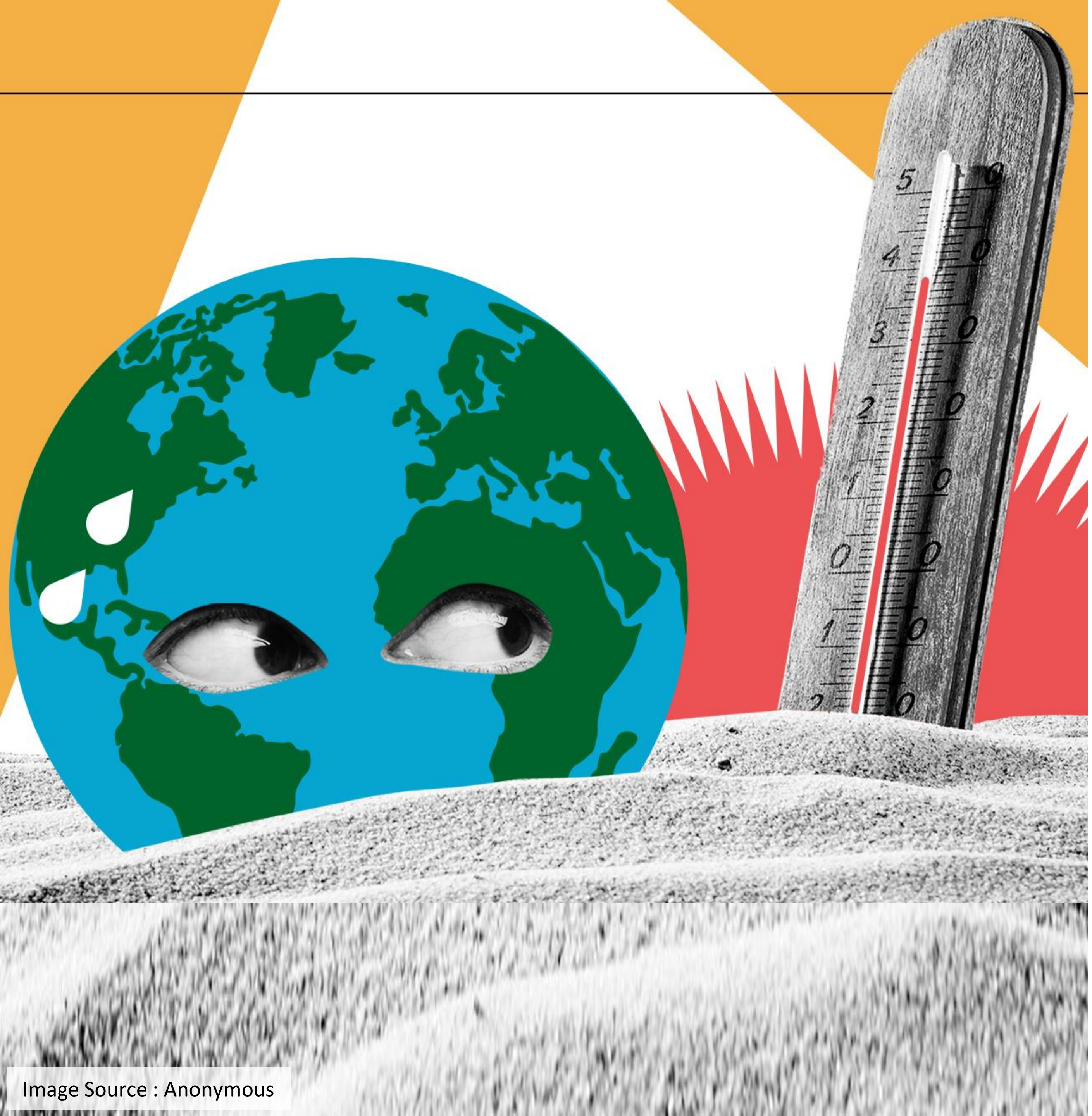

Image Source : Anonymous

Climate Resilient Cities in Context of Urban Water and Sanitation

Sakshi Darak | PUI20299

Master's in Urban Infrastructure
Directed Research Project – 2022

Guides: Upasana Yadav | Dhwani Sheth

CWAS CENTER FOR WATER AND SANITATION | CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION | CEPT UNIVERSITY

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Definitions

Climate Change:
Long term shifts in temperatures and weather patterns which may be due to natural internal processes or external forcing's, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Leads to

Hazard:
The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.

Vulnerability:
The propensity or predisposition to be adversely affected.

Disaster Risk:
The likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response.

Could be combated by

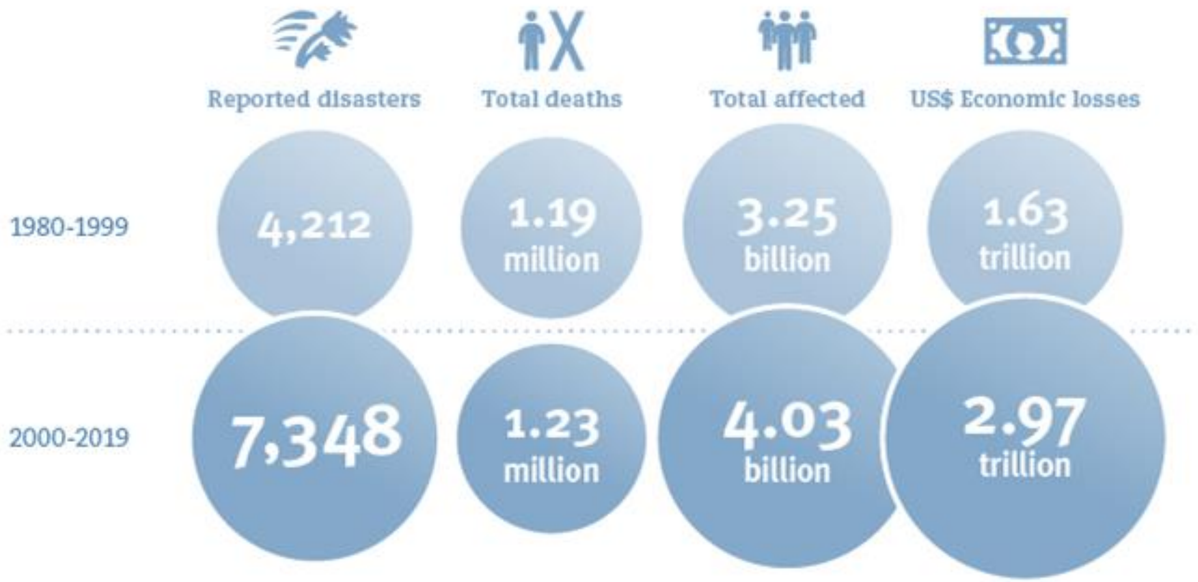
Resilience:
Resilience is the ability and capacity of systems and society to cope with hazardous events and bounce back to normal/ baseline

Climate Resilience:
Climate resilience is the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate

Source : IPCC Glossary, 2012; United Nations Climate Action

According to IPCC's fifth synthesis report, human influence on the climate system is clear and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.

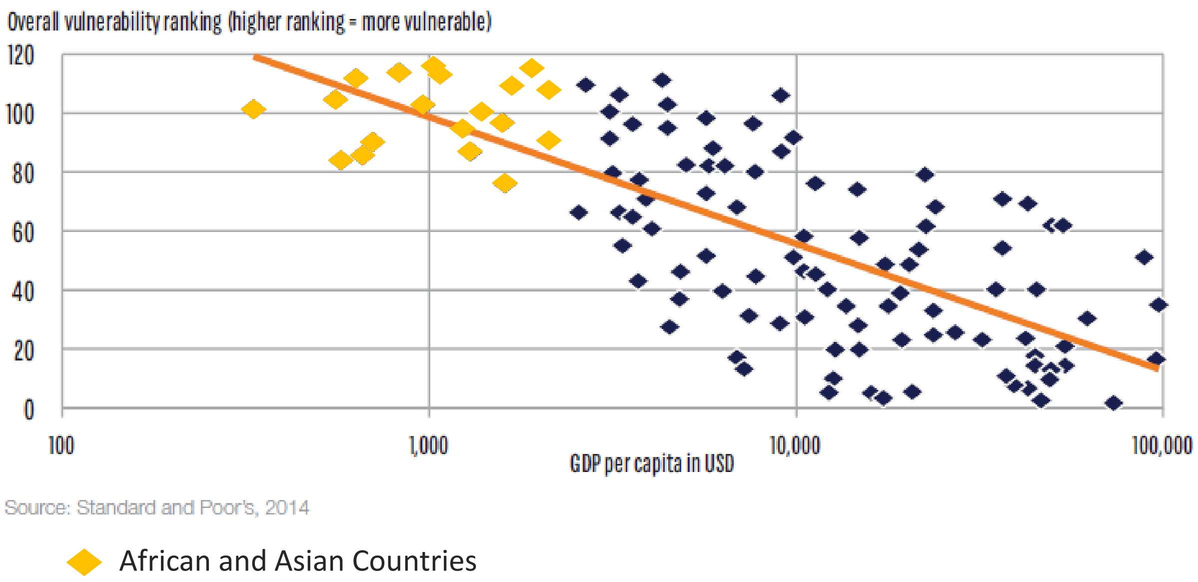
Comparative Analysis of reported disasters in last two decades



87% of these reported disasters are climate related disasters

74% of economic losses are caused by climate related disasters

Vulnerability ranking v/s GDP per capita (USD)



Source : Climate Change 2014, Synthesis Report, IPCC; Human Costs of Disaster: An overview of the last 20 years (2000-2019), UNDRR, 2020

History of Climate Change across the World

1972 — **First UN environment conference in Stockholm.** Climate change hardly registered on the agenda

1990 — **IPCC produces First Assessment Report.** It concluded that temperatures have risen by 0.3-0.6C over the last century

1997 — **Kyoto Protocol agreed.** Developed nations pledge to reduce emissions by an average of 5% by the period 2008-12

2000 — **Millennium Development goals (MGDs)** were launched

2010 — **Copenhagen Accord** Developed countries promised to provide $30bn for the period 2010-2012

2015 — **COP 21: Historical Paris Agreement Adopted**

2016 — **Sustainable Development Goals (SDGs)** were launched

2018 — **IPCC confirms the importance of 1.5 degree Celsius goal.** Governments adopt a robust set of guidelines for implementing the landmark 2015 Paris Climate Change Agreement: 'Katowice Climate Package'

2021 — **COP 26: Glasgow Climate Pact** – further cuts down carbon emissions, an explicit plan to reduce use of coal and a prospect of a trillion dollar a year fund to developing countries from 2025

Despite numerous actions been taken at international level, **their impacts are very low**.

Carbon levels in the air have kept on increasing in spite of so many agreements

Even after setting up targets in Paris agreement, South Africa faced **day zero**, South Korea, Nigeria, Japan and India experienced **flooding** because of heavy rains in 2018.

Source : https://unfccc.int/timeline/ ; https://www.bbc.com/news/science-environment-15874560

Actions taken by India to Combat Climate Change

Despite all the policy and project based efforts and reduction in emissions, India has still faced **numerous floods due to heavy rainfall** in Kerela (2018), Assam (2020) and Maharashtra (2021)

A severe drought hit southern India during 2016-2018 which was the **worst drought** to hit the region **in over the past 150 years**.

2003

- **National Clean Development Mechanism (CDM) Project Approval Authority under Kyoto Protocol's 'flexibility mechanisms'** - Setting up of **Indian Renewable Energy Development Authority.**
- **"Coal Cess"** - a form of carbon tax at the rate of Rs 50 per ton on domestic and imported coal.

2008

National Action Plan on Climate Change (NAPCC) was launched and its implementation would take place through eight National Missions.

2010

In the COP 15 meeting in Copenhagen, **India voluntarily offered to reduce the emissions intensity of its GDP by 20–25%** by 2020 compared to 2005 levels.

2015

Swacch Bharat Mission was launched

2016

Signed Paris Agreement and agreed to reduce the GHG emissions by 33-35%

2018

2020

2021

- **Jal Shakti Abhiyan**
- **AMRUT 2.0**
- India made an **announcement of new climate action targets at the COP-26 summit in Glasgow**.

Policy Level (2003–2015)

Project specific/ Action based (2015–2021)

Source : Shifting discourses of climate change in India, 2014; India's Progress in Combating Climate Change, 2014; https://www.downtoearth.org.in/news/climate-change/india-s-national-action-plan-on-climate-change-needs-desperate-repair-61884; https://www.ideasforindia.in/topics/environment/the-clean-development-mechanism-in-india-is-it-working.html;

SDG 6 on clean water and sanitation and SDG 13 on climate change are inextricably linked

SDG 6: Ensure availability and sustainable management of water and sanitation for all

SDG 13: Take urgent action to combat climate change and its impacts

- **Climate change is water change**. Climate change is often discussed in terms of carbon emissions, but people feel the impacts largely through water.
- **Rising temperatures** mean increasingly **severe floods, droughts** and unpredictable weather patterns across the world, **damaging water supplies and sanitation services**.
- **Climate change impacts have direct consequences for water security and conflict.**
- SDG 13 calls for 'urgent action to combat climate change and its impacts'. **Both the Paris Agreement on climate change and the 2030 Agenda require each country to increase the resilience of development interventions, including WASH**.
- Universal access to WASH increases water availability in times of scarcity, which provides the supplies for basic living needs to ensure food, health and livelihoods. **Water is therefore a key ingredient in helping communities adapt to climate change**.

Improved safe water supply + decent sanitation and hygiene →

Reduce the overall disease burden on **poor and marginalized communities**, so they are better able to **cope with other impacts of climate change.**

Source : Water Aid; International Union for Conservation of Nature (IUCN)

Aim and Objectives

Aim:

This study aims at identifying the implications of climate change and preparation of climate action plan from urban water and wastewater perspective for an Indian case city.

Objectives:

1. To identify the implications of climate change on urban water and wastewater systems through review of programmes and case studies at national and international level.
2. To prepare a climate action plan from urban water and wastewater perspective – A case of Solapur city.

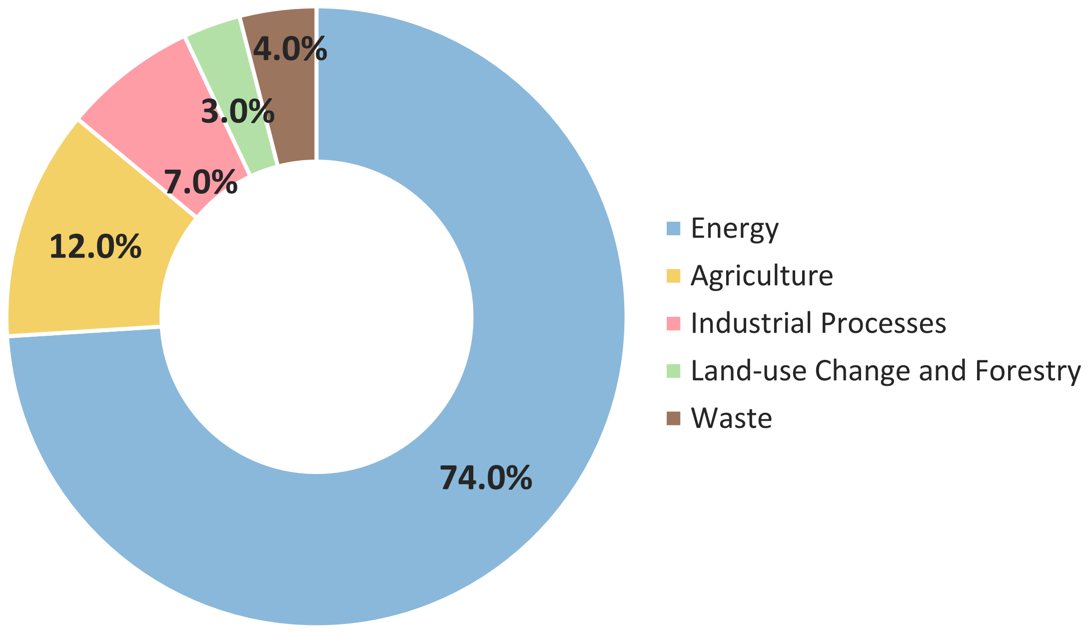
Limitations:

1. This study is limited to water and wastewater sector and does not include the implications of climate change on solid waste and hygiene part of WASH sector.
2. It is limited to Indian context and is subjected to replicability only in the urban areas with similar population, area, topography, climatology and geology.

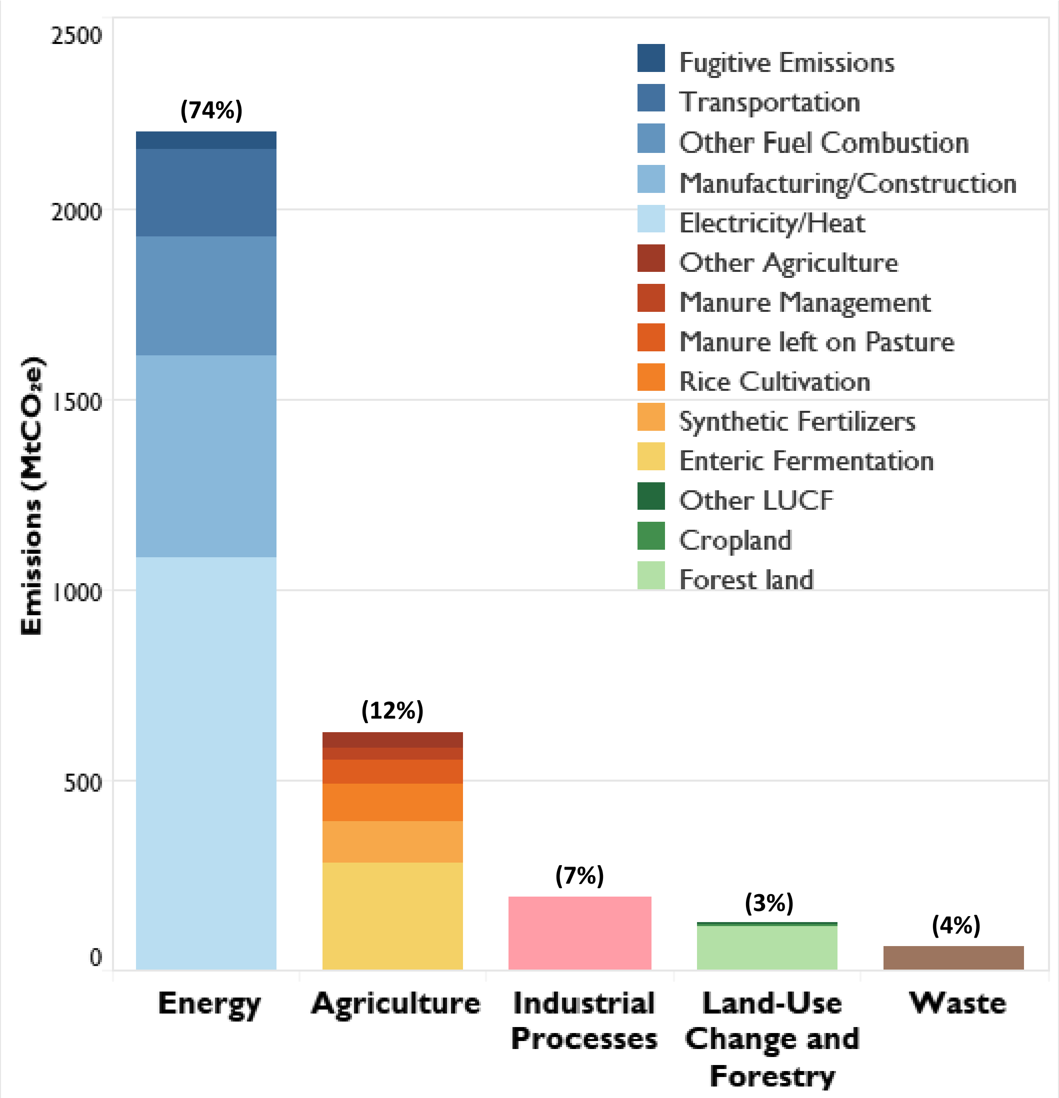
Sector Wise GHG Emissions in India

- Anthropogenic greenhouse gas emissions since the pre-industrial era which are higher than ever now are extremely likely to have been the dominant cause of the observed warming since the mid-20th century.
- These **GHG emissions are the most important reason for Climate Change in India**.

