

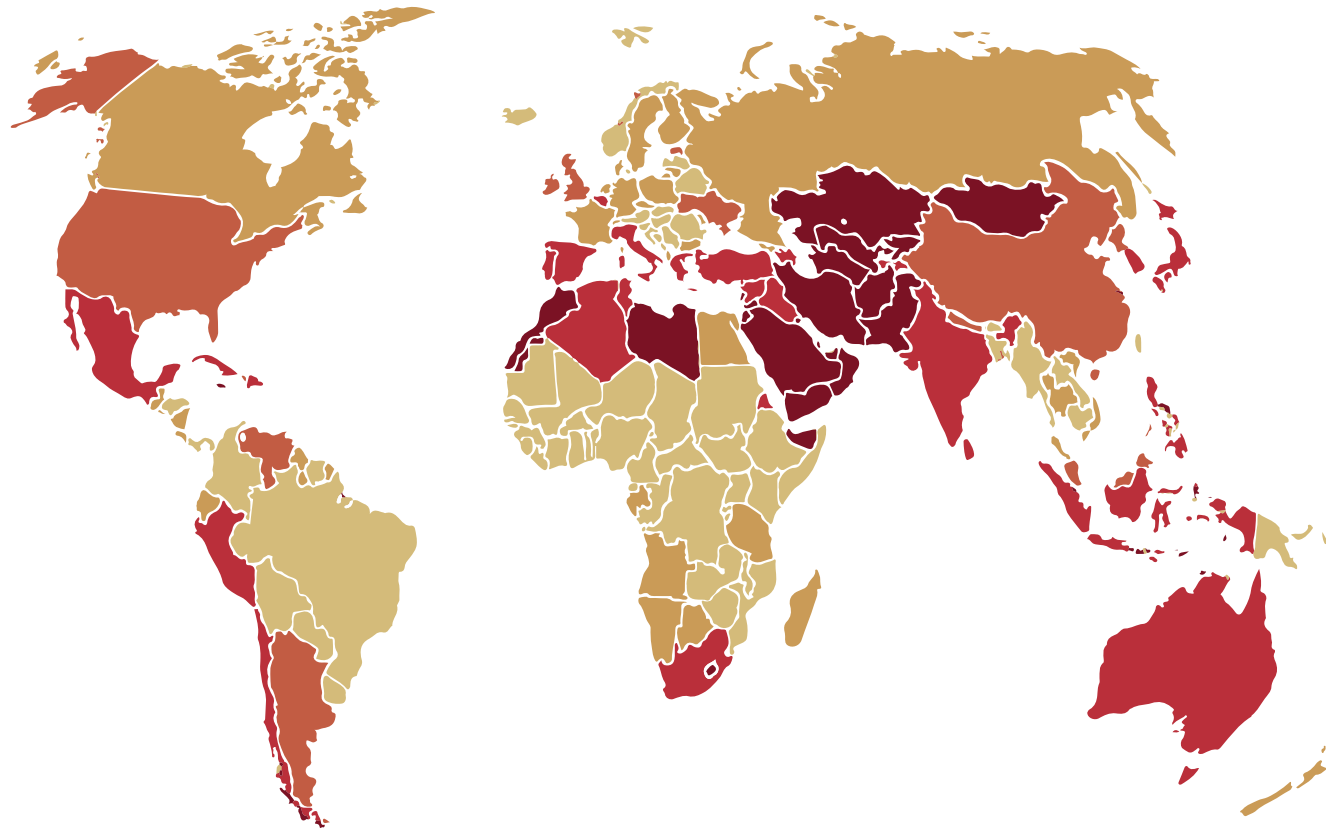
RE-HYDRATING JAIPUR

Scarcity | Security | Metropolitanization

Towards a sustainable integrated urban water management for the region of
Jaipur, India

Anubhuti Chandna [4741811]
MSc Urbanism

Water Scarcity and Security: Global Context



This map shows the average exposure of water users in each country to water stress, the ratio of total withdrawals to total renewable supply in a given area. A higher percentage means more users are competing for limited supplies.

Ratio of Withdrawals to Supply

- Extremely High Stress [$>80\%$]
- High Stress [40-80%]
- Medium to High Stress [20-40%]
- Low to Medium Stress [10-20%]
- Low Stress [$<10\%$]

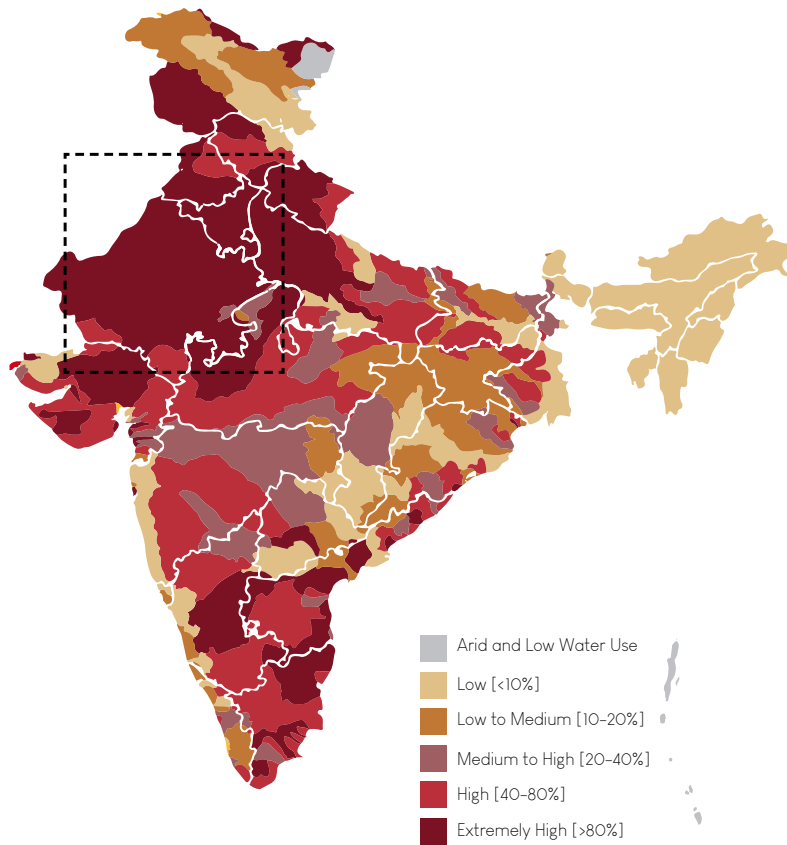
Source: WRI Aqueduct. Gassert et al 2013

