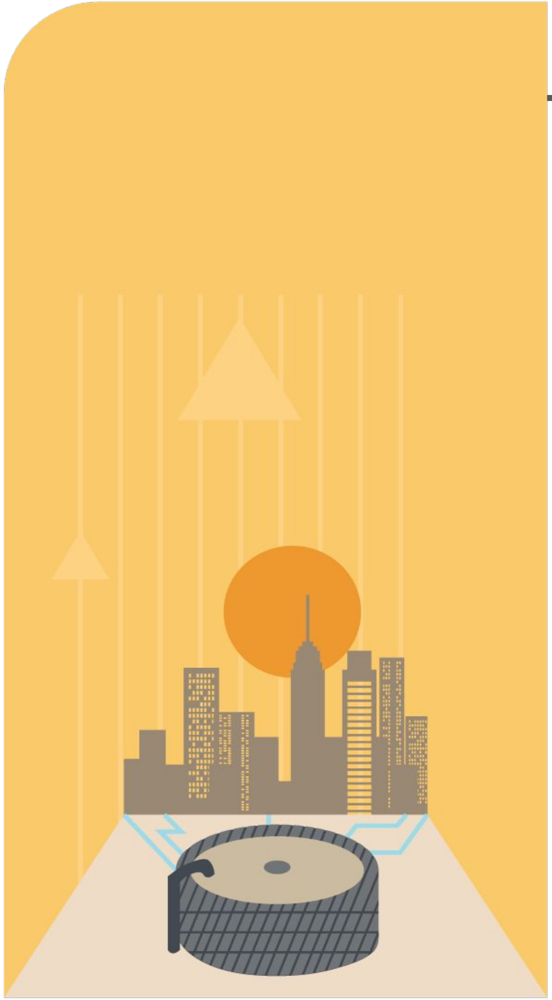
REGULATOR

- Government (BWSSB/KSPCB)
- Third-party certifier

The actors have been grouped into three broad categories:

- **INFLUENCERS** - private agencies & research institutes
- **DECISION MAKER** - residents & builders
- **REGULATORS** - government agencies

CONTEXT



Decentralised sewage management is being promoted to address the sewage treatment gap in Indian cities

Indian cities are grappling with an ever-growing freshwater demand due to rapid urbanisation and exponential population growth. The treatment of the resultant wastewater has proved equally challenging. A lack of treatment facilities leads to the disposal of partially-treated or untreated wastewater causing surface and groundwater contamination.

According to a CPCB report [i], nearly 72% of the sewage is left untreated in India.

In most cities, the existing centralised wastewater treatment infrastructure is either non-operational or underutilised due to limited sewerage network access and budget restrictions. Utilities are upgrading the existing centralised infrastructure but cannot keep pace with the current sewage generation rate.

Centralised STPs require an extensive network of sewer lines to collect sewage from buildings in their catchment areas. Most Indian cities need to retrospectively lay out this infrastructure, which requires digging under existing buildings and roads. This is not only inconvenient but also has huge environmental and economic costs. In order to address this, decentralised sewage management is being promoted in cities.

Decentralised treatment uses off-grid wastewater treatment technology to treat sewage at the source of generation. Urban local bodies have been promoting decentralised sewage treatment in building typologies that house large populations like multistorey apartments and commercial complexes to help bridge the sewage gap in cities.

Government agencies in Bengaluru have issued mandates for decentralised WW treatment along with 100% WW reuse to ensure that zero WW is discharged

Notice to stop disposal of sewage into streams, 2014 (under section 24/25A, Water Act 1974)

- Prohibit sanctions for buildings disposing sewage into water bodies.
- Undertake cleaning up of water bodies.
- Strict actions against polluters.

BWSSB Act, 2016

Modular Sewage Treatment Plants (STPs) and dual piping in residential buildings with 20 or more houses/ apartment units, with retrospective effect.

Urban waste water policy, 2016

- Enable environment for reuse of municipal wastewater.
- Water quality standards.

Strengthening of monitoring mechanisms, 2017 (under section 33A, Water Act 1974)

- Online effluent monitoring (OEM) system at the STP outlets.
- Insert camera and flowmeters in channels.
- OEM data uploaded to CPCB server.

Bangalore Sewerage Amendment (Regulations), 2018

- Residential projects (50 units and more), commercial projects (built-up area of 2,000 sqm or more) and educational institutions.
- Install STPs and ensure reuse of treated water.

Office memorandum on STPs KSPCB, 2021

- Guidelines for design and location of STPs
- Ideal STP technologies, unit operation details, location of STP, treated sewage standards, installation of sensors and usage of treated sewage.
- For newly proposed STPs or modifications or upgradation to existing STPs.

Fig. 1 Mandates and government orders issued till date for decentralised WW treatment and reuse in Bengaluru

The mandates on decentralised sewage treatment have led to the treatment of almost 30% of the sewage in the city. Despite this, a lot of treated WW goes unused

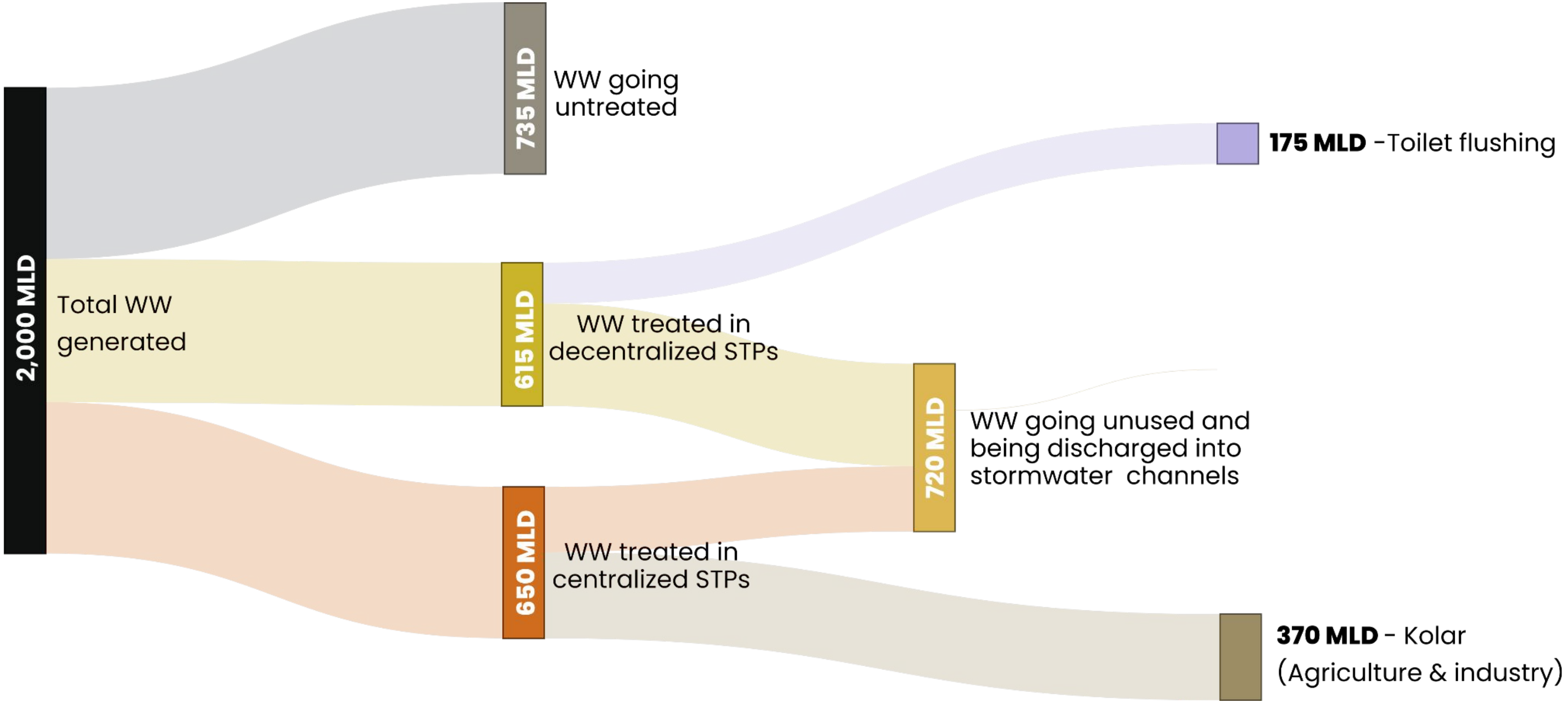
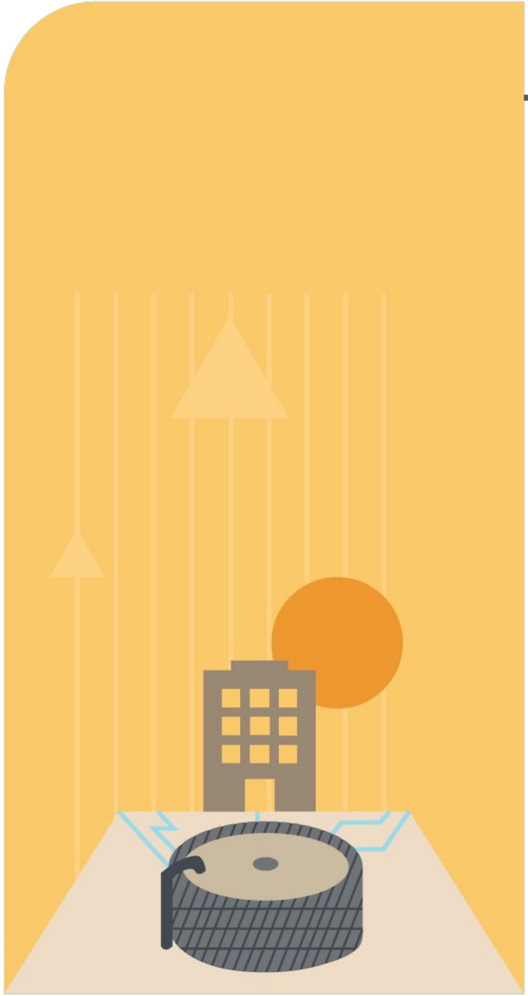


