Saph Pani

Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India

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Report on management plans

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Content

List of figures

List of tables

1 Introduction

Many natural water systems in India are contaminated, therefore, they cannot be used as a potable water supply, especially in the urban periurban settings. Existing natural treatment systems (NTSs) can play an important role in contaminant attenuation, enhancing its potential use and address the water scarcity issues in a country like India. The natural treatment processes are simple, and offers treatment of polluted waters through a combination of natural soil aquifer processes and plant-root systems (Nema et al., 2001; Kaldec & Wallace, 2008). NTSs like soil aquifer treatment (SAT), Managed Aquifer Recharge (MAR) or constructed wetlands (CW) are robust barriers, that can remove multiple contaminants, minimise the use of chemicals, use relatively low energy and have a small carbon footprint (Sharma et al., 2008; Zurita et al., 2009; Missimer et al., 2014), and utilise locally available resources. These systems have been applied for wastewater treatment (as pre-treatment, main treatment or post treatment) and reused for multiple uses (Sharma et al., 2011).

This deliverable attempts to explore the possibility of including the NTSs as part of the urban water supply system and develop an integrated management plan (human health, environment, economic and social) for its effective use. It envisages the development of a framework that is analogous to a city sanitation plan, which will allow the use of natural treatment processes to enhance the natural water systems that are contaminated, thereby rendering them fit for drinking or reuse in agriculture. Here we explored two types of natural treatment options, one in Hyderabad for agriculture use, and the other in Chennai, to enhance the recharge of ground water, as a potential drinking water source and augment the existing supply.

Based on the quality of the source water, the management plan should cover number of aspects. Thus, this task will attempt to develop an integrated management plan to incorporate the natural treatment systems as part of the urban water supply system, depending on its use. The following description will look at two natural treatment systems that has the potential to attenuate contaminants in water, for agriculture and drinking purposes which can help alleviate some of the water scarcity issues in the two cities.

2 Natural Treatment Systems in India

A national survey of NTSs, identified over 108 sites that has operational systems to varying degrees (Saph Pani WP3 - Asolekar et al. 2014, IIT Bombay, India, unpublished data). The study showed that most of the operating systems of the NTSs were enhanced by the addition of mechanical pre-treatment for the removal of gross solids, especially where sufficient lands suitable for the purpose is available. It was observed that they were cost effective options in terms of both construction and operation especially in the urban areas. The operation and maintenance of these systems were managed either by communities who were users or agencies, and the involvement was either direct or indirect and dealt with collection, treatment and disposal. The primary aim of the agencies was to improve the sanitation facility as well to protect human health. Some of the types of examples are hyacinth and duckweed ponds, lemna ponds, fish ponds, waste stabilization ponds, oxidation ponds and lagoons, and algal bacterial ponds, and polishing ponds of

Sewage Treatment plants. Of the commonly utilised systems are the waste stabilization ponds which account for nearly 73 % of the cases.

In India, only 37% of the wastewater generated in Class I and II is treated (CPCB, 2009). Where the network coverages are attributed to this poor state of sanitation, there is ample opportunity to set up NTSs as decentralised systems to lessen the burden on the larger network systems. Natural water bodies will vary in response to environmental conditions. It is important to understand how these systems function, which in turn helps to identify the sources and fates of contaminants. Once the mode of contaminants removal is identified, it can be replicated in engineered way for the large scale wastewater treatment systems. However, this requires a good assessment and a management plan, for collection, treatment and final disposal to the environment. This will free up the domestic supply to meet the demands of the rising population. This will not only help network the small-scale businesses and illegal connections, it will also reduce the indiscriminate discharge to the environment that leads to pollution. All these systems however, have to be managed in a sustainable manner, so that a regular alternative of water supply is generated. For the water treated through NTSs, the uses are many, for instance, industry, agriculture and landscaping can be the largest beneficiaries if it becomes part of the larger water management planning in any city. NTSs, can be cost effective and can be modelled to suit a setting, which is manageable and involves communities or private-public partnerships for sustainable solutions. Further, it helps environmental experts and policymakers work to define legislation with the intention that water is maintained at an appropriate quality for its identified use.

3 City sanitation plans

The Ministry of Urban Development (MoUD) approved the ‘National Urban Sanitation Policy (NUSP)’ in October 2008. The MoUD has requested all major cities to develop their CSPs, and a large number of cities have started to do so. The Administrative Staff College of India has helped develop a number of CSPs. The objective of this policy is to transform urban India into community driven, totally sanitized, healthy and livable cities and towns. Cities and towns are requested to develop City Sanitation Plans (CSPs) as an overarching strategic approach to improve their sanitation conditions. City Sanitation Plans are strategic planning processes for citywide sanitation sector development. Addressing technical and non-technical aspects of sanitation services, city sanitation plans include the vision, missions, and goals of sanitation development as well as strategies to meet these goals. However, CSP development is a challenging task which needs involvement of experts and public bodies such as urban planning, sanitation, technical infrastructure and financing. Improvements in the sanitation sector concern every urban citizen and, therefore, require a participatory approach. For implementing a CSP, capital investments, adjustments of by-laws, strengthened administrative structures and adequate expertise might be necessary.

Technical aspects, including strategies and programmes for the development of (a) domestic wastewater services, (b) solid waste management services, and (c) micro drainage services.

Non-technical aspects, including strategies for the development of non-physical aspects such as (a) community awareness and participation, (b) policy and regulation, (c) institutional capacity, (d) private sector engagement, (e) NGO engagement, (f) financing and tariffs, and (g) monitoring and evaluation. Frameworks for the development of csps have been published, amongst others, by Tayler et al. (2000), Rosensweig et al. (2002), MoUD (2008), and WSP (2010).

In the state level sanitation planning, it is envisaged that the following can be achieved[1].

- Meeting the service level benchmark on drinking water supply (water sources, water purification, water distribution) and sanitation services (wastewater collection), sewerage, wastewater treatment, solid waste management, and storm water drainage (stormwater management and open channels and drains).
- Analyse and respond to the state level situation, challenges and issues.
- Improving city sanitation rating and ranking (National Award Scheme for Sanitation for Indian Cities).
- Mobilising funds through flagship programs such as JNNURM, RAY (financing and economic tools in wastewater treatment).
- Linkages with performance based grants under 13th Finance Commission.
- Improving public health and environmental outcomes (see also health and hygiene issues and environmental issues).

4 Water supply and sewerage management in Hyderabad and Chennai

4.1 Hyderabad

4.1.1 City Water Supply

Hyderabad is the fourth most populous city in India with its 6.8 million people. With the recent bifurcation of the former state of Andhra Pradesh, it will serve as the capital for both states for a period of 10 years, after which it will be capital city of Telangana. The city administration is governed by the Greater Municipal Corporation of Hyderabad (GHMC), covering an area of 650 km^2 (Figure 1).