Water Stress in India

'The situation has developed steadily and dramatically with the per capita freshwater availability declining from 6008 M³ per year in 1947 to approximately 2200 M³ per annum after 50 years'
(D. Mehta & Ballabh, 2000)

Surface Water Stress in India 2010

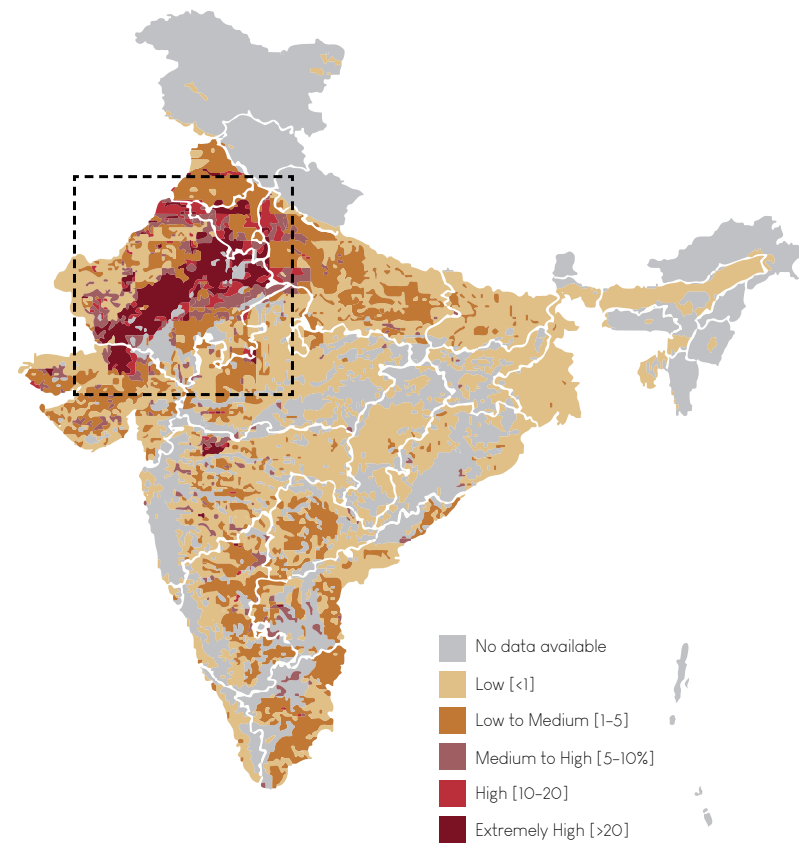
The Surface Water Stress measures the ratio of total water withdrawal over available supply



Source: Aqueduct 2015. World Resources Institute

Ground Water Stress in India 2010

The Ground Water Stress metric measures the ratio of groundwater extraction over recharge



Source: Deltares & Utrecht University 2016. World Resources Institute

Research Gap

In general, they were based on a development thinking, where the significance of both natural resources limitations and climate were underestimated, and the importance of technology and large scale projects was overestimated.

*Malin Falkenmark, Jan Lundqvist, Carl Widstrand
Macro Scale Water Scarcity requires Micro Scale Approaches*

Contemplating 100 years of Rainfall



“सात काल सत्ताईस ज़माना
तरिसठ कुड़िया काचा
तीन साल ऐसा वेला
माँ पूत मलि न पाचा”

‘7 years of drought, 27 years of good harvest, 63 years of average rainfall and 3 years of extreme famine
in which either the mother or the son will survive’

Printed from
THE TIMES OF INDIA

Water woes deepen for residents as private tankers overcharge in Jaipur

TNN | Sep 22, 2018, 12:10 AM IST

Jaipur: Water crisis spills over onto streets

Water scarcity ravages Rajasthan villages even decades after Independence

Villagers have to walk long distances to get water for domestic needs.

Printed from
THE TIMES OF INDIA

Jaipur residents to get less Bisalpur water from Wednesday

TNN | Aug 29, 2018, 10:13 AM IST

Jaipur left dry in 'water-tight' Compartment

Private tanker owners flourish as Jaipur reels under severe water crisis

Owners of private water tankers that are in heavy demand do brisk business, charging from Rs 300 onwards for a supply of 4,000 - 5,000 litres of water.