Sector Wise GHG Emissions in India, 2015



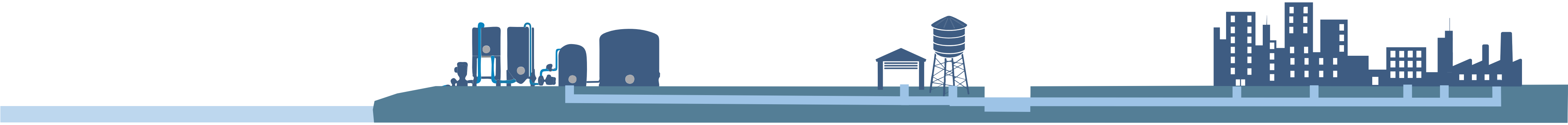
Sub-Sector Wise GHG Emissions in India, 2015 ($MtCO_2e$)



Waste Sector contributes to 4% of India's GHG emissions (2016) which is 75,232 $GgCO_2e$

Source : Greenhouse Gas Emissions in India, 2014; http://www.ghgplatform-india.org/

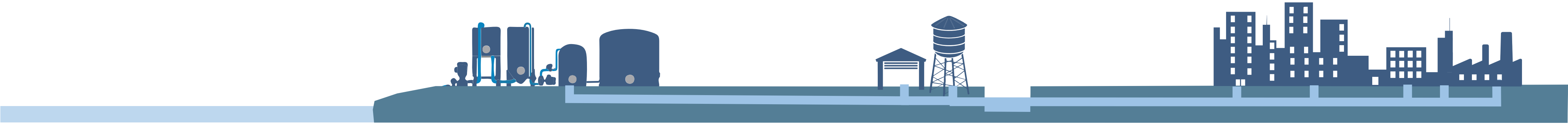
Impacts on Water Supply Services



	Water Source	Water Treatment	Water Distribution	User End
Rising sea levels	**Saltwater intrusion affects the quality of water at source** as high salts get dissolved in to water	**Infrastructure corrosion** **Consumption halted** when salt levels in the water distributed reach a certain threshold and the water is no longer suitable for drinking.		
Urban Flooding and Cyclone	**Pollution of surface water then groundwater** (after infiltration) as pollutants leach into the soil. **Latrine pits are flooded**, and **higher volumes of wastewater are discharged untreated**. **Poor infiltration of rainfall during intense rainfall events.**	**Facilities are weakened, less efficient and damaged**: flooded wells, silting, flooded electrical equipment, erosion of facilities, weakened and burst pipes causing network leakages, etc. **Water reservoirs are weakened** after having been placed under too much pressure and stress.		**Service interruptions** due to damaged facilities. **Water points** are inaccessible (landslides – floods). **Drop in the quality of water distributed** due to greater pollution and higher turbidity of water resources caused by soil leaching and flooded sanitation facilities.

Source : WASH Services and Climate change – Impacts and Responses, pS-Eau, 2018

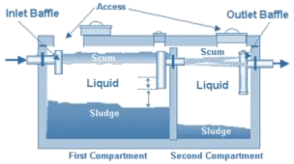
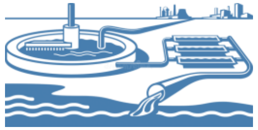
Impacts on Water Supply Services



	Water Source	Water Treatment / Water Distribution	User End
Heatwaves and Droughts	**Lack of surface water and groundwater** at the end of the dry season **Reduced river flows**, particularly in low-water periods **Higher concentrations of various pollutants** in the water due to poor dilution **Decreased groundwater recharge** Algae blooms that disrupt water bodies natural processes **Increased salinity**	**Increase in water needs and in volumes withdrawn** for all uses, **facilities are over-used during droughts** to meet high demand; dry pumping can **damage pumps**; **concrete can crack** during heatwaves	**Interrupted or temporarily reduced services** due to lack of available water resources. **Drop in the quality of water distributed** as the raw water, which has high concentrations of pathogens, physicochemical pollutants, salt, etc., is difficult to treat.

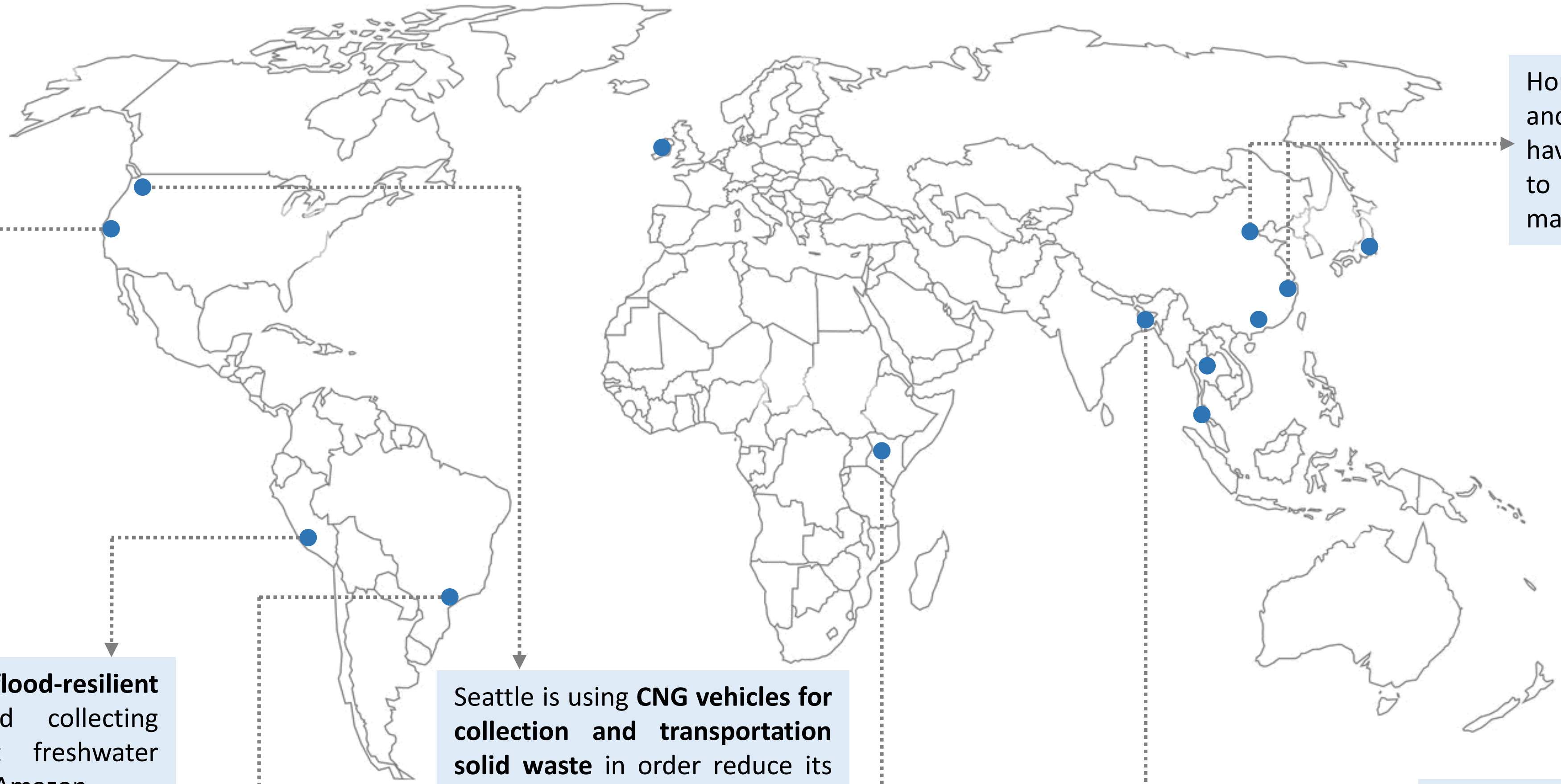
Source : WASH Services and Climate change – Impacts and Responses, pS-Eau, 2018

Impacts on Sanitation Services

	User Interface	Collected and Storage	Transportation	Treatment	Disposal/ Reuse
					
 Heatwaves and Droughts	**Problems with usage of flush latrines because of unavailability of sufficient water** to flush or clean the latrine. **Choking of sewer systems** because of insufficient water	**Olfactory pollution** due to increased nitrous oxide emissions (N_2O). Hydrogen sulphide (H_2S) production is exacerbated by the heat increasing the **risk to staff of poisoning through H_2S inhalation**, especially sewer workers.		**Biological treatment processes fail to function.** **Condition of infrastructure and facilities deteriorate** for instance, concrete structures deteriorate due to the increased production of hydrogen Sulphide	**The wastewater discharged is not properly treated and there is a lower dilution of pollutants** resulting in: **A drop in water resource quality** and **disruptions to ecosystems and biodiversity**
 Rising sea levels, Urban Flooding and Cyclone	**Collapse of latrines** that are not built to recognized standards.	**People no longer have working sanitation facilities available**, as these have been destroyed. **Increase in waterborne diseases**	**Pit emptying services are disrupted** (some areas become inaccessible) **Flooding leads to breakdowns** of pumps and electrical systems.	**Treatment processes fail to function correctly** due to hydraulic overload.	**Increase in untreated wastewater discharged into the environment**

Source : WASH Services and Climate change – Impacts and Responses, pS-Eau, 2018

International Case Studies – Actions in WASH to combat climate change



Hong Kong, Shanghai, Beijing and many other cities in China have developed **sponge cities** to reduce urban flooding and manage storm water

Berkley developed **storm water drains in form of green infrastructure** using infrastructure bond as financing tool

Peru is constructing **flood-resilient ECOSAN latrines** and collecting rainwater to protect freshwater sources in the Peruvian Amazon

Seattle is using **CNG vehicles for collection and transportation solid waste** in order reduce its GHG emissions

Tokyo, Singapore, Bangkok, Sao Paulo, Dublin and many other cities have **successfully reduced their NRWs by network refurbishment, water metering, innovative technology and PBCs**.

Uganda is using **Solar powered water supply** for drought-prone communities to address future impacts of climate change

Bangladesh is creating **safe underground water stores using Managed Aquifer Recharge (MAR)**

Fiji is rolling out the **Drinking Water Safety Planning (DWSP) approach** to safeguard vulnerable island water supplies from the impacts of climate change

Source : WASH Climate Resilience: A Compendium of Case Studies; Chennai Resilience Strategy

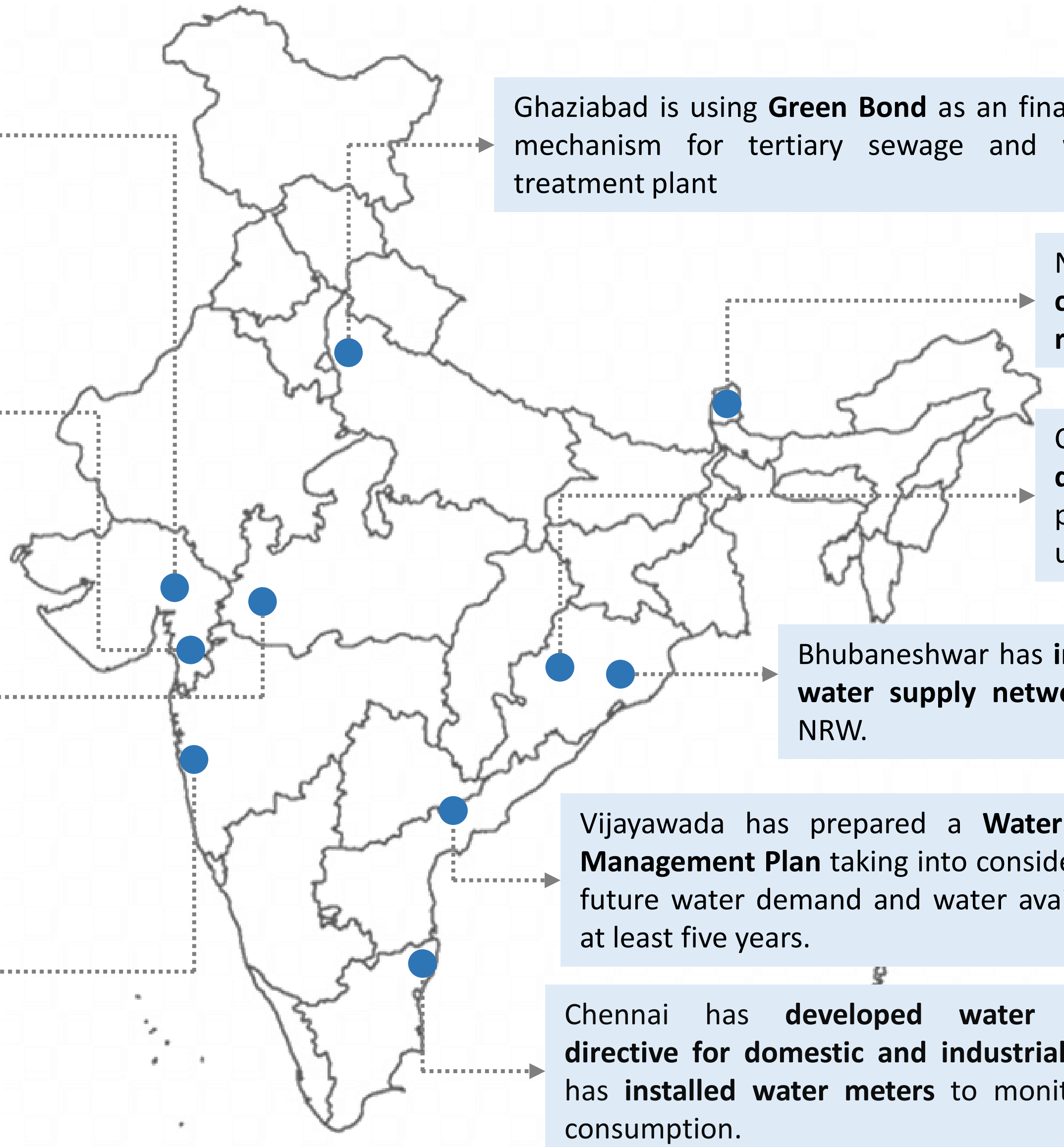
National Case Studies – Actions in WASH to combat climate change

Ahmedabad has conducted the **energy audit** and the potential energy saving and cost saving has been highlighted with possible measures.

Surat has established a **NRW cell** to take up dedicated actions such as leakage mapping, 24x7 water supply with 100% metering, etc. Also developed an **action plan which promotes the reuse of treated sewage** for different non-domestic purposes.

Indore has **replaced the traditional electromechanical equipment of the existing wastewater management system with a solar energy system** that has helped in 22% reduction in the energy consumption.

Mumbai is aiming towards **localized water conservation and improving availability and accessibility to water and toilets** in its climate action plan



Ghaziabad is using **Green Bond** as an financing mechanism for tertiary sewage and water treatment plant

Namchi has implemented **a strategy for water conservation & reuse using co-polymer based rain water harvesting technology.**

Cuttack has prepared an **integrated city level disaster management plan** which is a preparedness and response plan to combat urban flooding.

Bhubaneshwar has **improved and expanded its water supply network** efficiency for reducing NRW.

Vijayawada has prepared a **Water Resource Management Plan** taking into consideration the future water demand and water availability for at least five years.

Chennai has **developed water recycling directive for domestic and industrial use** and has **installed water meters** to monitor water consumption.

Source : CSCAF 2.0 Cities Readiness Report, 2021; Chennai Resilient Strategy; Surat Resilient Strategy; Mumbai Climate Action Plan, 2022; Pune Climate Action Plan, 2019

Learnings from Literature Review and Case Studies

Smaller, cost effective and easily implementable solutions can create larger impacts in adaptation to climate change

Higher dependency on **renewable energy sources** and **tapping local water resources** can make the water and wastewater sector in urban areas more capable to adapt to climate change.

Grey green infrastructure approach using **nature-based solutions** is the way ahead. These solutions not only help in adapting to current impact of climate change but also mitigate the future possibilities of impacts.

Presence of a full proof **monitoring and feedback mechanism** leads to better and easier implementation of climate adaptation/ mitigation strategies

Though numerous cities have undertaken innovative initiatives to combat climate change, but a **lot more needs to be done in water and wastewater sector**, since water is the key ingredient in helping communities adapt to climate change.