Fig. 2 Sankey diagram showing the sewage balance of Bengaluru



In the domestic context, residents of gated communities are unable to achieve 100% reuse

Following the decentralised STP mandate, Bengaluru now has over 2,000 decentralised STPs [ii]. These STPs cumulatively treat approximately 110 MLD [ii], which is 8% of the total sewage generated.

We conducted interviews with 20 apartment RWAs (appendix 1) to get a better understanding and overview of the ground reality. We uncovered that

almost 50% of the apartments did not comply with the ZLD mandate.

Also, smaller apartments with less than 50 units found it particularly difficult to utilise their excess treated wastewater due to less quantum of demand.

The interviews revealed that smaller apartment complexes (with less than 150 units) were less likely to comply with the reuse mandates.

Decentralised STPs in the residential context were seeing limited success with respect to the reuse mandate. As most of the wastewater is generated in apartments, we reviewed more reports to uncover the reason.

The 4S report (Vol-I) on small-scale decentralised STPs in apartments by Eawag revealed that most of the STPs installed were poorly maintained, resulting in limited reuse of wastewater and illegal discharge of excess into open drains and water bodies [iii].

To uncover why WW is going unused in these gated communities, we followed a four-step approach:

A Literature review

Collating data from published articles, mandates and guidelines.
Reading case studies to understand best practises.

B Primary data collection

Site visits (2)
Survey with RWAs (20)
Interviews with builders (4)
STP operators (5) and
MEP consultants (2)
Consultation with experts

C Systems mapping

We turned the gaps identified through the preliminary data collection into levers that would be needed to achieve each of the solutions.

A mapping of the key levers for change under each insight helped identify interlinkages within the system.

We also mapped the key levers for change to the potential actors who would be influencers to bring in tangible outcome on ground.

The subsystems were connected together on a larger systems map (Refer Pg:) which bought out several interlinkages among several subsystems.

D Stakeholder mapping

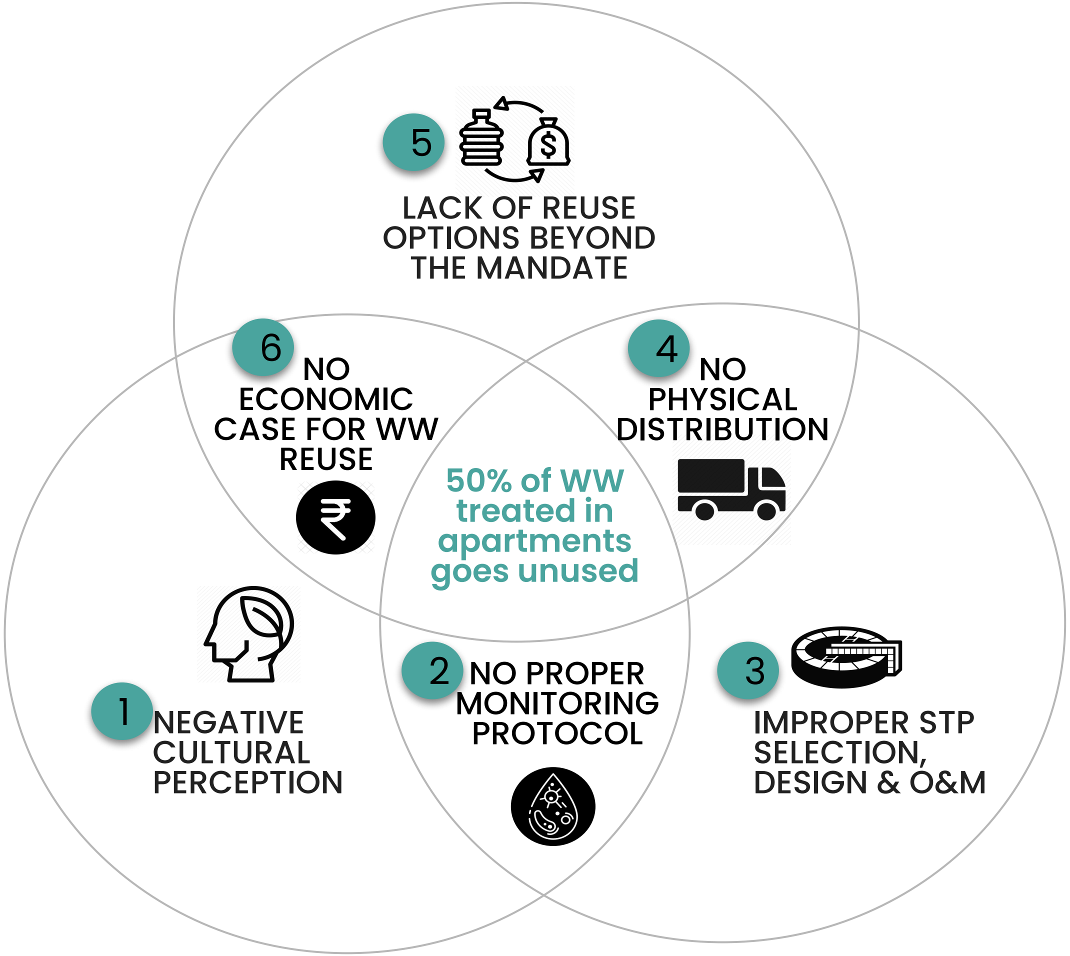
The government relies on CSR funds for lake rejuvenation.