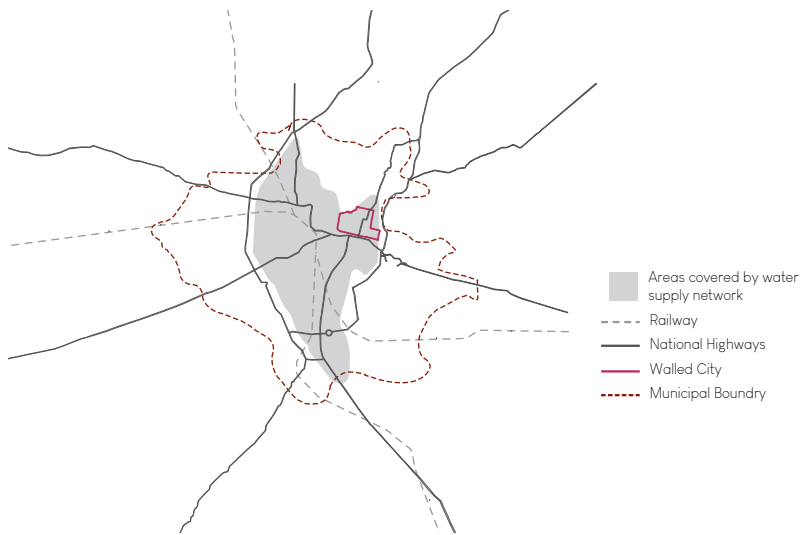
Printed from
THE TIMES OF INDIA

No proper water rationing in city: Residents

TNN | Sep 5, 2018, 09:48 AM IST

Water news: Water crisis in the offing for Jaipur and Ajmer

Water Shortage in the City

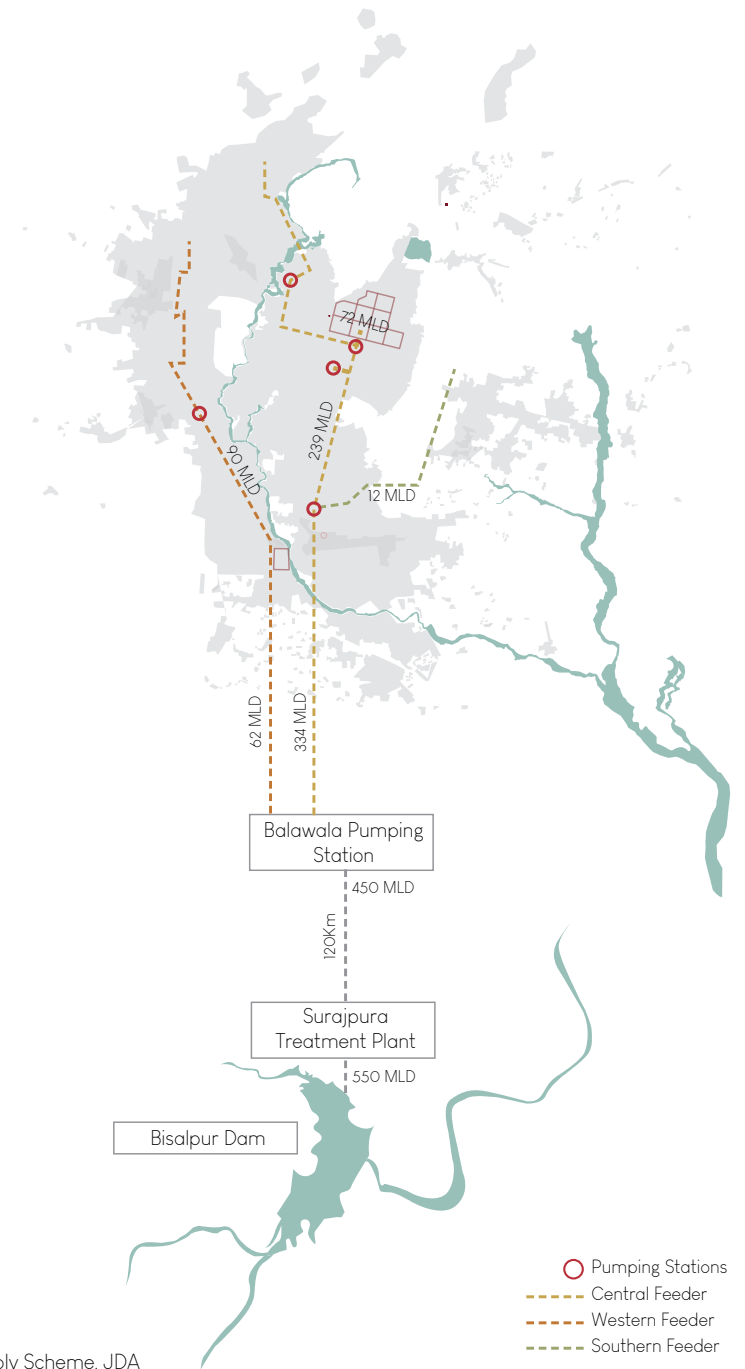


Current Supply: 450 MLD

Water Demand of Jaipur City through Bisalpur Water Supply

Population (million)				LPCD Litres per capita per day	Water Demand (MLD)				Raw Water Demand assuming 20% loss			
2001	2011	2021	2025		2001	2011	2021	2025	2001	2011	2021	2025
2.3	3.1	5.3	6.5	150	348	485	799	975	417	575	958	1170