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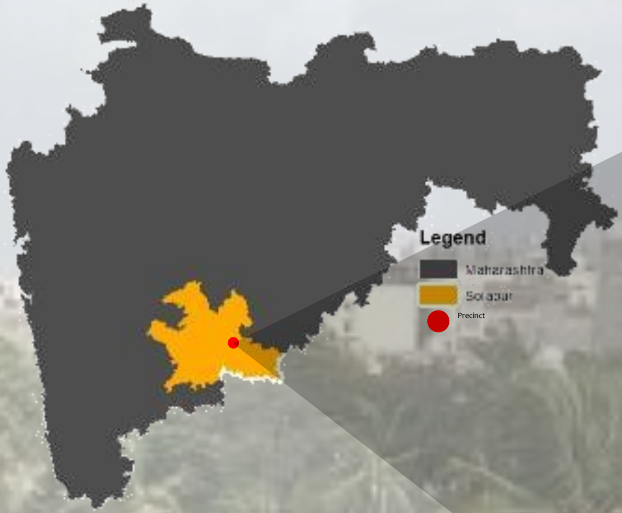
About Solapur



9.51 lakh
Population (census 2011)

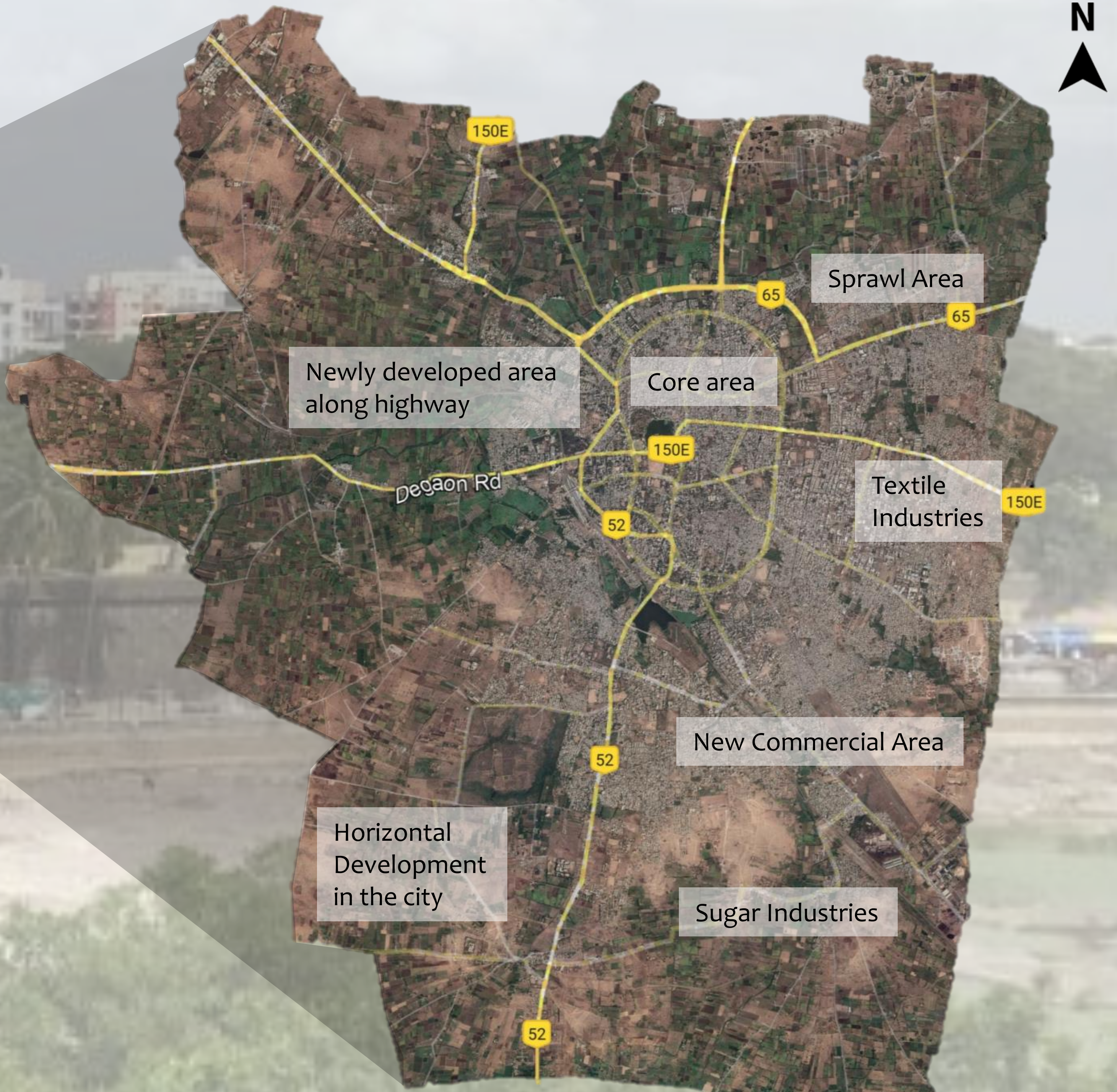
12.2 lakh
Population (2019-20)

178.6 sq. km
Area

Solapur Municipal Corporation
Administrative Body

Hot and Dry
Climate

524 mm
Average Annual Rainfall



Source : Primary Survey, Solapur Municipal Corporation, 2022; PAS local action indicators, 2019-20

Solapur has been one of the drought prone regions in Maharashtra since last 30 years

Drought hits Maha, Solapur worst affected

976 tankers pressed into service in Pune region, state government starts 286 cattle feeding camps

PUNE | Updated: May 28, 2019 17:03 IST

HT Correspondent
Hindustan Times, Pune

Poor rain in Solapur a cause for concern: CM Devendra Fadnavis

Nisha Nambiar | TNN | Updated: Oct 21, 2018, 21:51 IST

A- A+

PUNE: Maharashtra chief minister Devendra Fadnavis on Sunday expressed concern over the drought-like situation in Solapur during his visit.

The chief minister has urged the government machinery to ensure proper coordination to

Solapur: 12,000 wells and ponds to be used only for drinking water purposes

No commercial, agricultural activity allowed; decision hopes to tackle water scarcity.

Written by Shubhangi Khapre | Mumbai | March 7, 2016 3:23:32 am

In a policy shift to tackle drought, greater emphasis is being laid on requisitioning existing water structures for public utility with strict ban on using the water for commercial and agriculture activities in chronic villages facing water scarcity. It means a total ban on allowing digging of new wells in the drought-hit villages.

In Solapur, district collector Tukaram Mundhe has evolved a new model to beat the drought. To begin with, he has declared 12,000 water structures including rig wells, tube wells and ponds for solely drinking water purpose for the public. It is almost double compared to 6,400 acquired last year.

The decision comes with a rider that none of these water structures would be allowed for commercial activities or even agriculture beyond one km. In every

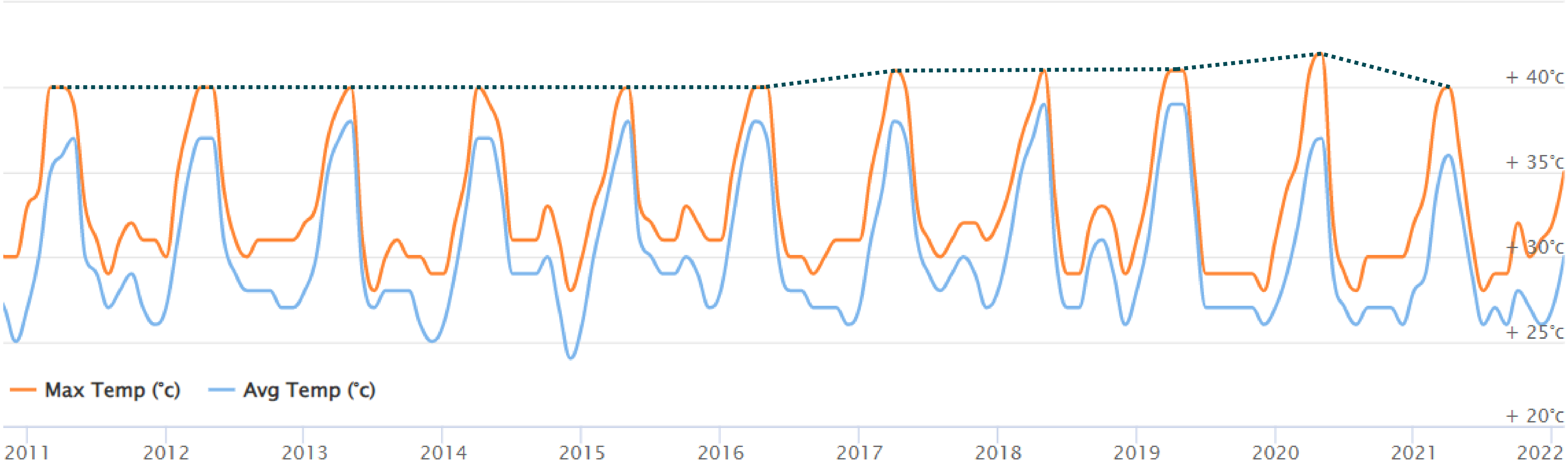
POLITICS | 13-minute read | 25-04-2016

DAILYO @dailyo_

Source : https://www.worldweatheronline.com/solapur-weather-averages/maharashtra/in.aspx

But in past decade, these droughts have intensified and additionally problems like heatwaves and reduced rainfall have emerged

Maximum and Average Temperature (2011-2021)

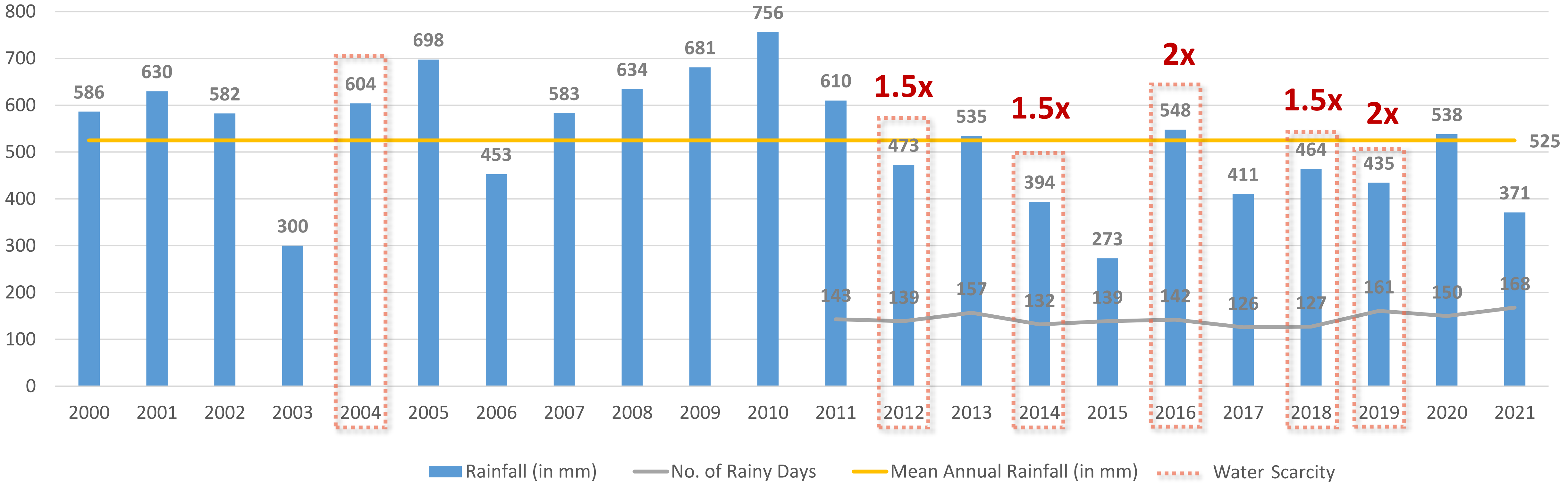


Temperature has increased by 1.2ºC in past decade and summers are becoming warmer.

Source : https://www.worldweatheronline.com/solapur-weather-averages/maharashtra/in.aspx

But in past decade, these droughts have intensified and additionally problems like heatwaves and reduced rainfall have emerged

Intensity of Rainfall and number of rainy days (2011-2021)



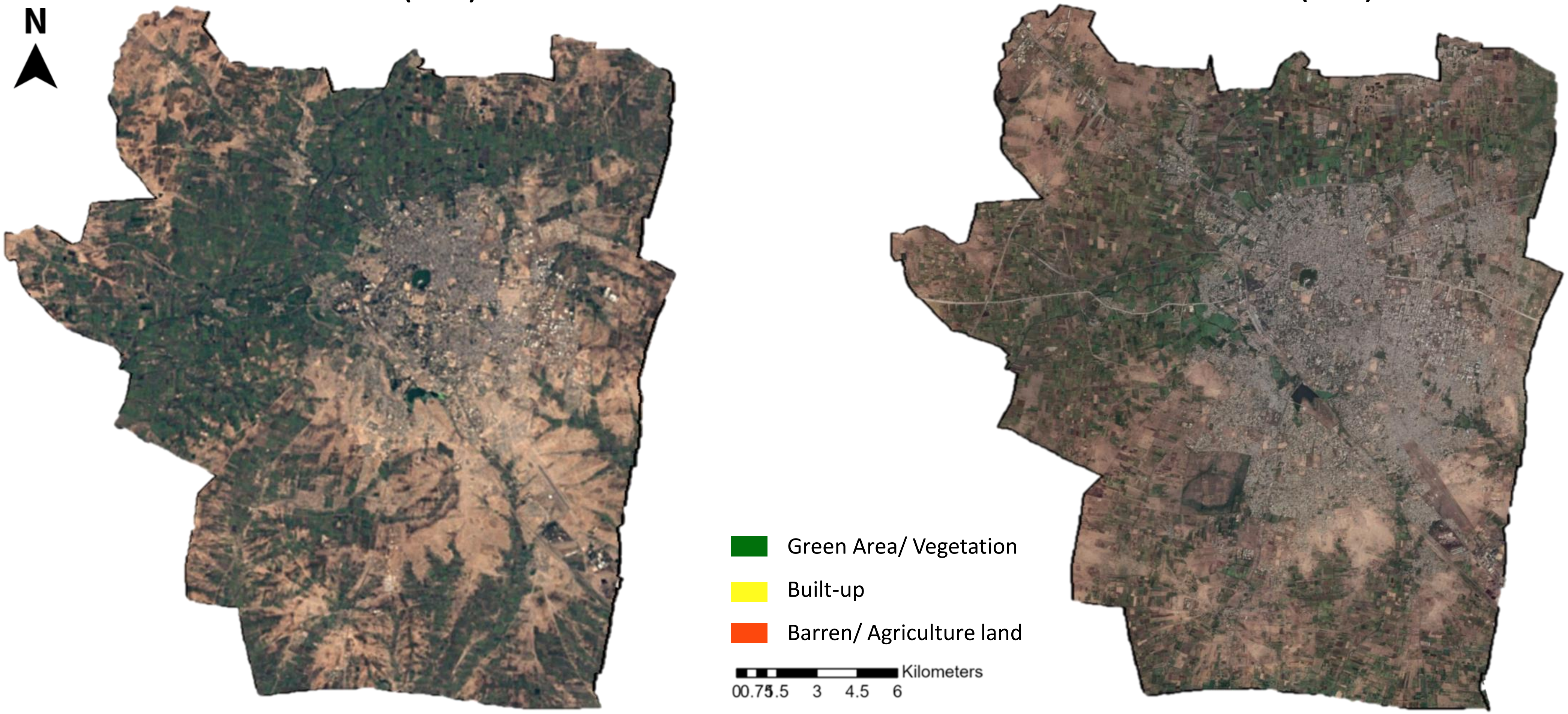
Intensity of rainfall is observed to be **less than the mean annual rainfall in the recent years.** This leads to **water scarcity in the city.**

In case of water Scarcity, **extra water is taken from Bhima river.** This especially done in the months of **may to July. In last 20 years, it has been done 6 times**

Source : https://solapur.gov.in/en/rainfall/; https://www.worldweatheronline.com/solapur-weather-averages/maharashtra/in.aspx; Primary Survey, Solapur Municipal Corporation, 2022

Green cover in the city has decreased by 4.2% in last 2 decades

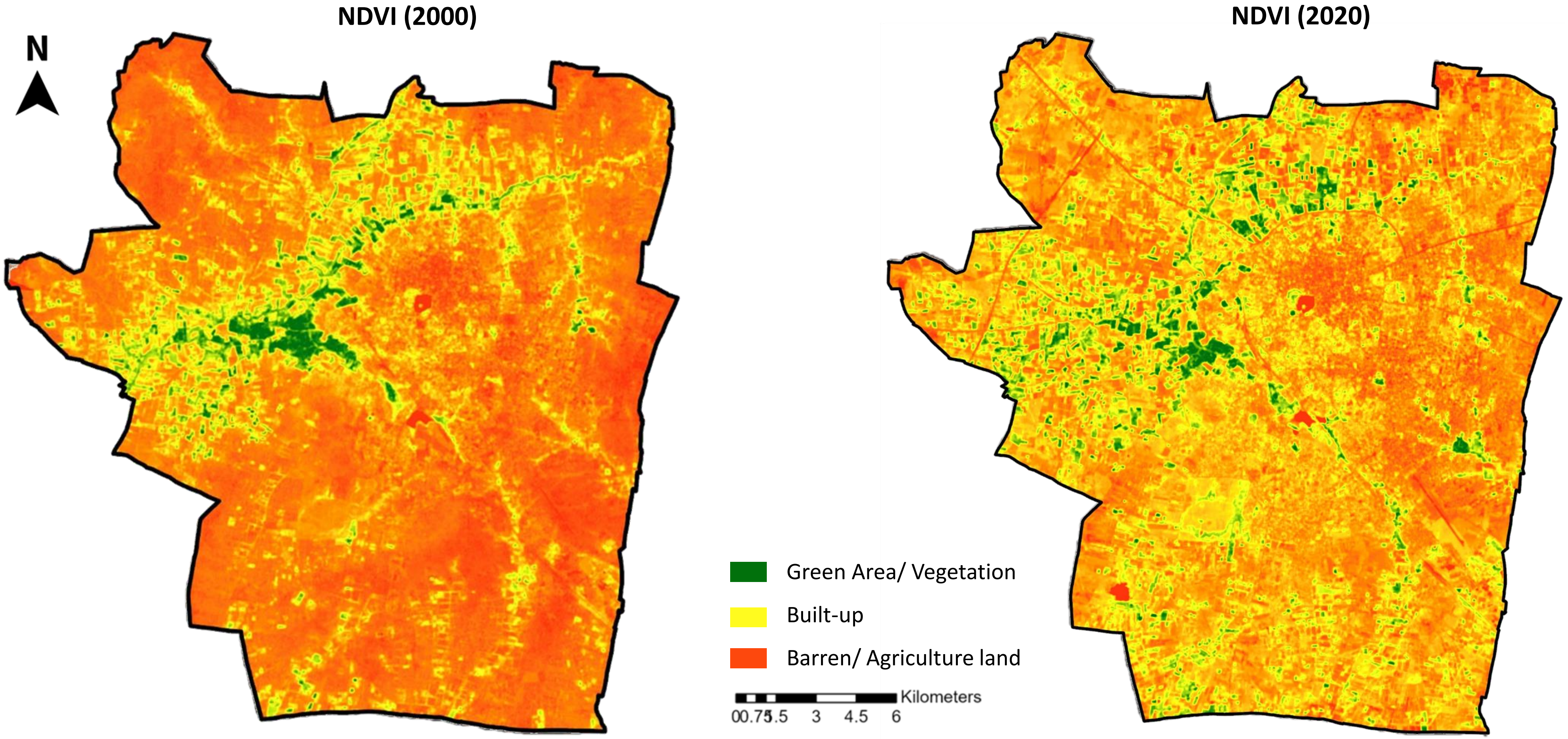
NDVI (2000) NDVI (2020)



Amount of green cover and vegetation as well as barren land in Solapur has decreased over years.

