ASSESSING OPTIONS FOR

GREY WATER MANAGEMENT

IN SMALL AND MEDIUM TOWNS

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CWAS CENTER FOR WATER AND SANITATION | CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION | CEPT UNIVERSITY | FP FACULTY OF PLANNING CEPT UNIVERSITY

PRESENTATION FLOW

SIGNIFICANCE OF GREYWATER

- Global water stress
- Greywater and its properties

RESEARCH OUTLINE

- Research aim
- Objectives
- Data collection methods
- Case studies

SITUATION ANALYSIS

- Wai grey water profile
- Typical layout
- Surveying strategy
- Survey results
- Other site findings

OPTIONS FOR GREYWATER MANAGEMENT

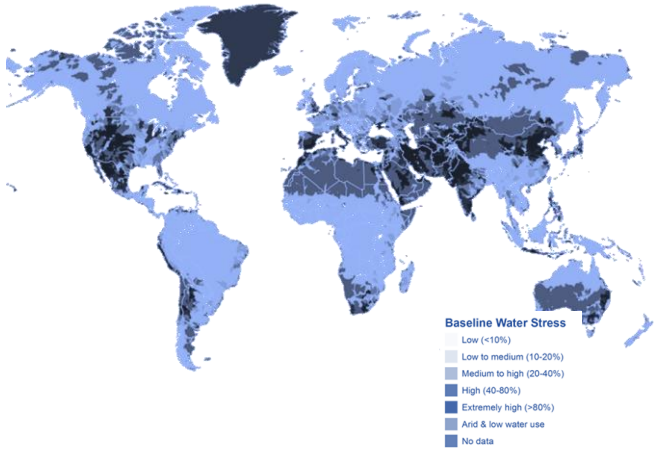
- Options available for management across the chain

GREYWATER MANAGEMENT OPTIONS FOR WAI

- Potential greywater management options
- Comparison with proposed DPR

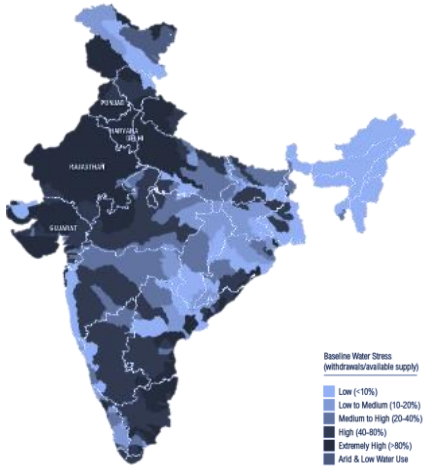
GLOBAL SCENARIO

GLOBAL WATER STRESS



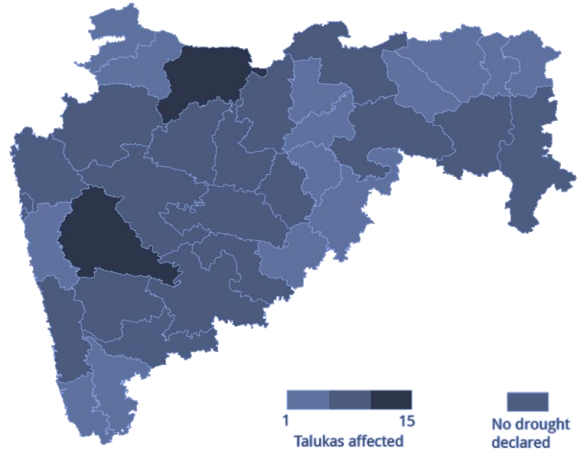
20%

Water scarcity is a problem emerging globally. It is estimated, that around 1.2 billion people of the world's total population lives in areas of scarcity.



33%

In India alone, the International Water Management Institute predicts that by 2025, one person in three will live in conditions of absolute water scarcity

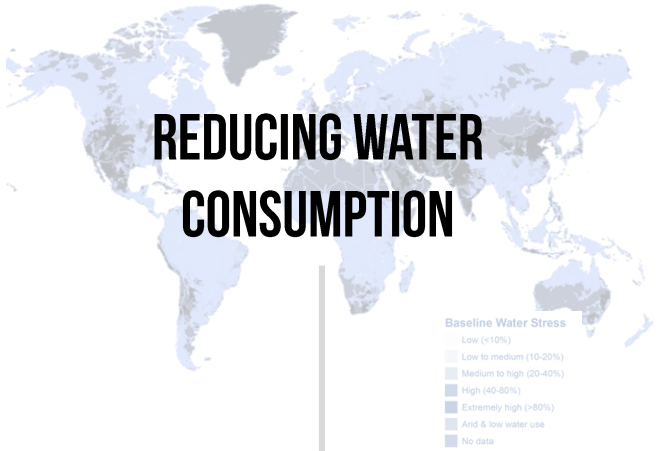


50%

Nearly half of Maharashtra is facing severe water crisis

Source-World Resource Institute; UNwater(2007); IWM(2003); Singh(2018) Scroll (2019)

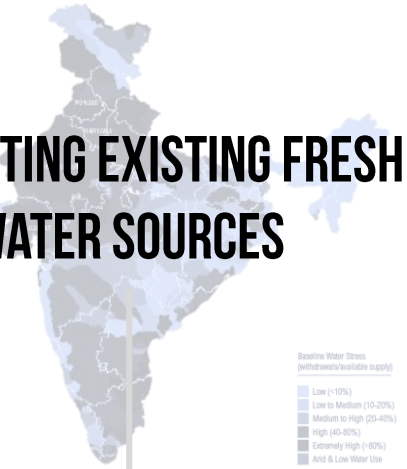
MITIGATING WATER STRESS



REDUCING WATER CONSUMPTION

1520 LPCD

Water consumed globally



PROTECTING EXISTING FRESH WATER SOURCES

78.7%

Wastewater disposed into rivers without treatment

REUSING TREATED WASTEWATER

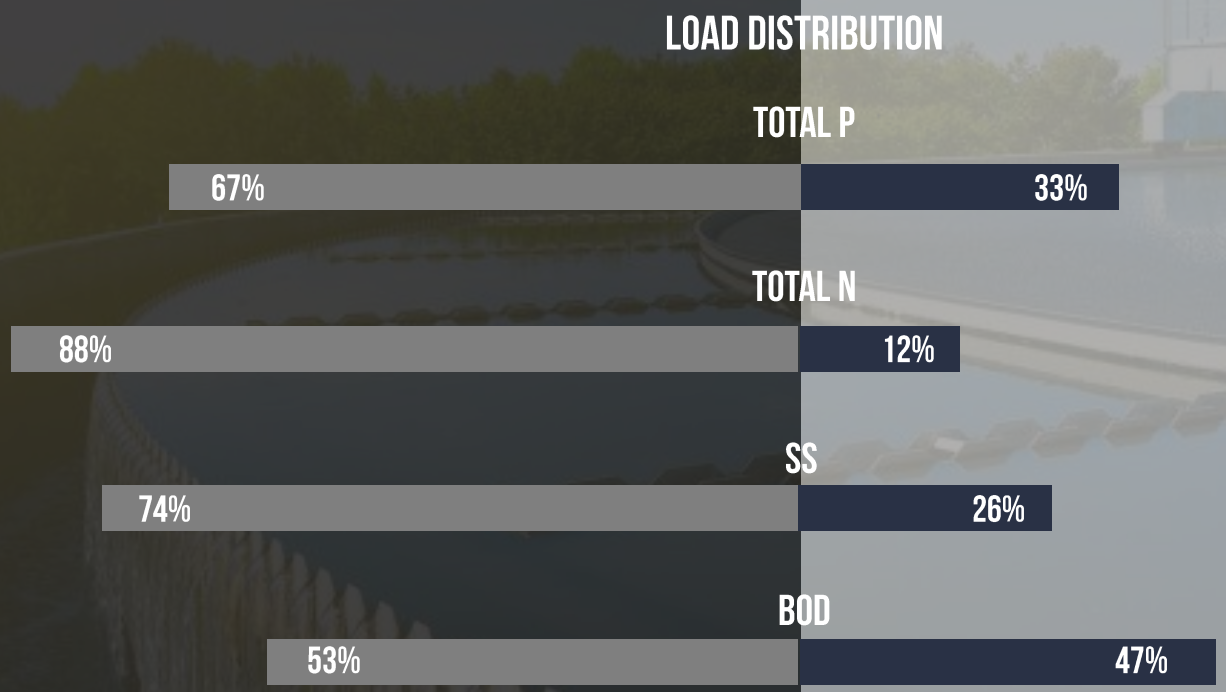
2%

Of wastewater is being reused worldwide

Source: International Water Institute (2018); The World Counts; CPCB (2008); Water Recycle and Reuse – A Case Study of NMIMS University Campus

WASTEWATER DISTRIBUTION

BLACK WATER (25%)



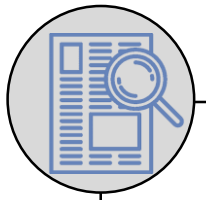
GREY WATER (75%)

- Grey water is the wastewater from bathroom, kitchen and laundry, free from fecal matter
- Lower in BOD concentration, suspended solids, nitrogen concentration and phosphorus concentration; alkaline; Hgher in alkaline and salt content

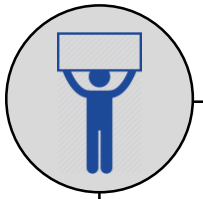
Grey water sources	Washing machines	Baths, showers, washbasins	Kitchen & dish washing	Non separated greywater
BOD [mg/l]	45-682	19-200	669-756	41-194
COD [mg/l]	375	64-8000	26-1600	49-623
pH	9.2-10	5-8.6	6.3-7.4	6.1-8.4

Source: Comparison of Three Systems for Biological Greywater Treatment (2014)

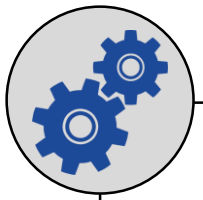
"To assess potential options for greywater management in small and medium towns"



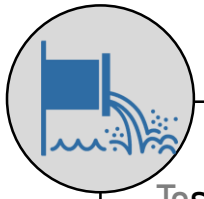
To review guidelines, manuals and policies that are applicable in the sector of wastewater management and support grey water management



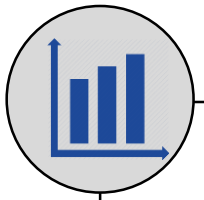
Understand the practical challenges behind framing a system by project implementation



Assess the parameters that influence a grey water management system



To study various grey water management options already available i.e. looking into components like collection, conveyance, treatment/reuse

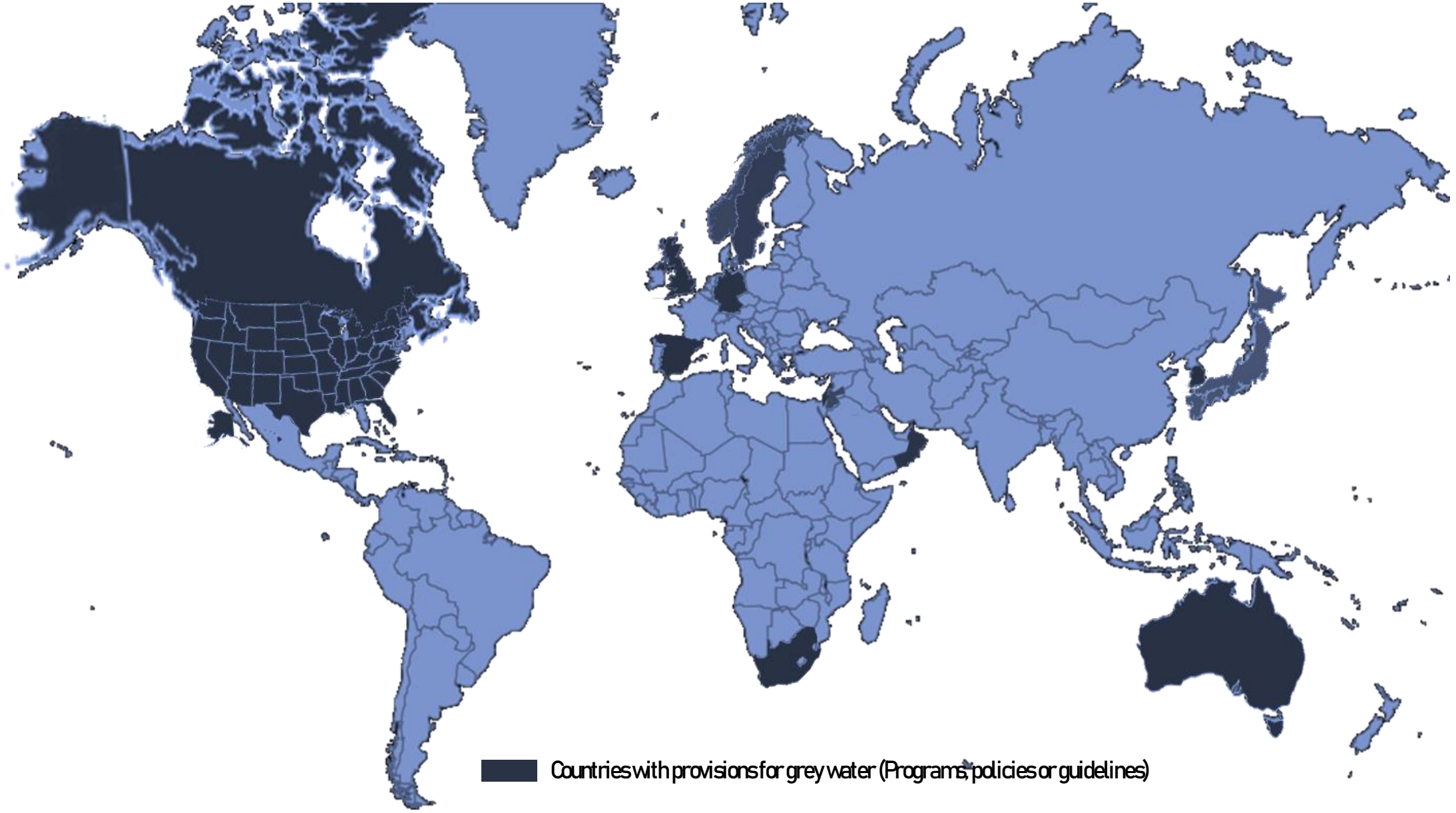


To conduct a comparative analysis and derive the most suitable options for small and medium towns of Maharashtra

PROVISIONS FOR GREY WATER MANAGEMENT

PROVISIONS FOR GREYWATER

Globally



Source: CSBE(2003); Overview Of Greywater Reuse(2010)

PROVISIONS FOR GREYWATER
Globally

Australia

A national level guideline "Australian Guidelines for Water Recycling: Managing Health and Environmental Risks," and rebate on installing greywater system ($500).

Greywater from the home was diverted through a coarse gravel filter to the small sub-surface constructed wetland or Greywater from the household is collected to a surge tank/treatment system also located under the house

United Kingdom

The Water Regulation Advisory Scheme (WRAS) has published information and guidance on reclaimed water systems, some of which is relevant to greywater systems (Water Regulation Advisory Scheme 1999a & 1999b).

In the UK the Code for Sustainable Homes (CSH) for rating and certifying the performance of new homes, to achieve the highest levels of the code, per person daily water use has to be less than 80 liters for which, either greywater reuse is often used

Japan

Not only are there incentives for installing greywater systems, but they are mandatory for buildings with an area of over 30,000 square meters, or with a potential to reuse 100 cubic meters/day

Apartments, municipal buildings and office buildings in the cities of Japan have long implemented greywater recycling units due to potable water shortages. The greywater generated in these buildings are used to flush toilets and to fill artificial ponds or fountains

Other countries with provisions: South Africa | Cyprus | Oman | Jordan | Canada | USA | Israel | South Korea | Spain | Germany | Sweden | Norway

Source: CSBE(2003); Overview Of Greywater Reuse(2010); Greywater for domestic users: an information guide; Greywater for domestic users: an information guide (2011)

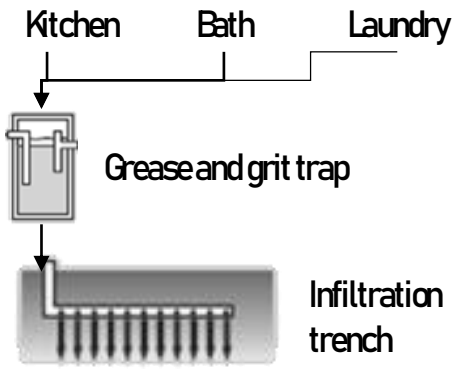
GREYWATER MANAGEMENT ACROSS THE GLOBE

Djenne, Mali

Project period–Jan. 2000–Jan. 2003

Project scale– 600 households

Methodology: –



Performance: –

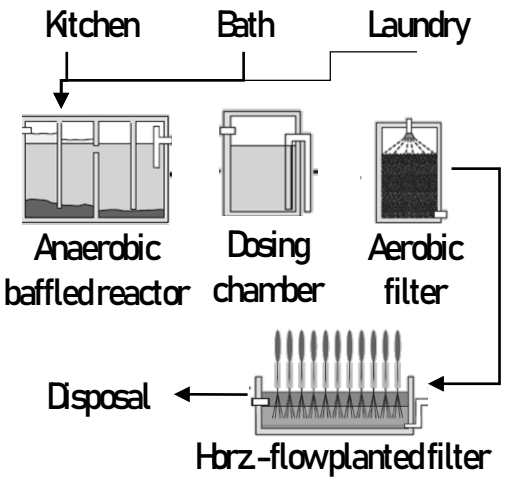
- The streets with adjacent infiltration systems were dry and clean
- Water samples taken from 10 wells did not reveal any ground water contamination caused by the greywater disposal system