Source: Masterplan 2025, JDA and PHED Daily Report



Source: Bisalpur Water Supply Scheme, JDA

Inefficient Infrastructure

Textile Factories at Sanganer



Toxic Water being used for cultivation in peri urban areas



The newly constructed canal of Dhrayavati



Recently developed park along the river



Location and Coverage of STPs

Current Water Supply: 480 MLD

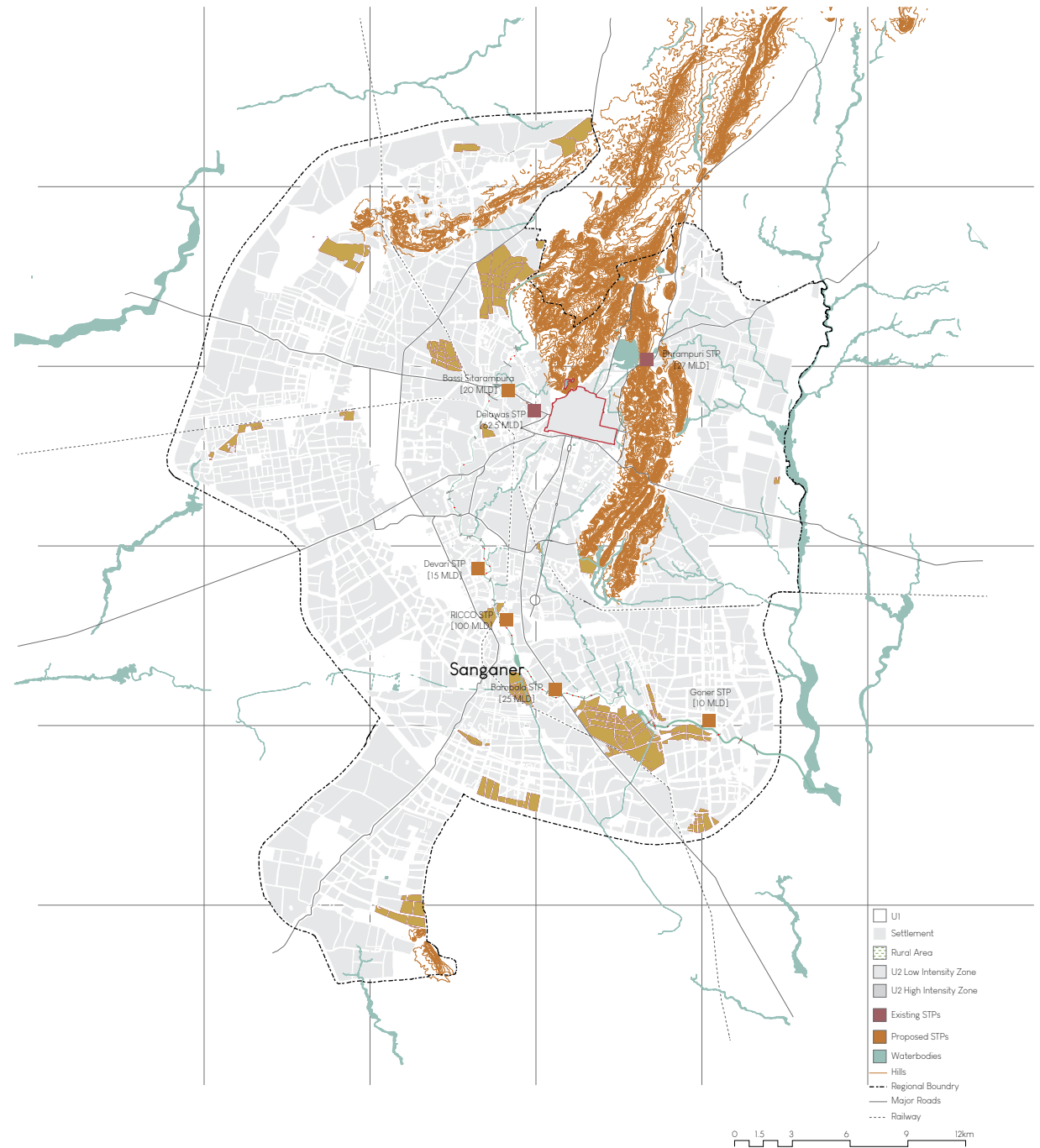
Projected Water Supply 2021: 958 MLD

Water Supply after Transmission loss: 452 MLD

For 2021- 766 MLD Sewerage (80% of water supply)

Existing STPs Coverage: 259.5 MLD (33.8%)