Source : United States Geological Survey (USGS) Imagery, 2000 & 2020

Green cover in the city has decreased by 4.2% in last 2 decades

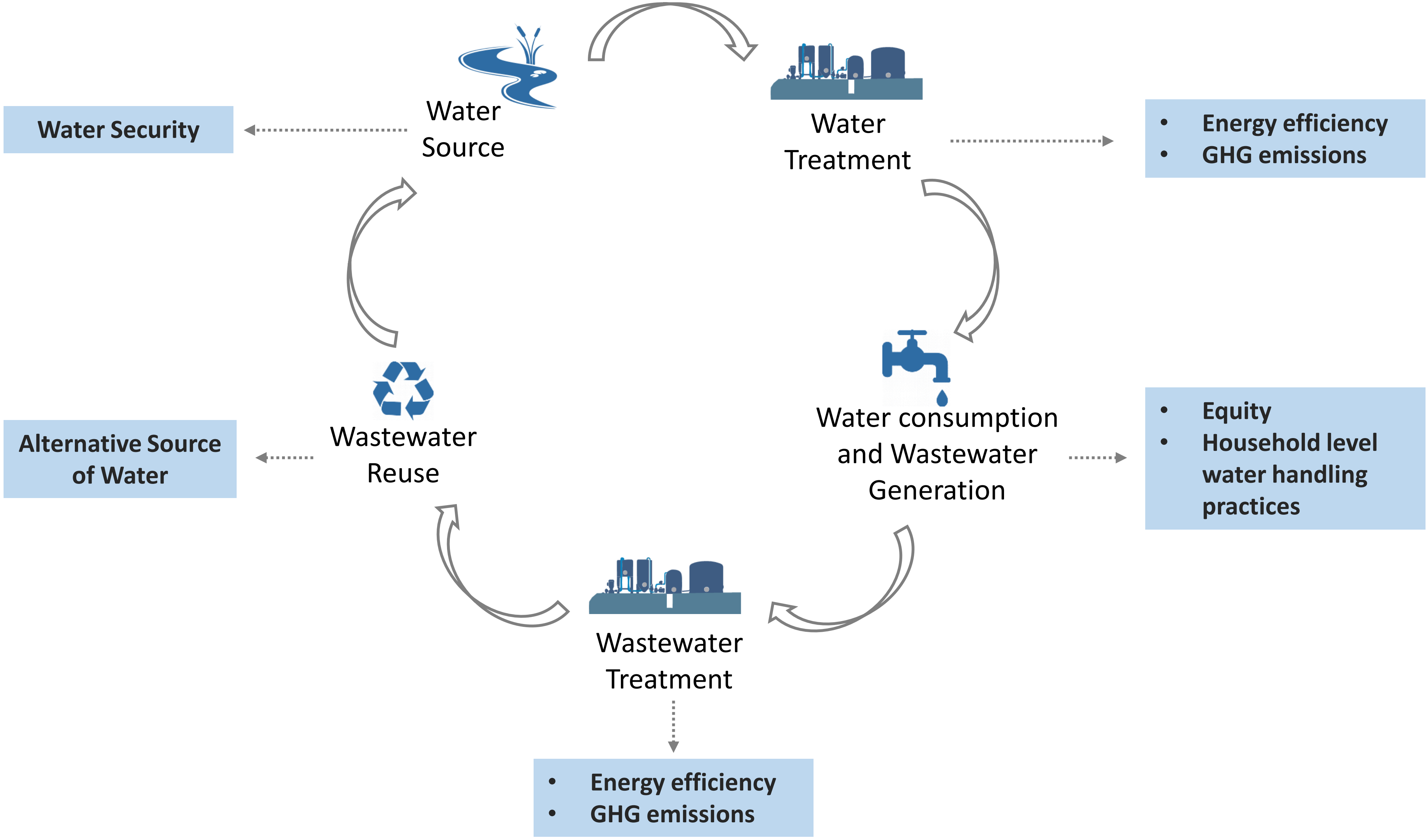


Amount of green cover and vegetation as well as barren land in Solapur has decreased over years.

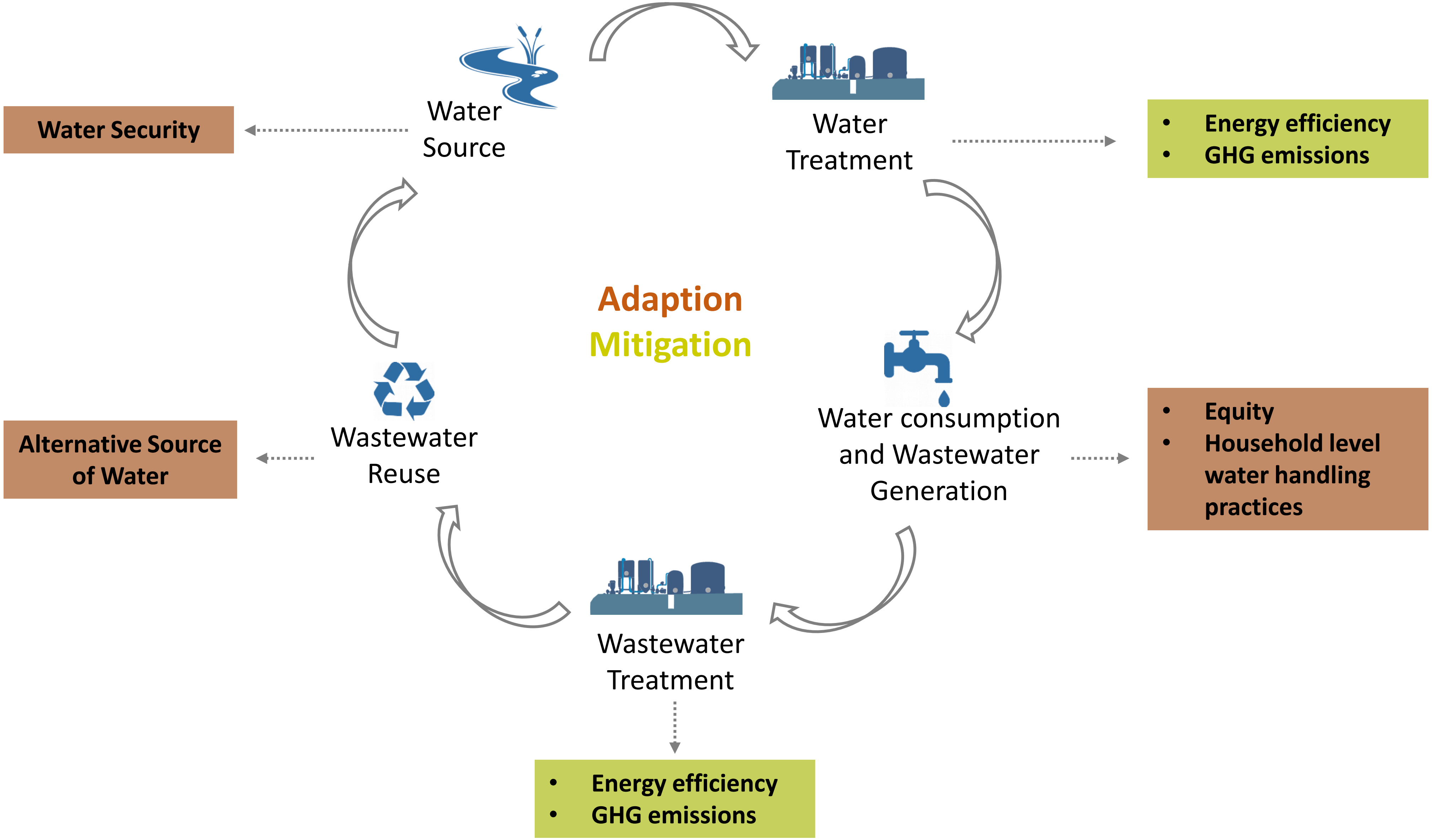
Increase in temperature and decrease in rainfall and green cover, proves that **climate change has intensified the drought condition in Solapur and is leading to increased water scarcity.**

Source : United States Geological Survey (USGS) Imagery, 2000 & 2020

City Assessment in context of Climate Change and WASH



City Assessment in context of Climate Change and WASH



Water Supply in Solapur

Surface Water → **Bhima River**, **Ujjani Dam Reservoir**, **Ekrukh Pond**

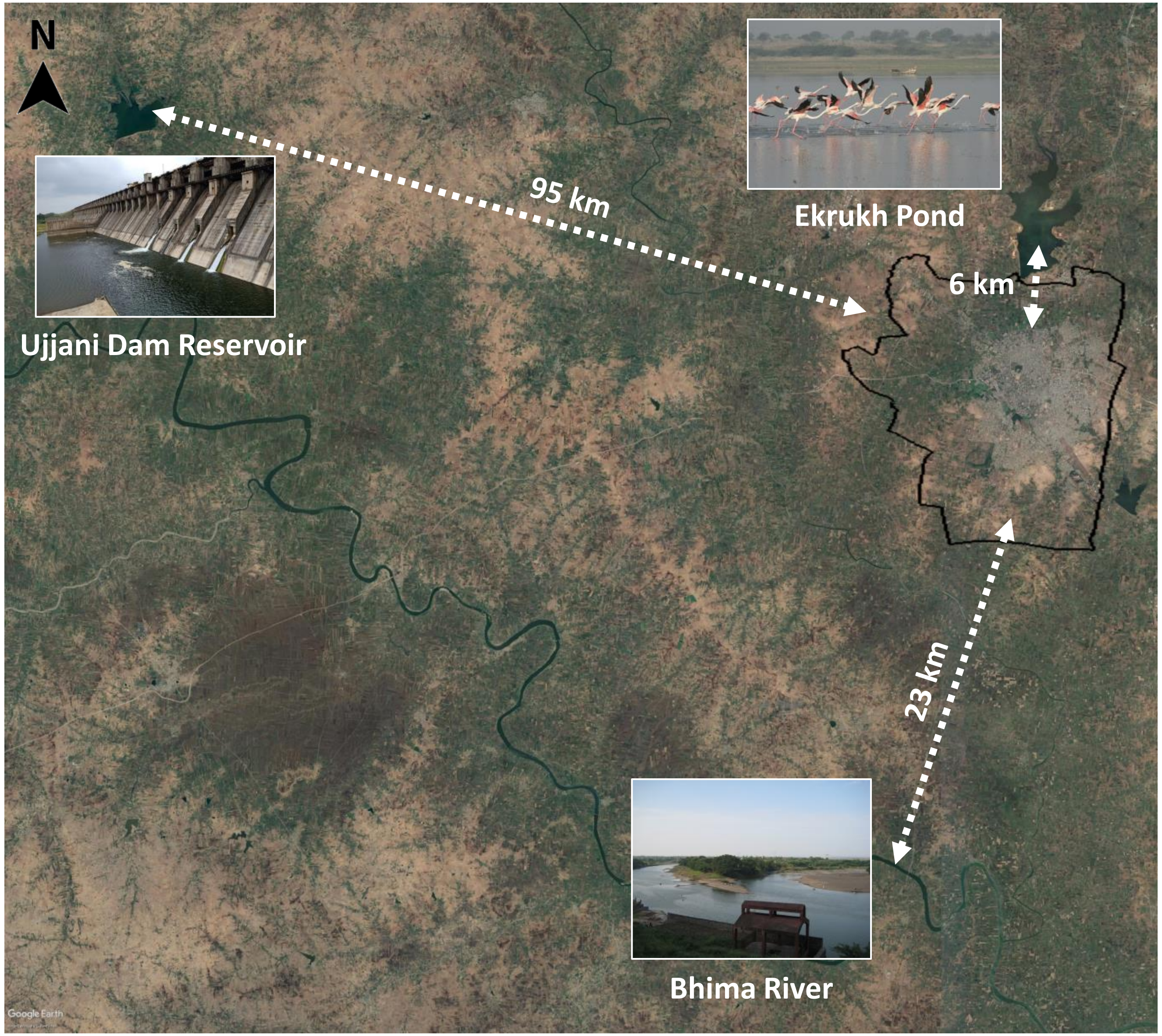
Groundwater → **Borewells**, **Water Tankers**

73%
Water Supply Connection Coverage

81 lpcd
Per capita supply at user end

Once in **4** days
Frequency of Water Supply

1.5 – 3 hrs
Duration of water supply



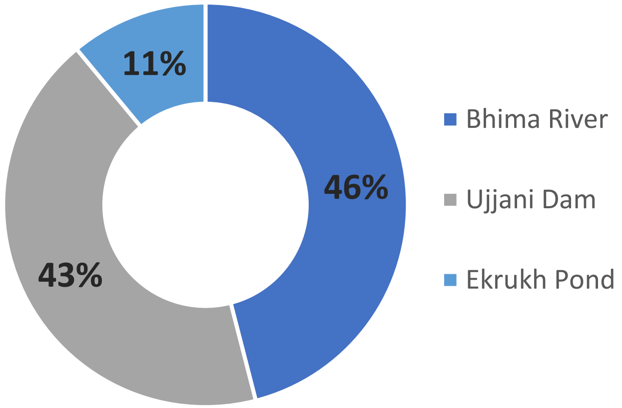
Source : Primary Survey, Solapur Municipal Corporation, 2022; PAS local action indicators, 2019-20