Kuching, Malaysia

Project period–Dec. 2003

Project scale– 9 households

Methodology: –



Performance: –

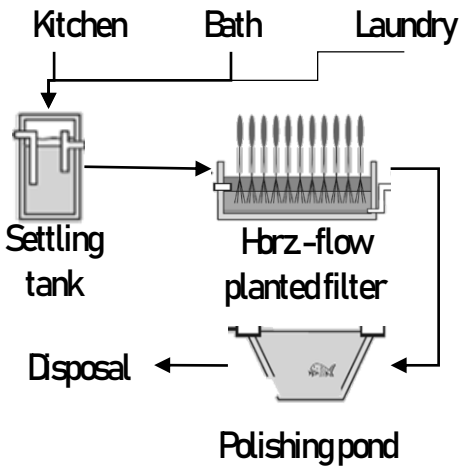
- The system was able to achieve desired results by a comfortable margin

Monteverde, Costa Rica

Project period–Mar. 2001–Aug. 2002

Project scale– 4 households

Methodology: –



Performance: –

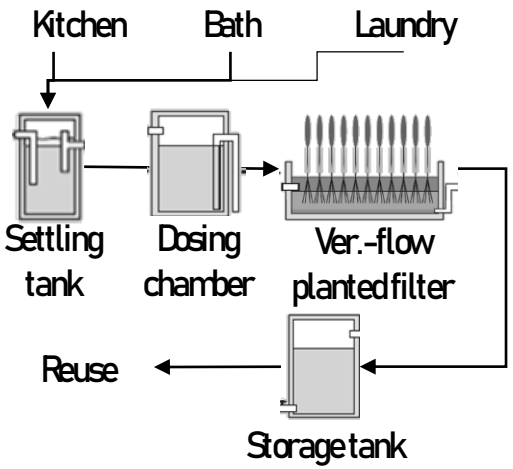
- Systems performance was generally satisfactory
- From a public health perspective, the treated water quality was equivalent to some of Monteverde's most pristine streams

Kathmandu, Nepal

Project period–Apr. 1998–May. 2000

Project scale– Single household

Methodology: –



Performance: –

- Although ammonia removal efficiency exceeds 90%, total nitrogen removal probably does not exceed 60–70% given the missing denitrification step

SOURCE: SANDEC (2006)

NEED FOR PROVISIONS in India

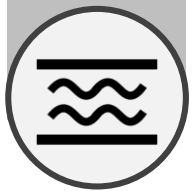
Large and urban cities

Programs like AMRUT and Smart City that focus on providing urban infrastructure services **only in large cities**

Containment of WW

The **containment of human waste** will be largely achieved under SBM, its **conveyance and treatment still pose a huge challenge**

Conveyance and Treatment



Achieving ODF+ and ODF++ status would require appropriate system for both, which currently does not exist

Small and medium towns

Over **4000+ small and medium towns** do not get attention despite of these missions prevailing provisions

Provisions for greywater

Lack of dedicated guidelines for greywater management (except for rural areas)

Settled sewer, Punjab

Project period-2013

Project scale- 100 villages

Type-Conveyance and treatment

Lower capital costs compared to conventional sewers and availability of less quantity of waste water in rural areas for effective functioning of conventional sewerage system

The total cost of sewerage system including treatment is in the range of Rs. 2400-2700 per capita.

Green bridge, Ahar river

Project period-operational since 2010

Project scale- Water body/river

Type-Treatment

- Designed Capacity: 100 MLD
- Capital cost : Rs 33 lakhs (This cost denotes the amount incurred by Udaipur. The actual capital cost would be according to Rs. 2-5 lakhs/MLD)
- O&M: Rs 2-3 Lakhs per year

Kawardha, Chhattisgarh

Project period-operational since 2013

Project scale- City wide

Type-Conveyance and treatment

- Implementing organization: PHED and Laxmi civil engineering, Nagpur
- Designed Capacity: Minimum 2.1 MLD
- Sullage treatment plant of Kawardha is designed for BOD load of 430 mg/liter and suspended solids of 300 mg/liter

Greywater treatment, Bengaluru

Project period-operational since 2017

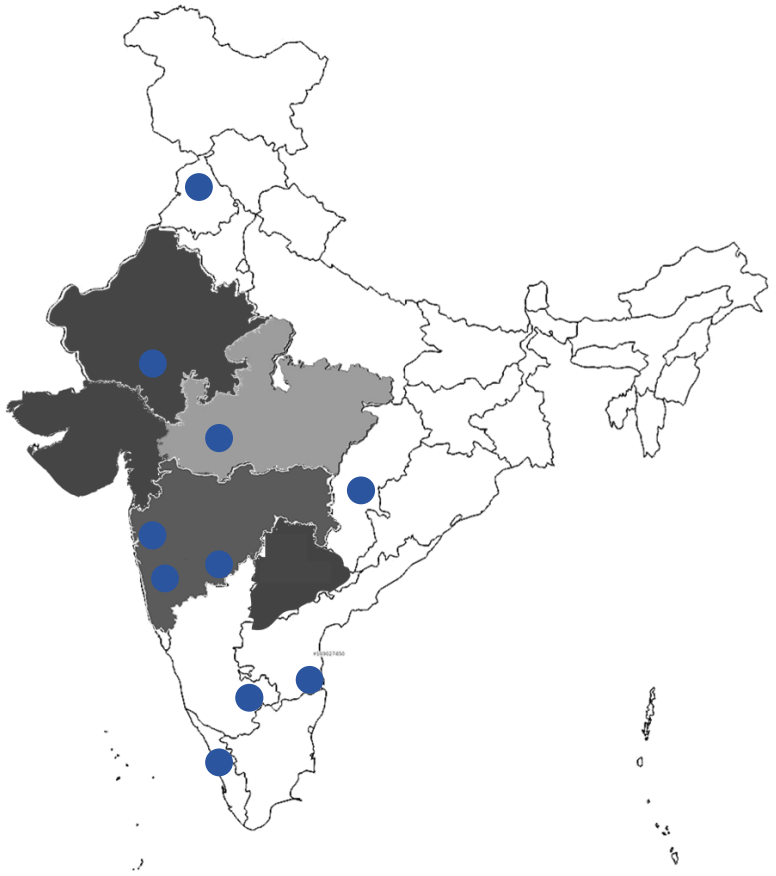
Project scale- Neighbourhood

Type-Treatment and reuse

- All the bath and kitchen water is pumped into an overhead tank, which is connected to all the flush toilets in the building.
- Small amount of alum and bleach are added in order to make water free from impurities and odour

SOURCE: SANDEC (2006)

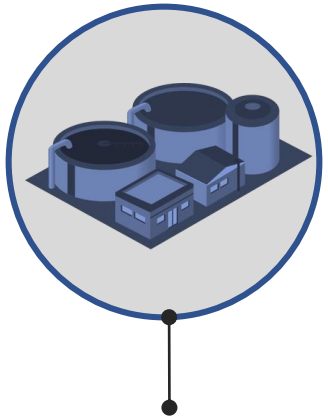
MAHARASHTRA WASTEWATER REUSE POLICY



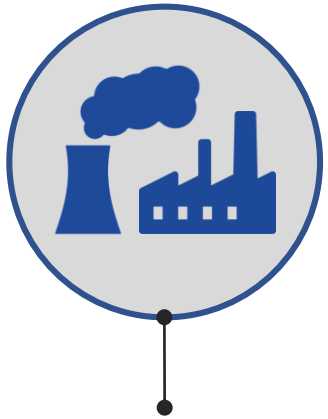
Projects on greywater management

States with wastewater reuse policy

Uhder this policy, the treated wastewater is supposed to be used for the purposes like serving industrial estates, cooling thermal plants and other non-potable purposes



Water supply for non-potable purposes from industrial estates and power plants would be withdrawn if they are located in a vicinity of 50 km for any of these 71 municipalities



The policy targets to reuse at least 6,888 million liters of treated wastewater daily, generated from 71 urban agglomeration by the year 2020

Wastewater from households → Treatment systems → Conveyance to industries → Reuse for non potable purposes

SOURCE: Maharashtra government (2017); Gujarat government; Rajasthan government; Madhya Pradesh government;

SITUATION ANALYSIS : WAI

MODES OF COLLECTING DATA

Primary surveys

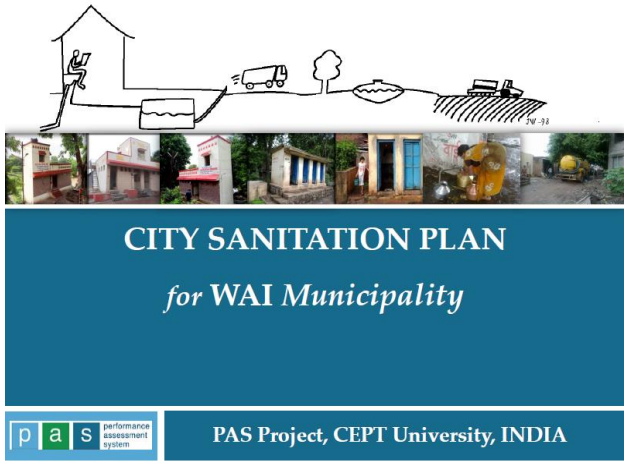
- Focussed group discussion
- Household surveys
- Perception study

Interacting with officials and workers

Interacting with other stake holders like:-

- Chief officer
- Sanitation inspector
- Engineer
- Local masons

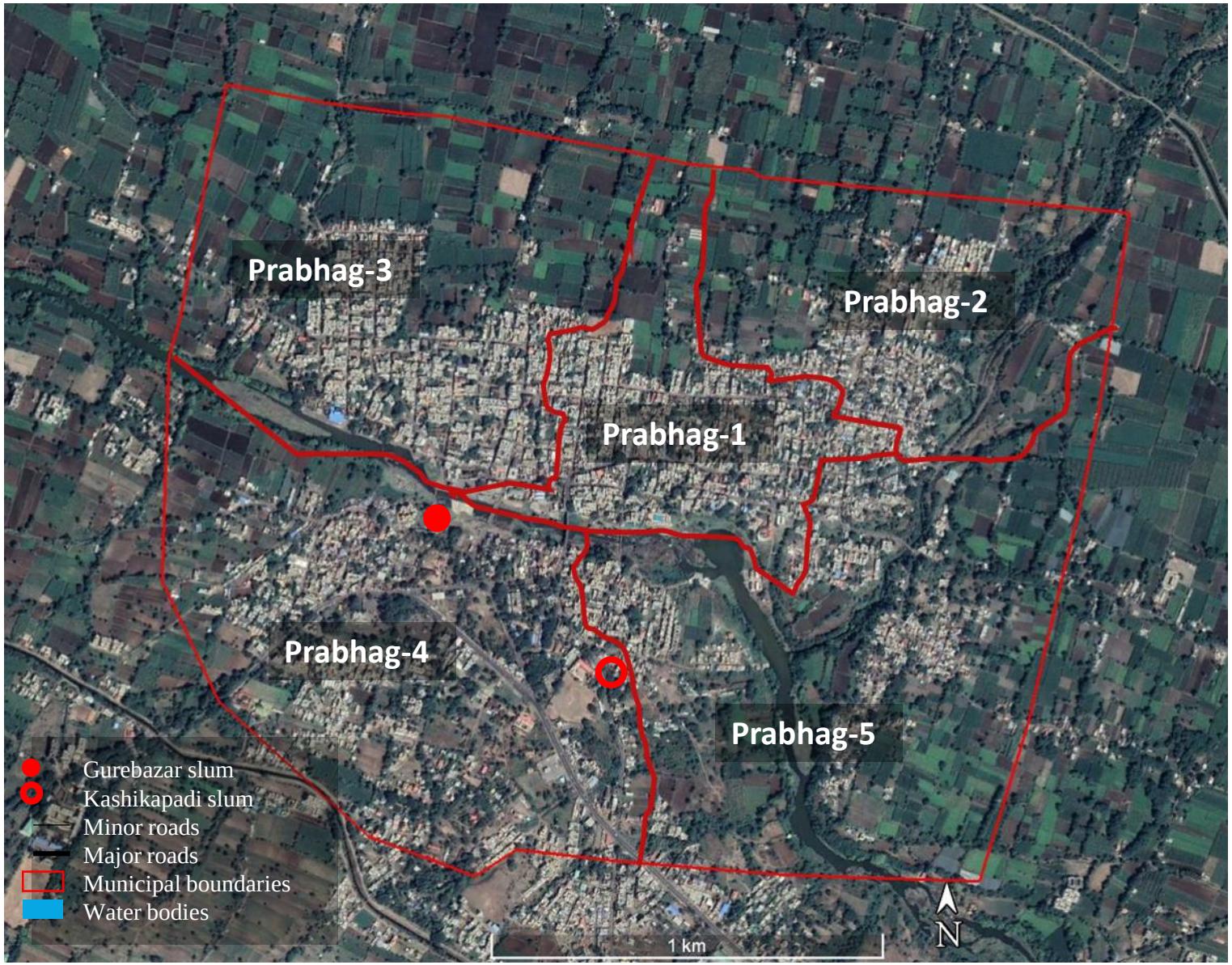
Literature review



Looking into other secondary sources like: -

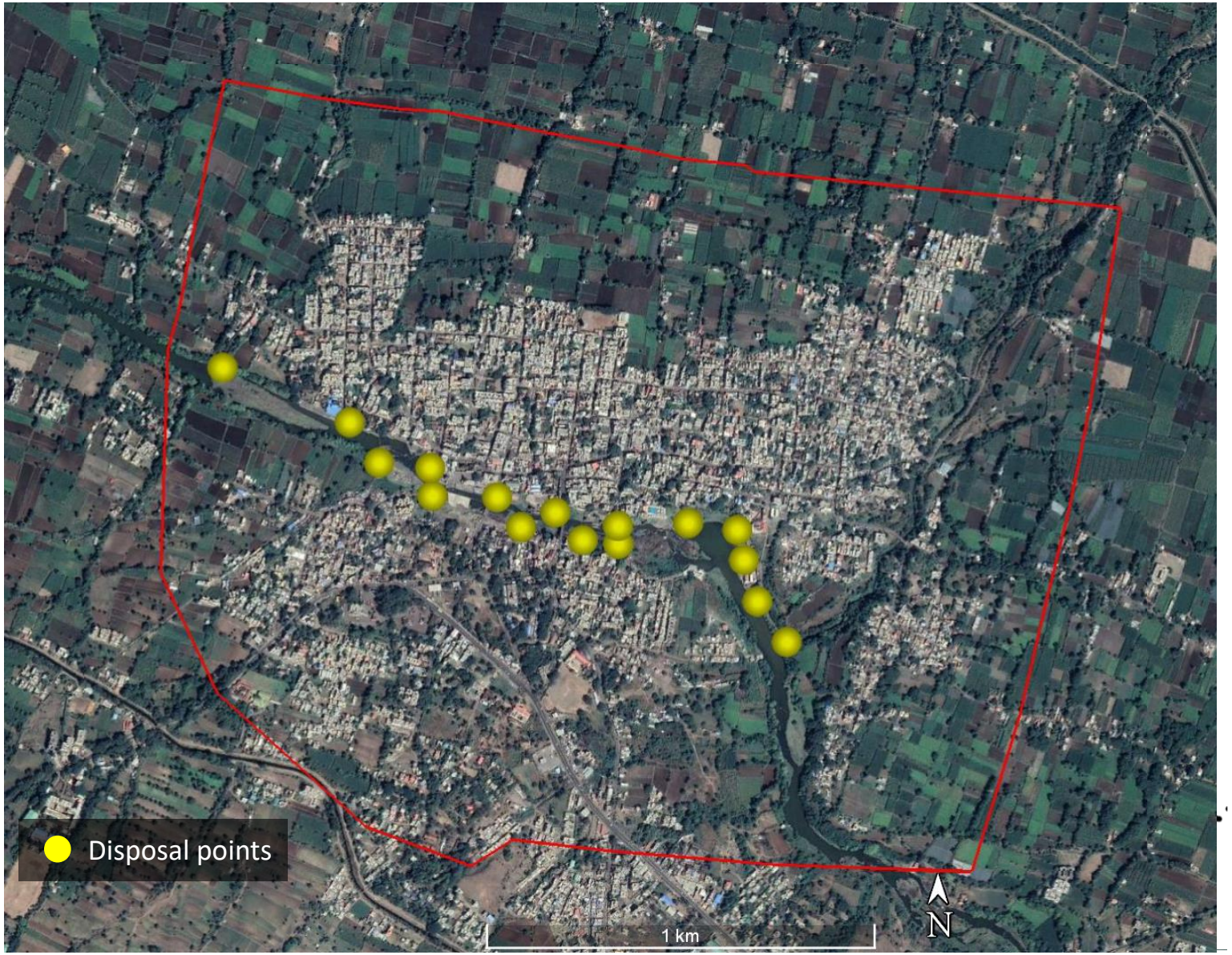
- CSP 2014
- Septic tank assessment Wai
- MPCBs repot of river pollution

SAMPLING STRATEGY



- Sampling type– Purposive sampling
- Population of Wai (2011)– 47,268
- Sample size– 101
- Samples from HHs abutting water bodies– Minimum 3 from each Prabhag
- Sample size from each Prabhag were calculated based on their respective population weightage

Location	Samples to be taken
Prabhag-1	17
Prabhag-2	18
Prabhag-3	21
Prabhag-4	20
Prabhag-5	18
Gurebazar slums	4
Kashikapadi slums	3



Current situation (for year 2019)

- Considering population = 47,268 for the year 2019
- The values given have been calculated on the basis of population given above

6.8 MLD — Total water supply

5.4 MLD — Total wastewater generation

100 % — Percentage of greywater conveyed through drains

0 % — Percentage of greywater treated

16 NO. — Number of disposal points in river Krishna

SOURCE: CSP Wai (2014); Primary survey

User interface and containment

Manhole: Septic tank

- Average septic tank dimensions for individual HHs
- Length- 1.82 m; Width- 1.21 m; Depth- 1.37 m; Volume = 3.01 cu.m
- Ground water table's average depth range- 6.09 m to 7.62 m and the soil is of coarse shallow type which makes it infeasible to install soak pits

Supernatant and greywater outlets

- Almost all HHs have a separate plumbing system for wastewater from toilets and greywater
- Sanitation inspector quoted that "There may be almost 5-10% households (not based on any survey result, just an assumption) that may bypass their septage directly into drains."