Limitations of the research brief :
The inferences in the research brief are based on a small sample size - both in terms of number of stakeholders interviewed (x) and number of STP reports audited (12).

The actions and actors that have been identified are only a representative sample.

INSIGHTS

We uncovered six reasons for why WW is going unused



From our interviews with various stakeholders across different stages of the STP process, we uncovered six factors for why treated wastewater goes unused.

We also identified the potential *levers for change*, along with the *actors required* for on-ground *impact* for each one of these insights.

We will delve into each insight in this research brief.

INSIGHT 1

1 **Negative cultural perception of wastewater hinders reuse**

Reuse of blackwater comes with negative perceptions, for cultural and aesthetic reasons, especially within homes

Fig. 3 Prevailing reuse trends of treated wastewater in apartments

RWAs

Only 5 out of 20 RWAs trusted the treated WW output, judging water quality based on colour, odour and presence of particles.

Fig. 3 summarises the WW reuse trends within apartments. Landscaping, toilet flushing and washing common areas were the most popular reuse options. However, most residents using WW for toilet flushing did it reluctantly and complained of how the WW smelled and discoloured toilets. When the same WW was used for landscaping or for washing common areas, there were few or no complaints. This highlighted how **proximity and communal vs private use of WW influence acceptance**.

Builders & Architects

In 2019, the BWSSB mandated usage of treated WW from centralised STPs for construction. Despite this, most builders and architects are hesitant to reuse WW for construction. We found a few builders who are following the mandate, but are reluctant to publicise this due to the following reasons:

1. New home buyers have a negative cultural perception about treated WW.

"Clients feel that WW is impure, and are uncomfortable with using it to construct their homes (especially puja/prayer rooms)."

2. Lack of WW reuse standards for construction in India. It is difficult to 'prove' safety to home buyers.

3. Logistical issues like long transport distances and variable WW quality.

Surveys showed that residents preferred reusing GW over BW. However, resident behaviour showed this alone is insufficient to boost WW reuse.

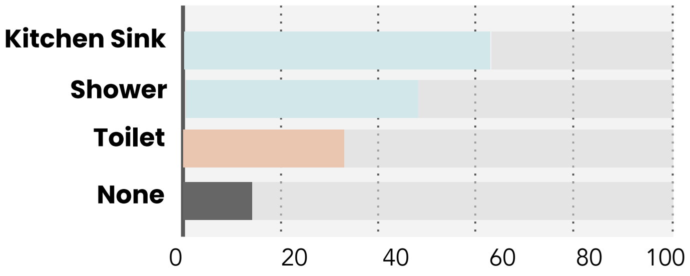


Fig. 4 Likelihood of reuse based on the area of the house the water is recycled

There was a clear **'yuck factor'** associated with reusing treated toilet water (blackwater) (Fig. 4).

Respondents were found to be 2x more willing to reuse treated greywater than treated blackwater.

The surveys indicated that a key reason for poor reuse is that most STPs in apartments combine blackwater with greywater before treatment.

We conducted a site visit in an apartment separately treating GW and BW to validate this. What we found was that the rate of reuse and trust in the treated wastewater among the residents did not change much with separate treatment of GW & BW.

The **treated blackwater (BW)** was not being used at all. It was directly discharged into stormwater drains after treatment.

The **treated greywater (GW)** was being utilised only for landscaping and toilet flushing. Using this treated water for other uses like common area washing were not considered.

Fig. 5 Bar screen before water enters GW tank

Residents were discarding waste like plastic bottle caps and shampoo sachets into their shower drains (Fig. 5). This indicated that they did not really value their treated greywater despite the separate treatment.

We collated our insights from the interviews into a detailed systems map to identify the levers and the key stakeholders needed to change perception

1

KEY LEVERS FOR CHANGE

- Build awareness on successful international WW practices for WW of different qualities
- Study current WW perception & reuse behaviours to uncover end user preferences
- Prescribe cultural acceptable WW treatment/reuse options
- Install tech to monitor WQ to build trust in WW & show water savings to boost WW reuse
- Build awareness on role of WW reuse on overall water security
- Map city's current water and sewage balance

OUTCOME: Higher acceptance & willingness to reuse treated WW

ACTORS REQUIRED FOR TANGIBLE OUTCOMES

INFLUENCER

- Media outlets
- Academia
- CSOs
- STP operators & STP vendors
- monitoring & reuse cos.
- MEP/STP consultants

DECISION MAKER

- End users (RWAs/home buyers)
- Builders

REGULATOR

- Government (BWSSB/KSPCB)
- Third-party certifier

INSIGHT 2

2 **Residents do not trust wastewater because RWAs and STP operators have little incentive to comply with water quality standards**

2

The interviews revealed that WW testing is infrequent. High cost of testing and rent seeking by agencies are problems.

Reports by the KSPCB reveal that almost 80% of the decentralised STPs are not adhering to the minimum discharge standards. We wanted to understand how frequently treated wastewater is tested.

We asked RWAs about WW monitoring frequency and compared them to the guidelines, which require apartments to test their wastewater at a National Accreditation Board for Testing and Calibration Laboratories (NABL) every two months.

Only 3 out of 20 RWAs were monitoring their STP output water quality regularly.

We found there were two main reasons for this:

Testing is expensive

The average cost of NABL lab tests is Rs. 2,500/test (Appendix. 2). But there were no incentives in place to encourage better monitoring of water quality, nor were the RWAs required to submit the test results.

Rent seeking by agencies

Although apartments are meant to generate NABL lab reports every two months, the frequency of testing across the range of apartments varies and is often less frequent than required.

However, this goes under the radar as rent seeking is a big problem. The majority of STP operators and RWAs interviewed mentioned that the site visits can encourage rent seeking instead of pushing for compliance.

To avoid this, the best practice internationally is to have a distinction between the makers of regulations from the enforcers of the regulation.

2

We collated our insights from the interviews into a detailed systems map to identify the levers & key stakeholders needed for improve monitoring of WW

KEY LEVERS FOR CHANGE

- Incentivise apartments to treat WW to meet the prescribed standards
- Prescribe reuse options for WW of different qualities
- Build capacity of PCB officials for checking STPs
- Create user awareness on water quality parameters and testing mechanisms
- Prescribe viable standards for WW discharge & reuse

OUTCOME:
Improved water quality monitoring protocols

ACTORS REQUIRED FOR TANGIBLE OUTCOMES

INFLUENCER

- Media outlets
- Academia
- CSOs
- STP operators & STP vendors
- monitoring & reuse cos.
- MEP/STP consultants

DECISION MAKER

- End users (RWAs/home buyers)
- Builders

REGULATOR

- Government (BWSSB/KSPCB)
- Third-party certifier

INSIGHT 3

3 **Incentive mismatch among the different stakeholders causes improper STP selection**

3

There is a structural incentive mismatch that results in improper STP selection and design

STPs can fail due to a variety of reasons. According to the 4S report (Vol-III) [iv] the main causes for failure of STPs were:

- **Financial constraints**
- **Lack of trained human resources**
- **Improper STP design**
- **Weak regulation**

To uncover the key levers for these failures, interviews and journey mapping tools were used. An STP journey mapping was done to identify stakeholders involved at each stage of the process. The map outlines their roles, key motivations and brings out gaps (Fig. 6).

We interviewed RWAs, builders and STP consultants, and asked them the same set of questions to understand differences in knowledge, interests and incentives.

The main highlights from the interviews are alongside.