[1] http://www.sswm.info/content/state-sanitation-strategy

Figure 1 State of Telangana (Districts in white) and Andhra Pradesh (Districts in cream) after bifurcation in 2014. Saph Pani studies took place in the city of Hyderabad.

The Hyderabad Metropolitan Water Supply and Sewerage Board (HMWSSB) is responsible for the city water supply and sewage management. Once, dependant on lakes and reservoirs close to the city, Hyderabad now lifts water from over 114 km to bring Krishna water to the city. This increasing demand, has placed pressure on freshwater resources more than ever, and requires that it protects its freshwater supplies and also treat its wastewater for alternative uses. The division of the former state has brought in a separate issue to the fore front, which is sharing the source water from (Krishna).2 Therefore, the city of Hyderabad will have to depend on some of its lakes and rivers within the state to provide drinking water for its citizens but also water for food production. However, most natural water bodies are polluted and the Musi River which runs through the city receives large volumes of wastewater (1252 MLD - both domestic and industrial) from the city, which is estimated as 80% of total water supply to the city.

Currently, there are five sources of water supply to city and Osmansagar on Musi River, Himayatsagar on Esa River, Manjira Barrage on Manjira River, Singur Dam on Manjira

2 http://timesofindia.indiatimes.com/city/hyderabad/Telangana-Andhra-Pradesh-water-conflict-may-leave-city-thirsty/articleshow/44965332.cms

River and Krishna Water. As against the demand of 2182 – 2273 MLD, HMWS&SB is presently supplying water to their full potential at 1500 – 1546 MLD from all the five sources[3]. With around 682 MLD water shortage and additional demand of 20 per cent, water supply status is worrying. While the ground water does cover the gap to a certain extent (an estimated 40% of the supply is said to be from ground water) in the drier months the bore wells dry up, the HMWSSB is pressured to increase its supply (Figure 2 and 3).

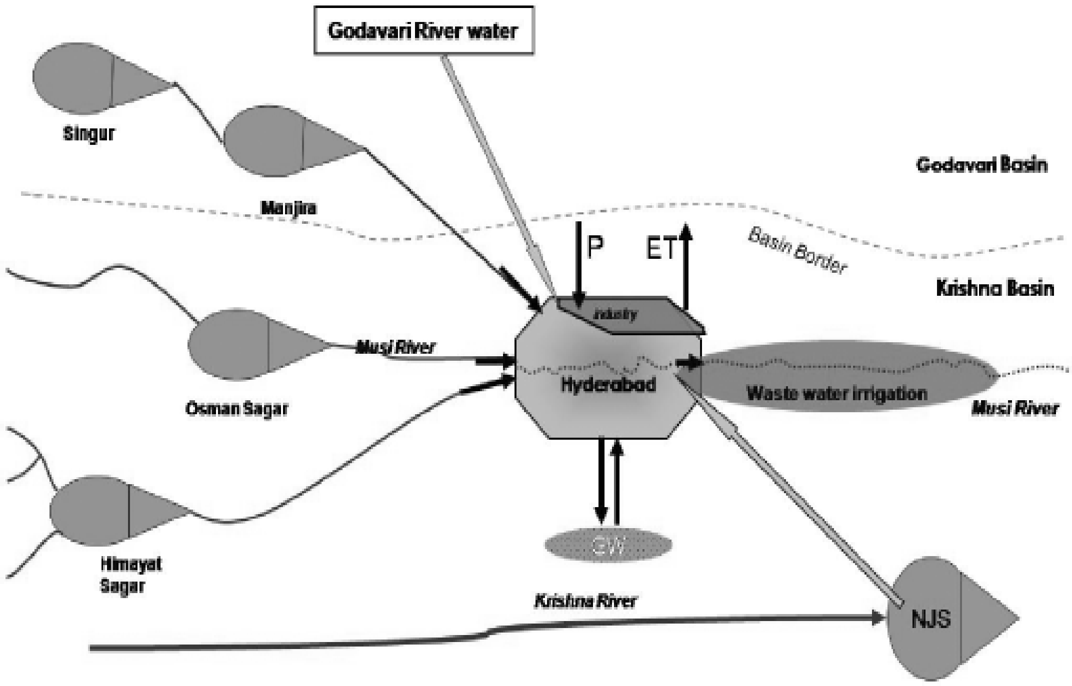

Figure 2 Drinking water supply to the city of Hyderabad. GW = Ground water, NJS = Nagarjuna Sagar reservoir. (Source: Van Roojan et al., 2005).

3 http://www.newindianexpress.com/states/andhra_pradesh/Water-Woes-Rising-Demand-Poor-Supply-Plague-Hyderabad/2014/03/03/article2087706.ece

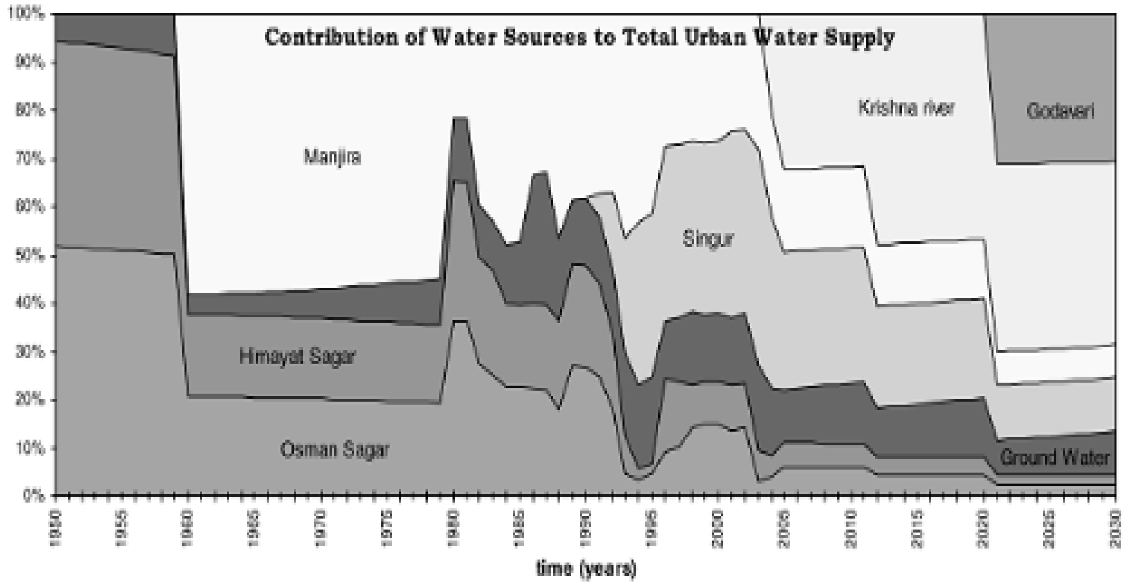

Figure 3 Hyderabad urban water supply patterns. Relative contribution of the water sources for urban water supply in Hyderabad in the period 1950–2030. Source: Wakode, H. (2011) http://www.waterandmegacities.org/urban-growth-and-its-effect-on-water-supply-demand-in-hyderabad/ accessed 15 January 2015