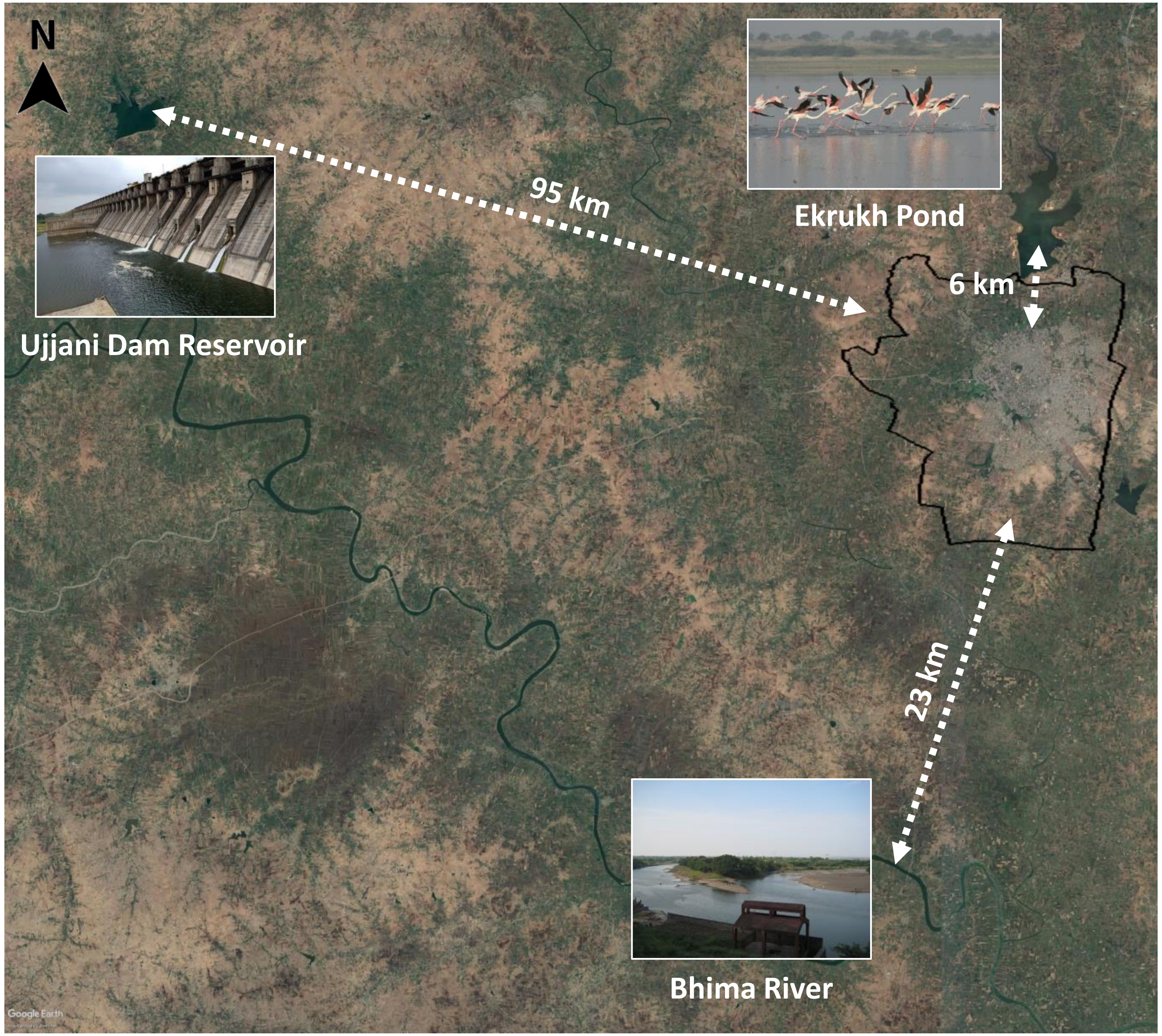
Water Supply in Solapur

Surface Water → **Bhima River**, **Ujjani Dam Reservoir**, **Ekrukh Pond**

Groundwater → **Borewells**, **Water Tankers**

Quantity of Water drawn from each Source



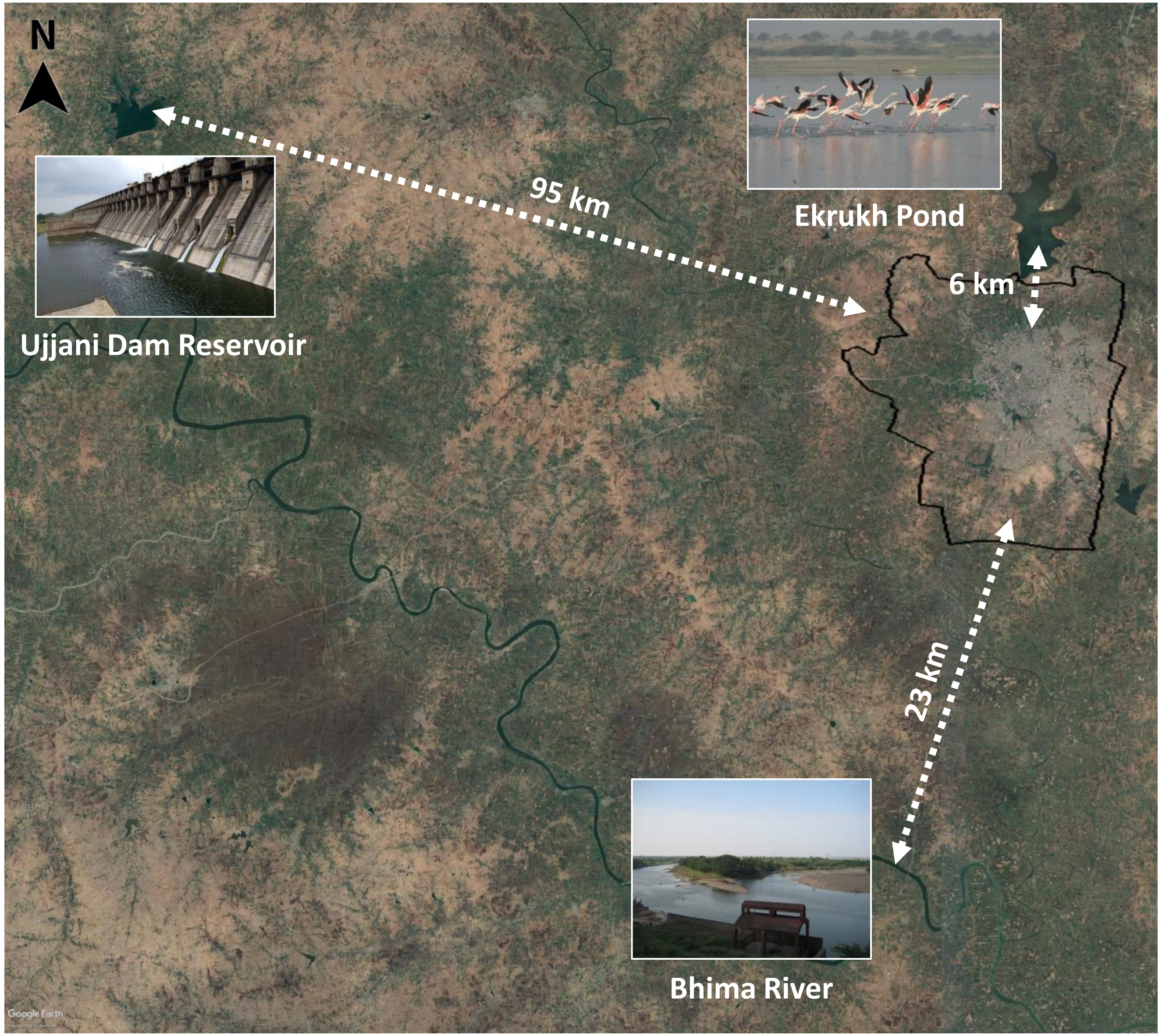


Source : Primary Survey, Solapur Municipal Corporation, 2022; PAS local action indicators, 2019-20

Water Supply in Solapur

Surface Water → Bhima River, Ujjani Dam Reservoir, Ekrukh Pond

Groundwater → Borewells, Water Tankers



Issues with the Water Source

5 water scarcity events have happened **in past decade** when, extra water is withdrawn from Bhima river.

45%
Non-Revenue Water

Source : Primary Survey, Solapur Municipal Corporation, 2022; PAS local action indicators, 2019-20

Sources of Water - Borewells

Bhima River

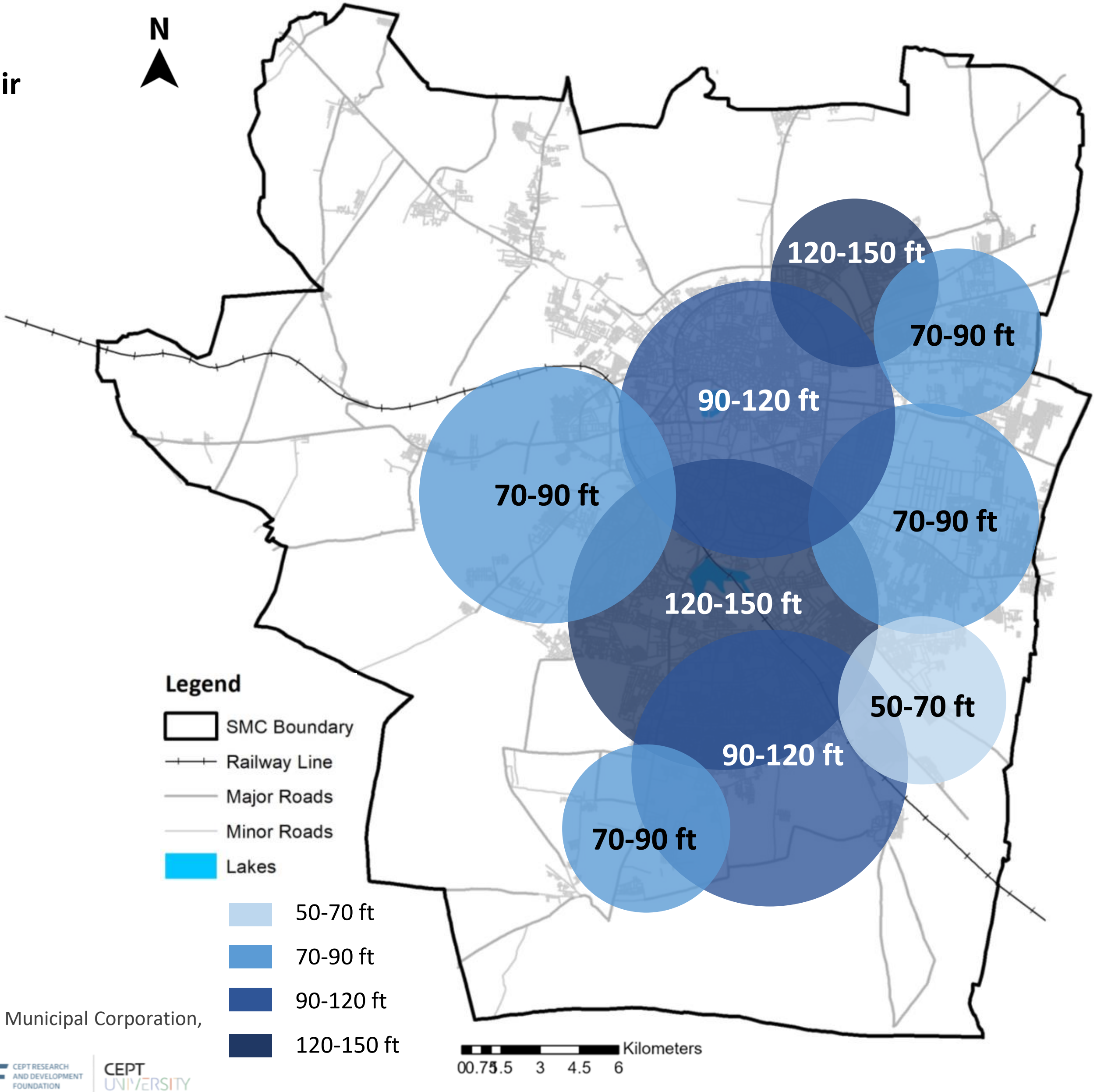
Ujjani Dam Reservoir

Ekrukh Pond

Borewells

Water Tankers

Depths of Public Borewells



Source : Primary Survey, Solapur Municipal Corporation, 2022

4,444
borewells in the city

109 Public Borewells

391 Subsidized Borewells

3,944 Private Borewells

70-150 ft Depth of Public borewells

140-500 ft Depth of Private Borewells

Issues

- In last decade, **20 ft increase in depth of borewell is observed** across the city
- **No permission** or restrictions on **setting up of private borewells**

Source of Water

Water Treatment

Wastewater Treatment

Wastewater Disposal

Sources of Water - Borewells

Bhima River

Ujjani Dam Reservoir

Ekrukh Pond

Borewells

Water Tankers

4,444
borewells in the city

109 Public Borewells

391 Subsidized Borewells

3,944 Private Borewells

70-150 ft
Depth of Public borewells

140-500 ft
Depth of Private Borewells

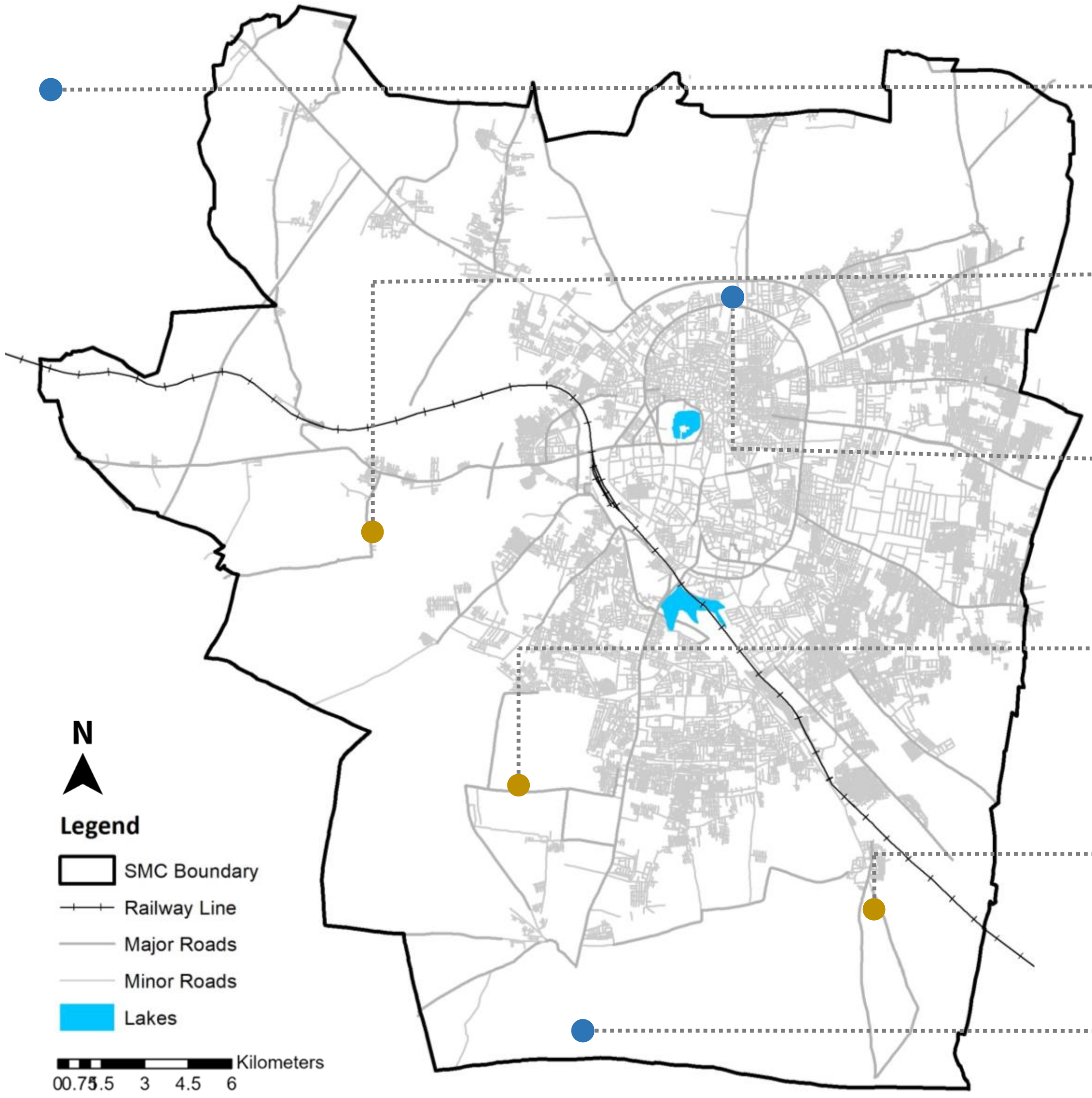
Parameters	Desirable Limit	Maximum Permissible Limit	Samples with conc. < DL	Samples with conc. in DL-MPL	Samples with conc. >MPL
TH (mg/L)	300	600	2	21	13
NO_3 (mg/L)	45	No relaxation	17	-	27
F (mg/L)	1.0	1.5	42	2	0

Quality of **groundwater in Solapur is not suitable for drinking** based on Drinking Water Standards. It is **very hard and has higher nitrate content than the desirable limit.**

Source : Groundwater information of Solapur District, CGWB, 2013

Water and Wastewater Treatment

WTP and STP Locations



Pakhni WTP
Source: **Ujjani Dam**

Degaon STP
Source: **Open Nala**
(water from zone 1 to 6)

Bhavani Peth WTP
Source: **Ekrukh Pond**

Pratap Nagar STP
Source: **Sewer Network**
(water from zone 7)

Kumte STP
Source: **Sewer Network**
(water from zone 8)

Soregaon WTP
Source: **Bhima River**

Water Production

215 MLD
Design Capacity of WTPs

185 MLD
Utilized Capacity of WTPs

Wastewater Treatment

102.5 MLD
Design Capacity of STPs

90.3 MLD
Utilized Capacity of STPs

Source : Primary Survey, Solapur Municipal Corporation, 2022; PAS local action indicators, 2019-20

Water and Wastewater Treatment


Solar panels in both WTPs and STPs

Generating 753 KW electricity daily in WTPs has led to 35% reduction in the electricity bill

Generating 1 MW electricity daily in STPs has lead to 25% reduction in electricity bill


International Urban Collaboration (IUC) with German company for quality monitoring


WTPs and STPs operated through SCADA system


Methane generated from anerobic digestion is used for electricity generation (450 KW) and electricity is reused in the STP

Source : Primary Survey, Solapur Municipal Corporation; PAS, 2019-20

Water and Wastewater Treatment

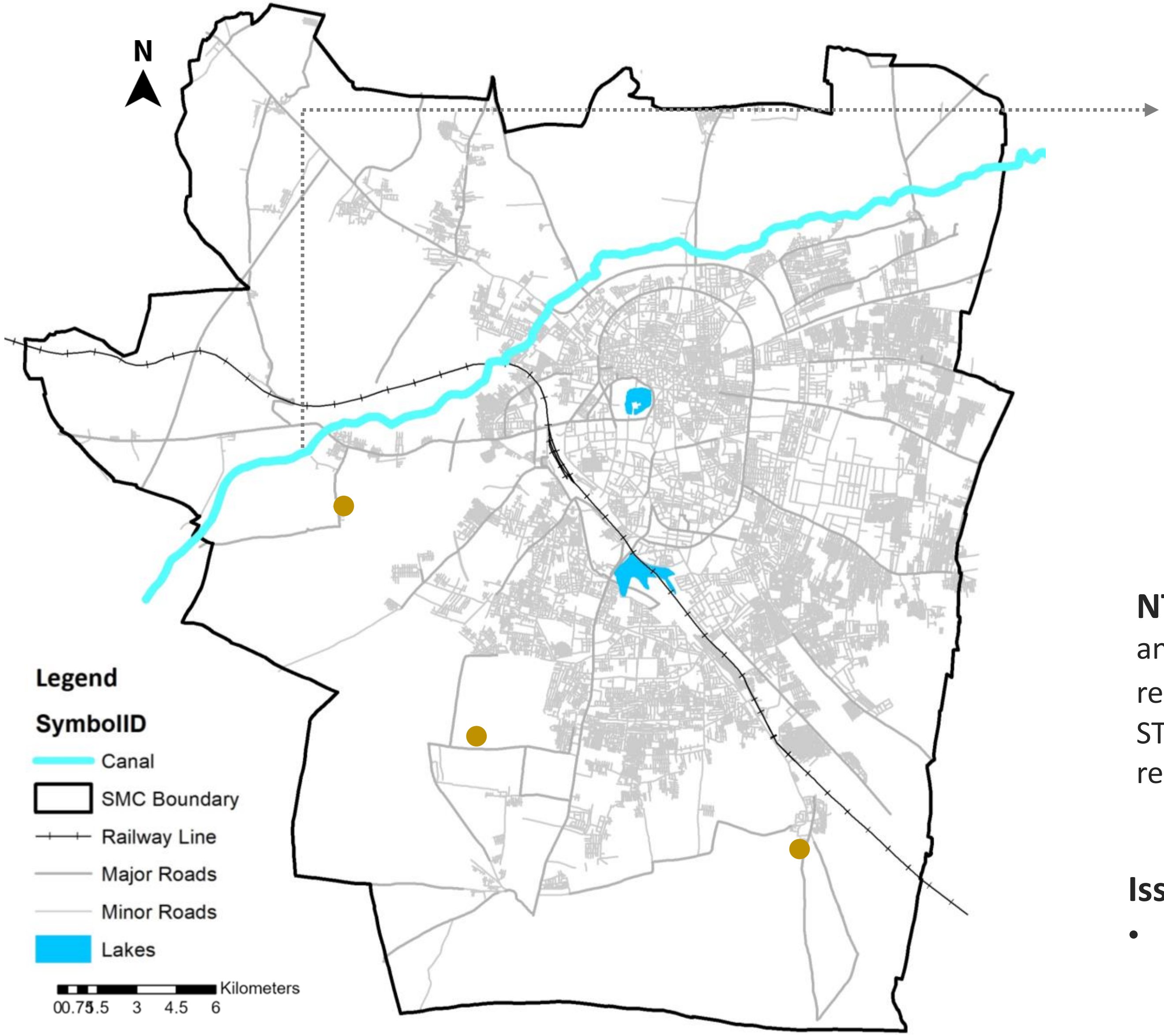
Issues

- Being very old, **pumps require lots of maintenance**
- Despite presence of solar panels, **huge electricity bills because of higher energy consumption** by older pumps

- **STPs are being underutilized during summers** because of reduced wastewater generation.
- **Methane** generated during monsoon is **unfit for electricity generation** is directly **let in to atmosphere.**

Source : Primary Survey, Solapur Municipal Corporation, 2022; PAS local action indicators, 2019-20

Wastewater Disposal and Reuse



Source : Primary Survey, Solapur Municipal Corporation, 2022

Disposed in an irrigation canal which is further used for agriculture

NTPCL in the process of setting up a tertiary treatment plant and reuse the treated wastewater for cooling in the power plant. It requires about **52 MLD** of water which will be supplied from Degaon STP. But this project is currently on hold because of huge finances required by NTPCL for setting up of a tertiary treatment plant.