1. Builders give primacy to economic concerns over end-user preferences when selecting STPs. The focus for most builders is to install STP technologies that occupy less space and have lower CapEx. This results in poor long-term performance of the STP and low WW reuse as RWAs struggle to pay the high maintenance costs.

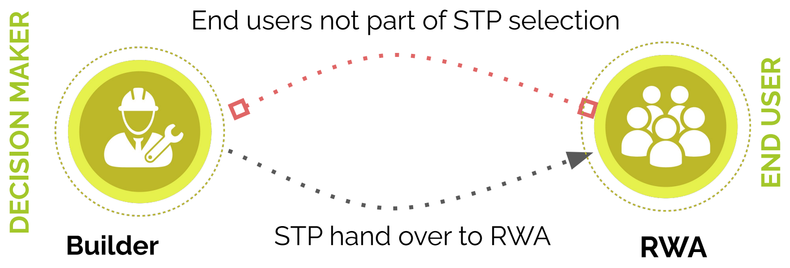
2. RWAs lack the knowledge and expertise required to manage and run an STP. This usually results in poor maintenance. RWAs are heavily reliant on building facility managers who sometimes lack capacity. As a solution, many RWAs turn to STP operators for advice but face challenges making independent judgements on technical recommendations.

3. The experts are biased. STP operators and MEP consultants advising builders and RWAs often favour familiar technologies or vendors even if they aren't the right fit for the site.

Fig. 6: Journey map showing stages where different stakeholders are involved and outcomes

	SELECTION	IMPLEMENTATION	O&M/UPGRADATION
INFLUENCER	**MEP/STP consultant** Seek repeat business from builders => keep capital costs low. Push profitable technologies.	**STP vendors** Skip on essential electro-mechanical components like blowers to help builder cut costs.	**STP operators:** Struggle to manage a poorly-built STP. **STP consultant:** Conduct STP audits and retrofit STPs upon RWAs approval.
DECISION MAKER	**Builder** Selects an STP as suggested by the MEP/STP consultant	Undertakes civil works, sometimes undersized tanks to cut construction costs.	*Builder hands over STP to RWA* **RWAs:** Lack knowledge of O&M for complicated STPs. Don't want to allocate funds for high O&M costs and needed upgrades.
REGULATOR	**KSPCB** Desk approve the STP design and STP capacity as per guidelines.	Field teams are understaffed and do not have technical expertise to verify proper installation and may engage in rent seeking.	Lacks capacity and manpower to conduct periodic checks to the STP.
OUTCOME	STPs with low CapEx and low space requirement are selected, even if they result in higher long-term O&M costs.	Poorly-designed STPs of inappropriate technology, which would require high maintenance in the long run, are installed.	Poor performance of the STP due to lack of maintenance leading to poor WW quality and lack of WW reuse.

Home buyers need to be educated on STP selection and contract design



One way to ensure a better STP design is to ensure future home owners interests are taken into account so the process ends up selecting STPs that are easy to operate and have a lower OpEx. The problem is the home owners do not come into the picture till after the STP has already been built.

Educating potential home buyers about the key attributes of STP design is critical.
Bengaluru Apartments Federation (BAF) & Confederation of Real Estate Developers' Associations of India (CREDAI) can be platforms to provide knowledge to inform and guide the end users.

To understand how we might better educate home buyers, we analysed 12 STP audit reports with capacities ranging from 130 KLD to 1,500 KLD (appendix. 3) to distill the main causes for failure. We found that STPs had over 40 different underlying causes of failure. In other words, we could not come up with a simple checklist for home buyers.

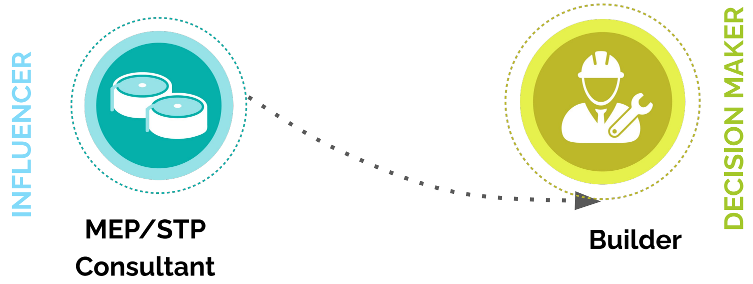
The only way to ensure that home owners' interests are aligned with builders is to ensure that the builder is required to contractually maintain the STP for at least 10 years after the RWA is formed. In other words, home buyers need to be educated on two considerations:

1. **STP technology must be low OpEx and easy to maintain.**

2. **A long-term service contract that requires the builder to maintain the STP to meet service level benchmarks for at least 10 years after it's handed over to the RWA.**

3

In the absence of standardisation, there are inconsistencies in STP selection. Unbiased experts are crucial for proper STP design & selection.



The STP design process is inherently biased. During the journey mapping, it was evident that builders rely on experts for STP selection.

STP operators often push their own technology as being unique in the market. The MEP consultants tend to choose technology that they are familiar with or have relationships with rather than designing based on engineering principles and using standard software packages.

SBR, MBBR and MBR are the most widely used technologies for decentralised STPs in the residential context.

The initial lower occupancy rate of apartments is not factored in during selection and design. Often, new apartment complexes take years to achieve full occupancy. In this initial period of low occupancy, STP operators lack clear operational rules on what to do.

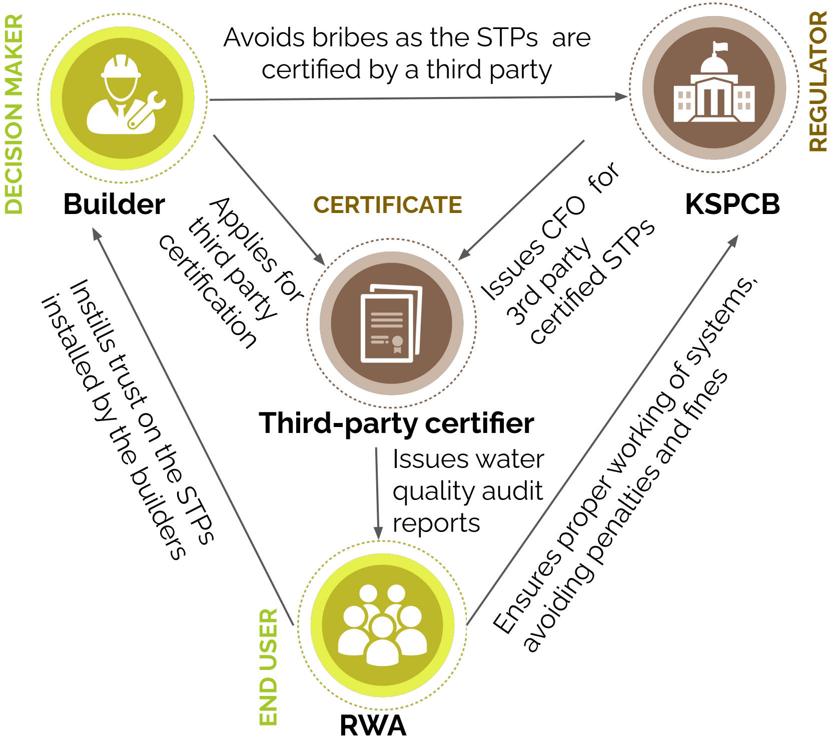
Technology such as SBR can work efficiently only when there is a minimum 30% occupancy rate.

Only a few STP operators ensured proper functioning of essential electro-mechanical components; most lacked the technical capacity to address multiple points of failure (appendix. 4).

Third-party certification and service contract models could be a way forward to solve the inconsistencies at various stages of the STP journey. Operational manuals that can address different occupancy levels are also needed.