4.1.2 Sewage treatment and managment

The sewage is collected via a sewerage network system and treated at 3 treatment plants (Table 1). The treatment plant at Attapur is yet to be commissioned. The network coverage for conveyance is only 60% therefore, only 52% of the sewage is treated at these plants that are operational. The rest is discharged to waterways. Thus, the Musi River which runs through the city receives both partially treated and untreated wastewater and immediately downstream it is used for agriculture. If this water can be treated to a level suitable for agriculture, via NTSs, it can not only be used for agriculture, but for other uses like gardening, washing cars to relieve the pressure on the domestic water supply. It also helps to improve the sanitation conditions in the city, if it is planned as part of the water supply and sewage treatment systems.

Table 1 Current wastewater treatment capacity of sewage treatment plants and systems associated with lakes

	Value (MLD)	Source of information
Sewage (80% of water supply to the city)	1252	Hyderabad Water Supply & Sewerage Board
Treatment capacity	652.8	
Amberpet	339	
Nagole	172	
Nallacheruvu	30	
Attapur	51	
Hussain Sagar	20	Greater Hyderabad Municipal Corporation
Patel Cheruvu	2.5	Hyderabad Metropolitan Development Authority
Pedda Cheruvu	10	
Durgam Cheruvu	5	
Mir Alam Cheruvu	10	
Saroor Nagar Lake	2.5	
Safil Guda Lake	0.6	
LangarHouz Lake	1.2	
Noor Mohammad Kunta	4	
Ranghadhamini Lake	5	
Untreated	599	

According to the Shyamala Rao, IAS, Managing Director HMWS & SB ((2013) (http://www.icrier.org/pdf/hyd_short_presentation.pdf), the core city drainage network coverage is about 80%, most of which are 30-40 years old and is not sufficient to cater to current sewage flows. Peripheral city network coverage is about 30%. City needs about 1300 MLD sewage treatment capacity but existing treatment capacity is about 700 MLD. The sewerage issues are inadequate finances to maintain because it is non revenue activity and depend on water cess to maintain these lines, and high cost of land in urban areas for construction of new STPs.

Currently, the Hyderabad conventional sewage treatment plants (STPs) are capable of treating only 52% of the sewage generated in Hyderabad city. The existing sanitation practice includes an underground sewerage systems in the urban area, septic tanks in suburban and open release of sewage in general. Hyderabad Metropolitan Water Supply and Sewerage Board (HMWS & SB) looks after the water and wastewater management in Hyderabad city. For strengthening and improvement of existing sewer network, refurbishment project taken up in the Old city area of core city and in two municipalities of peripheral areas. Certain remodelling sewer works are being taken up under the State Budget. For newly merged municipal areas, detailed project reports for creation of sewer network are posed for JICA loan assistance.

For treatment of sewage generated in the core city and peripheral areas, steps are taken to formulate the DPR proposals under National River Conservation Plan of NRCD, of GoI, for creation of 610 MLD capacity of STPs at various locations. Models are being worked out to recycle the STPs water. The sanitation issues are 1) sweeping – forenoon / afternoon / night sanitation 19500 working, SWG units 2500 Nos, 2) Self Help Groups, 6800 km road length being sweeped. 3) Week days sweeping, safety measures to the personnel, provided road accident policies, radium jackets, quality implements, etc. 4) monitoring and evaluation by resident welfare associations and self help groups, women groups, and 5) community based sanitation involving local welfare associations & self help groups. Collection of solid waste is by Tricycles provided at free of cost to rag pickers for collecting the household waste at minimal cost. Dumper bins provided at every 500 M distance intervals. Rag pickers are also permitted to segregate the waste at dumper bin locations. Pin point program prepared for lifting of dumber bins. Solid waste transported from dumper bin location through designated transfer station and then to major dumping yard at 40 Km away from the city. Initiatives have been taken for scientific disposal of solid waste through BOOT/PPP Modes (i.e. compost, RDF, landfill & leachate treatment). Reclamation and reuse of existing dump sites. Development of scientific landfills. Developed 137 public toilets with good facilities.

4.1.3 City sanitation plan

Currently, there is no city sanitation plan for Hyderabad. However, there was a state level workshop to discuss the key needs for such a plan . A three tiered approach was suggested for better exchange of knowledge and experiences. These were National (NUSP), State (SSP) and local urban body (CSP -municipality) levels (Figure 4). The different components of the SSP were also discussed (Figures 4 and 5)