Issue

- Despite the city facing water scarcity issues, **there is no reuse of treated wastewater**

GHG Emissions

Methane (CH_4)	Collection systems (septic tanks), sewage network, anaerobic digestion, digested sludge storage facilities
Nitrous Oxide (N_2O)	Sewer lines, biological wastewater treatment
Carbon Dioxide (CO_2)	Power consumption

Conversion Factors

1 MWt of Electricity	=	0.82 tCO_2
1 kg methane	=	84 kg CO_2
1 kg nitrogen oxide	=	298 kg CO_2

Water Supply Process

Sr. No.	Particular	Emissions (tonnes CO_2)
1	Electricity (Raw water pumping)	5,751
2	Electricity (WTPs)	679
3	Electricity (WDSs)	1,178
	Total	7,608

Wastewater Treatment Plants

Sr. No.	Particular	Emissions (tonnes CO_2)
1	Electricity	531
2	Methane	48390
3	Nitrogen Oxide	
	Total	48921

Water supply and wastewater sector leads to total of 0.06 million tonnes of CO_2e **of GHG emissions.**

Source : (i) Analysis of Greenhouse Gas Emissions in Centralized and Decentralized Water Reclamation, Technical University of Munich, 2019; (ii) CO2 Baseline Database for the Indian Power Sector, Central Electricity Authority, 2018; (iii) Mumbai Climate Action Plan, 2022; (iv) Ahmedabad Climate Action Plan, 2022;

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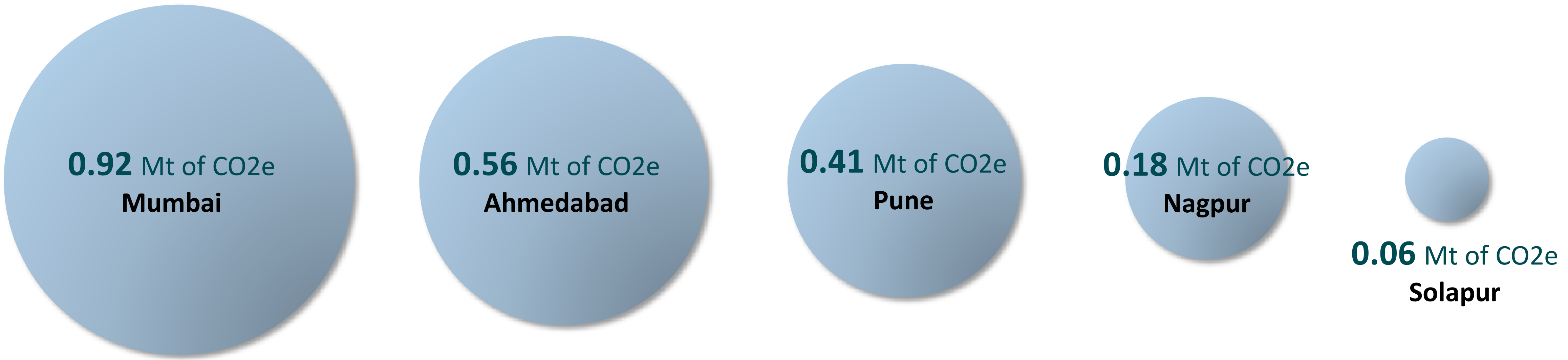

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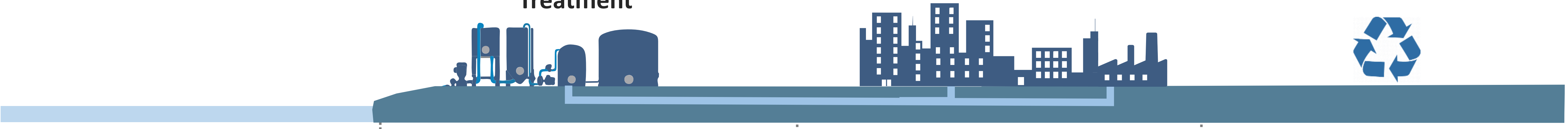
Issues in Water and Wastewater Sector in Solapur from Climate Perspective



Water Source

- **Water scarcity**
- Only **one own water source i.e. groundwater**.
- **Groundwater depletion and no monitoring on it**
- **High NRW in the city**

Water and Wastewater Treatment

- **High energy consumption** leading to **huge electricity bills**
- **High maintenance cost** of pumps

User End

Slums near the nala are facing the **problem of overflooding during monsoon.**

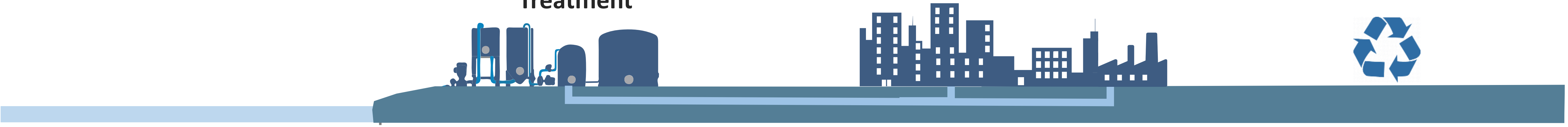
Wastewater Reuse

Despite water scarcity**, no reuse of treated wastewater**

Source : Primary Survey, Solapur Municipal Corporation, 2022

Issues in Water and Wastewater Sector in Solapur from Climate Perspective

Water Source	Water and Wastewater Treatment	User End	Wastewater Reuse



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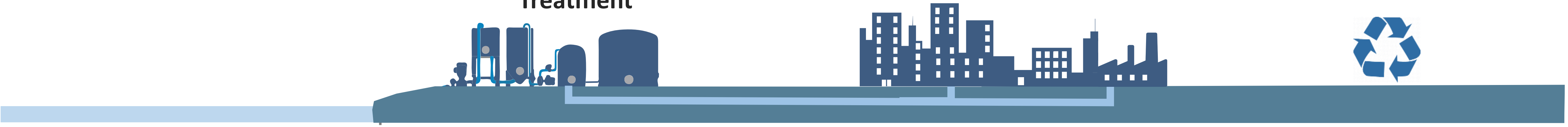
- Only **one own water source i.e. groundwater**.
- **Groundwater depletion and no monitoring on it**
- **High NRW in the city**

- **Groundwater Recharge –**
  (a) Rooftop Rainwater harvesting
  (b) Recharge through existing ponds
  (c) New recharge structures in open areas
- **Measures to reduce NRW**

Source : Primary Survey, Solapur Municipal Corporation, 2022

Issues in Water and Wastewater Sector in Solapur from Climate Perspective

Water Source | Water and Wastewater Treatment | User End | Wastewater Reuse



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  - (b) Recharge through existing ponds
  - (c) New recharge structures in open areas
- **Measures to reduce NRW**

" Because of availability of any other source of water in 200 km radius, **augmentation of new source of water** for Solapur Municipal Corporation **would be financially straining**. On the contrary, **augmenting the local water resource i.e., rainwater would mean smaller cost efficient solutions leading to larger impact**. "

Source : Primary Survey, Solapur Municipal Corporation, 2022

Groundwater Recharge: (a) Rooftop Rainwater Harvesting

Rainwater harvesting is done in public buildings under AMRUT mission

Provision of **2% rebate in property tax for rain water harvesting**/ percolation wells **in private buildings**. But the scale of implementation of this is very low in the city.

Average roof size in Solapur
Selected 30 random building footprints – 10 samples each of bungalows, apartments and row houses.

Average roof size = 122 sq. m

Average Rainfall Intensity = 524 mm

No. of properties in Solapur = 1,88,936

Amount of Water Harvested = 10870.47 million liter

Average water availability per property = 122 liter/ day

20%
of the total water supplied by **municipal corporation annually**

Groundwater Recharge: (a) Rooftop Rainwater Harvesting

Mandating RWH, by making it compulsory in DCR or passing a bill, in all the upcoming buildings to harvest rainwater and utilize it for either internal purposes or **for infiltering into the ground.**

For existing buildings, give **time of 2-3 years for installing RWH system**

Incentives for faster and wider implementation

1. Allocation of **extra 0.5 FSI** on inclusion of rainwater harvesting in the buildings
2. **Green Building certification**

In case of **violations, levy of additional charges on the water bill as a penalty**.

Training programmes for developers and technicians

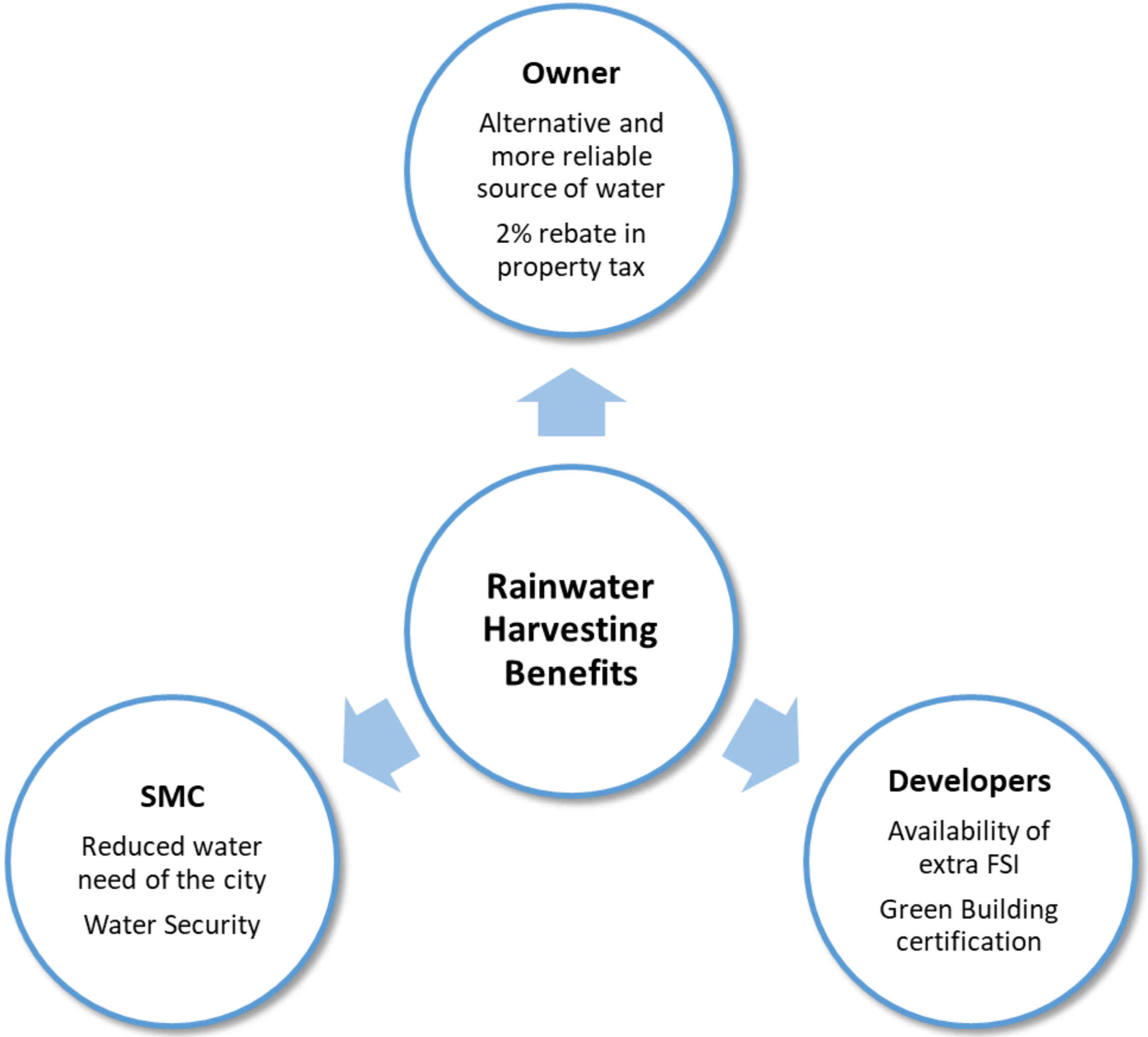
Need to **spread awareness** amongst the community

Start RWH campaign by **targeting schools, hospitals and other larger buildings**

Recharging would also improve the groundwater quality by diluting the hardness and nitrate content in water.

Source : Bangalore Rainwater harvesting case study; Groundwater information of Solapur District, CGWB, 2013

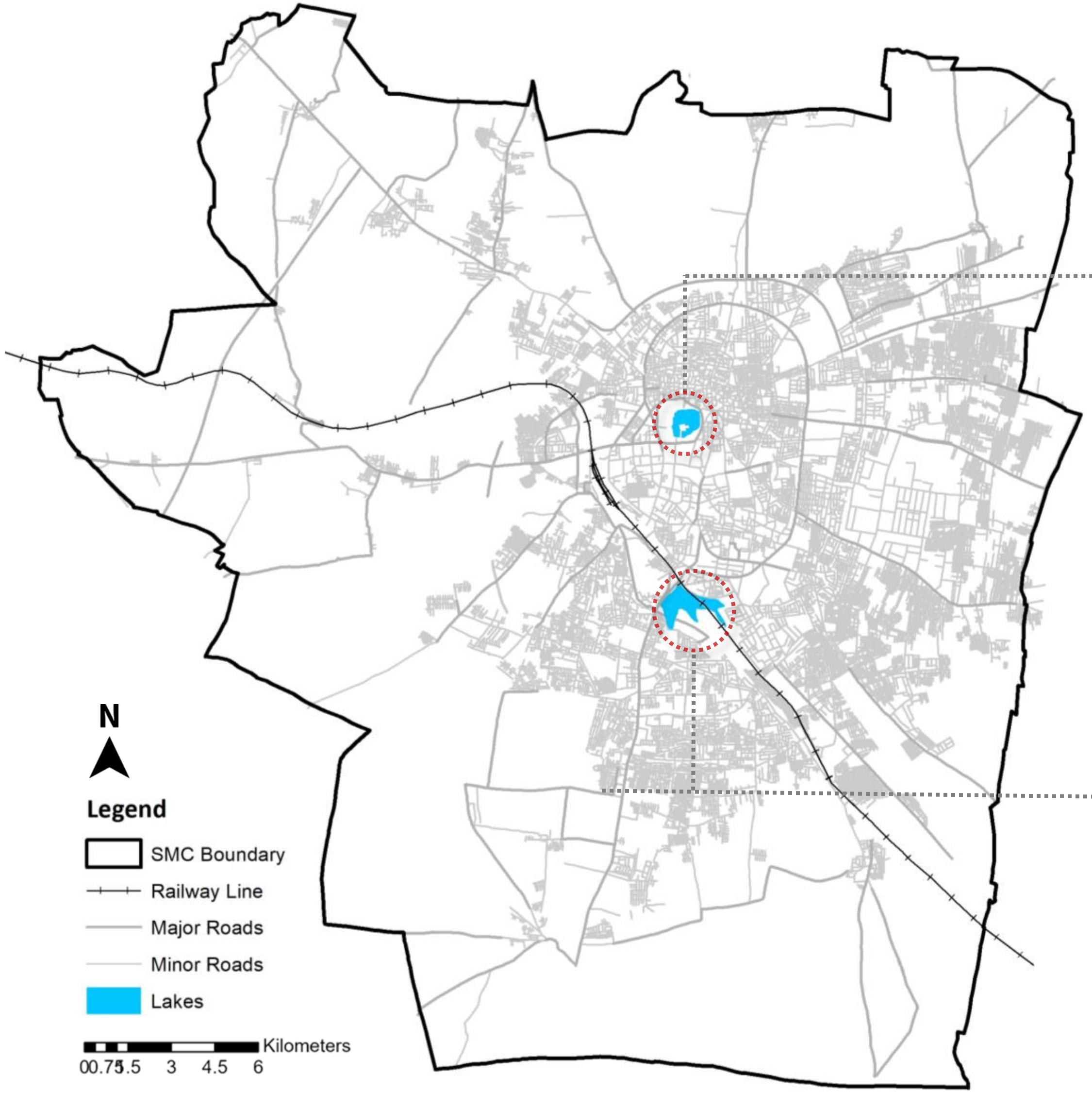
Groundwater Recharge: (a) Rooftop Rainwater Harvesting



Source : Bangalore Rainwater harvesting case study; Groundwater information of Solapur District, CGWB, 2013