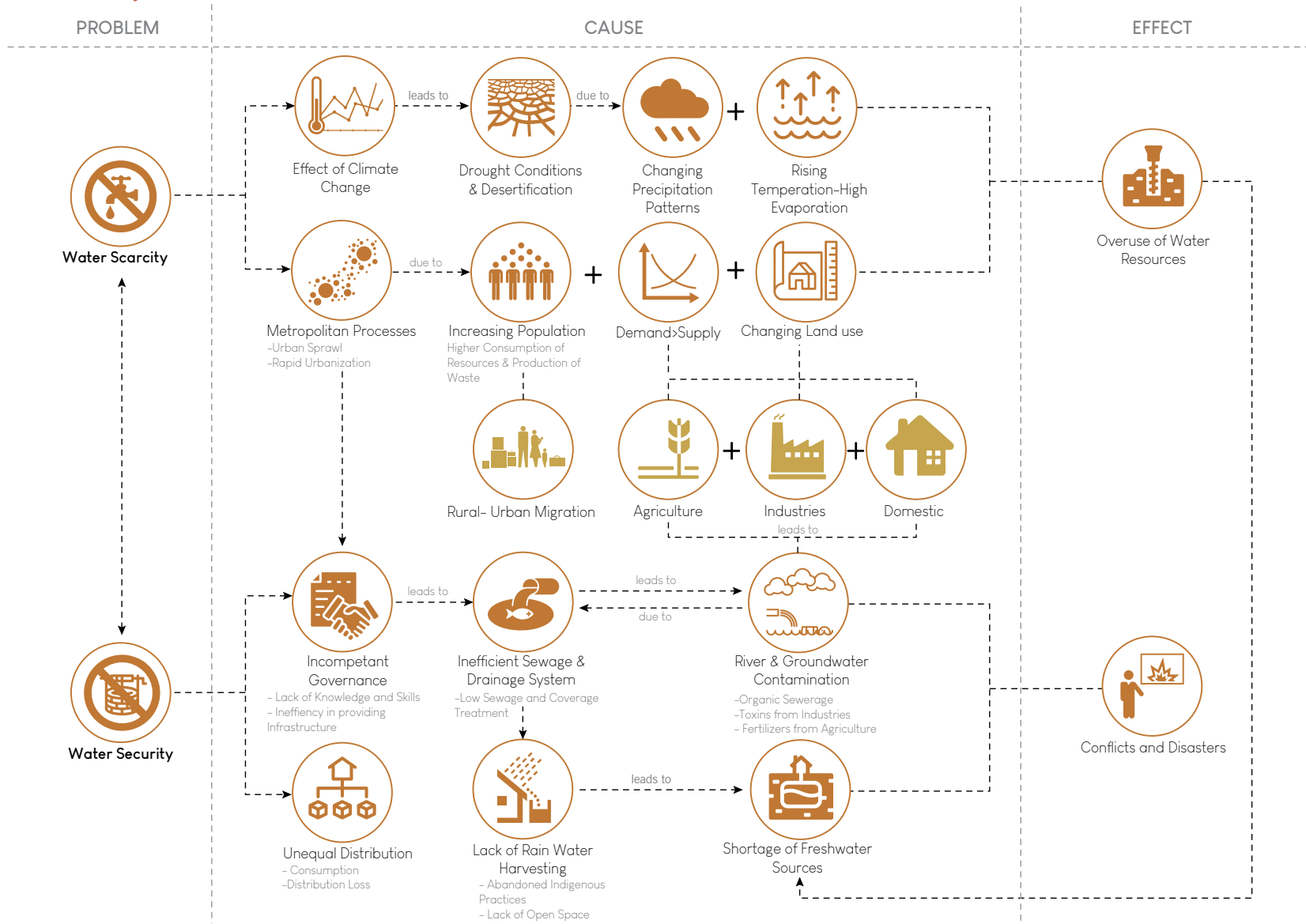
Shortage: 507 MLD



Lack of Drainage Systems in the City



Problem Statement



Traditional Water Management Practices in the State



1. Baori [Stepwell]



2. Beris/ Kui



3. Chaukas



4. Johad



5. Khadin



6. Tanka



7. Kund



8. Jhalara

Current Condition

An abandoned Stepwell at Nagargarh Fort



A dried Johad in Jaipur District



A Handpump in the walled city



Public Well in the walled city



Turn to traditional wisdom of water harnessing says Anupam Mishra - Article from The Hindu

Article and Image courtesy: [The Hindu](#)

How villages in Jaipur have become water-sufficient by using the simplest water conservation methods

By [KP Narayana Kumar](#), ET Bureau | Sep 13, 2015, 10.33 AM IST

The success story of KRAPAVIS: Sacred Forests and Rainwater Harvesting in Rajasthan, India

Posted on [February 18, 2014](#)

RWH: A tale of two successful states

Authored By : [Centre for Science and Environment](#)
Posted By : [aarti kelkar kh...](#)

Posted Date : Mon, 2015-02-16 21:11
[1 Comment](#)

Rainwater harvesting is a cost effective solution to bridge the gap between water availability and demand. Jodhpur and Goa, areas with low and high rainfall, have shown how.

Rajasthan's Kolila Joga village uses rainwater harvesting to turn parched pond into reservoir

Jaipur Laporiya, a village 80kms from Jaipur, has been defying drought for the past 30 years with a collective effort of water harvesting by 350 families.

Developmental Challenges



Source: CSE (2017). Water Sensitive Urban Designing and Planning: A practitioner's Guide.

19th Century Solutions to Urban Water Management

Water Supply

Large scale water supply from few large sources

Stormwater

Collect it all and discharge to receiving waters

Engineer water courses and drains

Sewerage

Collect it all and discharge after some treatment to receiving waters

i.e. "BIG PIPES IN - BIG PIPES OUT"

The question however is not how much water is needed to meet the demands, but how can we best manage within what we have?

Infrastructure

Resources

Space

Main Research Question

How can the integration of **traditional systems** and **state of the art in water management** have a positive effect on the **metropolitan region of Jaipur** in order to ensure resilience against **water scarcity and security**?

Design

Engineering

Context

Problem

Sub-Research Questions

Engineering

Design

Context

A2. What are the main challenges and opportunities of integrating conventional and traditional water systems?

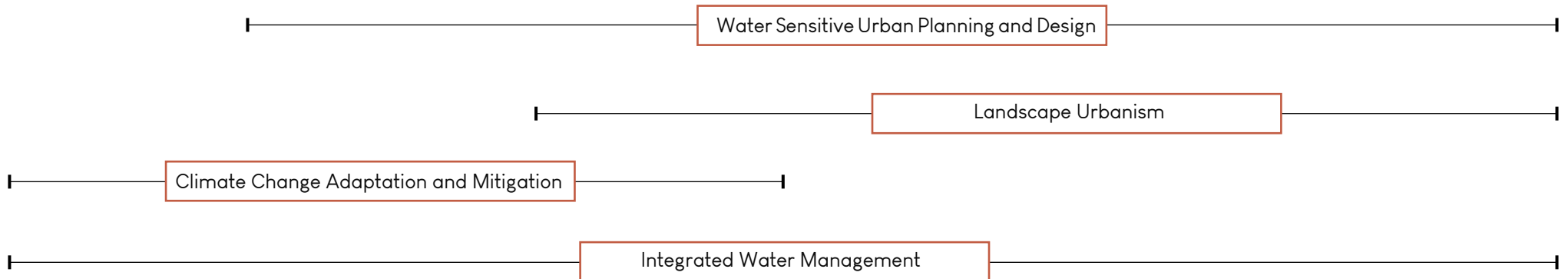
B1. How can landscape as a design approach be used to ensure resilience to water shortage in Jaipur?

C1. What are the characteristics of an urban plan in which spatial planning and urban water management are integrated?