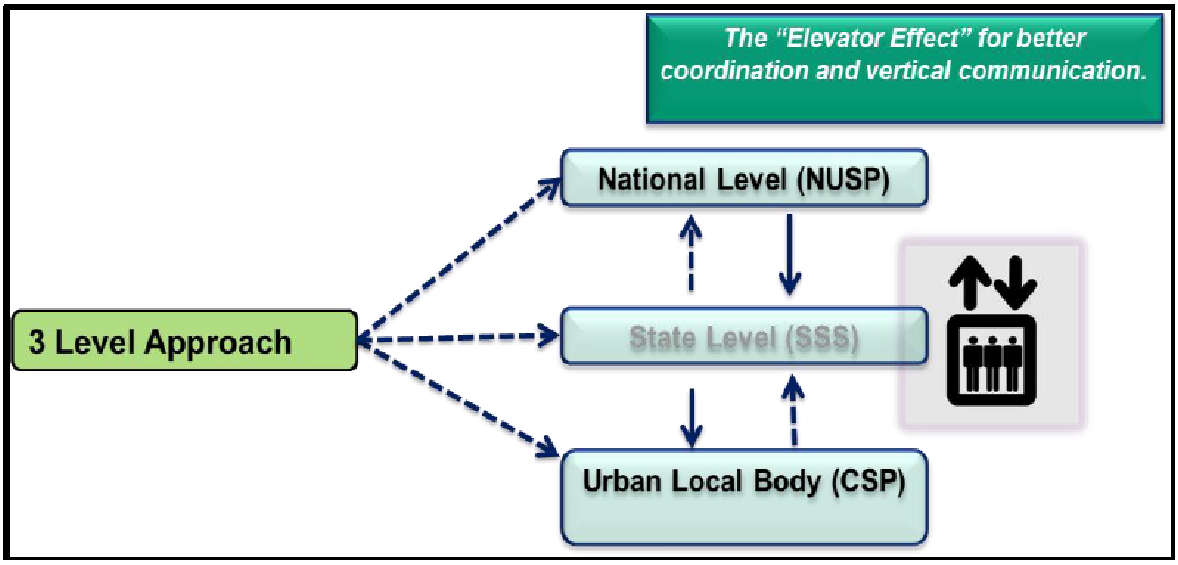

Figure 4 Levels of planning to develop the CSP. Source: given in foot note

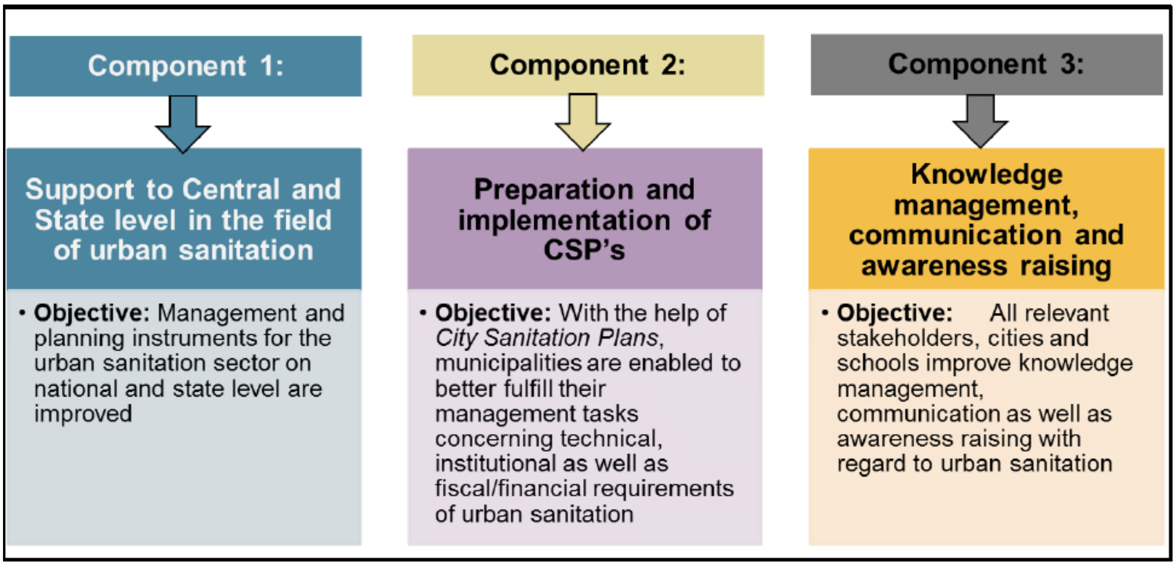

Figure 5 The activity plan for the State level sanitation plan.

Current sanitation related activities

Currently, the conventional sewage treatment plants (STPs) are capable of treating only 52% of the sewage generated in Hyderabad city. The underground sewerage network system also is linked to the storm water drainage system to release the excess flooding during the monsoon seasons. According to the Managing Director HMWS & SB ((2013)[4] the core city drainage network coverage is about 80%, most of which are 30-40 years old and is not sufficient to cater to current sewage flows. Peripheral city network coverage is about 30%. City needs about 1300 MLD sewage treatment capacity, but the existing treatment capacity is only about 700 MLD. The main reason is the revenue generated is insufficient to meet the cost of maintenance, and the high cost of land is prohibitive for establishing new treatment plants. In the recent past the state budget has been utilised for strengthening and improving existing sewer network. For newly merged municipal areas, detailed project reports for the creation of sewer network have been submitted for for JICA loan assistance. Furhter, treatment of sewage generated in the core city and peripheral areas, steps are taken to formulate the DPR proposals under National River Conservation Plan of NRCD, of GoI, for creation of 610 MLD capacity of STPs at various locations. Models are also being proposed to recycle the STPs treated water.

Some of the major sanitation issues covered are 1) sweeping – forenoon / afternoon / night sanitation 19500 working, SWG units 2500 Nos, 2) Self Help Groups, 6800 km road length being sweeped. 3) Week days sweeping, adoption of safety measures, provision of road accident policies, radium jackets, quality implements, etc. 4) monitoring and evaluation by resident welfare associations and self help groups, women groups, and 5) community-based sanitation involving local welfare associations & self help groups. Collection of solid waste is by tricycles provided at free of cost to rag pickers for collecting the household waste at minimal cost. Dumper bins provided at every 500 M distance intervals. Rag pickers are also permitted to segregate the waste at dumper bin locations.

[4] http://www.icrier.org/pdf/hyd_short_presentation.pdf,

Pin point program prepared for lifting of dumber bins. Solid waste transported from dumper bin location through designated transfer station and then to major dumping yard at 40 Km away from the city. Initiatives have been taken for scientific disposal of solid waste through BOOT/PPP Modes (i.e. compost, RDF, landfill & leachate treatment). Reclamation and reuse of existing dump sites. Development of scientific landfills. Todate 137 public toilets are functional with good facilities.

4.2 Chennai

4.2.1 City water supply

Chennai, is one of the metro cities of India, in the state of Tamil Nadu, which relies on a system of reservoirs and lakes for its water supply Figures 7 and 8). It is heavily dependent on the monsoon rains for recharging the water bodies, as three of the largest rivers within the state are heavily polluted. With a population of 4,681,087 (Census 2011), the demand for domestic water supply has increased over time and as a consequence, ground abstraction has increased, which has resulted in the decrease of water levels in aquifers. Currently, the water needs of Chennai city is met by desalination plants at Nemelli and Minjur; aquifers in Neyveli, Minjur and Panchetty; Cauvery water from Veeranam lake; Krishna River from Andhra Pradesh; Poondi reservoir; and lakes at Red Hills, Chembarambakkam and Cholavaram (Mariappan and Julie, 2014). The current water supply from all sources is 985 MLD against a demand of 1200 MLD. The water supply to the city is managed by the Chennai Metropolitan Water Supply and Sewerage Board, which covers an area of 426 km2.