3 Third-party certification and service contract models will enable regular audits and accountability, ensuring smooth functioning of STPs

Third-party certifications are a cost-effective way to ensure compliance and smooth functioning of STPs. Third-party certification is a common practice globally.



In apartments, service contract models are common for elevators and other mechanical fixtures. Service contract models for STPs in apartments can potentially solve the issues the RWAs are currently facing. A service contract would ensure maintenance is undertaken by the same stakeholder who built the STP, addressing the CapEx-OpEx trade-off. This would ensure smooth O&M of the STP even after the apartment is handed over to the RWA.

Case study of Green's apartment

An apartment in Mahadevpura got its STP of 100 KLD capacity retrofitted 3 years ago. The retrofitting was done based on an STP audit conducted by a third-party STP operator. Following this, the STP operation and maintenance were taken over by the same operator. The residents are able to reuse 100% of their treated water as they now trust their output. Apart from using it for washing common areas, the treated water is being used to maintain a vegetable garden.

We collated our insights from the interviews into a detailed systems map to identify the levers & key stakeholders needed for smooth STP functioning

3

KEY LEVERS FOR CHANGE

- Builders respond to new home buyers & end users demands
- Educate new homebuyers & end users on STP selection & O&M
- Involve third party certifiers experts in STP selection
- Build capacity of STP operators to ensure better O&M
- Build capacity of PCB officials for checking STPs

OUTCOME: Better STP selection, design & O&M

ACTORS REQUIRED FOR TANGIBLE OUTCOMES

INFLUENCER

- Media outlets
- Academia
- CSOs
- STP operators & STP vendors
- monitoring & reuse cos.
- MEP/STP consultants

DECISION MAKER

- End users (RWAs/home buyers)
- Builders

REGULATOR

- Government (BWSSB/KSPCB)
- Third-party certifier

INSIGHT 4

4 **Tanker networks are hesitant to transport wastewater**

4

A lack of sustained demand for treated WW & fear of losing their main business of conveying freshwater have hindered WW transport by tankers

Tanker water is a major source of freshwater for apartments located in the peri-urban areas of the city. Most peri-urban zones lack access to pipeline infrastructure.

Over 40% of residents living in peri-urban areas don't have formal water connections and rely on tanker-supplied water.

9 out of 20 RWAs used tanker water to meet their water requirements.

Tanker suppliers predominantly source the water from borewells in surrounding areas. With groundwater levels depleting drastically, there is increasing concern among the tanker community about the long-term availability of groundwater.

An alternative business model for these tanker companies in the future could be transporting excess treated wastewater from apartments, to be used for other purposes.

We approached tanker operators to understand their willingness towards this business model. We realised that there was a lot of resistance for several reasons:

1. Fear of losing existing consumers who buy freshwater, because of the 'yuck factor'.
2. Lack of demand for transporting excess treated wastewater.
3. Presence of a tanker mafia — even if a tanker operator is willing to transport treated wastewater, they are afraid to come forward.

Creating a physical distinction by colour coding the tankers carrying treated wastewater can be a potential solution.

This can help overcome suspicion among residents that the same tankers will be transporting the fresh and treated water. Additionally, the inside of the shell can be EPI coated to prevent any chemical reaction between the tanker's metal and chemicals in treated WW.

4 Tankers carrying treated wastewater may not be economically viable

For treated wastewater markets to become viable, the following factors must be considered:

- Number of loads that are carried by the tanker from the apartment (source) everyday.
- The distance between the source and the sink (where the WW would be used).

Preliminary financial analyses show that:

Tankers must make 7-8 trips per day, on an average.

Considering that 6 KL tankers are the most commonly used, transporting a total 48 KL of wastewater everyday would ensure these transactions become economically viable.

Fuel being the most expensive component in transporting wastewater, it is imperative to minimise travel distances to keep costs low and ensure that treated wastewater can be priced substantially lower than freshwater.

Mapping the wastewater sources and sinks within the shortest transportation radius of 5 km would make these transactions viable.

Other factors like time taken to load and unload the tanker, along with efficient coordination at various sources and sinks, are critical to achieve the desired number of trips per day.

On an average, an apartment with 1,500 units buys 40 6 KL tankers of water/day at a cost of Rs. 6 lakh/month.

Selling treated wastewater to apartments currently buying tanker fresh water would facilitate creation of a WW market.

Finally, creating a digital platform to help sellers and buyers find each other will help scale this model across the city.

4

We collated our insights from the interviews into a detailed systems map to identify the levers & key stakeholders needed for WW transportation

KEY LEVERS FOR CHANGE

- Ensuring sustained business for WW tanker operators
- Colour coding the tankers to distinguish between freshwater & WW tankers
- A formal platform to bring in transparency of WW transactions
- Pricing of WW to be economically viable
- Policy for buying WW by government & private sector
- Quality assurance & trust building through GPS tracking & WQ sensor on the tanker

OUTCOME:
Robust WW transportation network

ACTORS REQUIRED FOR TANGIBLE OUTCOMES

INFLUENCER

- Media outlets
- Academia
- CSOs
- STP operators & STP vendors
- monitoring & reuse cos.
- MEP/STP consultants

DECISION MAKER

- End users (RWAs/home buyers)
- Builders

REGULATOR

- Government (BWSSB/KSPCB)
- Third-party certifier

INSIGHT 5

5 There are currently no viable reuse options beyond those listed in the mandate

5

Most residents are open to non-potable and indirect potable reuse options like WW for GW recharge.

Most apartments currently reuse their treated WW for landscaping, toilet flushing and common area washing (Fig. 3). Despite this there is a surplus of treated WW as there is a lack of culturally-acceptable reuse options within the apartment complexes.

Only 8/20 apartments were able to reuse 100% of their treated WW.

Residents drain the excess WW into stormwater channels. This is in direct conflict with the 2007 KSPCB mandate for Zero Liquid Discharge (ZLD).

It is impractical for apartments to comply with the policy of 100% reuse given that:

- Older apartments without dual plumbing use treated WW only for landscaping.
- Apartments do not water their landscapes during monsoon.

It is imperative to identify safe, economical and culturally-appropriate reuse options if residents are to reuse 100% of their WW.

One such reuse option could be to reuse the excess treated WW for groundwater recharge. This would be especially useful in densely populated areas of the city which are outside the BBMP water network limits where the main source of freshwater is groundwater.

100% RWAs were willing to use excess treated WW for groundwater recharge.

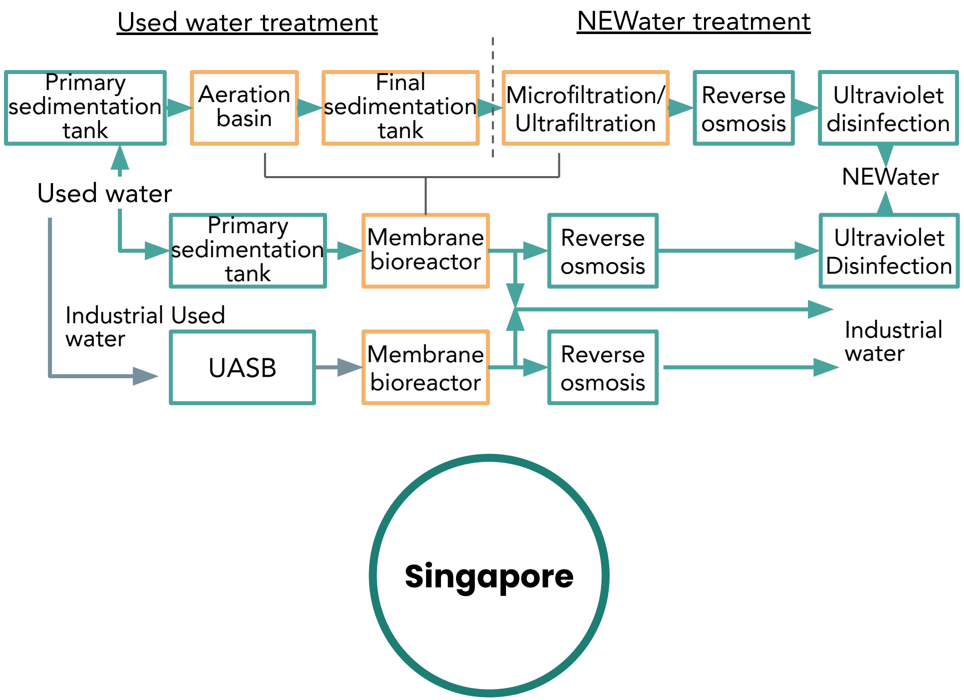
But it is crucial to monitor the quality of treated WW used for groundwater recharge as there could be a risk of groundwater contamination. The CPCB has outlined the technology and monitoring recommendations for aquifer recharge.