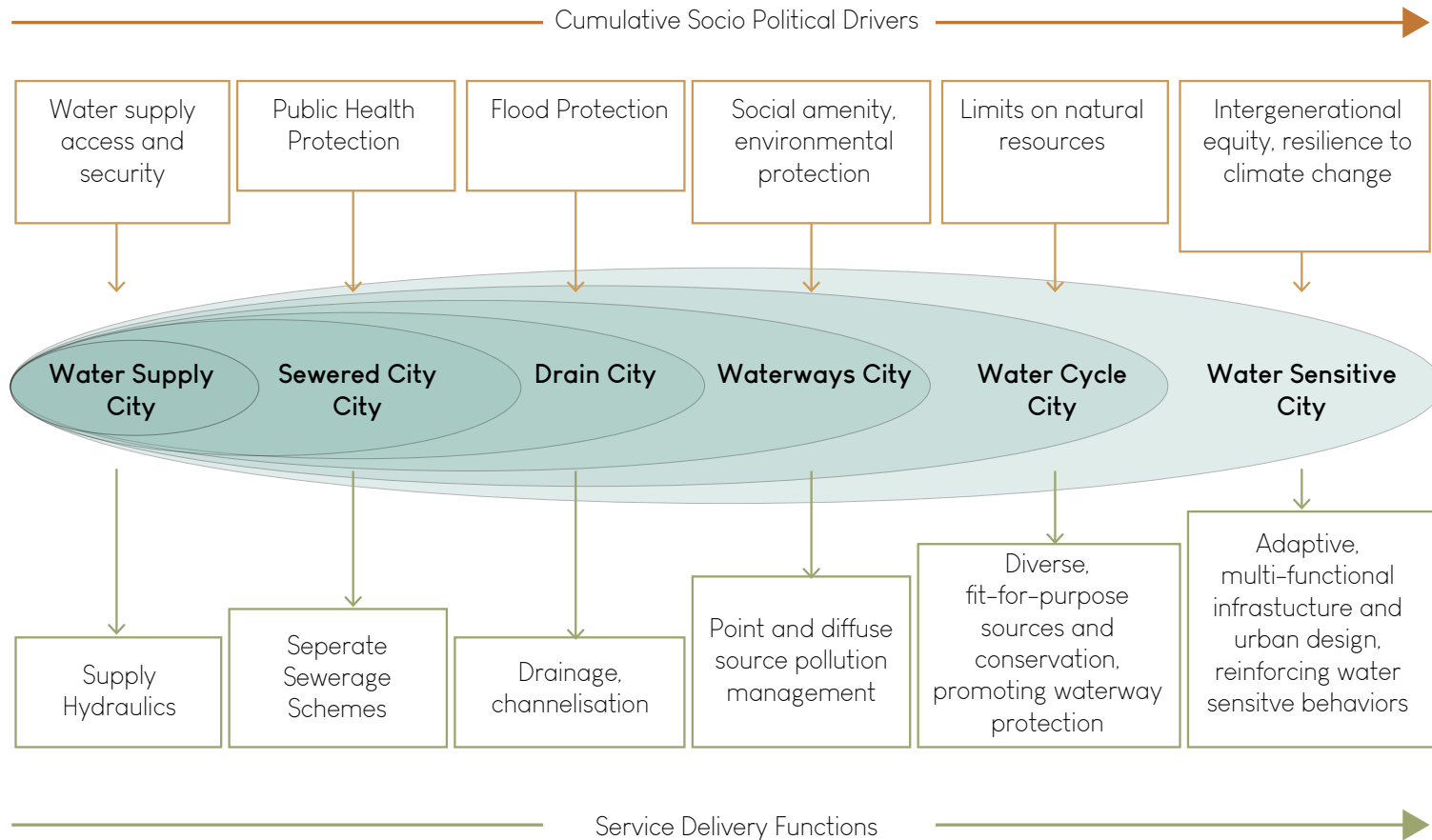
B2. What strategies in integrated watershed management can be used to mitigate drought conditions in arid rainfed regions?

C2. What is the impact of land use change on urban runoff?