SOURCE: CSP Wai (2014); Primary survey

Conveyance

Drains closed by residents

- Average drain dimensions
- Width range – 0.3 m to 1.5 m; Depth- 0.3 m to 0.9 m; Total length- 40.61 km
- The drains which are documented as closed are not typically closed but covered by informally by shop owners, residents, etc
- No steps till date have been taken till date to close the drains except a small attempt i.e. protecting these drains by placing MS wire mesh over drains. Post installation, most of this protecting mesh were either stolen or damaged.

Solid waste dumping in and around drains

- The instances of solid waste dumping into drains has decreased due to strict penal actions against violators i.e. 500 Rs. per violation.
- There was a dedicated contract for cleaning the drains active till the end of previous year, but as of now this activity (cleaning of drains) does not have a dedicated contract. Instead, the Nagarparishad has given a contract for freelance labourers (21) which help in maintenance of the drains along with 32 assigned sanitation workers. . Cleaning of all these drains is done once or twice weekly.

Krishna Nadi Sewa Samiti dredging solid waste

- Krishna Nadi Sewa Samiti works for the betterment of river Krishna in Wai
- It organizes weekly drives to dredge solid waste dumped in river Krishna.
- They have also started looking at managing greywater but no progress has been made as of now
- Currently the only envisioned project in the sector of grey water management is proposing an underground sewerage/sullage system, DPR of which has already been prepared.

SOURCE: CSP Wai (2014); Primary survey

Treatment and disposal/reuse

Untreated grey water flowing through the drains

Untreated grey water flowing into river Krishna

Comparison of Grey water and effluent quality test results with discharge standard limit:-

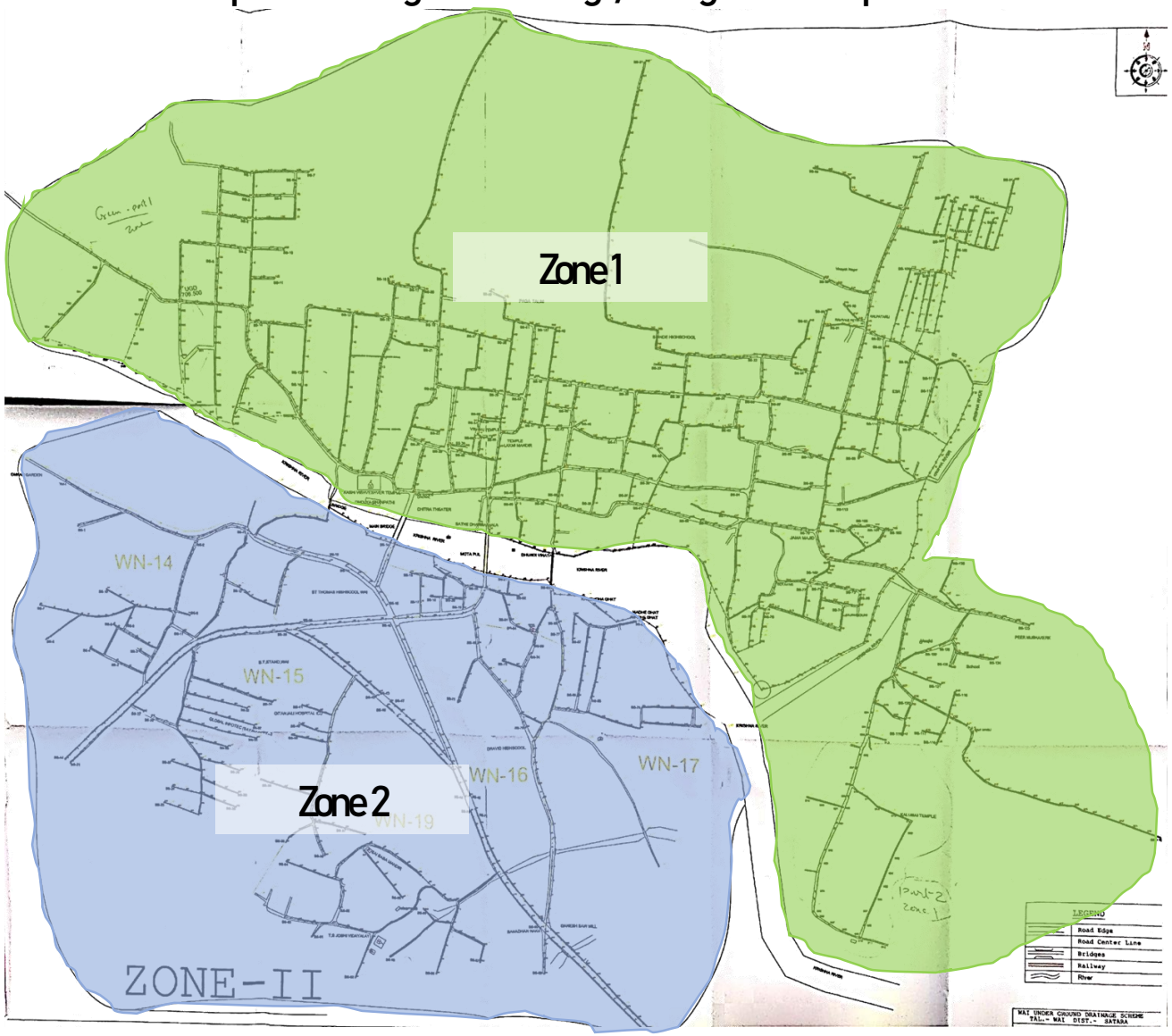
Parameters	Standard limit	Sample range	Samples above standard limit	Remarks
BOD mg/L	<30	50-100	2	Unsafe as per MPCB
COD mg/L	<250	150-250	2	2 values are nearer to limit value
Total coliform No./100 ml		>1600	6	Unsafe
Faecal coliform No./100 ml	<1000	>1600	5	Need to be treated before discharging

Comparison of River quality samples with standard limit:-

Parameters	Standard Limits for Class C river	River samples at up stream	River samples at down stream
BOD(mg/l)	<3	3.90	5.10
Total coliform(no./100ml)	<500	Uncountable	Uncountable
Faecal coliform(no./100ml)	**	>1600	>1600

SOURCE Underground Settled Sewer in Wai (PAS)

Proposed underground sewage/sullage network plan

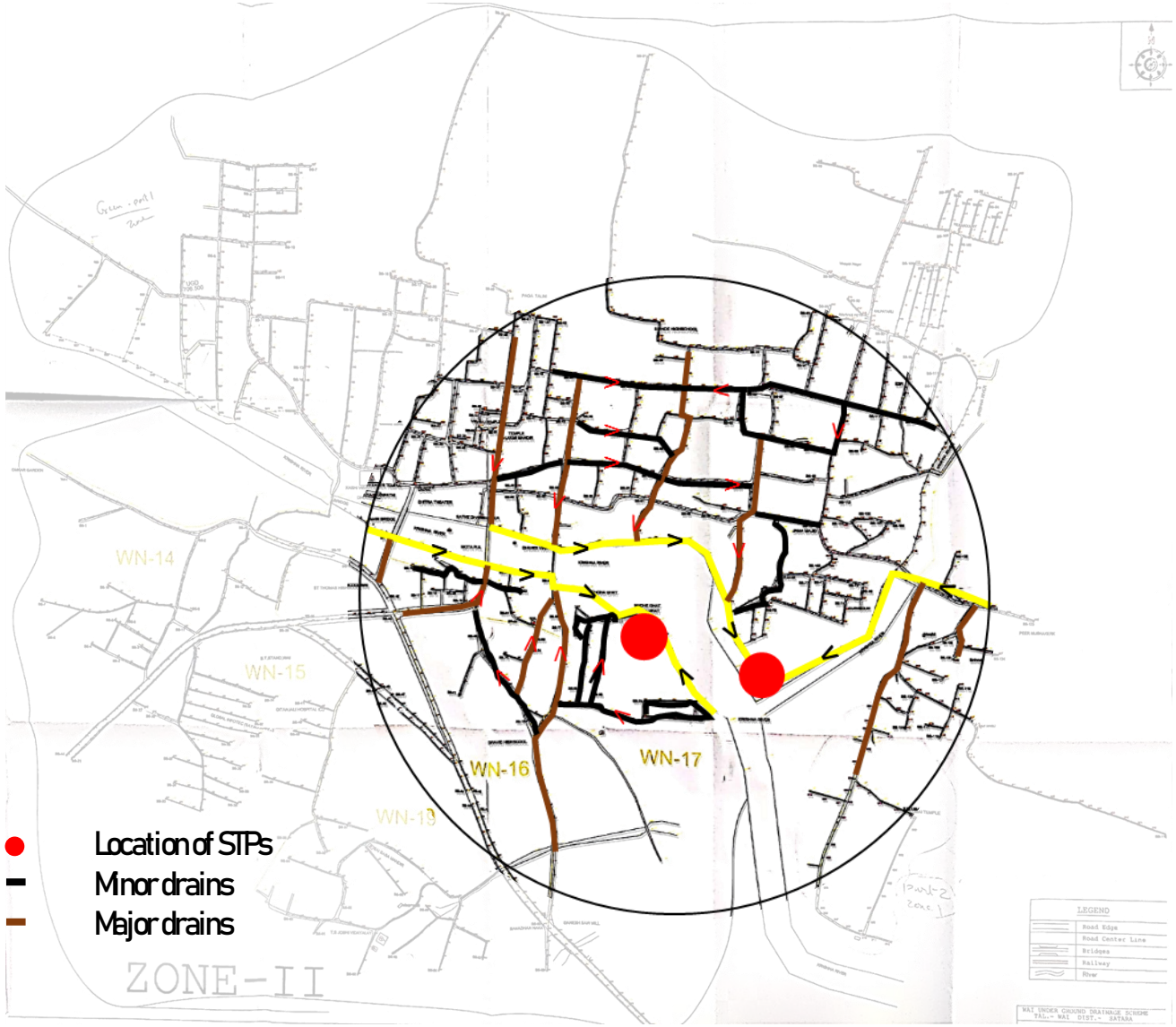


Divided into two zones-

1) Zone I (Northern side of river)
2) Zone II (Southern side of river)

SOURCE: Underground Settled Sewer in Wai (PAS)

Proposed underground sewage/sullage network plan



Divided into two zones-

1) Zone I (Northern side of river)
2) Zone II (Southern side of river)

Total length of proposed underground drainage network- 40.61 Km

- HDPE DWC pipes ranging from 200 to 300 mm
- RCC NP-2, NP-3 and NP-4 pipes ranging from 400 to 550 mm

Two treatment plants:-

1) Zone I- 3.00 MLD
2) Zone II- 2.50 MLD

Particulars	Wai (2017-18)	Sinnar (2018-19)	Hingoli (2013-14)
Design Population	56,608	1,41,776	1,38,019
Design length (km)	40.61	79.54	125
Design capacity(MLD)	6.30	16.84	14.90
Per capita Network cost .Rs	4,274	2,631	3,810
Per capita STP cost Rs	833	1,481	665
Per meter length cost Rs.	5,958	4,651	4,207
Total cost of project	34 Cr	68 Cr	67 Cr

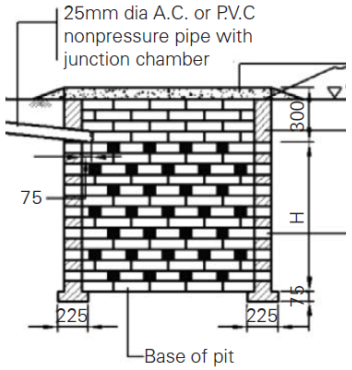
SOURCE: Underground Settled Sewer in Wai (PAS)

OPTIONS FOR GREY WATER MANAGEMENT

OPTIONS FOR GREYWATER MANAGEMENT ACROSS THE CHAIN

ON- SITE MANAGEMENT METHODS

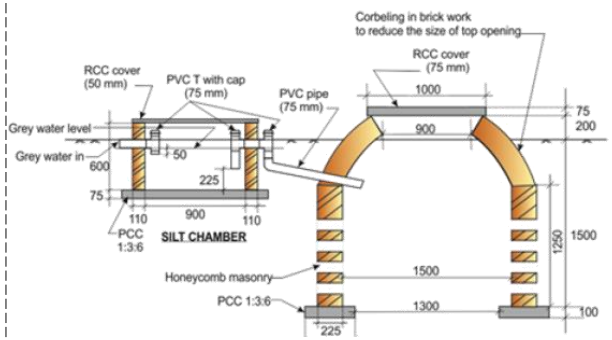
SOAK PIT



- Does not require conveyance
- Should be 3 m away from any ground water source
- Not suitable for areas with higher ground water table and low soil permeability

Capital cost	Rs. 7,000 (for one H-H)
O&M cost	Rs. 280 per annum

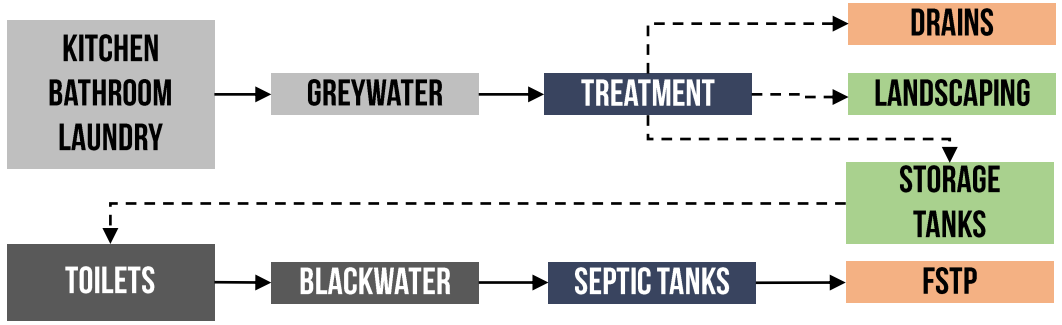
COMMUNITY SOAK PIT



- Should be located at a place where the natural gradient can be obtained
- It should be 5 m away from any ground water source
- Not suitable for areas with higher ground water table and low soil permeability

Capital cost	Rs. 8,600 (4 H-Hs)
O&M cost	Rs. 320 per annum

PACKAGED TREATMENT SYSTEMS



- Convenient transportation and installation
- Excellent adaptability
- Does not require conveyance
- Provides the potential of on site reuse

LOW TECH TREATMENT SYSTEMS

ADVANCED TREATMENT SYSTEMS

SOURCE: Government of Tamil Nadu (2017); Greywater management resource book; Household water treatment and safe: storage options in developing countries:

OPTIONS FOR GREYWATER MANAGEMENT ACROSS THE CHAIN

PACKAGED TREATMENT SYSTEMS

LOW TECH TREATMENT SYSTEMS

Sr no.	Description of technology	Performance	Ease of use	Dependence on utilities
1	Chlorine disinfection			
2	Coarse filtration + (disinfection with chlorine tablets)			
3	Coarse filter +100mm fine filter			
4	Sedimentation + (disinfection)			
5	Coagulation/floculation + Sédimentation + (désinfection)			
6	Filtration through soil bed			
7	Filtration over ceramic filter bed + (disinfection)			
8	Reed bed			
9	In-door reed bed with internal recirculation			

ADVANCED TREATMENT SYSTEMS

Sr no.	Description of technology	Performance	Ease of use	Dependence on utilities
1	Pre-membrane filter, sedimentation, UF membranes			
2	Biological treatment with activated sludge technology based on black water treatment units + UV disinfection			
3	Biological treatment with moving or fixed bed bioreactor + UV disinfection			
4	Biological treatment with RBC (rotating biological contactors) + UV disinfection			
5	Fine filter + activated carbon filters + MF filter			
6	Multilayer filter bed + RO (reverse osmosis)			
7	MBR (membrane bioreactor)			
8	Ozonisation, pre-membrane filter, UF membranes, final disinfection			

Good Moderate Poor

SOURCE: Overview and feasibility of advanced grey water treatment systems for single households (2014)

OPTIONS FOR GREYWATER MANAGEMENT ACROSS THE CHAIN

CONVEYANCE METHODS

OPEN DRAINS

- These drains can also convey supernatant produced from septic tanks
- Constructing these drains is relatively easy and does cost less, but do not provide hygienic disposal
- Closing these drains with the use of materials like precast RCC slab is also not advisable as it may create a hinderance in regular operation and maintenance procedures.

Capital cost Rs. 20,000 per Km

CONVENTIONAL SEWERS

- Conventional sewerage systems are widely used in densely populated urban areas.
- These large networks of underground pipes convey both black and greywater together from households to generally a centralized disposal/treatment facility mostly using gravity.
- These large networks of underground pipes convey both black and greywater together from households to generally a centralized disposal/treatment facility mostly using gravity.