In order to identify additional reuses we studied successful WW practices internationally to have a range of reuse purposes for wastewater of different qualities (refer pg 36). Countries that were not treating wastewater to potable water standards were still able to achieve almost 100% reuse through measures like the multi-barrier approach (refer pg 35).

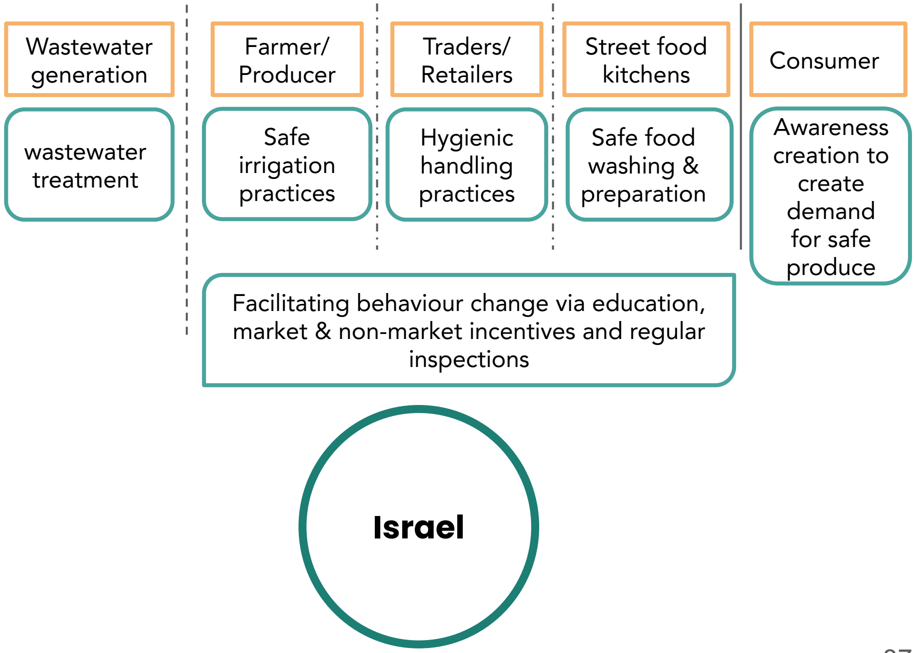
5

Some countries treat their WW to high discharge standards while others adopt a multi-barrier approach to treatment & reuse

Higher Discharge Standards (Treatment & Reuse without extra protection) [v]



Multi-barrier Reuse System (Treatment + protective equipment) [vi]



5

Countries internationally are treating and reusing their WW using a range of strategies, with different cost implications.

Israel [vii]

WW reused for :

Agriculture, fire protection and increasing river flows.

Case study :

Israel's Shafdan WW treatment plant treats 97 million GPD of municipal WW from the Tel Aviv area. Effluents undergo secondary and tertiary treatment, followed by filtration and disinfection. It is reused for irrigation.

Cost per KLD: $0.35[viii]

Japan [ix]

WW reused for :

Toilet flushing, fire protection, landscaping and recreational use.

Case study :

In the city of Saitama, GW has been exploited and the need to reuse treated WW is required. By adopting activated sludge process, the wastewater reuse project of Saitama city is an example of Japan's experience in reusing WW for non-potable purposes.

Cost per KLD: $2.47

United States of America [x]

WW reused for :

Toilet flushing, fire protection, landscaping, recreational field and GW recharge.

Case study :

In Florida, WW is treated using tertiary treatment with membrane filtration and UV radiation. The treated water is used for gardening, golf courses, parks and schools. Other uses are irrigation, industrial and groundwater recharge.

Cost per KLD: $3.44

Singapore [xi]

WW reused for :

Water fabrication, industrial and commercial estates, recharging reservoirs.

Case study :

The secondary effluent is subjected to microfiltration, RO and UV disinfection. Treated water is used for industrial and cooling purposes at water fabrication plants and commercial buildings. It is used for indirect potable use: introduced into raw water reservoirs.

Cost per KLD: $2.39-$3.69

5

There were also a few examples of apartments in Bengaluru using wastewater for potable purposes

Wastewater recycled to drinking water standards

T-ZED homes in Bengaluru is using treated WW for drinking. This apartment complex, with 91 units, converts treated wastewater into drinking water by using membrane technology and RO process.

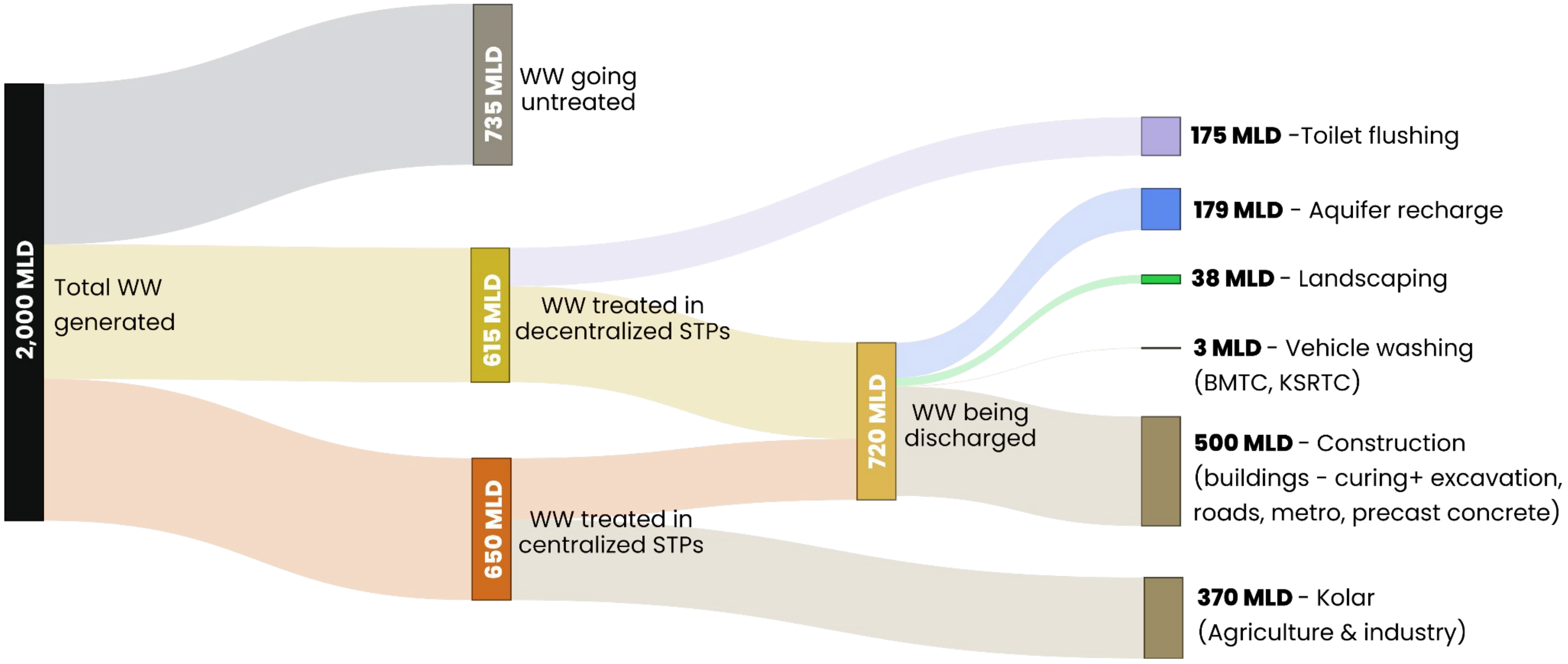
In 2012, there was a severe drought and water scarcity in Bengaluru. T-ZED homes had to depend on tanker water for its water requirements. It was unable to meet its water requirements even after buying 10 tankers of freshwater.