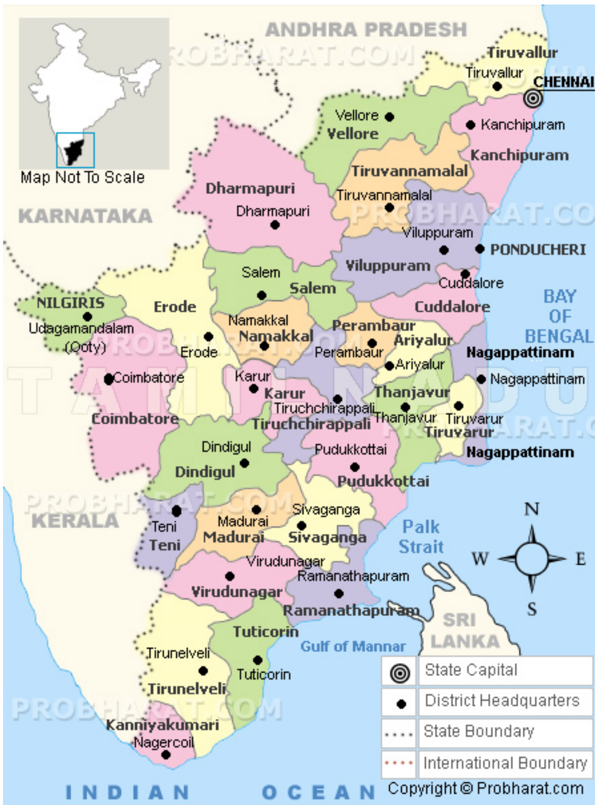

Figure 6 The State of Tamil Nadu and city of Chennai where Saph Pani studies were carried for the demonstration of NTSs for enhancement of water supply. Source: Probharat.com. Accessed on 29 January 2015

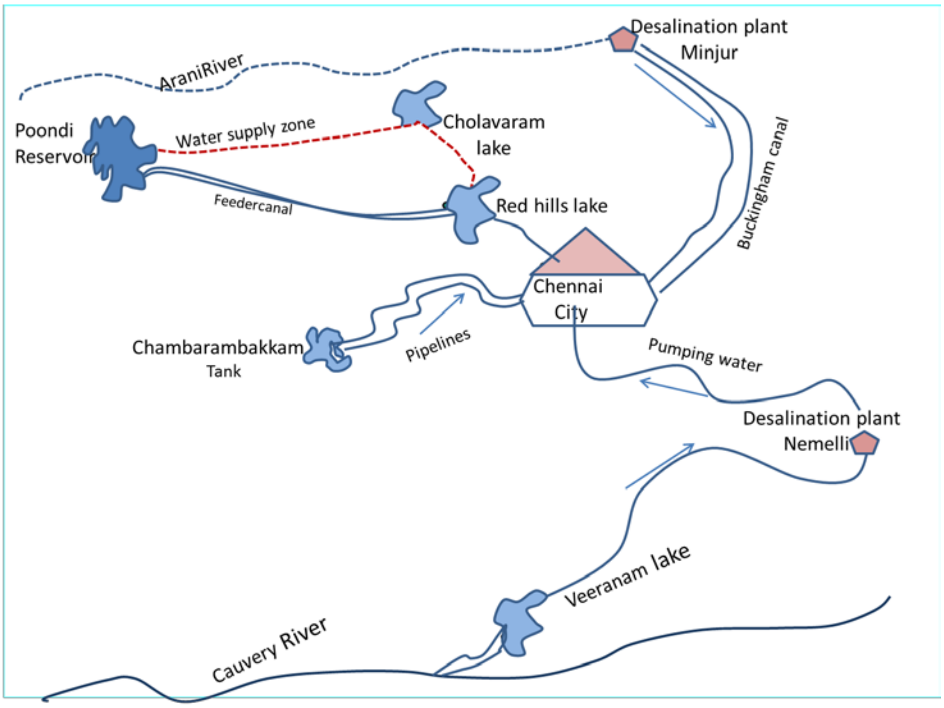

Figure 7 Urban water supply system in the city of Chennai. Source: IWMI

4.2.2 Sewage treatment and management

Chennai City Sewage System has been expanded over time to cater to the population increase. However, the sewerage network system is unable to handle the full flows especially, when the the storm water is released. The excess is drained into the natural waters close to the city viz. Cooum river, Adyar river, Buckingham canal and Otteri Nalla. The following are the Sewage Treatment Plants of CMWSSB as at February 2014; Kodungaiyur 270 mld (110+80+80), 2); Villivakkam 5 mld; Koyambedu 94 mld (34+60); Nesapakkam 117 mld (23+40+54); Perungudi 126 mld (54+60+12), totaling 612 mld (MLD) of which 378mld is powered by Biogas (produced during the Sewage Treatment) engines. City's inability cope with treatment also poses a great threat to the drinking water supply.

4.2.3 City sanitation plan for Chennai

Like for Hyderabad, there is no sanitation plan for Chennai. While the national and state leve guidelines are available the activities are planned in an ad hoc manner. In a recent report, it was stated on the national sanitation ranking Chennai received a score of 53% out of 100. Information on studies on sanitation was poorly documented, and key interviews were not held to collect information as such, this section should be updated with new information.

5 Case studies

5.1 Natural wetland in the Musi River micro-watershed

The details of the wetland function and performance is described in deliverable 3.2. The detailed assessment of the physical environment using hydrogeological, geophysical and bio-geochemical investigations at the study site (Figure x) reveal the potential for removal of selected contaminants in the natural state. It can be further enhanced by using appropriate engineered designs. The research findings of the experiment shows reduction in the pollutants (nutrients) load of wastewater up to 90-97 % in the wetlands (Figure 3). The detailed study of wetlands comprises calculation of wetland area, volume of standing water in wetland, volume/ biomass of Typha capensis grass and wetland outlet discharge measurements. The results shows, wetland area is 4.5 ha, volume of standing water is 16,295 m3, discharge of wetland is 1812 m3/day and the submerged biomass occupied is 18 kg/m2.