Capital cost Rs. 29 lakh per Km

SETTLED SEWERS

- This sewer system is designed only to carry liquid wastes coming from household
- Advantages- Reduced water requirement, reduced excavation costs, reduced material costs and reduced treatment requirements over conventional sewer system
- Disadvantages- Need for periodic evacuation and disposal of solids from each interceptor tank in the system. Some special precautions to be taken like to prevent illegal connections to avoid solids from households which can create problems

Capital cost Rs. 1.52 lakh per Km

SOURCE: CPHEEO; SITC; The Design of Small Bore Sewer Systems

OPTIONS FOR GREYWATER MANAGEMENT ACROSS THE CHAIN

TREATMENT METHODS

CONVENTIONAL

WASTE STABILIZATION POND	Does not require electrotechnical equipment Simple to construct, operate maintain High BOD and pathogen removal	High area requirement Odour and mosquito nuisance if poorly maintained	Capital cost O&M cost Land req.	1.5–4.5 million Rs./MLD 0.06–0.1 million Rs./MLD/year 0.8–2.3 ha/MLD
DUCKWEED POND	Low O&M costs Significant nutrient removal No odour and mosquito nuisance	Low pathogen removal Not suitable for extreme weather conditions especially cold	Capital cost O&M cost Land req.	1.5–4.5 million Rs./MLD 0.18 million Rs./MLD/year 2–6 ha/MLD
OXIDATION POND	Less sludge generation compared to aerobic process	Low suspended solids removal Large land requirement High power requirement for aeration	Capital cost O&M cost Land req.	30–80 million Rs./MLD 0.2–1.0 million Rs./MLD/year -
ACTIVATED SLUDGE PROCESS	Low area requirement Performance is not affected by seasonal variations	High energy requirement Requirement for skilled labourers Continuous power supply required	Capital cost O&M cost Land req.	2–4 million Rs./MLD 0.3–0.5 million Rs./MLD/year 0.15–0.25 ha/MLD
UP FLOW ANAEROBIC SLUDGE BLANKET	No external energy requirement Low sludge generation Can absorb hydraulic and organic shock loading	Require adequate post treatment for meeting discharge limit Poor coliform removal Sensitive to seasonal variations	Capital cost O&M cost Land req.	2.5–3.6 million Rs./MLD 0.08–0.17 million Rs./MLD/year 0.2–0.3 ha/MLD

SOURCE: Centre for Science and Environment; CPCB report 2015, Treatment system includes Secondary and Tertiary system; Wastewater Treatment Technologies- Existing and Upcoming; COMPENDIUM OF SEWAGE TREATMENT TECHNOLOGIES

OPTIONS FOR GREYWATER MANAGEMENT ACROSS THE CHAIN

TREATMENT METHODS

CONVENTIONAL	BIOLOGICAL TRICKLING FILTER	Lower process monitoring Simple O&M Generate sludge with better setting characteristics	Problem of blockages and clogging Requires more area compared to ASP	Capital cost O&M cost Land req.	2-4 million Rs./MLD 0.3-0.5 million Rs./MLD/year 0.25-0.65 ha/MLD
	ROTATING BIOLOGICAL CONTRACTOR	Better than conventional trickling filters Not susceptible to seasonal changes Can reduce BOD up to 80-90%	Energy consuming Skilled professional required for O&M	Capital cost O&M cost Land req.	3.36 million Rs./MLD 1.68 million Rs./MLD/year -
ELECTROMECHANICAL	FLUIDISED AEROBIC BIOREACTOR	Primary sedimentation not required Small space requirement Capacity to handle shock loads	Periodic cleaning of reactor bed required Excess biomass growth due to blockages	Capital cost O&M cost Land req.	3-5 million Rs./MLD 0.06- 0.75 million Rs./MLD/year 0.06 ha/MLD
	MOVING BED BIO REACTOR	Less space requirement	Energy consuming	Capital cost O&M cost Land req.	10.8 million Rs./MLD 1.4 million Rs./MLD/year 0.055 ha/MLD
	SEQUENTIAL BATCH REACTOR	Excellent effluent quality Less area required High N,P and coliform removal	Energy consuming Skilled operators required Uninterrupted power supply required	Capital cost O&M cost Land req.	11.5 million Rs./MLD 1.6 million Rs./MLD/year 0.055 ha/MLD

SOURCE: Centre for Science and Environment; CPCB report 2015, Treatment system includes Secondary and Tertiary system; Wastewater Treatment Technologies- Existing and Upcoming; COMPENDIUM OF SEWAGE TREATMENT TECHNOLOGIES

OPTIONS FOR GREYWATER MANAGEMENT ACROSS THE CHAIN

TREATMENT METHODS

ELECTROMECHANICAL	SUBMERGED AEROBIC FIXED FILM PROCESS	Less sludge production Less space requirement High BOD and TSS removal	Clogging of fiter Skilled supervision required High energy consumption	Capital cost	-
				O&M cost	-
				Land req.	-
	MEMBRANE BIO REACTOR	Low footprint Less retention time required High quality effluent Less susceptible to seasonal variations	Chemical cleaning of filter required High energy consumption	Capital cost	10.8 million Rs./MLD
				O&M cost	1.8 million Rs./MLD/year
				Land req.	0.0003 million Rs./MLD/year
	VORTEX TECHNOLOGY	Good substitute for planted filter as it requires less area Easy O&M Very effective in eliminating odour	Requires energy for operation Needs to be clubbed with other (primary/secondary) system	Capital cost	50,000 Rs./KLD
				O&M cost	8500 Rs./KLD/year
				Land req.	0.0003 million Rs./MLD/year
ECOTECHNOLOGY	GREEN BRIDGES	Suitable for in-situ treatment in rivers, flowing streams No skilled labour is required Improves aesthetics	Pollution load reduction upto 80% Increase in DO from 150-200%	Capital cost	200-500 Rs./KLD
	Method-Filtration, sedimentation, bio digestion and biosorption by microbes and plants Capacity: 50-200 KLD/sq.m			O&M cost	20-50 Rs./KLD/year
				Land req.	
	SOIL BIO TECHNOLOGY	Can be run at batch and continuous process No sludge production Mechanical aeration not require	Hydraulic retention time ranges from 30 min to an hour Overall operation time is 6-7 hours	Capital cost	10,00-15,000 Rs./KLD
	Method-Sedimentation, anaerobic treatment, plant root zone treatment, oxidation process Capacity: 5 KLD to tens of MLD			O&M cost	1800-2000 Rs./KLD/year
				Land req.	833 sq. m per MLD

SOURCE: Centre for Science and Environment; CPCB report 2015, Treatment system includes Secondary and Tertiary system; Wastewater Treatment Technologies- Existing and Upcoming; COMPENDIUM OF SEWAGE TREATMENT TECHNOLOGIES

OPTIONS FOR GREYWATER MANAGEMENT ACROSS THE CHAIN

TREATMENT METHODS

ECOTECHNOLOGY

SOIL SCAPE FILTER

Method–Filteration through biologically activated medium Capacity: 1 KLD to 250 KLD	COD reduction in the range of 70–98%	Area requirement is 1 sq. m	Capital cost	20,000–30,000 Rs./KLD
			O&M cost	1800–2000 Rs./KLD/year
			Land req.	

DEWATS

Method– Sedimentation, anaerobic treatment, plant root zone treatment, oxidation process Capacity: 1 KLD to 1 MLD	Consists of settler, anaerobic baffle reactor, plant filter and a pond Modules may be chosen based on requirement	Reduces BOD by 80–90% and odour Mnimal running cost as no electro-mechanical equipment used	Capital cost	35,000–70,000 Rs./KLD
			O&M cost	1,000–2,000 Rs./KLD/year
			Land req.	

FIXED FILM BIOFILTER TECHNOLOGY

Method– Settling and flow equalisation followed by enhanced natural degradation Capacity: 0.5 KLD to tens of MLD	Biofilter used may be stones, gravels, sand or PVC that provides maximum surface area and is easily available	Enhanced degradation of contaminants takes place in minimum area, since suitable micro-culture is added to the biofilter cell	Capital cost	25,000–35,000 Rs./KLD
			O&M cost	1,000–2,000 Rs./KLD/year
			Land req.	1 sq. per KLD

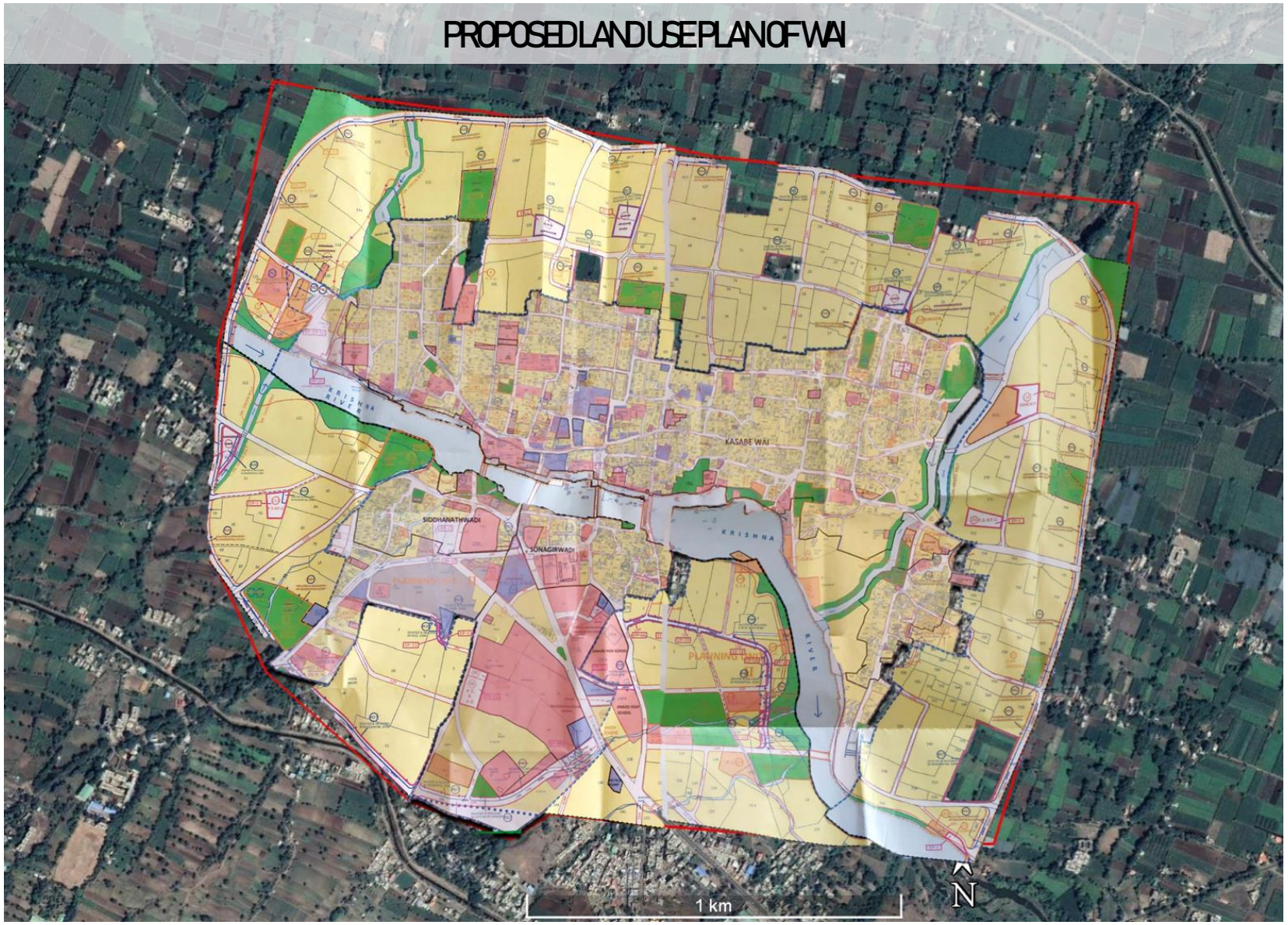
PHYTORID

Method– Settling and flow equalisation followed by enhanced natural degradation Capacity: 0.5 KLD to tens of MLD	Use of chosen wetland plants that are locally available Retention time is between 5–7 days	BOD & TSS removal efficiency 70–90% Faecal coliform removal efficiency 85–97% Average N and P removal 69–90%	Capital cost	14,000–35,000 Rs./KLD
			O&M cost	1,000–2,000 Rs./KLD/year
			Land req.	1,200 sq.m per MLD

SOURCE: Centre for Science and Environment; CPCB report 2015, Treatment system includes Secondary and Tertiary system; Wastewater Treatment Technologies– Existing and Upcoming; COMPENDIUM OF SEWAGE TREATMENT TECHNOLOGIES

OPTION 1: DECENTRALIZED MANAGEMENT

PROPOSED LAND USE PLAN OF WAI



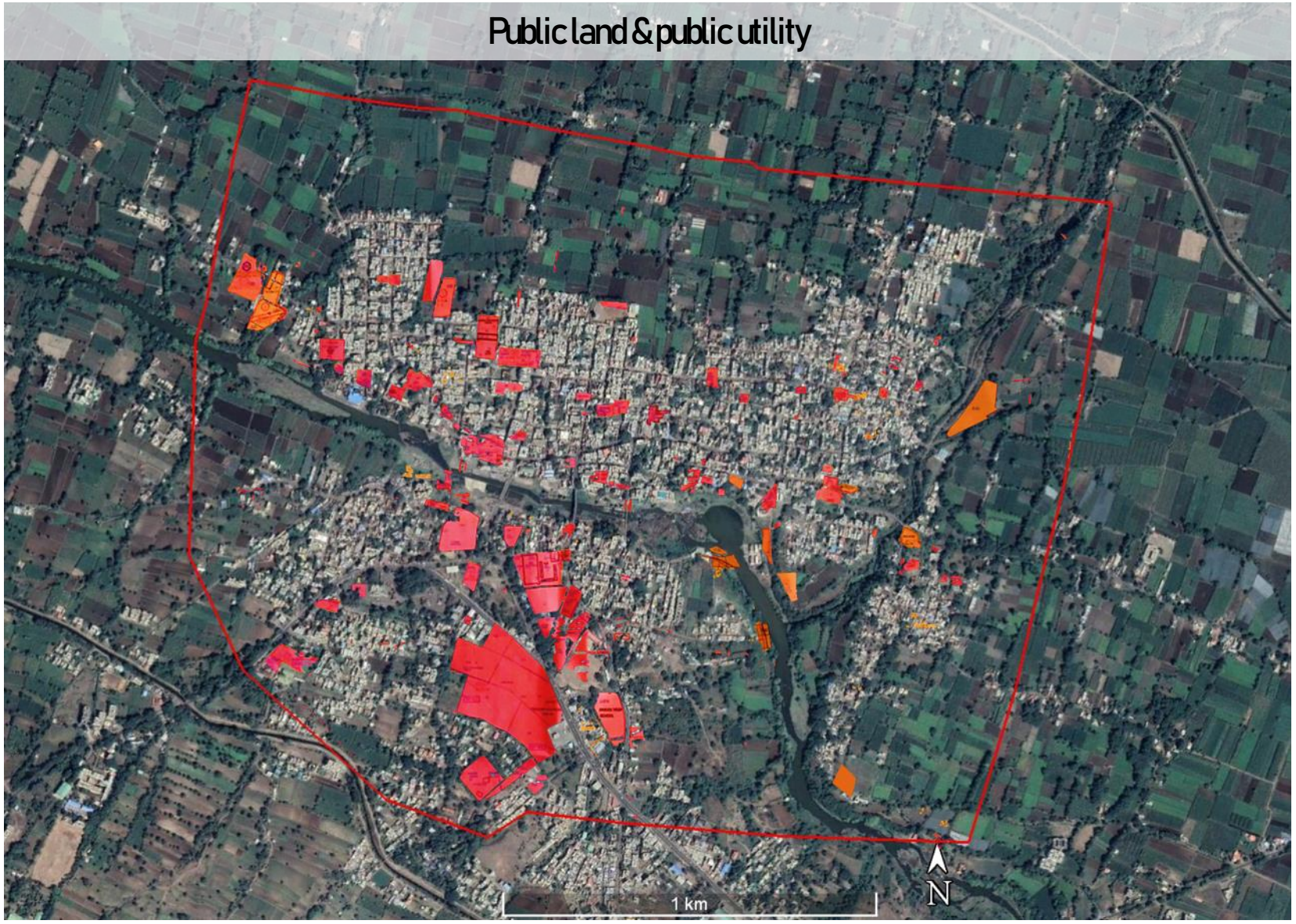
Legend	
Residential	
Commercial	
Industrial	
Public land	
Public utility	
Traffic and transportation (Parking)	
Recreational activity	
Agricultural/no development zone	
Water bodies	

SOURCE: Proposed land use plan of Wai

DECENTRALIZED MANAGEMENT

Public land parcels

Public land & public utility

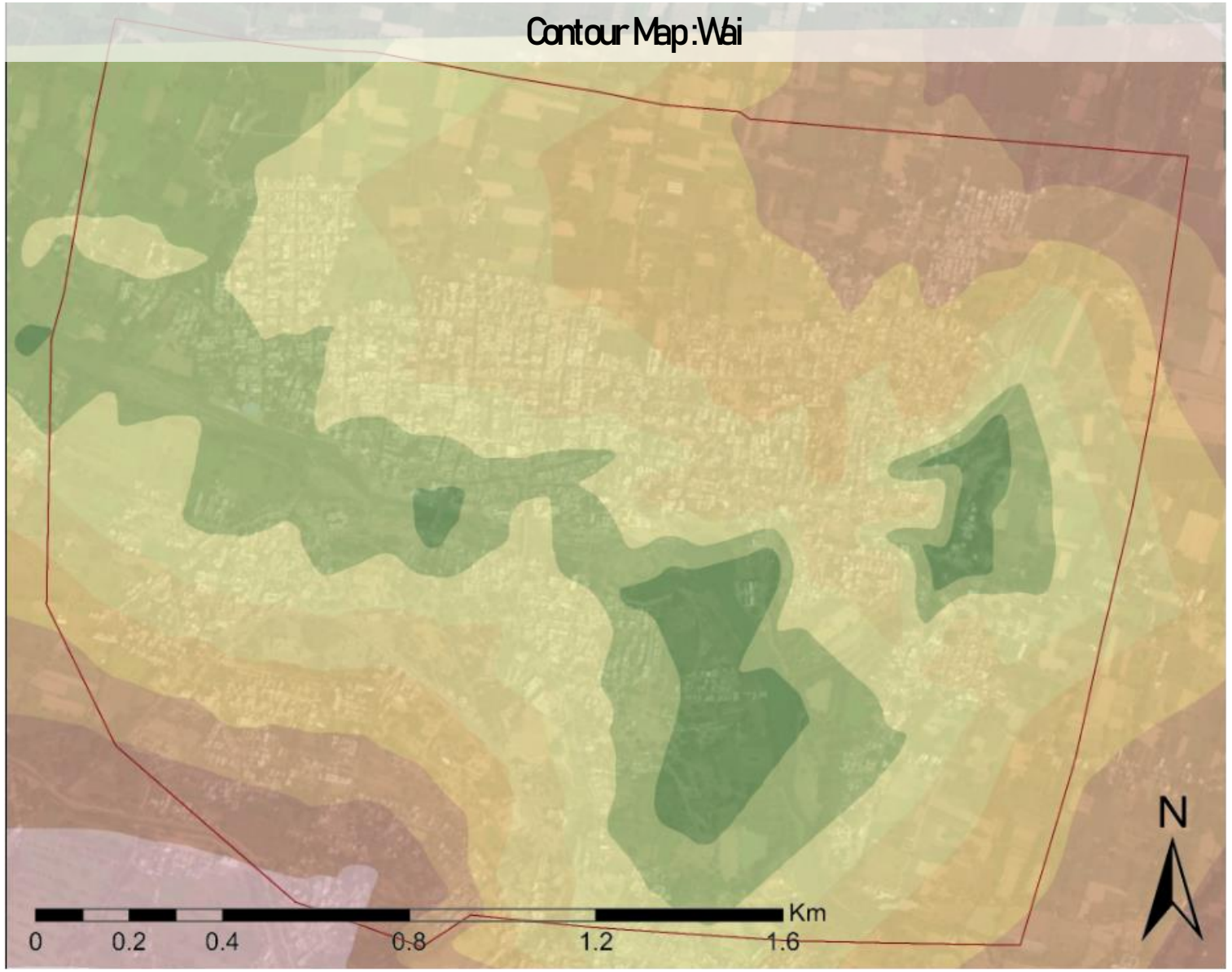


Legend	
Residential	
Commercial	
Industrial	
Public land	
Public utility	
Traffic and transportation (Parking)	
Recreational activity	
Agricultural/no development zone	
Water bodies	