Groundwater Recharge (b) Existing ponds and lakes

Lakes in Solapur



Two major lakes in Solapur

Sambhaji Lake

Siddheshwar Lake

2
No. of recharge structures

20 lakh INR
Total cost of building recharge structures

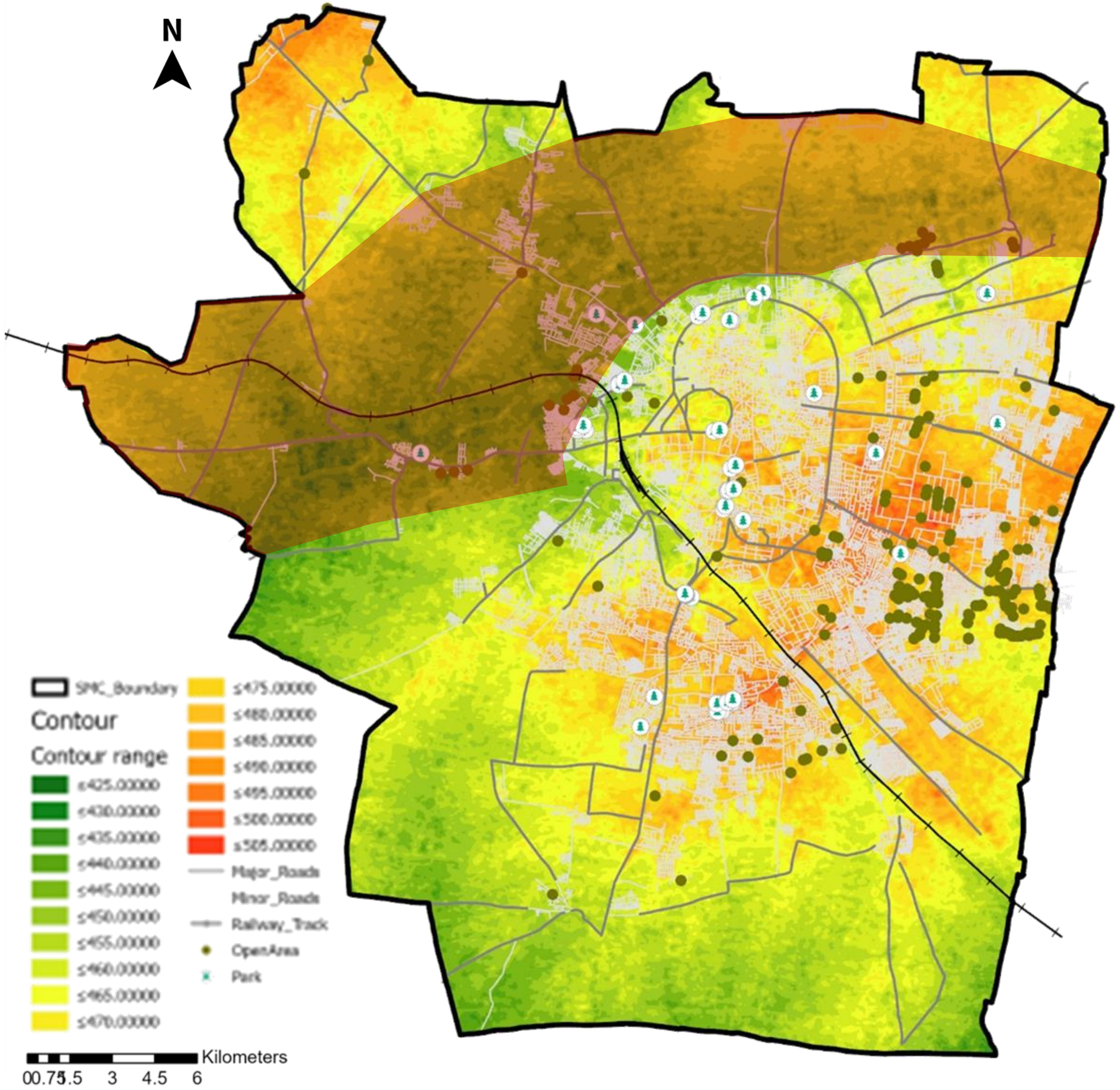
288 ML
Amount of water getting recharged

0.5%
of the total water supplied by **municipal corporation annually**

Source : Manual on Artificial Recharge of Groundwater, CPCB, 2007; Primary Survey, Solapur Municipal Corporation, 2022

Groundwater Recharge (c) New Recharge Structures

Contours



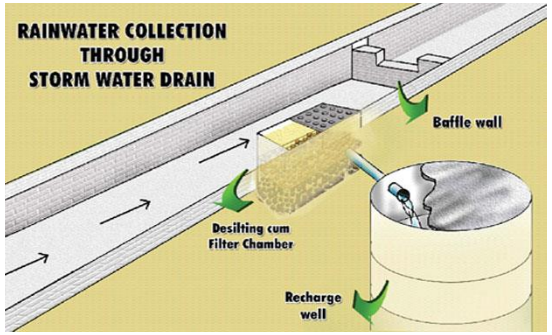
The rainwater that flows away as **surface runoff** could be caught and used for **recharging aquifers** by adopting appropriate **stormwater harvesting methods**.

RWH from run-off using Recharge Structures

46 sq. km

Basin area

RWH from roads through Storm Water Drains



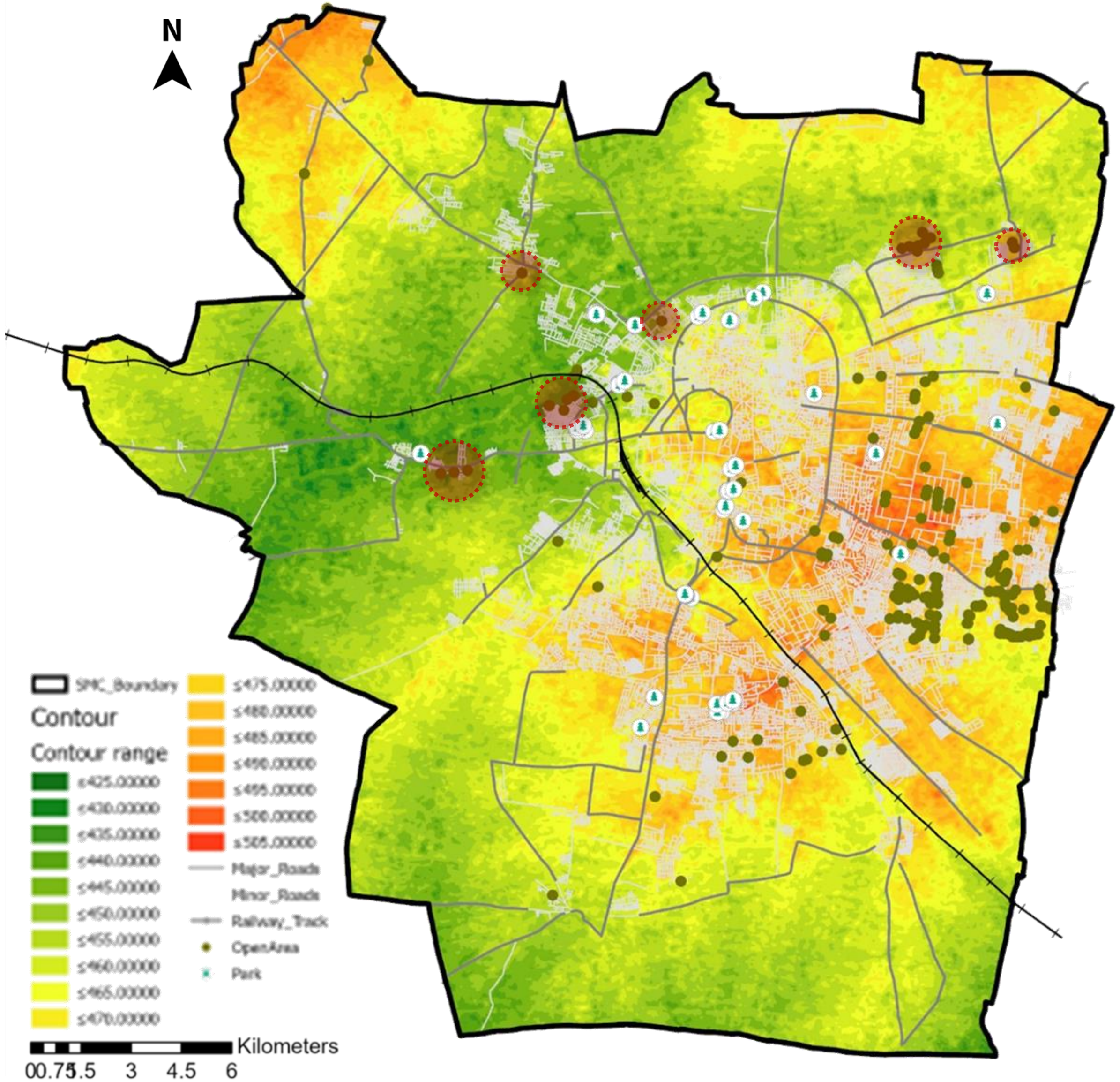
160 km

Major road length

Source : Manual on Artificial Recharge of Groundwater, CPCB, 2007; United States Geological Survey (USGS) Imagery, 2020; Primary Survey, Solapur Municipal Corporation, 2022

Groundwater Recharge (c) New Recharge Structures

Contours



RWH from run-off using Recharge Structures	**RWH from roads through Storm Water Drains**
30 No. of recharge structures	**2** No. of recharge structures
300 lakh INR Total cost of building recharge structures	**1.2** lakh INR Total cost of building recharge structures
864 ML Amount of water getting recharged	**1.7** ML Amount of water getting recharged

1.6%

of the total water supplied by **municipal corporation annually**

Source : Manual on Artificial Recharge of Groundwater, CPCB, 2007; United States Geological Survey (USGS) Imagery, 2020; Primary Survey, Solapur Municipal Corporation, 2022

Measures to Reduce Non-Revenue Water

In order to achieve **water security**, it becomes important to **not only improve city's water reserves but also reduce the wastage of water i.e. NRW**

Changing of pipes, installation of flowmeters and 16,000 household water meters in core area of city is proposed as an ABD project under Smart City Mission

Leakage detection and **refurbishment of dilapidated network**

Installing **flowmeters, pressure sensors and other hydraulic devices**

Household level water metering

Revising tariff structure – From flat tariff to volumetric tariff

Metering groundwater withdrawal too, for monitoring purposes

Source : Compendium of good practices - Urban water and sanitation in Indian cities, NIUA, 2015

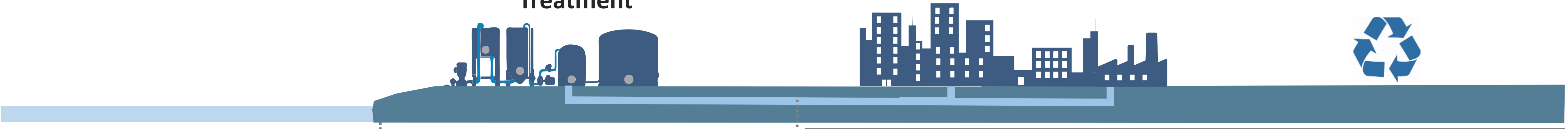
Issues in Water and Wastewater Sector in Solapur from Climate Perspective

Water Source

Water and Wastewater Treatment

User End

Wastewater Reuse



- Water scarcity
- Only **one own water source i.e. groundwater**.
- **Groundwater depletion and no monitoring on it**
- **High NRW in the city**

- **High energy consumption** leading to **huge electricity bills**
- **High maintenance cost** of pumps

Energy Efficient Pumps

Source : Primary Survey, Solapur Municipal Corporation, 2022

Energy Efficient Pumps

Vertical Turbine barrel or can type pumps are generally applied for these kind of services

6-8.5 lakh INR
Cost

35%
Energy Efficiency

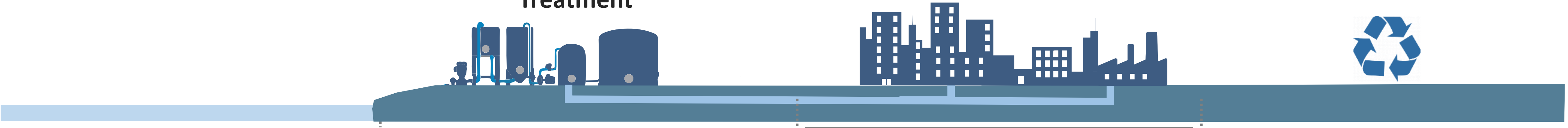
Business as Usual	After intervention
6,282 tonnes of CO_2e GHG emissions because of energy utilization using **normal pumps**	**4,083** tonnes of CO_2e GHG emissions because of energy utilization using **energy efficient pumps**

Switching to energy efficient pumps leads to 10% reduction in GHG emissions from water and wastewater sector.

Source : https://www.pumpsandsystems.com/factors-selecting-rotodynamic-or-positive-displacement-pump-energy-savings-demand; https://www.pumpsandsystems.com/energy-efficient-vertical-turbine-pumps-promote-sustainable-mining-efforts

Issues in Water and Wastewater Sector in Solapur from Climate Perspective

Water Source	Water and Wastewater Treatment	User End	Wastewater Reuse



Water Source

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Water and Wastewater Treatment

- **High energy consumption** leading to **huge electricity bills**
- **High maintenance cost** of pumps

User End

Wastewater reuse for non-potable public purposes

Wastewater Reuse

Despite water scarcity**, no reuse of treated wastewater**

Source : Primary Survey, Solapur Municipal Corporation, 2022

Wastewater Reuse for Non-Potable Public Purposes

65 MLD

Secondary treated wastewater available for reuse

Watering **62 public gardens**

Watering **80** km of **medians** and roadside **plantations**

Cleaning **1320 community** toilets seats

Municipal solid waste **bio-methanation process** and for **fire and dust issues**

Municipal Corporation has **4** water tankers of **7000** lit capacity which make **4-5** trips per day to transport the treated wastewater.

Based on the current infrastructure availability,

0.14 MLD of water can be reused daily

51.1 MLD of water can be reused annually

Source : https://www.fulongmagroup.com/bev-sprinkler-flm5250gqxdlbevs/

Wastewater Reuse for Non-Potable Public Purposes

65 MLD

Secondary treated wastewater available for reuse

Watering **62 public gardens**

Watering **80** km of **medians** and roadside **plantations**

Cleaning **1320 community** toilets seats

Municipal solid waste **bio-methanation process** and for **fire and dust issues**

42 lakh INR

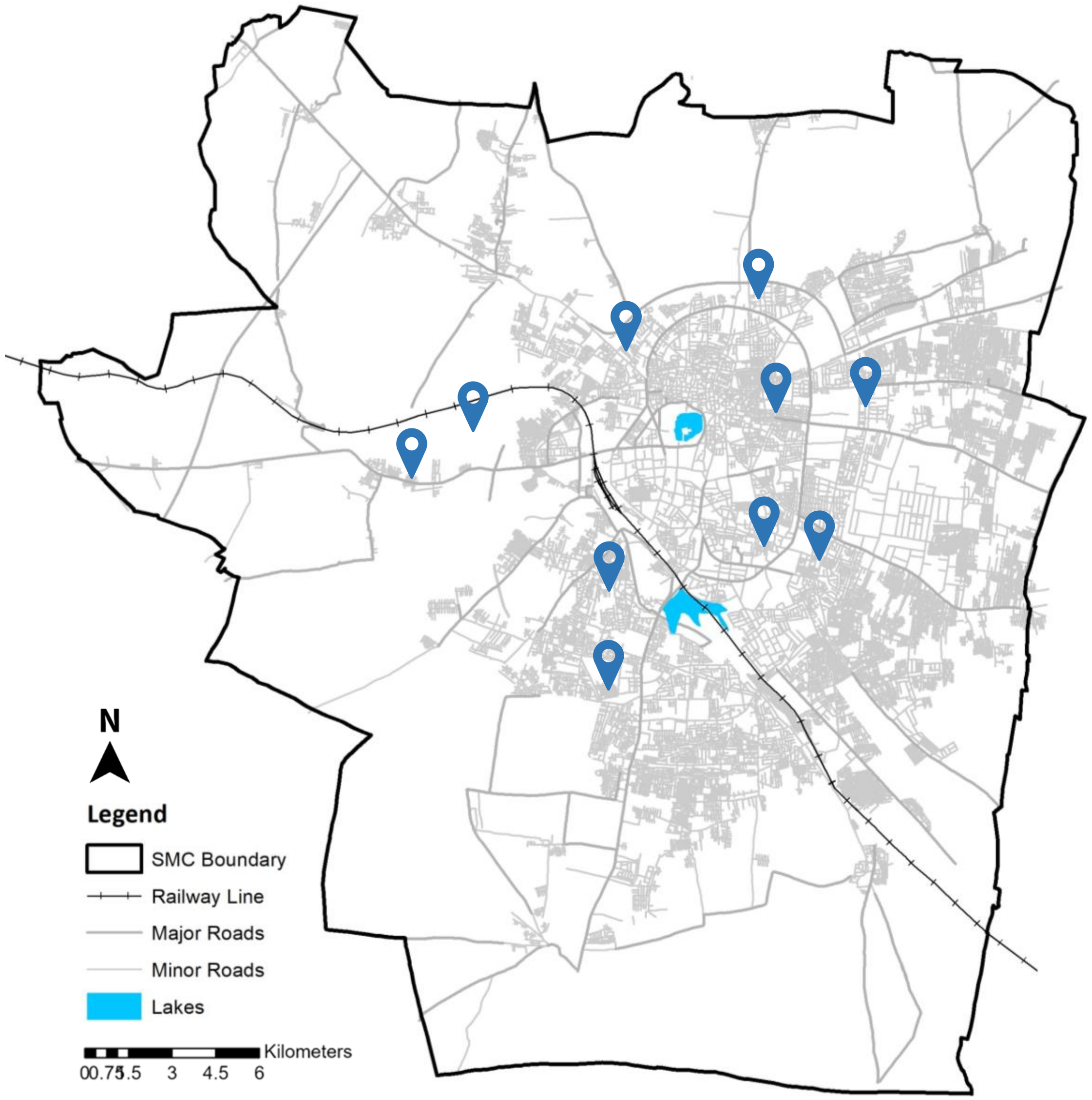
Cost

To reduce **GHG emissions because of transportation of treated wastewater**, the Municipal Corporation can **shift to electric water tankers over time**.