In order to solve the water scarcity problem at the apartment, the residents came forward and educated themselves on the water treatment. They installed series of filters and membranes in the treatment system that would convert the wastewater to drinking water.

Behavioral experiments to build trust in reusing wastewater

Initially, there was lot of resistance among the residents in accepting the treated WW as a source of drinking water. In order to remove this mental barrier, a lot of focus group discussions and awareness activities were conducted. One example is a social experiment in which residents were blindfolded and served with treated drinking water and freshwater. They were unable to spot the differences between the two. Apart from this, residents were are also guaranteed by a healthcare professional on the safety of treated drinking water. The blindfold experiment was crucial in helping residents change their perception towards treated drinking water. Their trust increased after speaking to the healthcare professional.

Here are some viable reuse options to address the problem of unused wastewater in the city



We have identified the key levers and stakeholders required for creating viable reuse options based on the interviews and case studies

5

KEY LEVERS FOR CHANGE

- Identify reuse options that are safe, economical and culturally appropriate for residents
- Build awareness on successful international WW practices for WW of different qualities
- Study current WW perception & reuse behaviours to uncover end user preferences
- City wide policy for wastewater treatment and reuse
- Enable logistics for transportation of WW for reuse beyond apartment fence

OUTCOME:
Viable reuse options beyond the mandate

ACTORS REQUIRED FOR TANGIBLE OUTCOMES

INFLUENCER

- Media outlets
- Academia
- CSOs
- STP operators & STP vendors
- monitoring & reuse cos.
- MEP/STP consultants

DECISION MAKER

- End users (RWAs/home buyers)
- Builders

REGULATOR

- Government (BWSSB/KSPCB)
- Third-party certifier

INSIGHT 6

6 There are insufficient financial incentives for reusing wastewater

6

There are no incentives for reusing treated WW, which leaves residents unmotivated to maintain STPs

Apartment communities in Bengaluru play a vital role in wastewater management by decentralised STPs in treating domestic wastewater.

However residents are

inadequately incentivised to make the decentralised WW policy in apartments a success.

The current approach to decentralised WW treatment and reuse involves penalties, not incentives. Many RWAs are burdened by the mandate.

Apartments that rely on expensive tanker water have a clear economic incentive to reuse treated wastewater and reduce tanker costs [iii].

However, those apartments with access to piped water networks have no financial incentive to reuse WW as the price of freshwater is very low. This is likely to become a bigger problem as BWSSB supply will extend to new areas.

In areas receiving piped supply, **lower tariffs for apartments that reuse all their wastewater will ensure wastewater is treated.**

Additionally, creating a market for selling excess treated WW could make it valuable. It would go a long way in incentivising residents to fund the proper maintenance of their STPs.

Waiver of sewerage and sanitation charges [xii]

Incentive: Residents of Bengaluru have to pay a minimum of Rs.100/household or 25% of the overall water bill (whichever is higher) in sewage and sanitation charges as part of their monthly domestic water bill. This can be waived if the residents are treating their sewage in decentralised STPs.

Gap: The average cost of STP maintenance exceeds the potential savings from the waiver of sewerage and sanitation charges by 4x.

6 There are gaps in the existing financial incentives for decentralised WW treatment and reuse, and they are not focused on apartments

As a starting point, to look at what incentives might work in the residential context, we looked at different financial subsidies offered domestically for different sectors. We found that these subsidies also have gaps, which is why there is a lag in WW treatment and reuse.

We then began to look at successful financial models offered internationally to see how they aided in boosting treatment and reuse. On pg. 40 is a list of incentives and policies in Singapore.

Karnataka

Financial subsidies on STP equipment for SMEs [xiii]

Incentive: In October 2014, Karnataka launched its industrial policy which implements subsidies of up to 75% of the cost of equipment for wastewater recycling by small and medium manufacturing enterprises.

Gap: This does not account for space constraints. Additionally, the support is provided only for small-scale industries

Telangana

Direct subsidies for STP technology innovation [xiv]

Incentive: In January 2020, Telangana announced the launch of Sanitation Hub to promote start-ups and innovations in water, sanitation, sewage management and WW recycling. A seed fund of Rs. 25 crore was earmarked for the initiative.

Gap: This subsidy is currently aimed at WASH projects. It does not focus on the decentralised sewage treatment plants.

6

To understand the components of a successful nationwide WW reuse strategy, we explored methods of incentivisation adopted in Singapore

An integrated approach by Singapore's Public Utility Board (PUB) to treating WW with incentives [xv] and grants has encouraged WW reuse.

Pricing

Singapore provides NEWater at a lower rate than regular water.

It does not apply Water Conservation Tax or water treatment fees to the sale of NEWater.

Grants

The government has shortened the grant disbursement period to three years from seven for water recycling initiatives and the use of alternative water sources.

Credits

Singapore offers a tax credit (percentage of CapEx) on projects that reduce potable water use.

Incentives

Water recycling initiatives and projects using recycled water receive higher funds per cubic metre of water saved.

6

We have identified the key levers and stakeholders required for creating an economic use case for wastewater based on the interviews and case studies

KEY LEVERS FOR CHANGE

- Provide incentives for apartment residents to reuse treated WW
- Pricing of freshwater based on actual cost without subsidies
- Encourage conscious use of freshwater by installing net metering devices
- City wide policy for wastewater treatment and reuse
- Build awareness on role of WW reuse on overall water security

OUTCOME:
Economic case for WW reuse

ACTORS REQUIRED FOR TANGIBLE OUTCOMES

INFLUENCER

- Media outlets
- Academia
- CSOs
- STP operators & STP vendors
- monitoring & reuse cos.
- MEP/STP consultants