SOURCE: Proposed land use plan of Wai

DECENTRALIZED MANAGEMENT

Identifying the land parcels for treatment plants

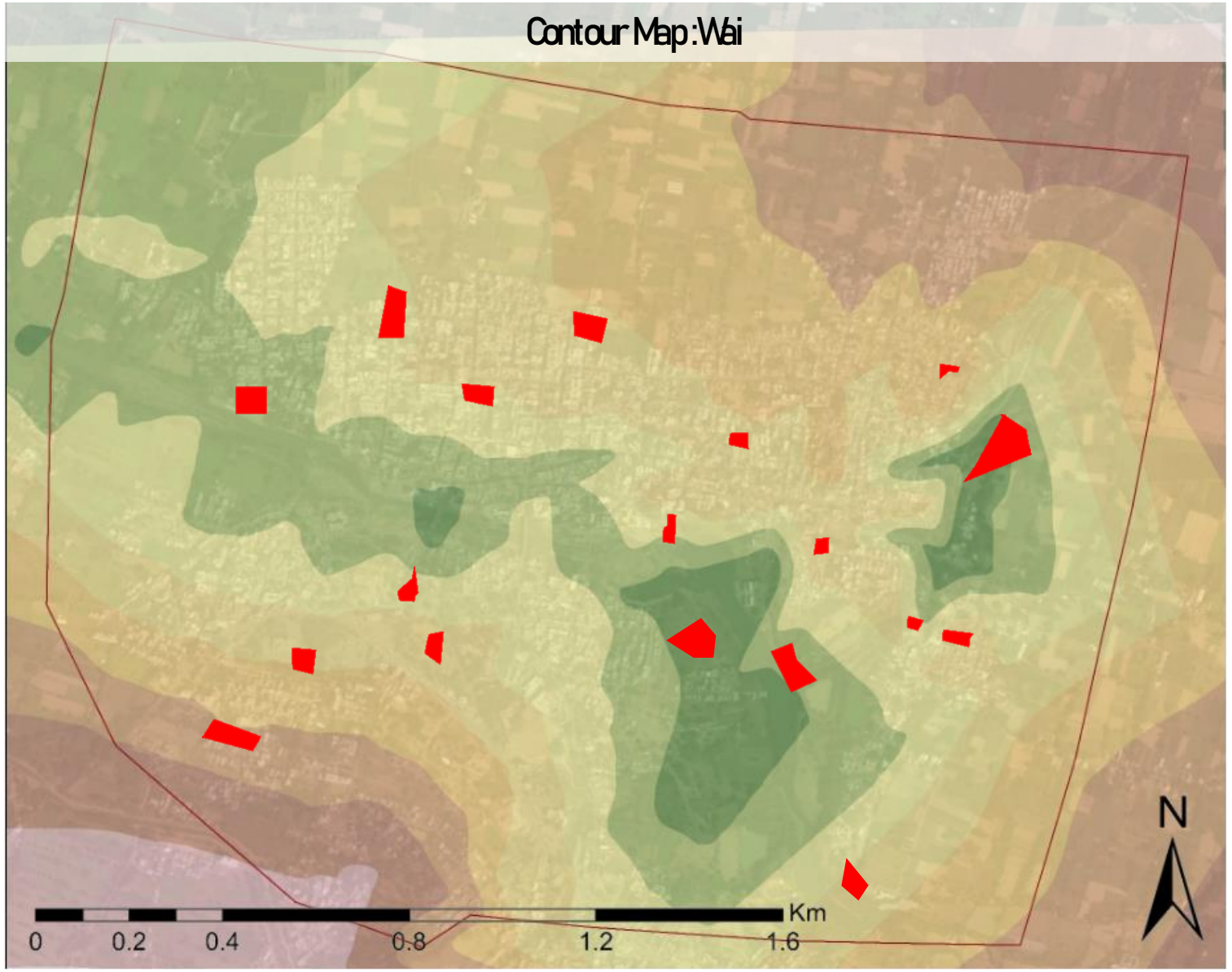


Legend	
693–697 m	
697–701 m	
701–705 m	
705–709 m	
709–713 m	
712–717 m	
717–721 m	
721–725 m	

SOURCE ARCGIS (contour map of Wai)

DECENTRALIZED MANAGEMENT

Identifying the land parcels for treatment plants



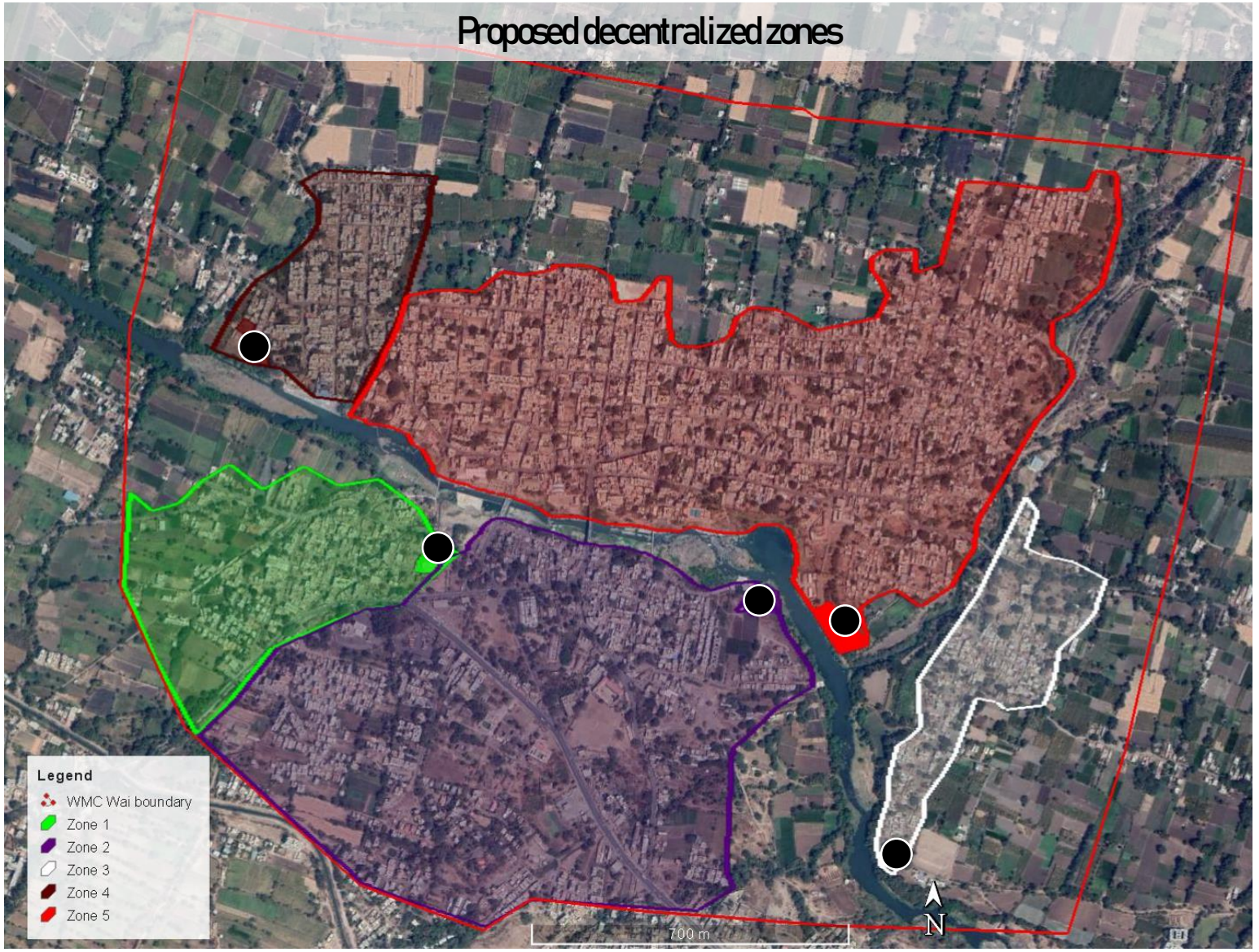
Legend	
693–697 m	
697–701 m	
701–705 m	
705–709 m	
709–713 m	
712–717 m	
717–721 m	
721–725 m	
Undeveloped public land	

SOURCE: ARC GIS (contour map of Wai) and Proposed land use plan of Wai

DECENTRALIZED MANAGEMENT

Decentralized catchment zone

Proposed decentralized zones



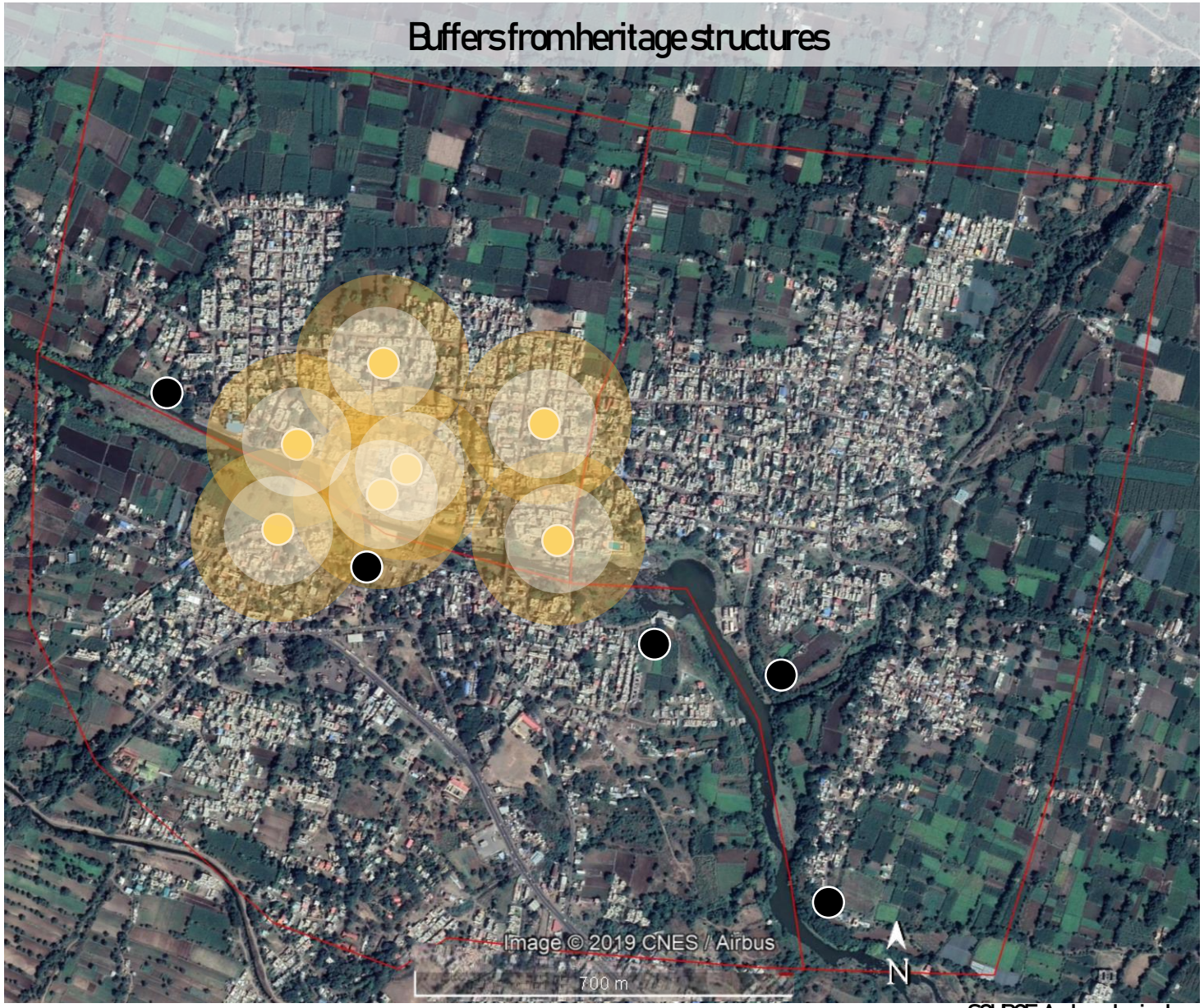
Unbuilt public land parcels in Wai

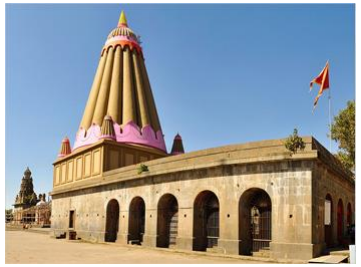
Legend			
Zone 1		Zone 4	
Zone 2		Zone 5	
Zone 3		Treatment plants	

SOURCE: ARC GIS (contour map of Wai); google earth imagery; Proposed land use plan of Wai

DECENTRALIZED MANAGEMENT

Buffers for heritage properties





Heritage structures in Wai

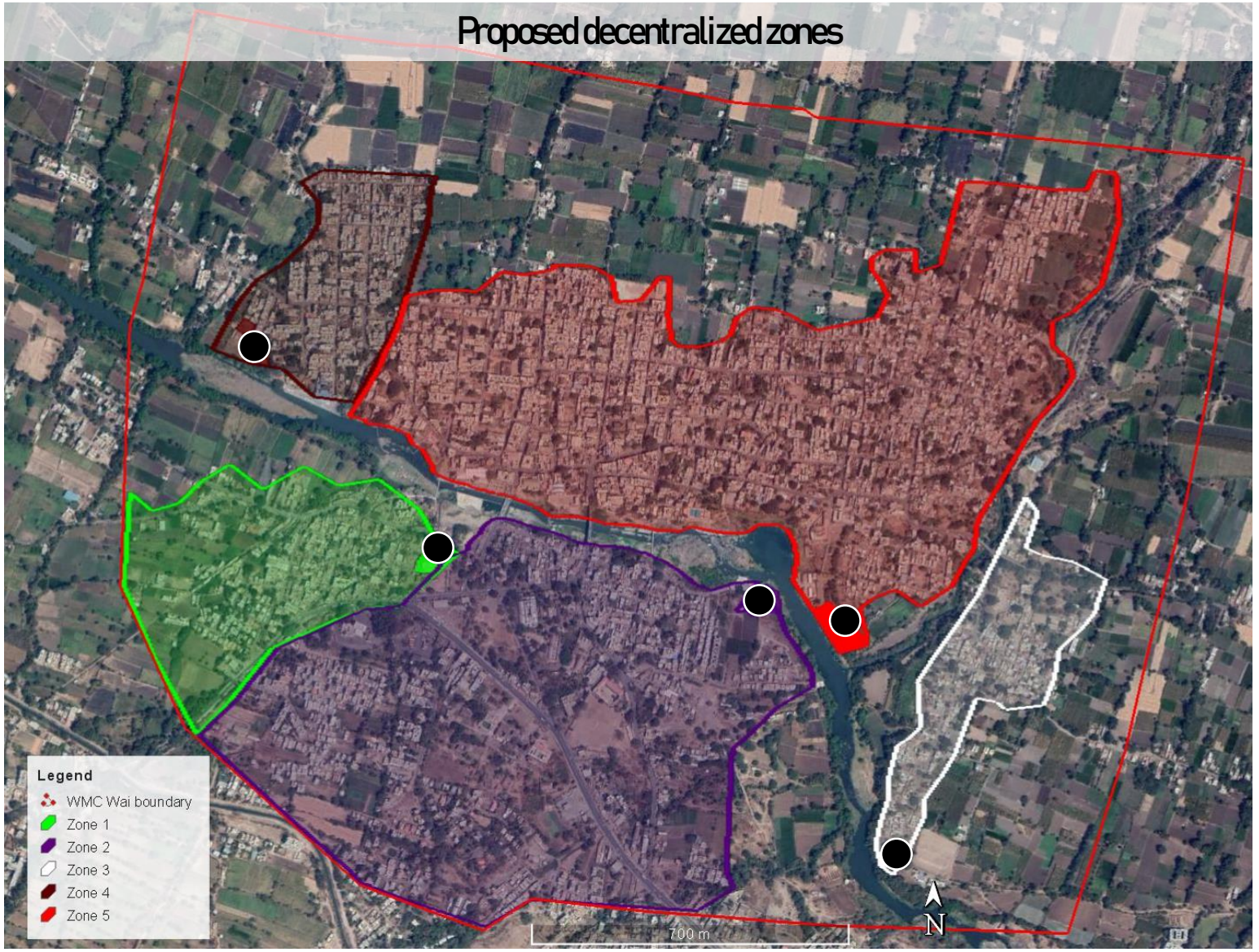
- "Prohibited Area" means area of the protected monuments declared as of national importance and extending to a distance of 100 meters in all direction.
- "Regulated Area" means area in respect of every ancient monuments and archaeological sites and remains declared as of national importance and extending to a distance of 200 meters in all direction.