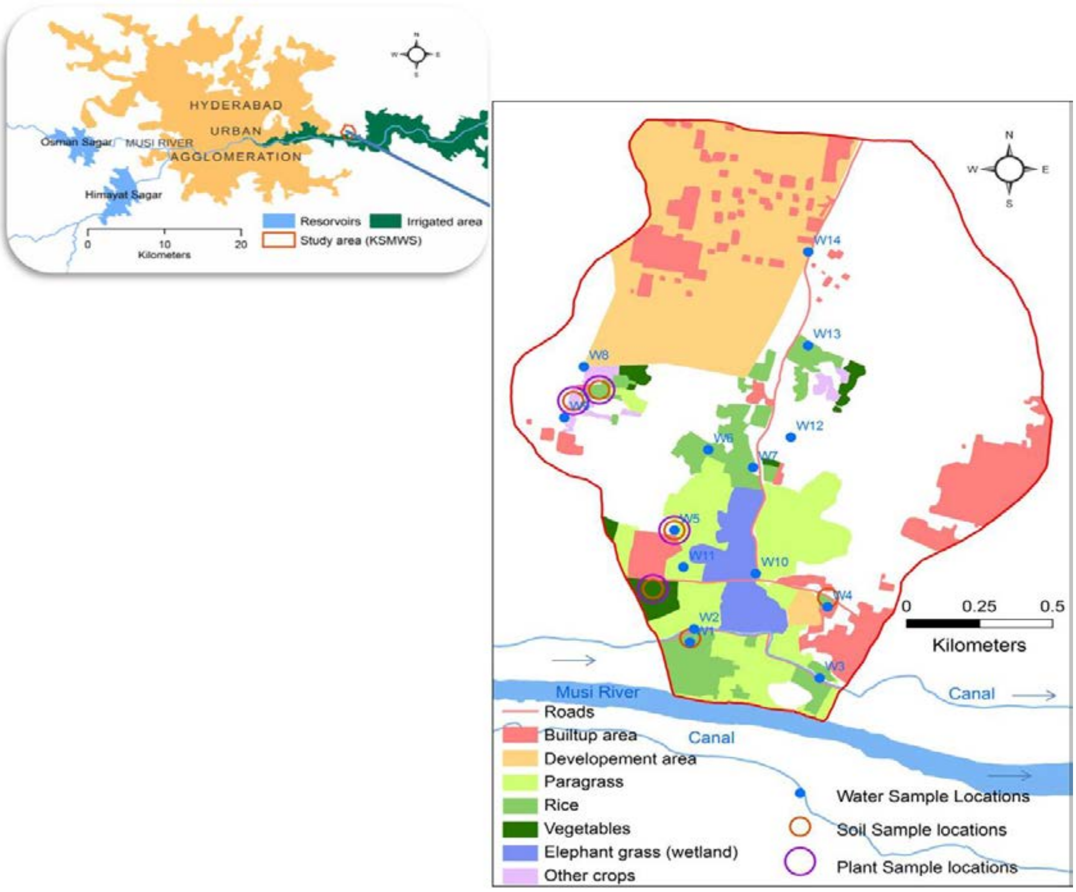

Figure 8 Location map of study area, Kachiwani Singaram, Hyderabad.

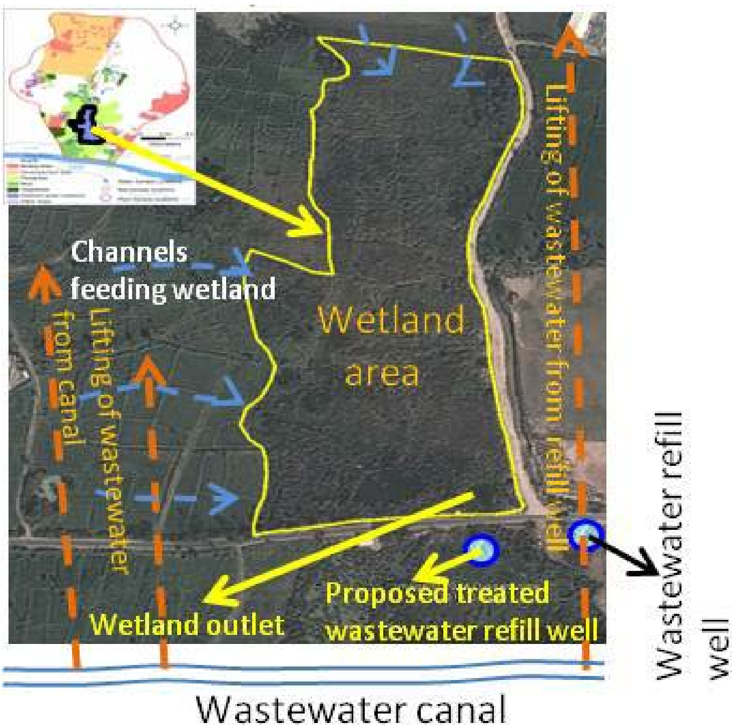

Figure 9 Proposed community-based wetland in the Musi River micro-watershed

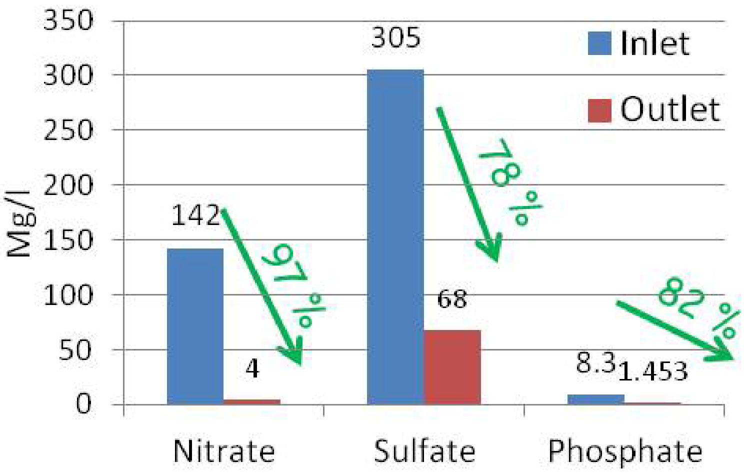

Figure 10 Reduction of the pollutants load in the wastewater at natural wetland

The eutrophic condition (enrichment of nutrients) is the primary indication of climax stage of ecological successions of lentic water body. The eutrophic condition enhances the biological oxygen demand (BOD) by reducing the dissolved oxygen (DO) concentration. Therefore, reduction in the nutrient concentration of water bodies is considered significant for the healthy ecosystem. Preliminary results at Musi case study show considerable reduction of nutrients such as nitrate, sulfate and phosphate concentration up to 97%, 78% and 82% respectively, in the natural wetland. The dominant process involved in the reduction of nutrient has to be replicated in engineered way. Based on the research findings of Musi river case study at Hyderabad few management plans have been proposed to upscale the pilot study.

5.2 Percolation pond and check dam in Chennai

5.2.1 Percolation pond

The pilot percolation pond is located at Andarmadam, Thiruvallur district of Tamil Nadu. The pond is constructed at a farm owned by Swamy Dayananda Vidyalaya Matriculation school, Andarmadam. The dimension of the pond is 8×8×1.75 m as length, breadth and height with a total capacity of 112 m3. The idea behind the structure is that maximum run off water from the surrounding area will be collected by the pond during rainy season and is allowed to percolate down in time to recharge the aquifer. This structure could dilute the highly salinized groundwater to an extent and groundwater level in the nearby areas is augmented (Deliverable D 2.3, Saph Pani). We could also recreate the structure in the nearby area on request of the people living there. Small percolation ponds can store limited quantity of water and the extraction of water should be minimized and quantified in order to get benefited by the recharge by the percolation ponds. The implementation of at least one percolation pond per each farm will significantly improve the groundwater storage and help in efficient aquifer management.

5.2.2 Check Dam

A check dam located at a distance of 50 km north west of Chennai across Arani River at Paleswaram was taken up for this study. The study revealed that about 50% of the water harvested is recharged every year. Approximately 1.1 Mm3 of water is recharged if the annual rainfall is about 1200 mm. A total of 19 check dams have been constructed in the Arani as well as Korattalaiyar River which are expected to improve the groundwater storage in the area.