Source : https://www.fulongmagroup.com/bev-sprinkler-flm5250gqxdlbevs/

Slums are most vulnerable and highly affected due to Climate Change

Slums Surveyed



Source : Primary Survey, Solapur Municipal Corporation; PAS, 2019-20

Focus Group Discussions (FGDs) in 10 Slums

Location and Connection

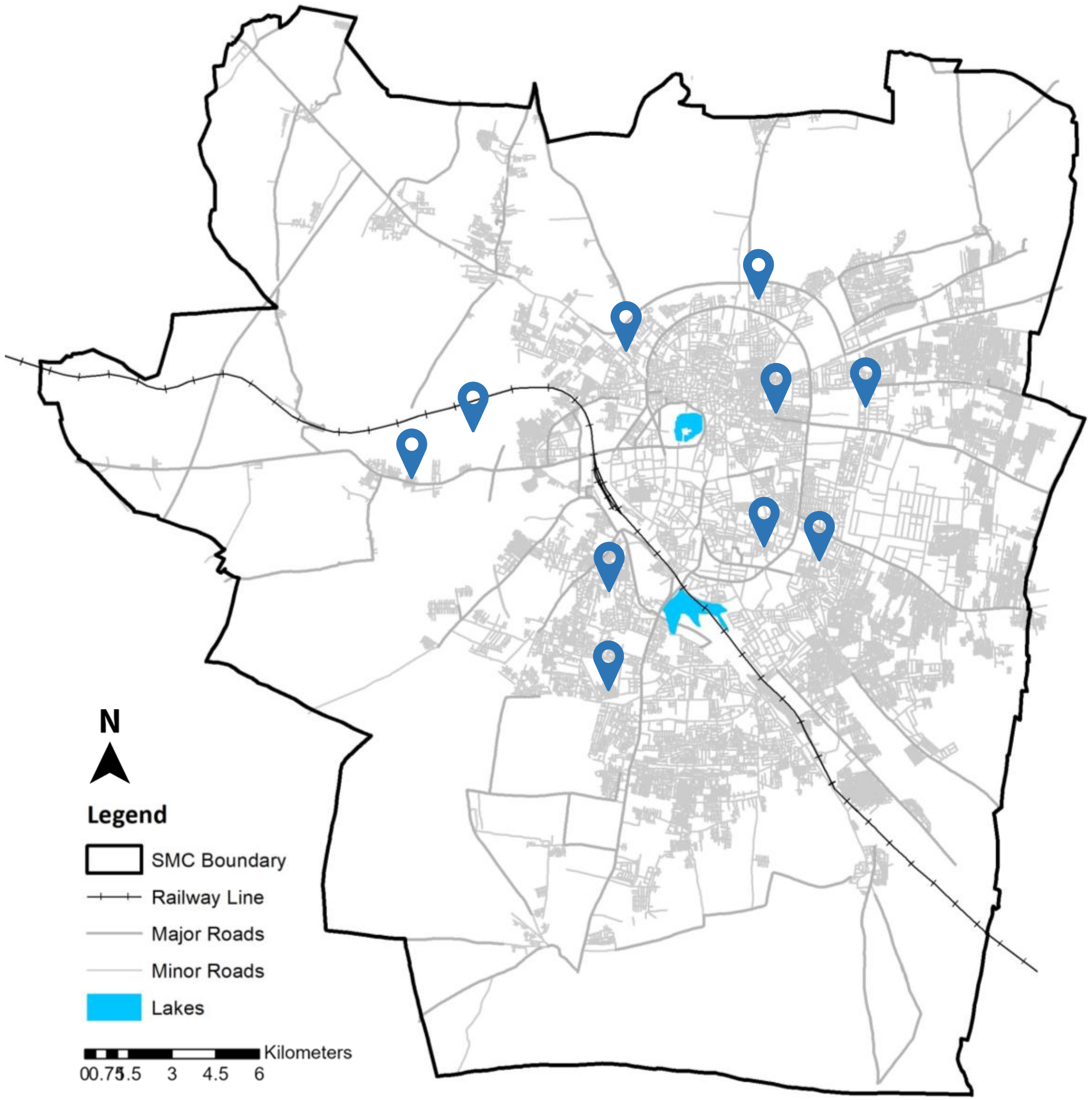
- **Individual connections** or shared connections between two households
- Water points are generally located outside the houses
- **Connections charges** in slums are Rs. 2100, which are **half the charges for other citizens**
- **Water tax** is Rs. 2760 annually, which **similar for entire city**

Duration, Quantity, Quality and Storage

- **Quality, quantity and duration** of water supplied **is same** across the city and there no inequity
- Water is generally stored outside the houses

Slums are most vulnerable and highly affected due to Climate Change

Slums Surveyed



Focus Group Discussions (FGDs) in 10 Slums

Toilets and Wastewater

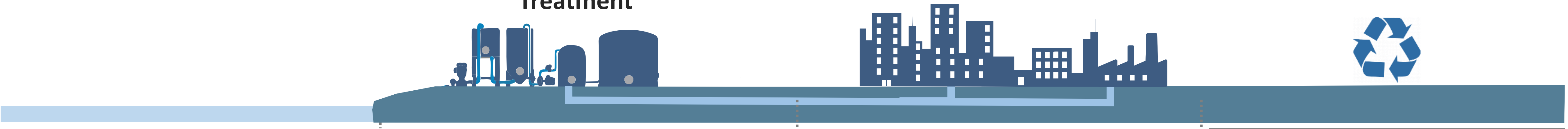
- All slums have **community toilets** present which are connected to sewer lines or septic tanks
- These toilets are in good condition and are operated and maintained well by the ULB

Stormwater

- **Problem of overflooding** in slums near the nalas during monsoon
- **Drinking water contamination** because of mixing of sewage.
- Affects accessibility and daily activities of slum dwellers.

Source : Primary Survey, Solapur Municipal Corporation; PAS, 2019-20

Issues in Water and Wastewater Sector in Solapur from Climate Perspective



Water Source	Water and Wastewater Treatment	User End	Wastewater Reuse
• Water scarcity • Only **one own water source i.e. groundwater**. • **Groundwater depletion and no monitoring on it** • **High NRW in the city**	• **High energy consumption** leading to **huge electricity bills** • **High maintenance cost** of pumps	**Slums** near the nala are facing the **problem of overflooding during monsoon.**	**Mini 24x7 Water Supply Schemes for Slums**

Source : Primary Survey, Solapur Municipal Corporation, 2022

Mini 24x7 Water Supply Systems for Slums

Solar energy powered submersible **pump** with required photovoltaic panels

HDPE storage tank of required capacity elevated at 3 meter height to give sufficient head for the distribution system

Steel structure for mounting HDPE Water Tank

Groundwater recharge well

Distribution system with individual tap connections for required number of households

Benefits

1. **24x7 water supply** to slum dwellers
2. No need to store water meaning **reduced contamination**
3. Pump working on **renewable energy**
4. **Groundwater recharge**
5. **Cost effective**

5-5.5 lakh INR

Cost of developing this structure with 30-40 individual household connections

ULB's budget
CSR funds
Capital Cost

Water tax from Slum dwellers
O&M Cost

Women Committees (SHGs)
O&M Operations

Source : Groundwater Survey and Development Agency

Impacts of the Suggested Interventions

	Business as usual	After interventions
Groundwater Recharge	**0** ML Groundwater Recharge Annually	**12,024** ML Groundwater Recharge Annually
	This equals to **22**% of the total water supplied by Municipal Corporation annually	
Treated Wastewater Reuse	**0** ML Treated Wastewater Reuse Annually	**51** ML Treated Wastewater Reuse Annually
GHG Emissions of Water and Wastewater Sector	**6,282** tonnes of CO_2e GHG Emissions	**4,083** tonnes of CO_2e GHG Emissions
	10% reduction in the GHG emission from water and wastewater sector	

Softer Aspects of Achieving Climate Resilience

For **wider and faster implementation** of these climate resilient WASH strategies

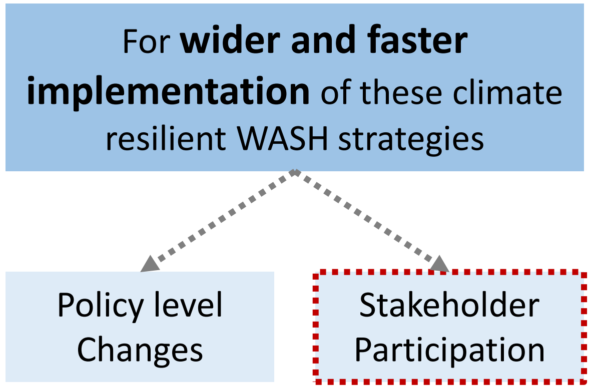
- Policy level Changes
- Stakeholder Participation

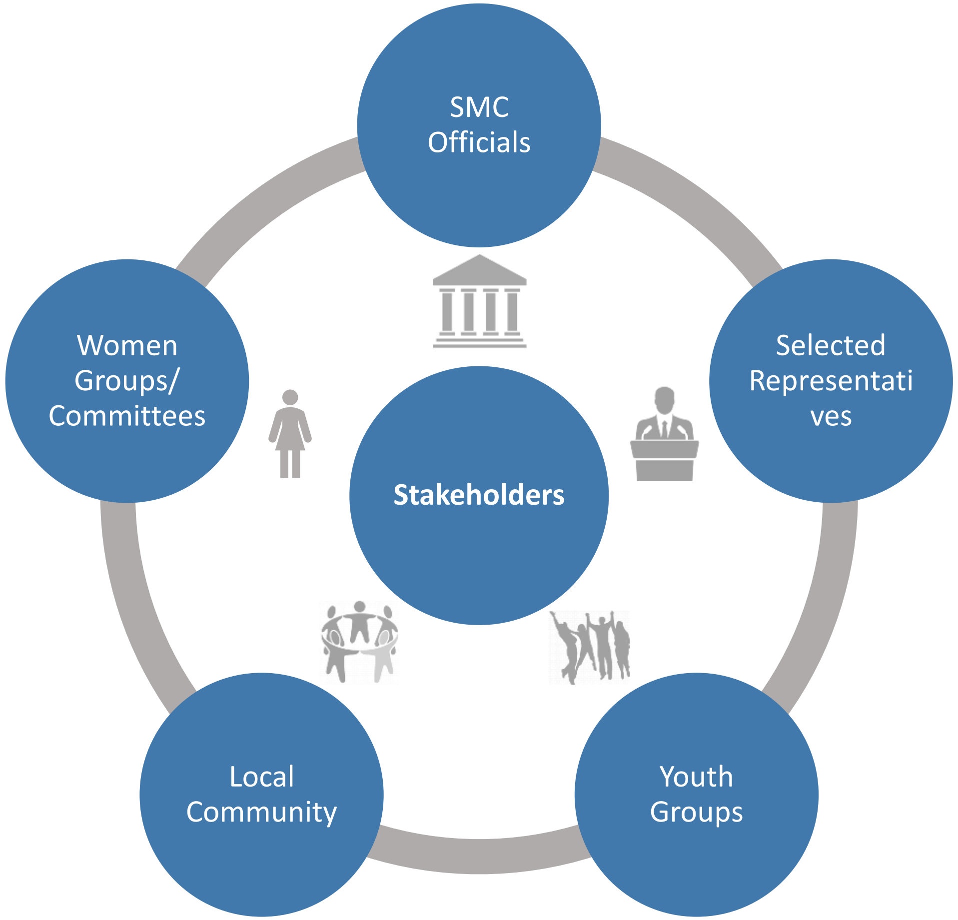
Mandating **consideration of climate change perspective in all the upcoming water and wastewater projects** in Solapur.

Mandating rainwater harvesting by passing a bill or including it in the DCR

Mandating societies with more than 50 household **to treat their wastewater on their own**.

Stakeholder Participation





Tackling climate change is not just the responsibility of SMC, but requires involvement of all other stakeholders. Spreading awareness about climate change and active participation from all the stakeholders will lead to better, faster and easier implementation of climate adaptation strategies.

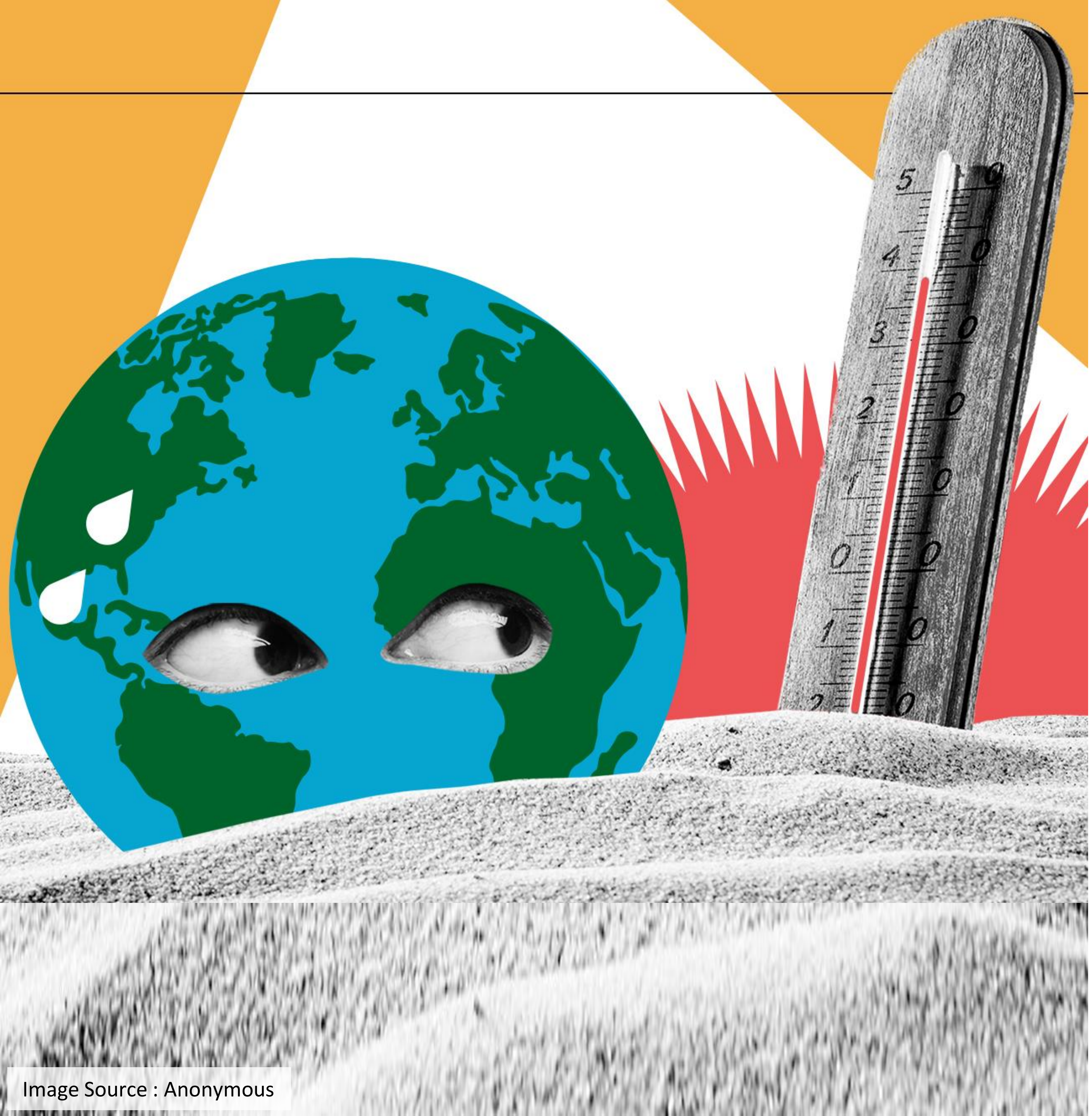


Image Source : Anonymous

Thank You!

Annexure I – GHG Emissions Calculations

Conversion Factors

1 MWt of Electricity = 0.82 tCO_2
1 kg methane = 84 kg CO_2
1 kg nitrogen oxide = 298 kg CO_2

Water Supply Process

Sr. No.	Particular	Monthly Power Consumption (MWt)	Annual Power Consumption (MWt)	Emissions (tonnes CO_2)
1	Electricity (Raw water pumping)	584.4	7,013	5,751
2	Electricity (WTPs)	69	828	679
3	Electricity (WDSs)	119.7	1,436	1,178
	Total	773.1	9,277	7,608

Wastewater Treatment Plants

Sr. No.	Particular	Emissions (tonnes CO_2)
1	Electricity	531
2	Methane	48390
3	Nitrogen Oxide	
	Total	48921

Water supply and wastewater sector leads to total of 0.06 million tonnes of CO_2e **of GHG emissions.**

Annexure II – Rooftop Rainwater Harvesting Calculations

Average roof size	= 122 sq. m
Average rainfall intensity	= 524 mm
No. of properties	= 1,88,936
Amount of water harvested (in lit)	= Average roof size (sq. m) x Average Rainfall Intensity (m) x No. of properties x 1000
Amount of Water Harvested	= 10,87,04,70,000 lit
Amount of Water Harvested	**= 10,870.47 million lit**
Average water availability per property	**= 122 lit/ day**

Annexure III – Recharge through Existing Ponds and Lakes Calculations

Area of lakes	= 0.43 sq.km
Quantity of rainfall per high rainfall day (in lit)	= Area of lake (sq. m) x quantity of water precipitated (m) x 1000
	= 90,00,000 lit
	= 9 ML
Recharge Rate considered	= 3,00,000 lit/ hr (30 ft diameter)
According to India Meteorological Department (IMD) data, there are 20 high rainfall days in Solapur	
Recharge done by one structure	= Recharge rate considered (lit/ hr) x 24 x no. of high rainfall days
	= 7.2 ML
No. of recharge structures required	= 2 (one in each lake)
Quantity of water recharged	= 288 ML
Cost of one structure	= 10 lakh INR
Total Cost	= 20 lakh INR

2
No. of recharge structures

20 lakh INR
Total cost of building recharge structures

288 ML
Amount of water getting recharged

Annexure IV - RWH from Runoff and Storage in Ponds Calculations

Selected Area	= 46 sq.km
Surface runoff (cu. m)	= 10 x runoff coefficient x intensity of rainfall (mm/hr) x Area (ha)
Solapur predominantly has light red and black soil and runoff coefficient it is 0.15. According to IMD data, rainfall intensity is 0.524 mm/hr on high rainfall days	
Surface runoff	= 3615600 cu. m
	= 3615.6 ML
Recharge Rate considered	= 60,000 lit/ hr (12 ft diameter)
According to India Meteorological Department (IMD) data, there are 20 high rainfall days in Solapur	
Recharge done by one structure	= Recharge rate considered (lit/ hr) x 24 x no. of high rainfall days
	= 28.8 ML
No. of recharge structures required	**= 30**
Quantity of water recharged	**= 864 ML**
Cost of one structure	= 10 lakh INR
Total Cost	**= 300 lakh INR i.e., 3 crore INR**

30
No. of recharge structures

300 lakh INR
Total cost of building recharge structures

864 ML
Amount of water getting recharged

Annexure V - RWH from Roads through Storm Water Drains Calculations

Road length	= 160 km
Area of roads	= 3.84 sq. km
Surface runoff (cu. m)	= 10 x runoff coefficient x intensity of rainfall (mm/hr) x Area (ha)
Runoff coefficient for roads is 0.85. According to IMD data, rainfall intensity is 0.524 mm/hr on high rainfall days	
Surface runoff	= 1710 cu. m
	= 1.71 ML
Recharge Rate considered	= 2,500 lit/ hr (1.5 ft diameter)
According to India Meteorological Department (IMD) data, there are 20 high rainfall days in Solapur	
Recharge done by one structure	= Recharge rate considered (lit/ hr) x 24 x no. of high rainfall days
	= 1.2 ML
No. of recharge structures required	**= 2**
Quantity of water recharged	**= 1.7 ML**
Cost of one structure	= 0.6 lakh INR
Total Cost	**= 1.2 lakh INR**

2
No. of recharge structures

1.2 lakh INR
Total cost of building recharge structures

1.7 ML
Amount of water getting recharged