Legend	
Treatment plants	●
Heritage structures	●
100 m buffers	○
200 m buffers	●

SOURCE: Archaeological survey of India: Handbook of Conservation of Heritage Buildings (2013); Google earth imagery

Decentralized catchment zone

Proposed decentralized zones



Unbuilt public land parcels in Wai

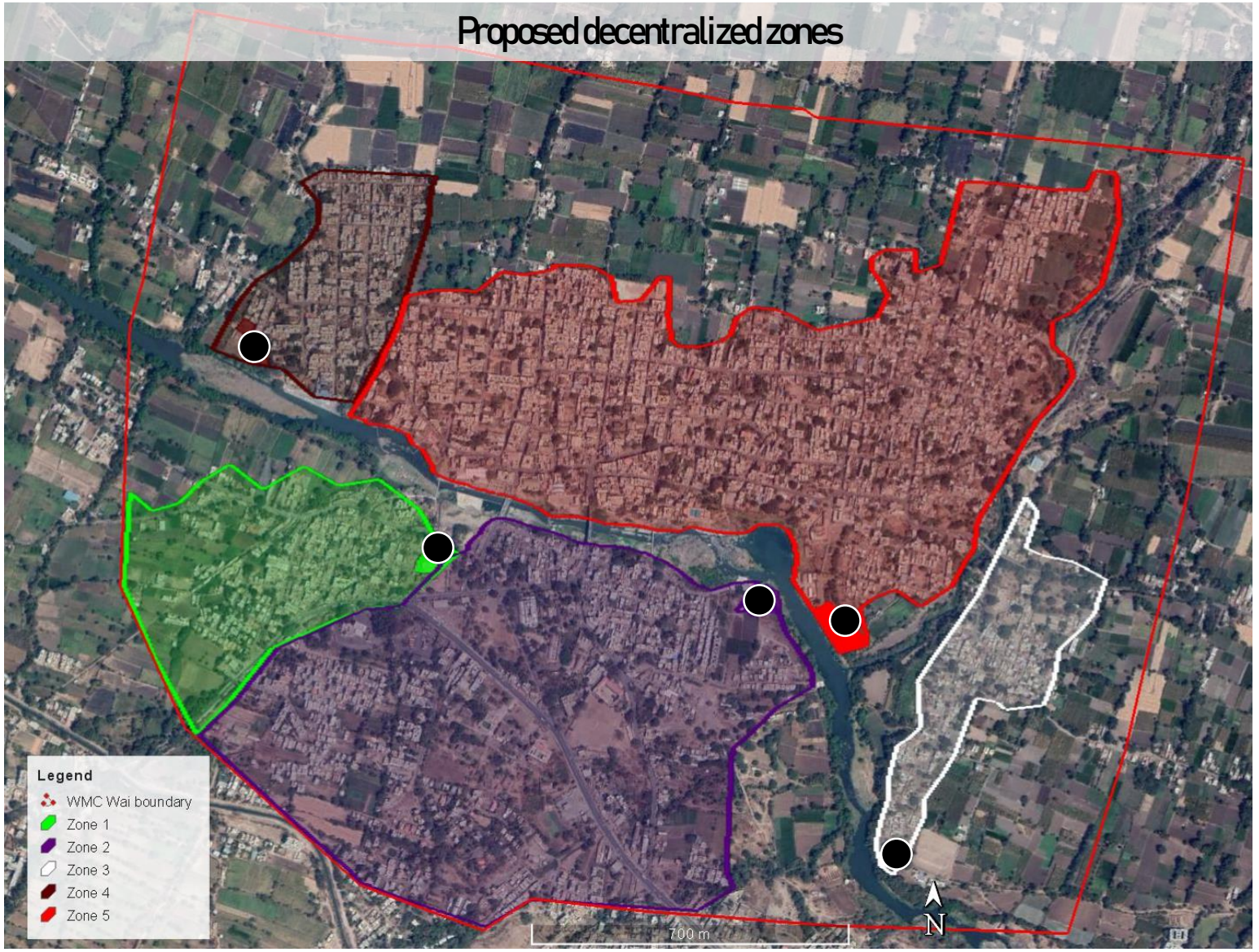
Catchment zone	Catchment area	Population under catchment (in hectare)	Land available for treatment plant (in hectare)
Zone 1	23.7	5319	0.28
Zone 2	76	17058	0.65
Zone 3	14.1	3165	0.10
Zone 4	12.8	2873	0.10
Zone 5	84	18853	0.95
Total	210.6	47268	2.08

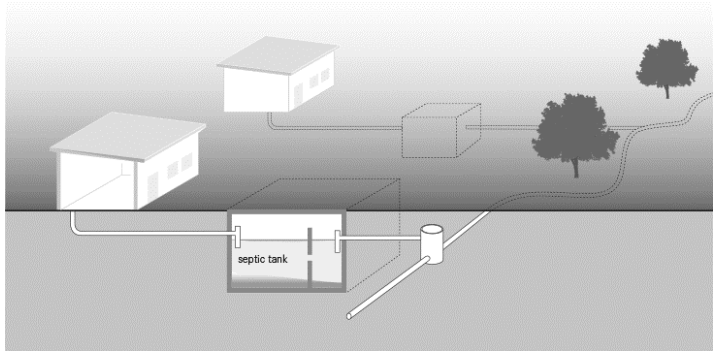
SOURCE: ARCGIS (contour map of Wai); google earth imagery; Proposed land use plan of Wai

DECENTRALIZED MANAGEMENT

Decentralized catchment zone

Proposed decentralized zones





Typical small bore sewer system

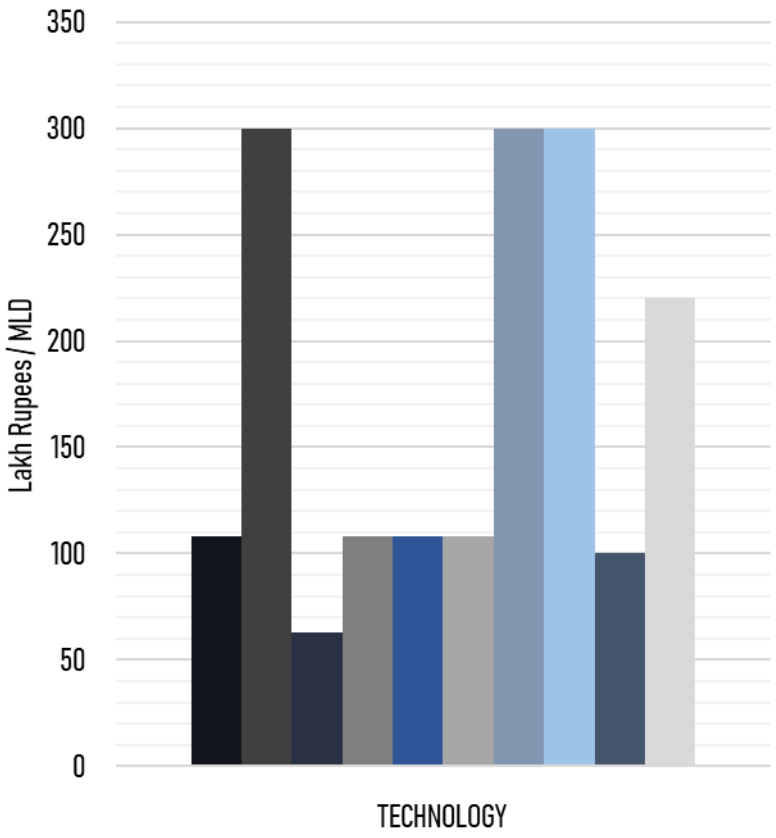
Catchment zone	Quantity of greywater generated in KLD	Estimated length of small-bore sewers in km	Estimated diameter of small bore sewers
Zone 1	619	3.647	120 mm
Zone 2	1985	11.693	180 mm
Zone 3	358	3.212	100 mm
Zone 4	335	2.915	150 mm
Zone 5	2195	19.133	180 mm
Total	5492	40.600	

SOURCE: ARC GIS (contour map of Wai); google earth imagery; Proposed land use plan of Wai : CPHEEO guidelines

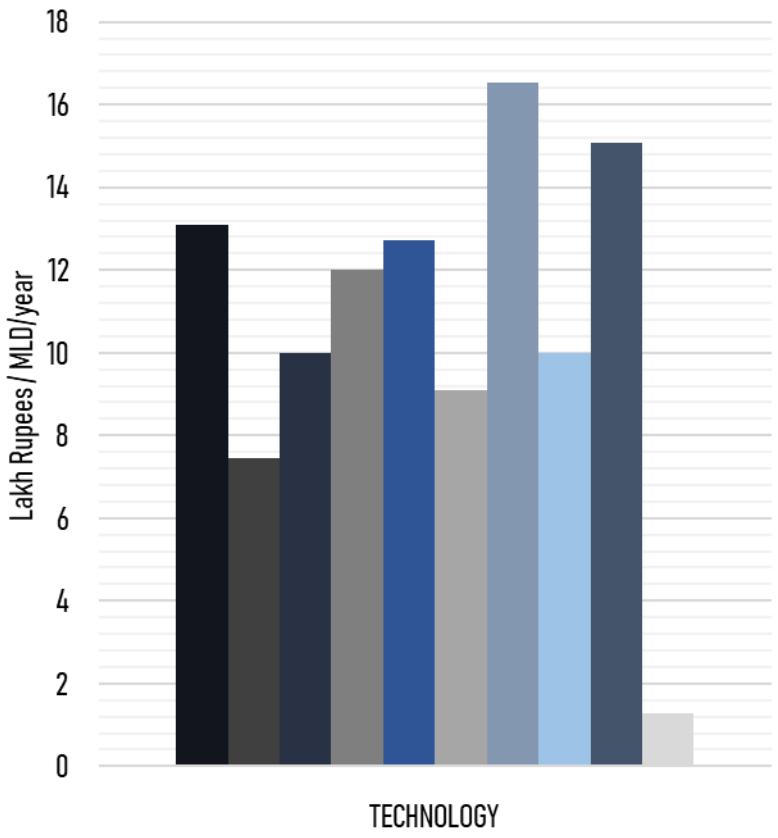
DECENTRALIZED MANAGEMENT

Identifying treatment technology

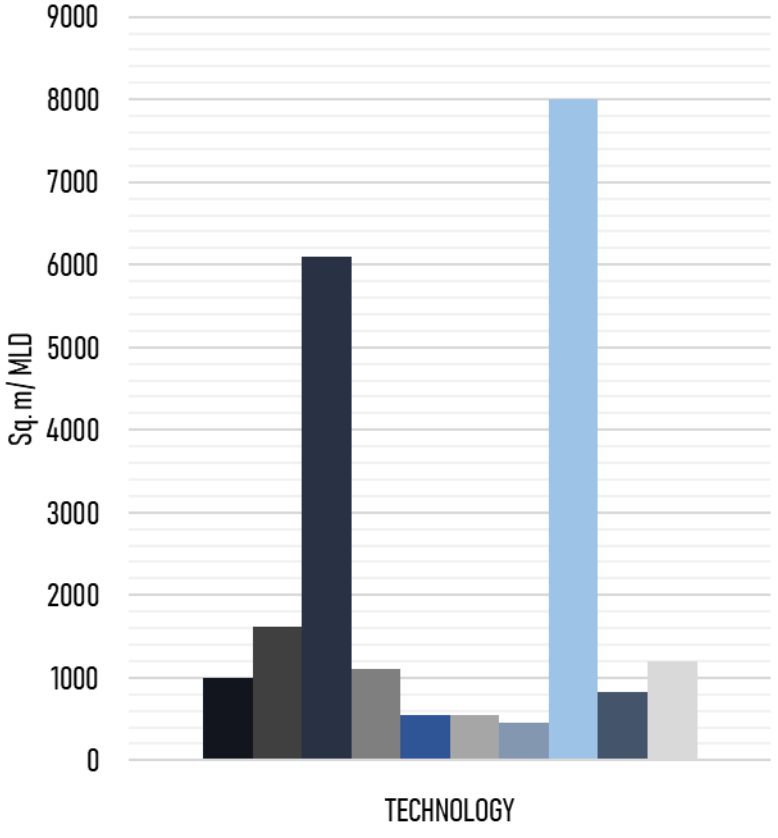
Capital cost



O&M cost



Land requirement



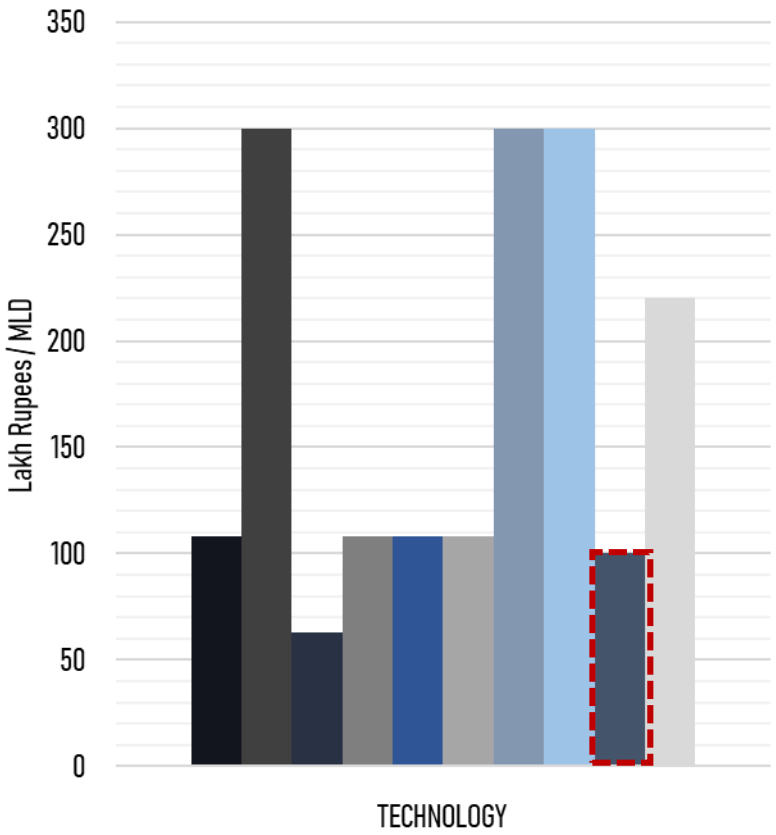
ASP | Trickling filter | WSP | UASB+TT | MBBR | SBR | MBR | HPGF | SBT | PHYTORID

SOURCE: Centre for Science and Environment; CPCB report 2015, Treatment system includes Secondary and Tertiary system; Wastewater Treatment Technologies- Existing and Upcoming; COMPENDIUM OF SEWAGE TREATMENT TECHNOLOGIES

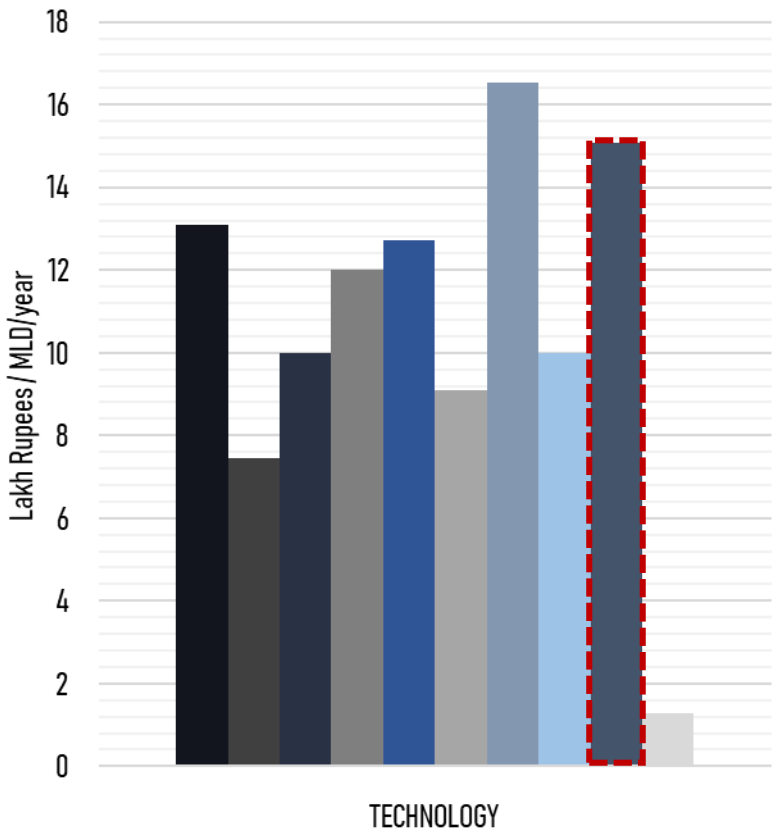
DECENTRALIZED MANAGEMENT

Identifying treatment technology

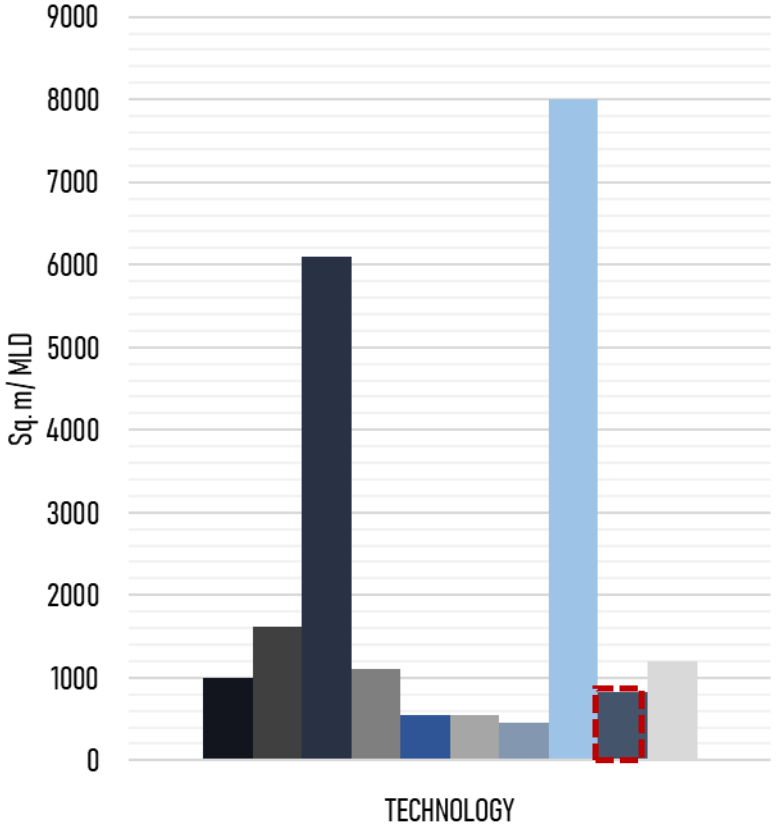
Capital cost



O&M cost



Land requirement



ASP | Trickling filter | WSP | UASB+TT | MBBR | SBR | MBR | HPGF | SBT | PHYTORID