6 An integrated management plan of NTSs

The integration of a NTS into the current water supply and sanitation plans is a new idea, It needs the concurrence of a number of stakeholders who will have stake in it. The efficacy of the two natural treatment systems described here. The pilot studies were carried out in Hyderabad – wetland for agriculture use and Chennai - managed aquifer recharge (MAR), towards enhancing the aquifer recharge for the ground water supply. respectively. Periodic monitoring helped to assess the performance of the NTSs, and the evidence indicates that both are potential systems that can help augment the water supply. Both need further fine tuning and adaptation to the local site and its own management plan to be monitored by the municipality. Here we discuss the acceptance of the NTSs as treatment system, and potential integrated management plans for its sustainability.

6.1 Outcomes of the stakeholder workshop held in Hyderabad

To upscale the pilot study and to seek the perceptions of stakeholders, one day workshop was organized on the topic “Wetlands as Natural Treatment Systems for Wastewater and

Reuse" at CSIR-NGRI, Hyderabad on Sep 12th, 2014 (Figure 5). The project findings were shared by the partners of the project i.e. IWMI, NGRI, CEMDS and IITB during the workshop. The participants discussed the aspects relevant to implementation, as the proposed plan was for a community based system. The stakeholders agreed that the evidence was convincing, and that it should be up-scaled for agriculture, horticulture as well as non-edible crops. Further, the two other possible scenarios that can be tested were also suggested based on the field setting. i) constructed wetland and ii) mini wetlands for individual farmers. It was highlighted that in all the cases, gravity flow was adequate to run the systems, and required low maintenance, however, quality control has to be part of the management plans. Staff from 13 departments participated at the workshop.

Table 2 List of participating agencies in the stakeholder meeting at Hyderabad

	Department/ Institute participated in the Stakeholder meeting at NGRI, Hyderabad on September 12, 2014
1	Groundwater Dept., Govt. of Telangana State TSGWD
2	CGWB, Min. of water resources, Govt. of India
3	National Remote Sensing Centre, ISRO, Hyderabad
4	Hyderabad Metro Development Agency
5	Central Research Institute for Dryland Agriculture, Hyderabad
6	Commissioner, Agriculture Telangana
7	Irrigation & CAD, WALAMTARI, Telangana State
8	Irrigation & CAD, AP
9	Special Commissioner, Dept. of Rural Development, AP
10	Dept. of Geochemistry, OU
11	IWMI, Patancheru
12	CSIR-National Geophysical Research Institute, Hyderabad
13	Centre for Environment Management and Decision Support, Austria

Figure 11 Stakeholder concurrence was sought at a special workshop chaired by the Chief guest Ms. Gayatri Ramachandran (Rtd. IAS) and Dr. Y. J. Bhaskar rao (Director, NGRI)

The following is a synopsis of the outcomes of the workshop.

- The wastewater in irrigation canals should not be applied directly to crops, unless the water quality is tested prior to application, and is found to be suitable..
- Based on the contaminants the NTSs should be designed for removal.
- NTS treated wastewater can be used conjuctively with ground water
- Since it is a community-based NTS, the government involvement is a must for quality control.
- Finance schemes to support communities with remunerations for start-up activities.

6.2 Outcomes of the stakeholder meeting held in Chennai

The gap between the supply and demand for water for the city of Chennai is increasing over the years. The current thinking of the water supply agencies is to plan for additional desalinization plants to reduce the gap between the supply and demand. However the cost of desalinization plants is work out to be INR 8712 Million (D6.2). To improve the groundwater storage in the urban part of the city, rain water harvesting is in practice since 2003. However, the efficiency of the functioning of rain water harvesting structures is questionable. There is a need for a regulatory authority to monitor the installation and functioning of these recharge structures and to assess the efficiency annually. In the peri urban and rural areas around cities, the groundwater recharge needs to be increased by the construction of small percolation ponds, and check dams to harvest the surface run off which is currently about 95 Mm^3 from the Arani River basin to the sea, north of city of

Chennai. 10,000 percolation ponds (8×8×1.75), if constructed, in the rural areas, north of the city of Chennai, will result in harvesting of about 11Mm^3, which is about 12% of the existing run off to the sea. The suggested recharge initiatives may lead to increase in groundwater availability by 10 Mm^3/year. Hence, the contribution of groundwater to meet the city water requirements can be increased rather than increasing the number of desalinization plants.

7 Conclusion

In this deliverable we refer to two NTSs and their integration into the urban water supply systems. In Hyderabad, about 15 km downstream of the city, in a micro-watershed of the Musi River, a natural wetland was assessed for its treatment capacity. The performance assessment of the wetland which received irrigation water from the Musi River, showed that there was a reduction in the contaminants in the outlet water supply (D3.2). If the natural wetland can be engineered further, the city has the potential to use its water for alternative purposes like landscaping, industrial cooling and other non-potable uses int he city.

The rapid and heavy rains in Chennai result in quick run-off with poor recharge via infiltration. This could be, to an extent, harvested by different structures developed for managed aquifer recharge (MAR). In Chennai, a check dam and a pilot percolation pond was studied for treatment potential. This was a good example for a successful MAR (NTS), which can be used for augmenting freshwater supplies in coastal areas.

In principle, the stakehodlers agreed that these are viable NTSs that can be tested further on the ground. The figures 12 and 13 were developed incorporating the ideas suggested at the stakeholder workshops in the two cities. It was felt that pilots will have to be run before upscaling, to see if the findings were replicable. At the time of implementation of such a programme a number of key government instiutions will have to play a key role in forming a platform for discussions and identifying the relative roles for effective and sustainable management. Then these systems could be part of the urban water supply system, and can be operated as an integrated system.