Theoretical Framework

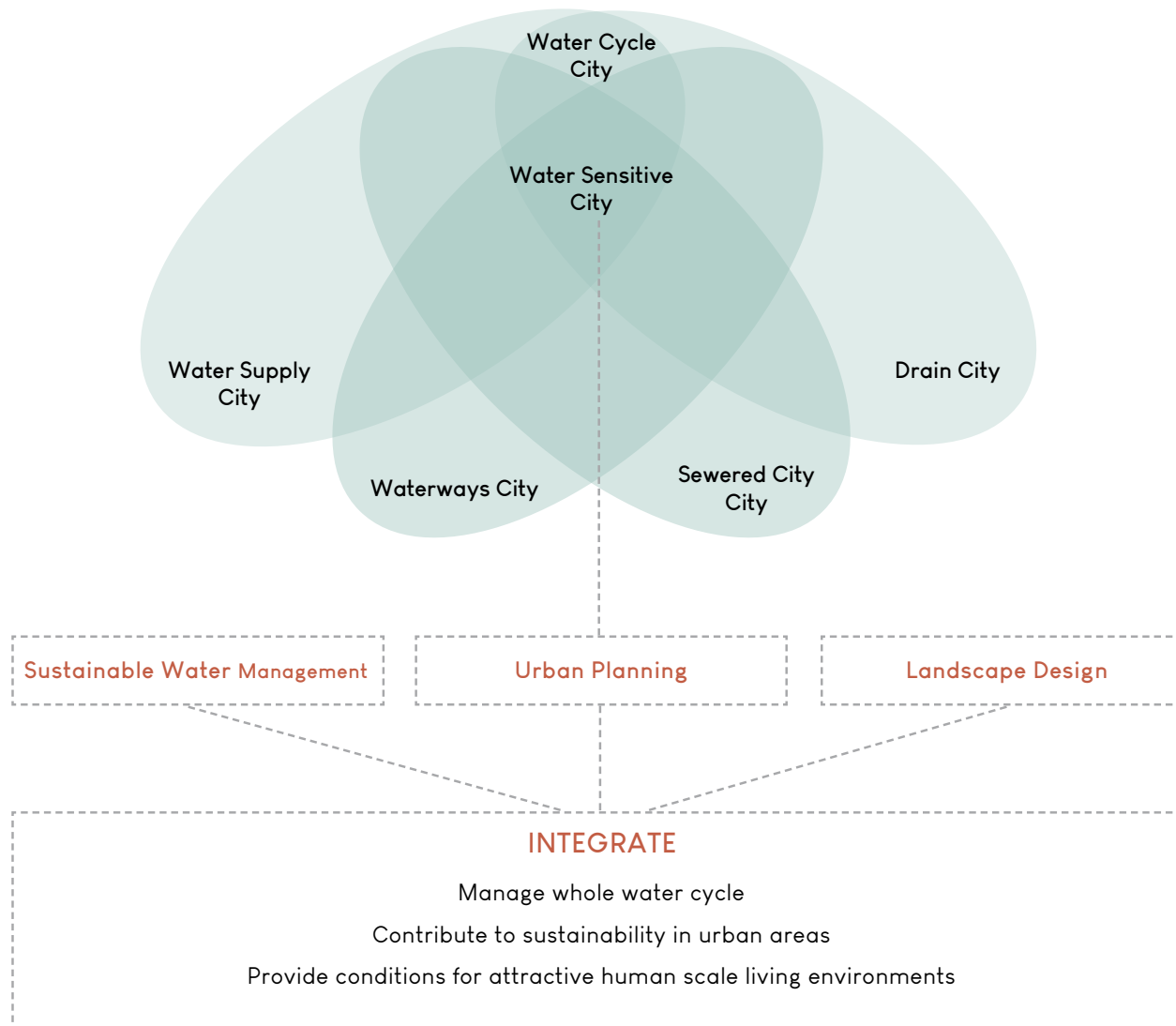


The Urban Water Transition Framework

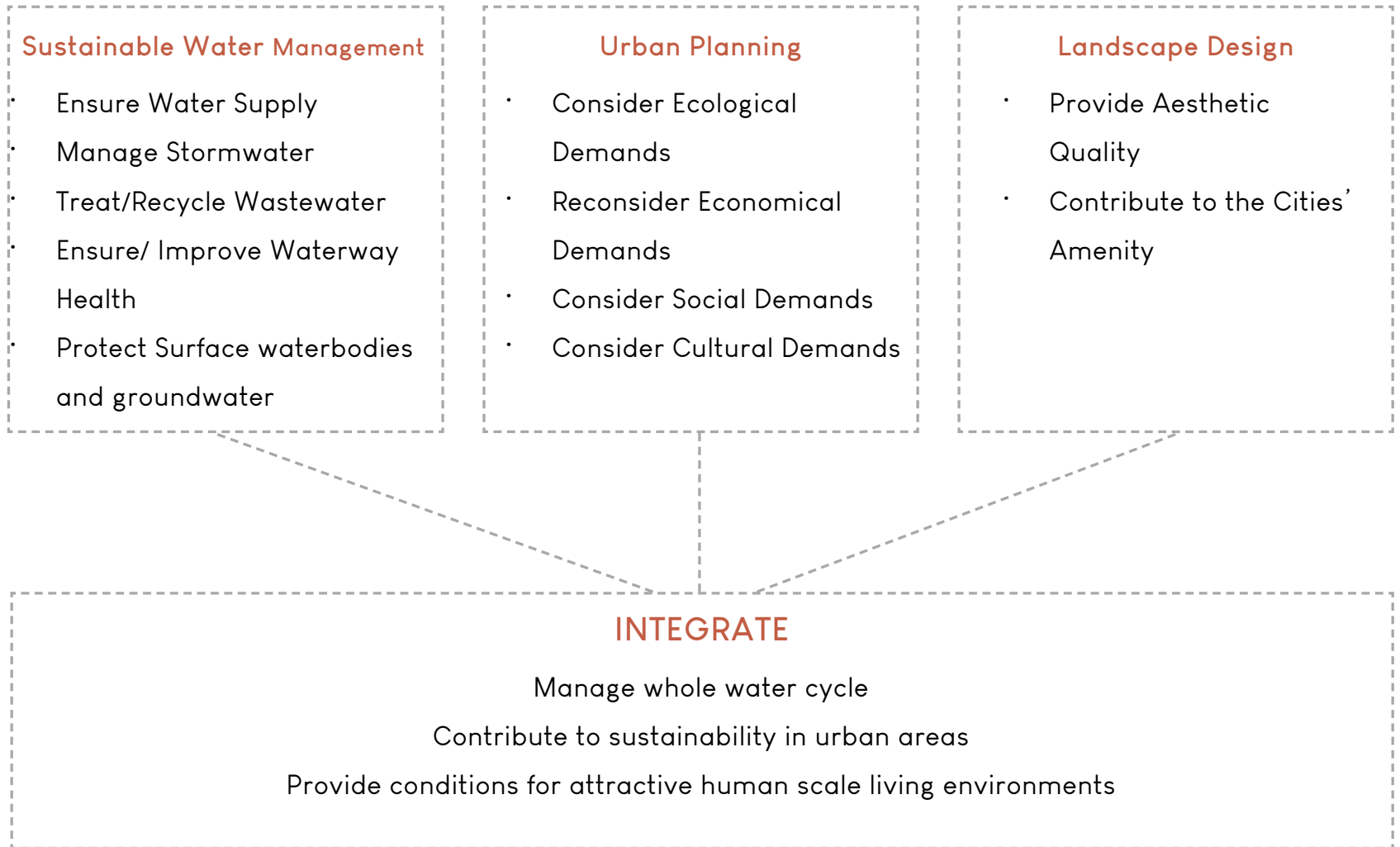


Source: R Brown, R. Keath, N., & Wong, T. (2009). Urban Water Management in Cities: Historical, Current and Future Regimes (Vol. 59).