SOURCE: Centre for Science and Environment; CPCB report 2015, Treatment system includes Secondary and Tertiary system; Wastewater Treatment Technologies- Existing and Upcoming; COMPENDIUM OF SEWAGE TREATMENT TECHNOLOGIES

DECENTRALIZED MANAGEMENT

Detailed cost estimates

Zone no.	Catchment area (in hectare)	Population under catchment	Land required for treatment plant (in ha)	Quantity of greywater generated in KLD	Estimated length of small-bore sewers in km	Cost of land required (Rs. lakhs)	Cost of small-bore sewer (Cr. Rs.)	Cost of treatment plant (SBT) (Cr. Rs.)	Total cost of each zone (Cr. Rs.)
1	23.7	5319	0.28	619	3.647	5.54	0.56	1.28	1.83
2	76	17058	0.65	1985	11.693	12.85	1.78	4.09	5.88
3	14.1	3165	0.10	358	3.212	1.98	0.49	0.76	1.25
4	12.8	2873	0.10	335	2.915	1.98	0.44	0.69	1.13
5	84	18853	0.95	2195	19.133	18.78	2.92	4.52	7.44
Total	210.6	47,268	2.08	5,492	40.600	41.12	6.19	11.34	17.53

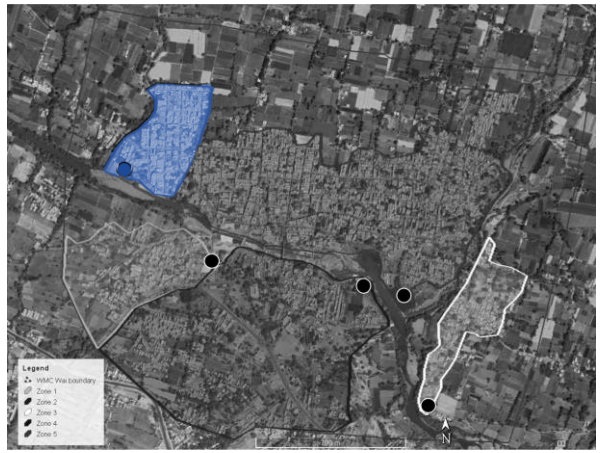
O & M COST PER YEAR= RS. 80 LAKHS PER YEAR

TOTAL COST OF THE PROJECT= RS. 17.6 CRORE

SOURCE: Maharashtra Schedule of rates(2014; : CPHEEO guidelines; PAS report on Punjab small bore sewers; Proposed land use plan of Wai

DECENTRALIZED MANAGEMENT

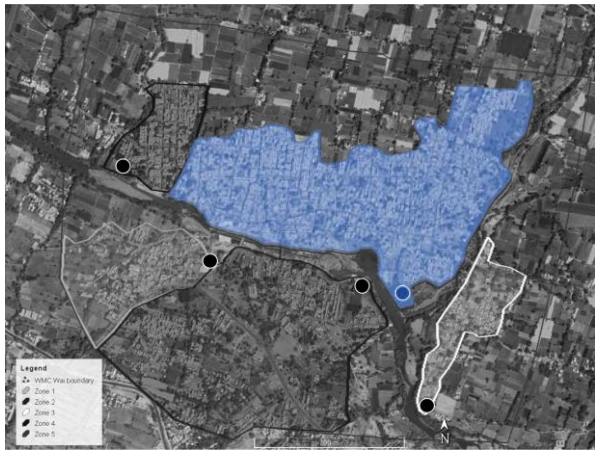
Decentralized catchment zone



Phase 1:- (Zone 4)

Due to factors like well operational periodic desludging, low catchment area and greywater generation this zone can be considered in the first pilot phase

Conveyance cost- Rs. 44 lakh
Treatment cost- Rs. 69 lakh
Total cost- Rs. 1.3 crore



Phase 2:- (Zone 5)

Post successful implementation of the first phase, Zone 5 would be considered for the second phase it covers the highest population, area and would also facilitate reuse of treated water in MIDC

Conveyance cost-Rs. 2.9 crore
Treatment cost- Rs. 4.5 crore
Total cost- Rs. 7.4 crore

Phase 3:- (Zone 1+Zone 2+Zone 3)

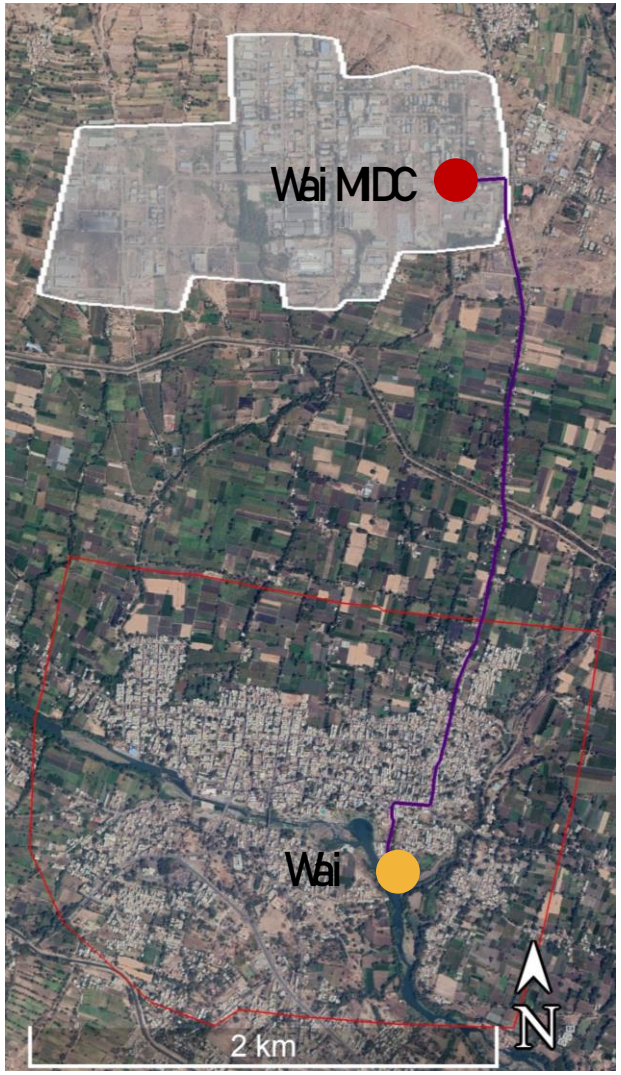
The final phase of the project would involve remaining three zones has comparatively have less population density

Conveyance cost-Rs. 2.8 crore
Treatment cost- Rs. 6.1 crore
Total cost- Rs. 8.9 crore

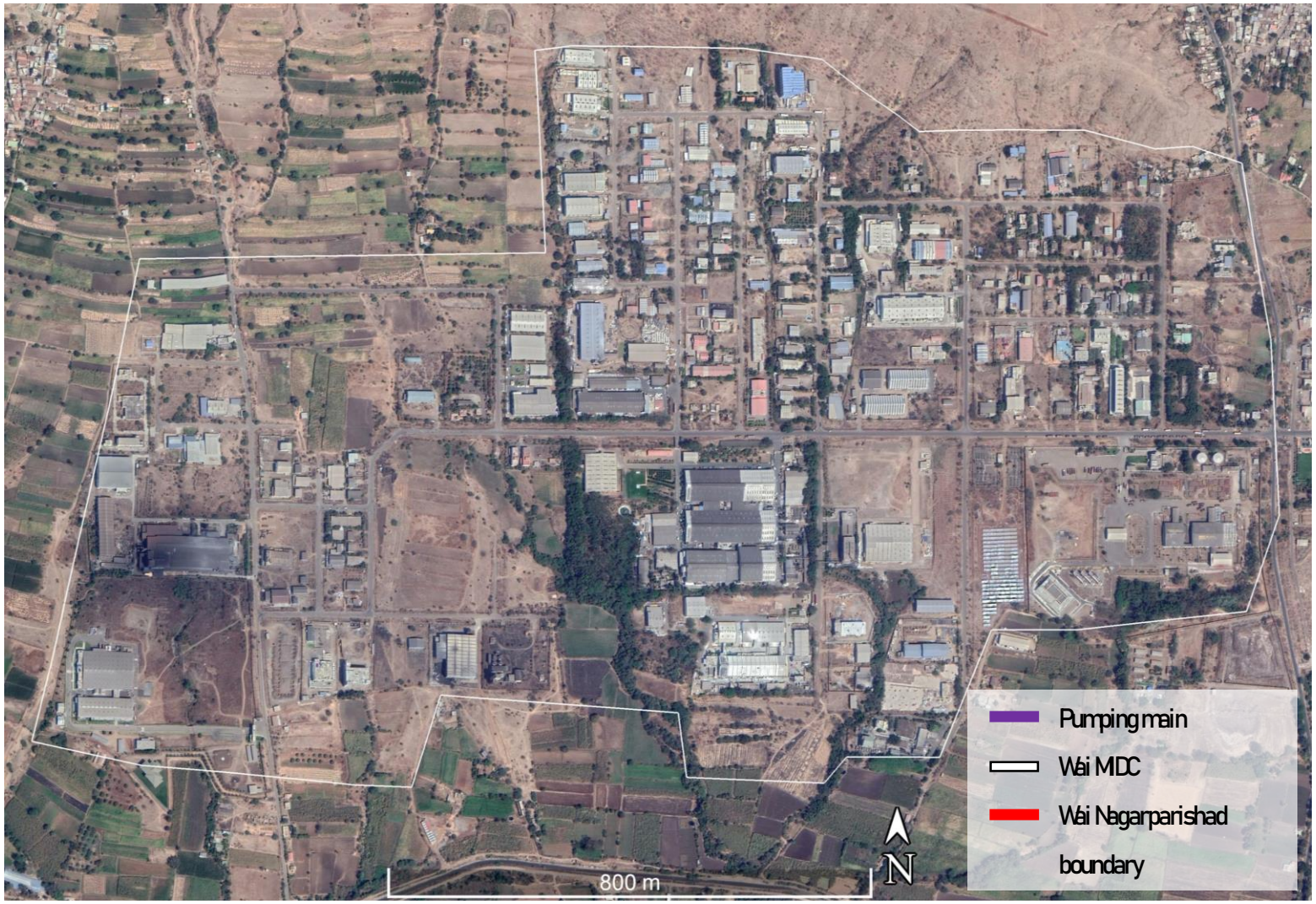
TOTAL COST OF THE PROJECT= RS. 17.6 CRORE

SOURCE: Maharashtra Schedule of rates(2014); google earth imagery; Proposed land use plan of Wai

REUSING TREATED GREYWATER IN MIDC

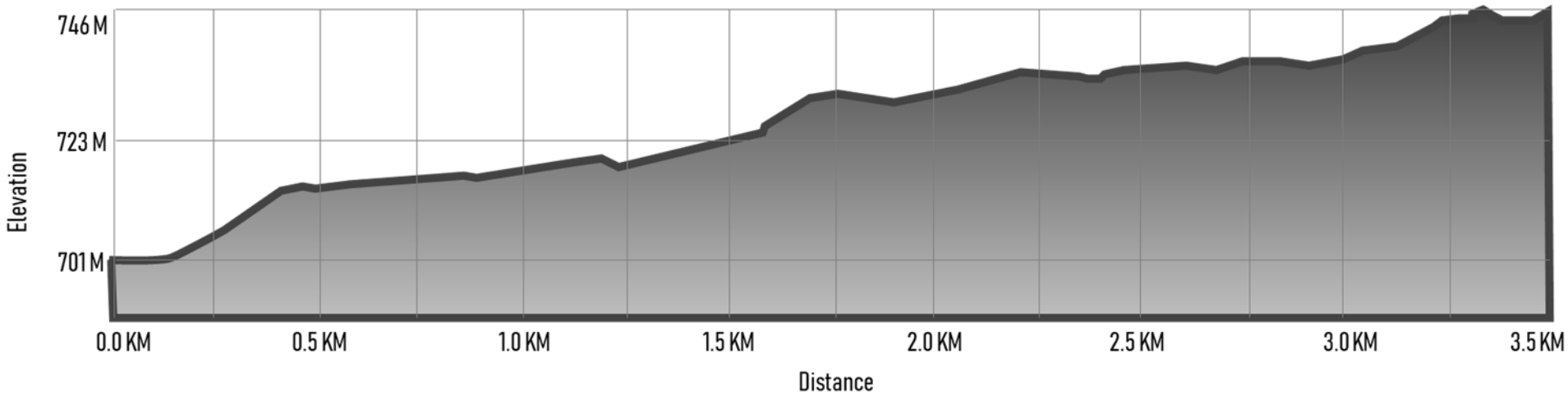


Distance from treatment plant - 3.5 kms



- Water requirement - 0.50 MLD
- MIDC land coverage - 2.02 sq. km
- Type of industries - chemical, pharmaceuticals, food, automotive, electronics, rubber, plastic and nylon industry

SOURCE: Maharashtra Industrial Development Corporation



- Total distance=3.5 kms
- Elevation gain/loss=+51.2m,-9.45m
- Maximum slope=+14.8%;-4.8%
- Average slope=+1.8%;-1.1%

Pumping

- Type of pump to be used- Submersible vertical turbine pump (preferred for heads higher than 40 m)
- Total daily pumping duration=20 hours
- Friction loss=0.18 m
- Discharge requirement= 6.95 LPS
- Required capacity of pump=5.0 HP

Conveyance

- Total quantity of water to be conveyed=0.50 MLD
- Pipe diameter required for pumping 0.50 MLD treated water in and hour =100 mm
- Here the RCC NP pipes cannot be used as these pipes would have a pressurized flow.
- So, for the purpose of the diameter of pipe required is 100 mm and the material of the pipe would be "Ductile Iron K-9" pipes

Cost of pumping system=Rs. 75,000 | Cost of pumping mains=Rs. 1100 per rmt=Rs 38 lakhs | Cost of sump=Rs. 5 lakhs

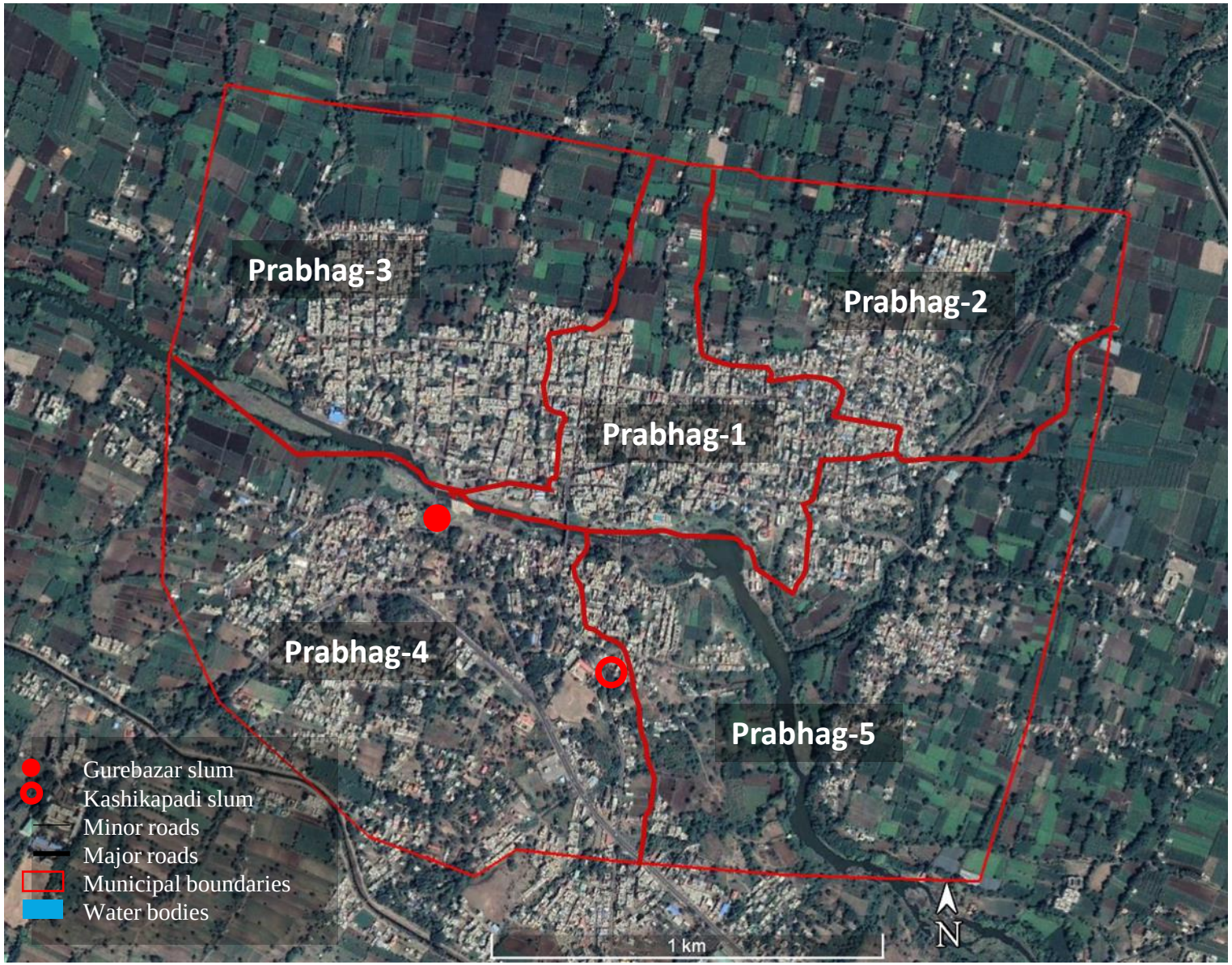
TOTAL O&M COST= RS. 2.5 LAKHS/YEAR

TOTAL CAPITAL COST= RS. 43.7 LAKHS

SOURCE: CPHEEO guidelines; Maharashtra Schedule of rates(2014); Maharashtra state electricity distribution corporation

OPTION 2: INTERCEPTOR DRAINS+ CLOSING DRAINS

BENEFITS OF CLOSING DRAINS



- Based on the household survey, most respondents have not observed choking of public drains
- If an incident of choking is observed, the frequency of it is hardly once or twice in a year which is resolved immediately.
- But 45% people also reported that they face problem likes, bad odour, health hazards, accidents, etc. due to open drains.