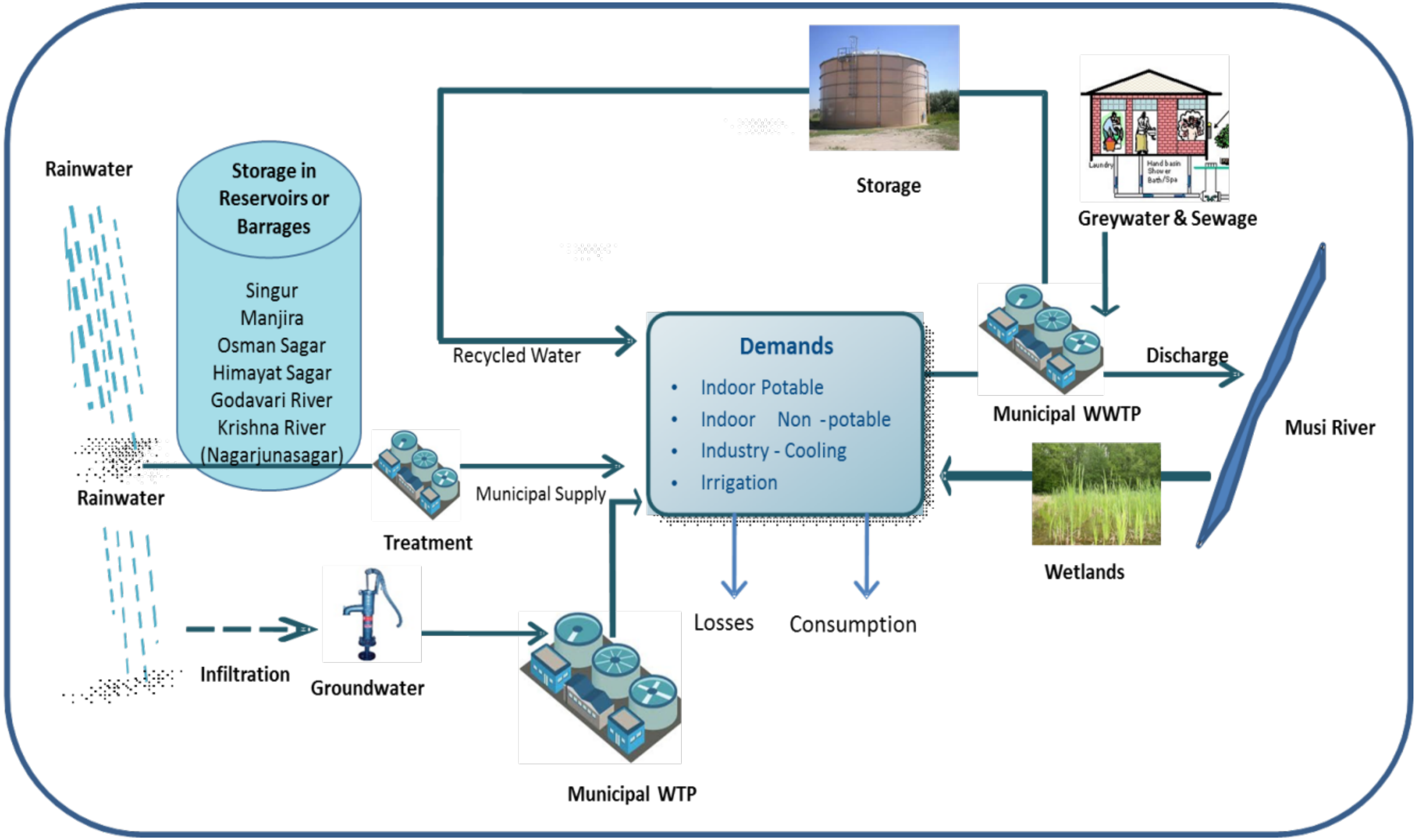

Figure 12 A schematic diagram of an integrated water management plan for Hyderabad that includes a Natural Water Treatment System (Wetland).

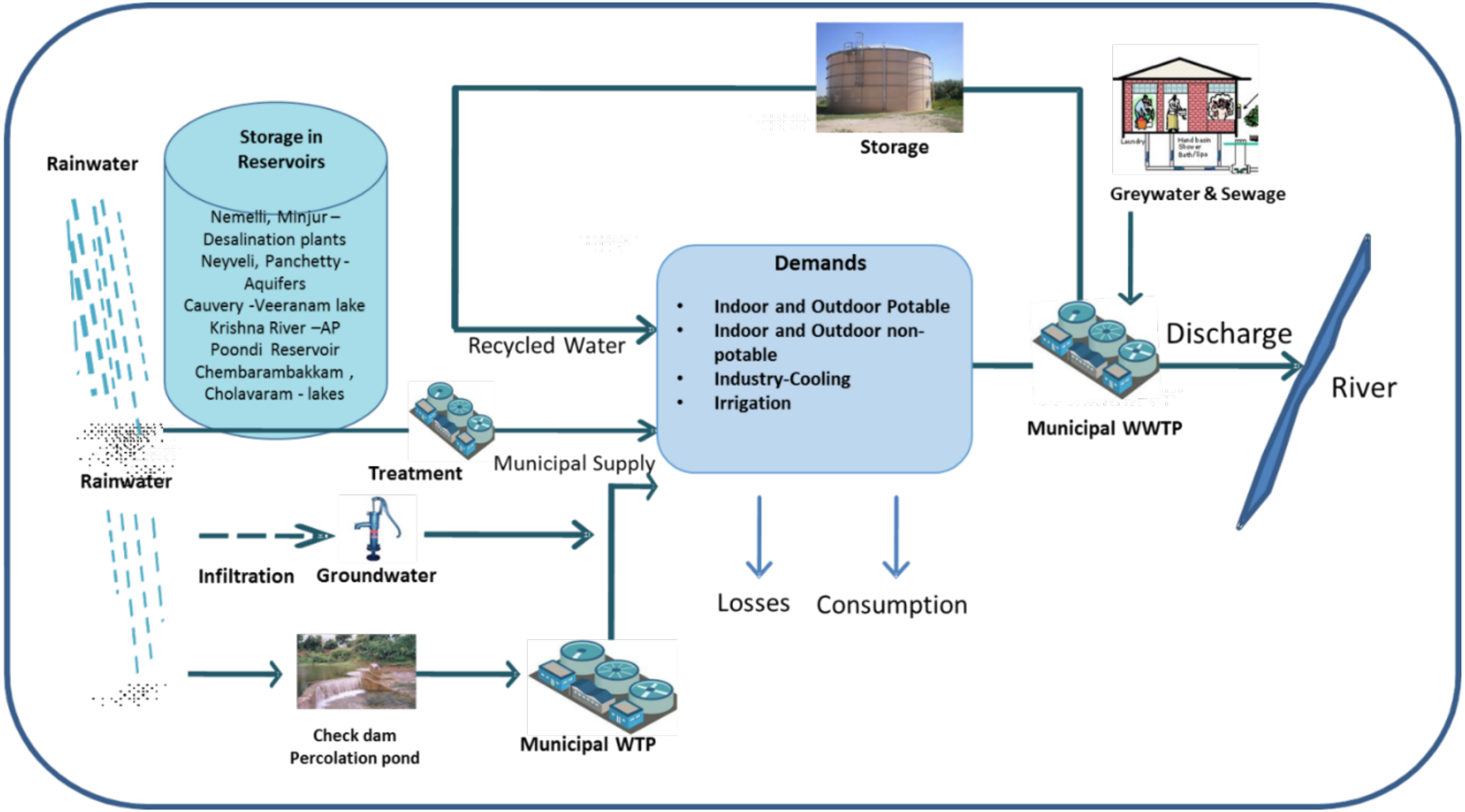

Figure 13 A schematic sketch of an integrated urban water management plan for Chennai that includes two Natural Water Treatment System (Check dam and percolation pond).

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