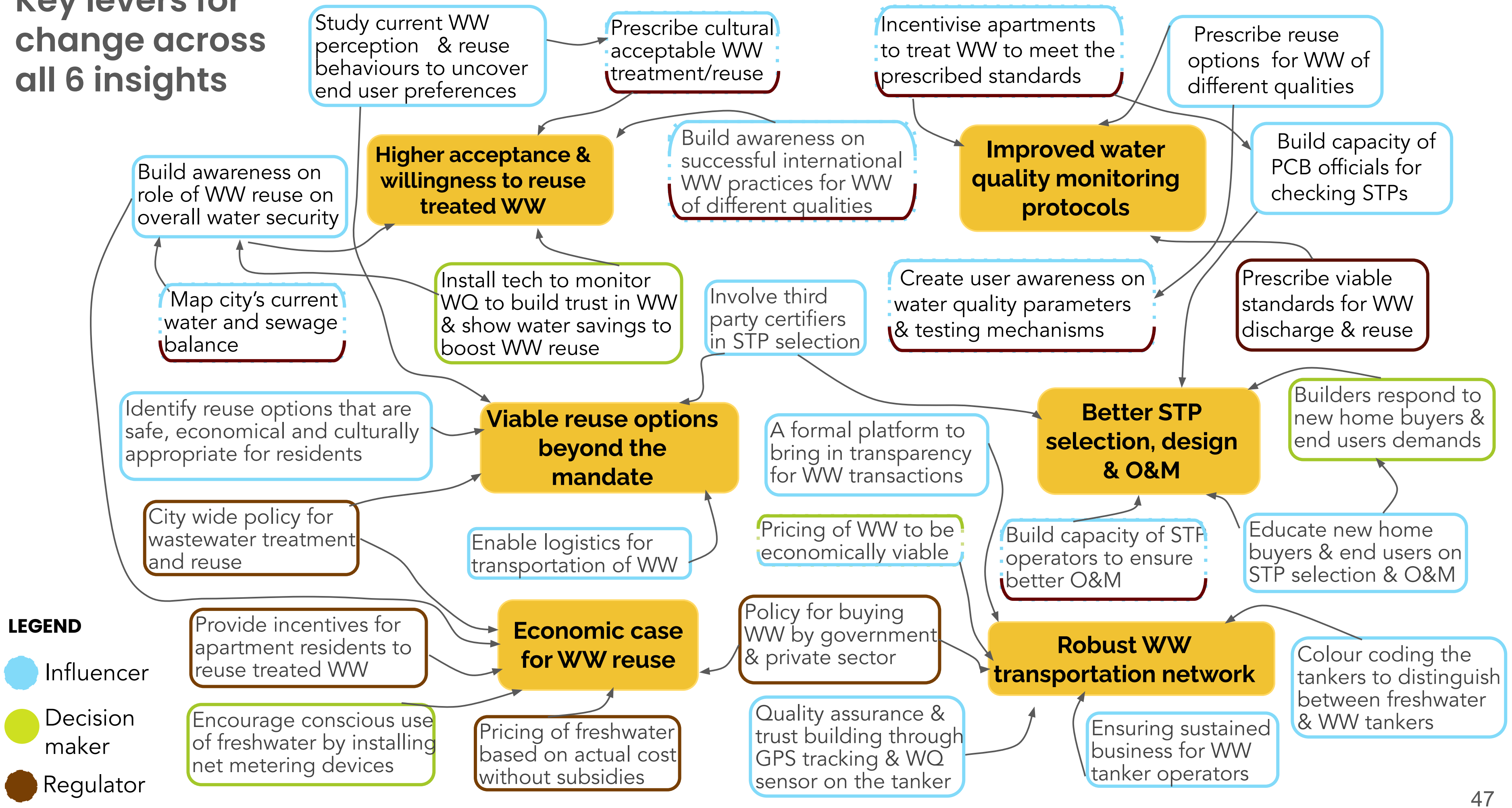
DECISION MAKER

- End users (RWAs/home buyers)
- Builders

REGULATOR

- Government (BWSSB/KSPCB)
- Third-party certifier

Key levers for change across all 6 insights



WAY FORWARD

Pilot projects to show proof of concept is the way forward

The way forward is to conduct pilots, which will provide an opportunity to gain an understanding of on-ground challenges. The pilot would help identify the stakeholders involved at each stage. The gaps that are identified in the process could inform implementation for scaling up across the city.

GREY to GREEN

- Parks, medians, road side greening
- Private green spaces
- Urban farms & large nurseries

GREY to BLUE

- Recharging aquifers
- Recharging water bodies

GREY to OTHER

- Building construction
- Road laying
- Brick manufacturing
- Floor washing in small scale industries
- Textile industry
- Cooling towers

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APPENDIX

Appendix 1 :
List of RWAs interviewed

S.No	Apartment located in Ward	Ward number	No. of units	STP capacity (KLD)
1	Chowdeshwari	2	754	325
2	Thanisandra	6	115	50
3	Bommasandra	11	25	10
4	Hoysala	80	550	No STP
5	Kadugodi	83	450	195
6	Kadugodi	83	500	216
7	Marathalli	86	72	32
8	Yelahanka satellite town	102	180	77
9	Konena agragara	113	324	140
10	Bellanduru	150	314	135

Appendix 1 :
List of RWAs interviewed

S.No	Apartment located in Ward	Ward number	No. of units	STP capacity (KLD)
11	Bellanduru	150	314	135
12	Bellanduru	150	250	108
13	Bellanduru	150	300	130
14	Bellanduru	150	312	135
15	Bellanduru	150	185	80
16	K.R puram	151	176	76
17	Madivala	172	700	302
18	Puttanahalli	187	108	50
19	Bilekhalli	188	1900	820
20	Parapana agragara	191	820	355

Appendix 2 :
Existing lab tests for monitoring treated water quality from the STPs

Test	Cost in Rs.	Parameters	Accepted as per KSPCB mandate	Reasons why this is not widely adopted
Private lab tests accredited by NABL	1,500-3,000	Multiple parameters	Yes	- Not affordable for regular monitoring - Failure to maintain quality assurance and quality control (QA/QC) compromises the reliability of lab results.
Jal Jeevan Mission testing labs (Government department of drinking water and sanitation)	50 per test per parameter/ 600 for 16 parameters	All 16 water quality parameters as per Jal Sakti framework	Yes	- Lack of information and idea of lab locations. - Only 66 of the 2,033 water testing labs are certified by NABL.
FFEM	2,500/50 tests	pH, nitrate, phosphate, arsenic and chlorine		- Not yet popular

Appendix 3:
STP Audit Reports

We analysed 12 STP audit reports having the following technologies. The reasons for failure of the components were identified and weightage was given to reasons that were predominant.

No. of reports audited	Treatment technology	Capacity of the STP (KLD)
6	Sequencing Batch Reactor (SBR)	130, 700, 700 , 304, 320 and 480
3	Moving Bed Biofilm Reactor (MBBR)	475, 150 and 435
1	Rotating Media Bioreactor (RMBR)	310
2	Extended Aeration Activated Sludge (EAAS)	670 and 1,500

Appendix 4:
Summary of key STP components and common reasons for failure

Physical components	Design failure	Operation or maintenance failure
Pumps	• Incorrect selection of pumps for raw sewage transfer • Incorrect pump selection for sludge feeding • Oversizing/undersizing of the pump capacity	• Pumps not in use for long time • Unnecessary use of multiple pumps • Water leakages
Tanks	• Oversizing/undersizing of the tanks • Improper tank depth in SBR tank • Insufficient air supply in tanks • Corrosion of screens in bar screen chamber	• Accumulation of dirt, solidified muck • Accumulation of sludge
Blowers	• No provision of concrete base for blowers • Improper capacity of the blowers • Lack of provision of acoustic linings	• Blowers are turned off at night to avoid noise
Ventilation	• Improper exhaust and ventilation ducts • Oversizing of the ventilation ducts	• STPs turned off at night to save costs on energy and emits unpleasant odour when turned on in the morning
Microbial balance	• Sludge gets accumulated due to turning off the STP and there is an imbalance in the food available for the microorganisms	• Addition of manure, bio agent or additives to speed up the process
Filter media	• Oversizing/undersizing of the pressure sand filter and activated carbon filter • Failure of pressure gauges	• Filter media replacement is not frequent