Rs. 5.1 Crore
Capital cost

Rs. 1 lakh per annum
Operation and maintenance cost

24,633 sq. m
Area increased in road widths

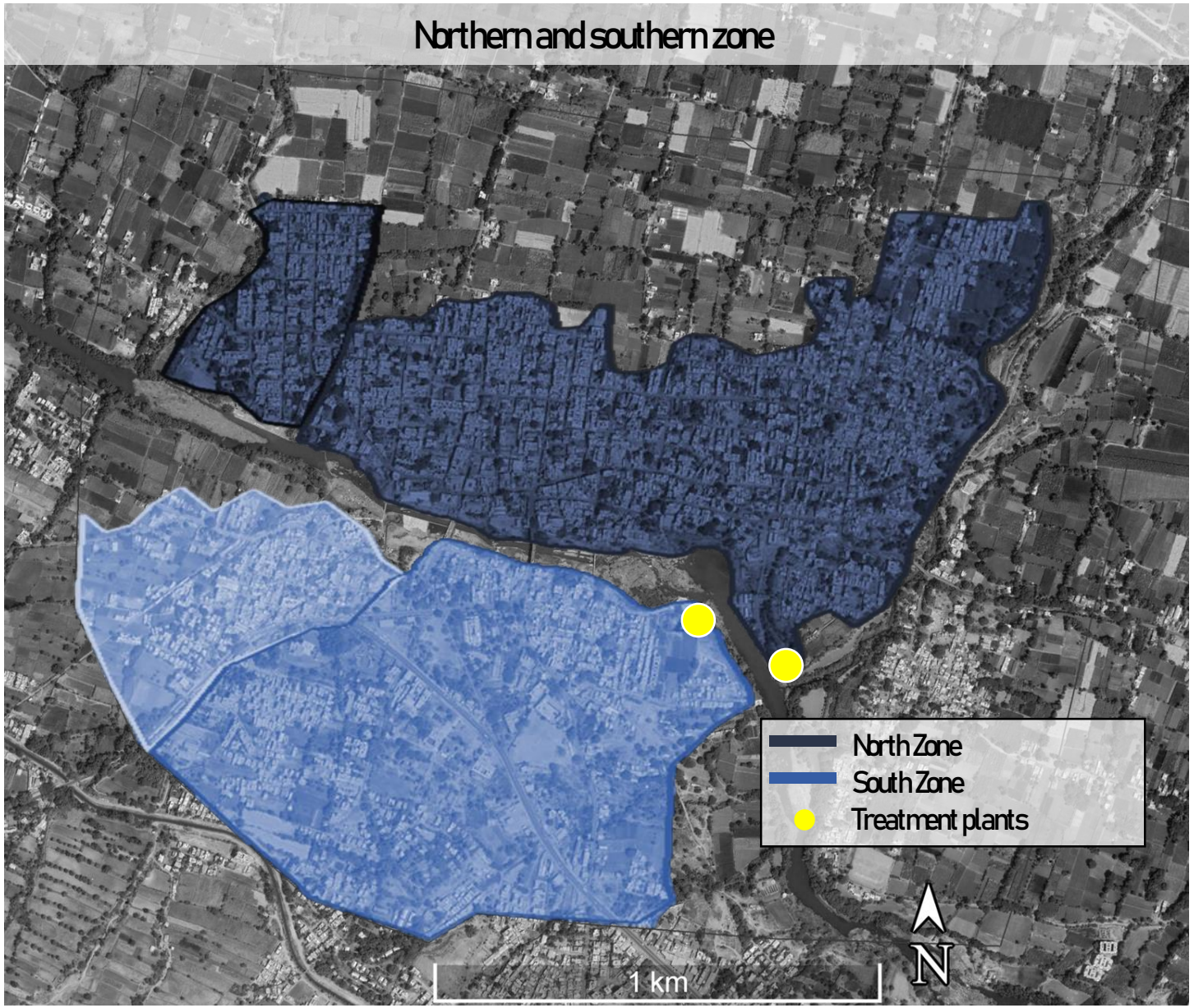
Rs. 48.7 lakhs
Cost benefit from increased road widths

2.5 times compared to open drains
Cost benefit ratio (based on case studies)

SOURCE: Primary survey; Effect of drains coverings on environment by using value engineering (2017); Maharashtra Schedule of rates(2014)

INTERCEPTOR DRAINS

+closing drains+treatment



Northern side of river Krishna

- The total length of interceptor drain – 1,740 m
- Pipe material – RCC NP-3 pipes
- Quantity of greywater to be conveyed– 3.0 MLD
- Diameter of pipe required– 250 mm
- Unit cost of pipe– Rs. 728 per rmt.
- Total cost of conveyance on northern side– Rs. 12.6 lakhs
- Treatment technology to be used –Soil Biotechnology

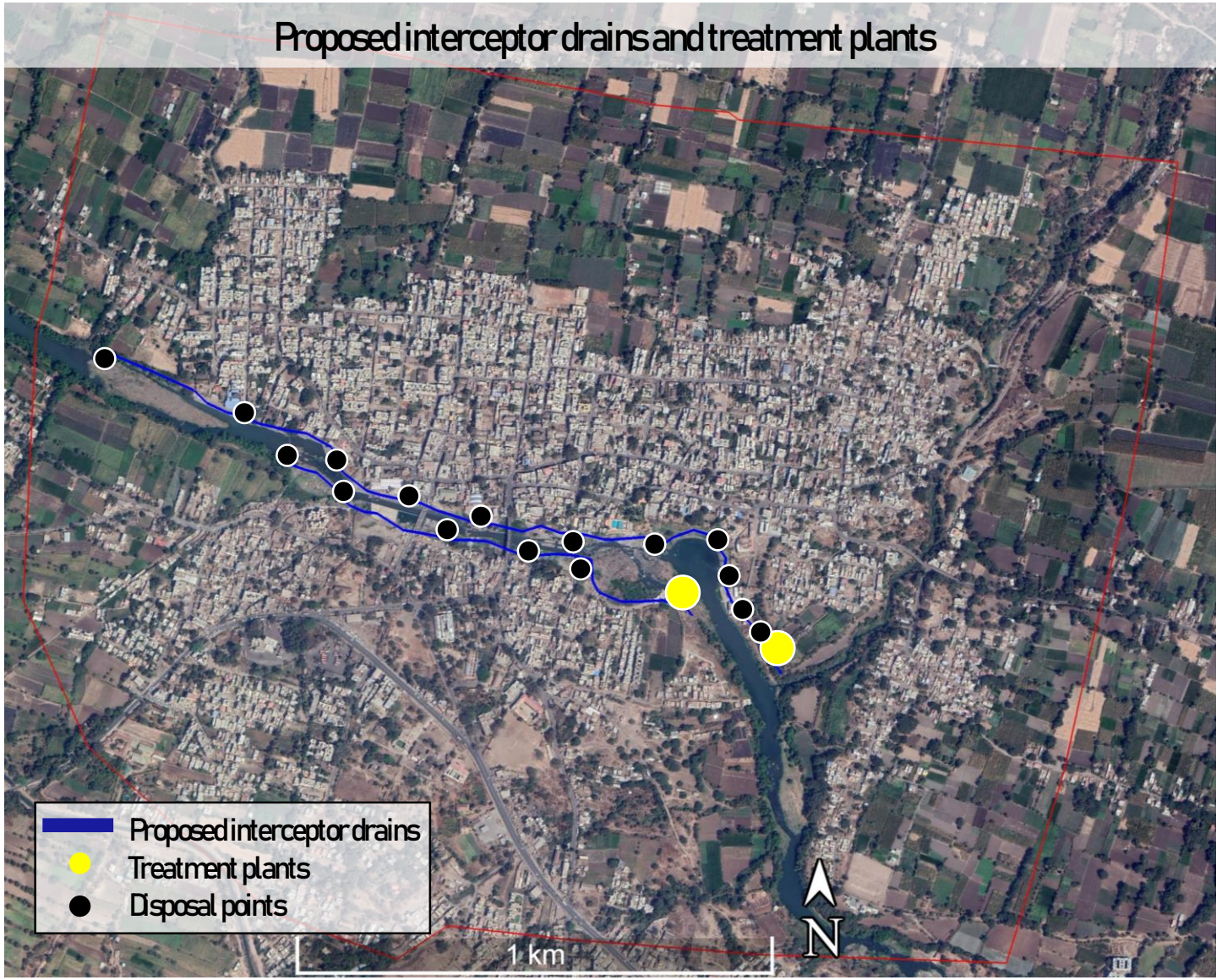
Southern side of river Krishna

- The total length of interceptor drain – 1,040 m
- Pipe material – RCC NP-3 pipes
- Quantity of greywater to be conveyed– 2.5 MLD
- Diameter of pipe required– 225 mm
- Unit cost of pipe– Rs. 622 per rmt.
- Total cost of conveyance on northern side– Rs. 6.4 lakhs
- Treatment technology to be used –Soil Biotechnology

SOURCE: Wai CSP (2014); CPHEEO manual; Maharashtra Schedule of rates(2014) ; Centre for Science and Environment

INTERCEPTOR DRAINS

+closing drains+treatment



Parameter	Unit rate	Total cost	
The total length of interceptor drain on the northern side of river Krishna is 1,740 m	Rs. 728/ rmt	Rs. 12.6 lakhs	Cost of interceptors Rs. 0.19 Cr.
The total length of interceptor drain on the southern side of river Krishna is 1,040 m	Rs. 662/ rmt	Rs. 6.4 lakhs	
Cost of treatment plant linked northern interceptor (3.0 MLD)	Rs. 1.0 Cr./MLD	Rs. 3.0 Cr.	Cost of treatment Rs. 5.5 Cr.
Cost of treatment plant linked northern interceptor (2.5 MLD)	Rs. 1.0 Cr./MLD	Rs. 2.5 Cr.	
Cost of closing the drains using precast RCC drain slabs (24,634 sq. m)	Rs. 2090/ sq. m	Rs. 5.1 Cr.	

O & M COST PER YEAR= RS. 67 LAKHS

TOTAL COST OF THE PROJECT= RS. 10.79 CRORE

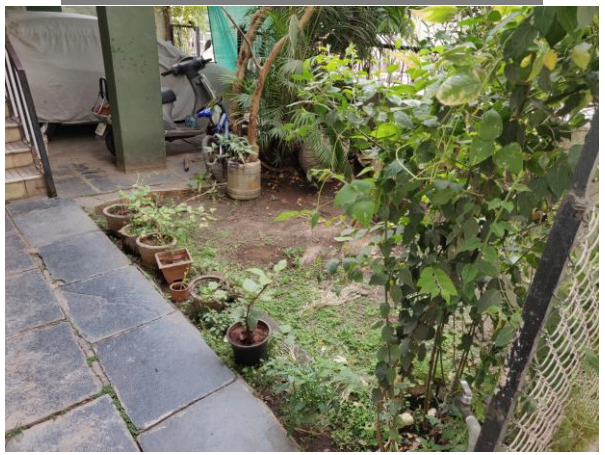
SOURCE: Wai CSP (2014); Maharashtra SOR; Centre for Science and Environment

OPTION 3: PACKAGED TREATMENT SYSTEM

PACKAGED TREATMENT SYSTEMS

Based on building typology

Individual bungalows



- Total number of households in Wai=1,865
- Considering household size = 4.02
- Population living in bungalows=7,497

- Therefore the total greywater generation per bungalow = 402 litres per day

- Treatment system required should be of capacity of more than 402 litres per day

- Treated water can be used for landscaping as most of the individual houses have spaces for horticulture

Row houses

- Total no. of households in row houses=4,417
- Considering household size = 4.02
- Population living in row houses=17,756

- Therefore the total greywater generation per row house = 402 litres per day

- Treatment system required should be of capacity of more than 402 litres per day

- Treated water cannot be reused in landscaping as there hardly are apartments with open areas

Apartments

- Total number of households in apartment=5,343
- Average no. of households per apartment block= 9
- Considering household size = 4.02
- Population living in apartments=21,479
- Population living in each apartment block=36
- Therefore the total greywater generation per apartment = 3,600 litres per day
- Treatment system required should be of capacity of more than 3,600 litres per day
- Treated water cannot be reused in landscaping as there hardly are apartments with open areas

SOURCE: Wai property data (PAS); Primary survey

PACKAGED TREATMENT SYSTEMS

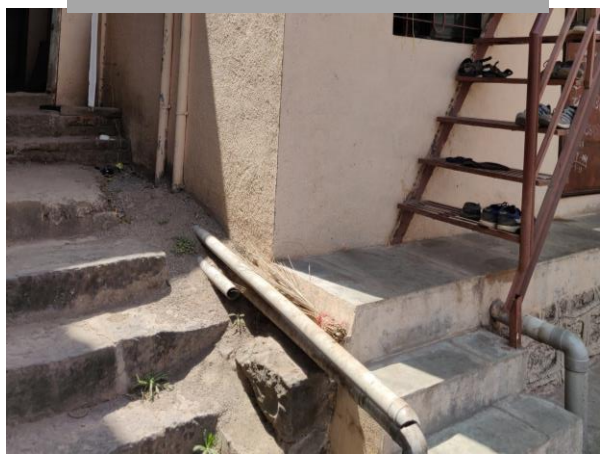
Based on building typology

Individual bungalows

- Treatment system – 5 KLD,
- Technique-Mixed Bed Bio Reactor; MBR
- Unit cost of proposed system=Rs. 1.5 lakh
- Total cost of installing in all individual bungalows= Rs. 27.97 crores

- Proposed treatment system – 1 KLD
- Technique- Fixed film biofilter technology
- Space requirement - 2.8 sq. m
- Unit cost of proposed system=Rs. 35,000 per KLD
- Total cost of installing in all individual bungalows= Rs. 6.5 crores

Row houses



- Treatment system – 5 KLD,
- Technique-Mixed Bed Bio Reactor, MBR
- Unit cost of proposed system=Rs. 1.5 lakh
- Total cost of installing in all individual bungalows= Rs. 66.25 crores

- Proposed treatment system – 1 KLD
- Technique- Fixed film biofilter technology
- Space requirement - 2.8 sq. m
- Unit cost of proposed system=Rs. 35,000 per KLD
- Total cost of installing in all row houses= Rs. 15.4 crores

Apartments

- Proposed treatment system – 5 KLD,
- Technique-Mixed Bed Bio Reactor, MBR
- Space requirement - 10 sq. m
- Unit cost of proposed system=Rs. 1.5 lakh
- Total cost of installing in all individual bungalows= Rs. 8.91 crores

- Proposed treatment system – 5 KLD
- Technique- Fixed film biofilter technology
- Space requirement - 2.8 sq. m
- Unit cost of proposed system=Rs. 35,000 per KLD
- Total cost of installing in all apartments= Rs. 10.3 crores

O & M COST PER YEAR= RS. 116 LAKHS

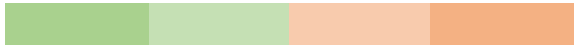
TOTAL COST OF THE PROJECT= RS. 32 CRORE

SOURCE: Wai property data (PAS); Primary survey; India mart; Overview and feasibility of advanced grey water treatment systems for single

CONCLUSION

COMPARING OTHER FEASIBLE OPTIONS WITH DPR

	DPR on underground sewage/ sullage network	Packaged treatment option	DEWATS+settled sewers	Closing the drains+interceptor drains+treatment
Capital cost (Rs.)	34 Cr.	32 Cr.	18 Cr.	10 Cr.
O&M cost (Rs./year)	74 lakhs	116 lakhs	80 lakhs	67 lakhs
Per capita cost (for current population) (Rs.)	7,139	6,346	3,808	1,904
Land requirement	Requires land mostly for treatment plants	Requires land for treatment plant that is in the property itself. So there is no requirement of acquiring additional land	Requires land five different land parcels in a decentralized manner	Requires land mostly for treatment plants and interceptor drains
Reuse potential	Does not include reuse potential	Minimal reuse in individual bungalows	Reuse potential in MIDC by a additional pumping system	Reuse potential in MIDC by a additional pumping system
Labour and excavation requirement	Higher requirement of labour and increased excavation costs for implementation	Increased costs linked with modification of plumbing	Comparatively lower cost of excavation than conventional due to lower depths	Quantity of land to be excavated for interceptor drains is very less
Complexity	More chances of failure- several cases of unsuccessful projects	Less complex, requires basic skills to construct, manage and operate	Less complex, requires basic skills to construct, manage and operate	Less complex, requires basic skills to construct, manage and operate
Relation with the existing system	Requires a lot of modifications to the existing system	Capitalizes on the existing management system	Requires a lot of modifications to the existing system	Capitalizes on the existing management system
Acceptability	As the modification required in the field of user interface are minimum, acceptability is high	High requirement of modifications in user interface decreases its acceptability	Areas in the vicinity of decentralized plants can oppose reducing its acceptability	Would not face many problems in terms of acceptability as cooperation would only be required for closing of drains

Performance indicator scale- High  Low

THANK YOU