Proposed Integrated Urban Water Framework for Developing Cities

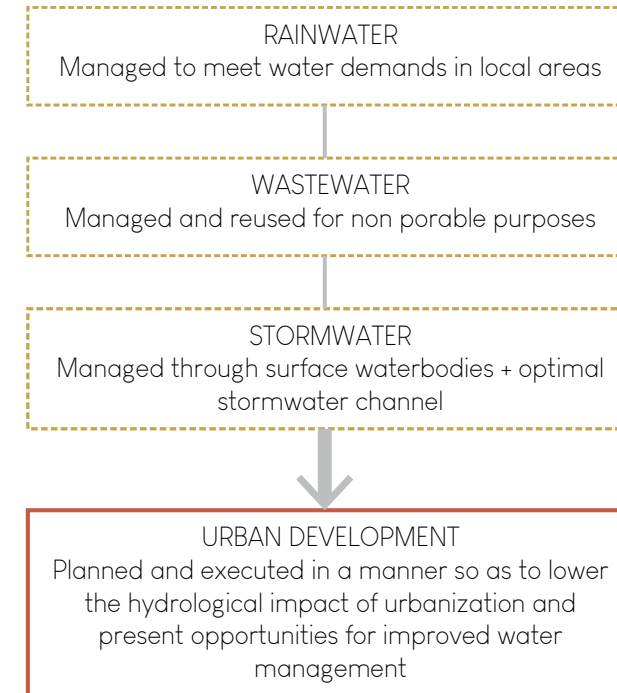
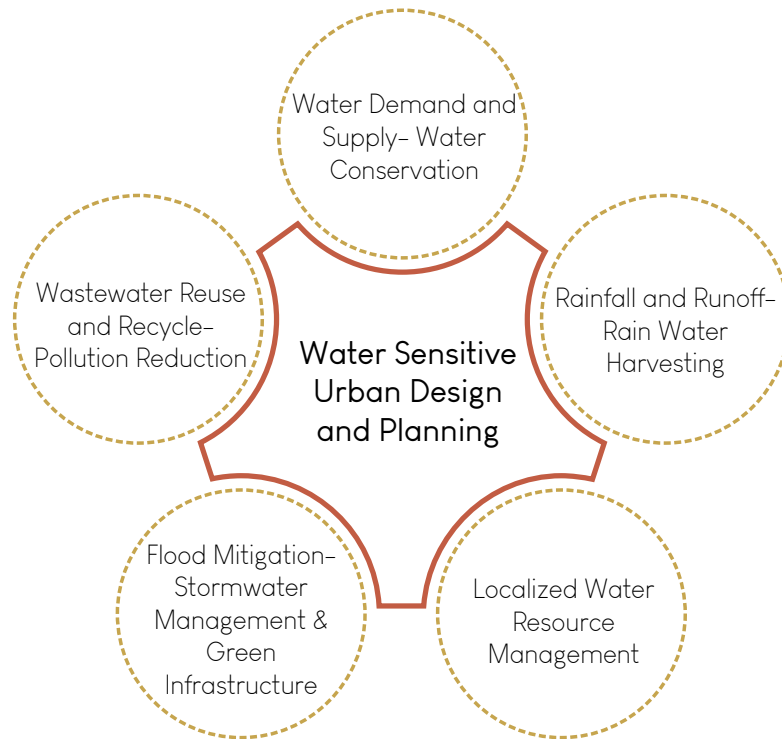


Componentets of Integration

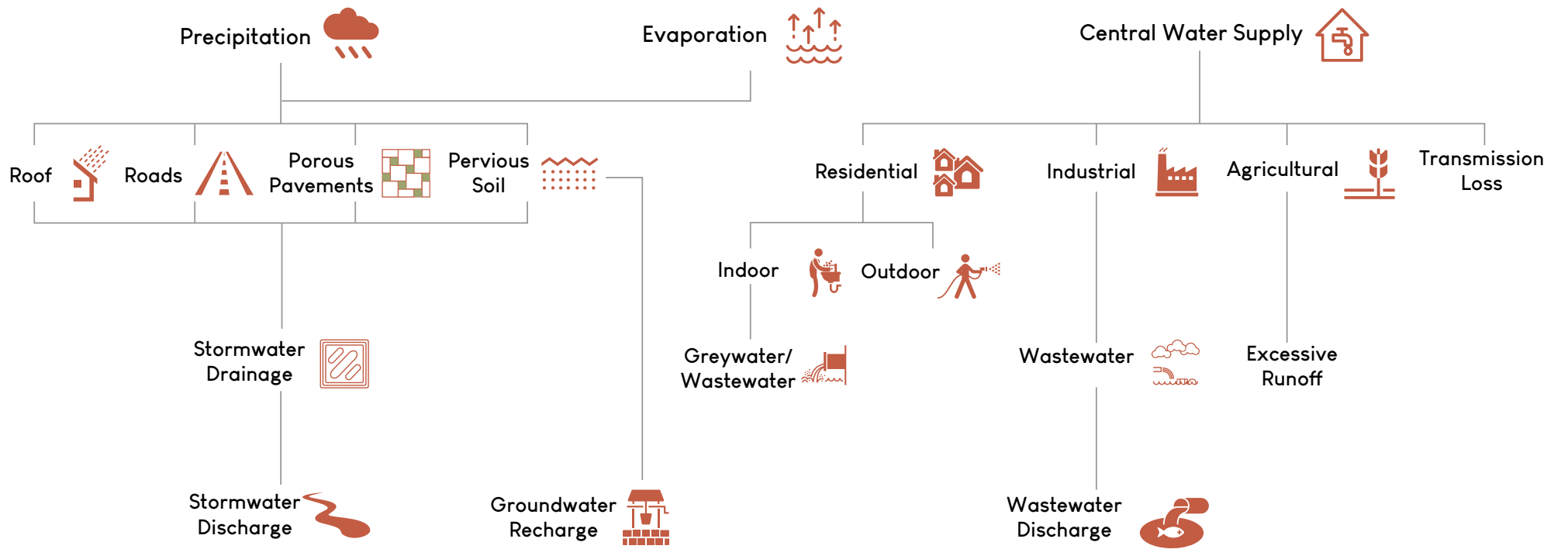


Source: SWITCH. (2006). Water Sensitive Urban Design: Principles and Inspiration for Sustainable Stormwater Management in the City of the Future-Manual.

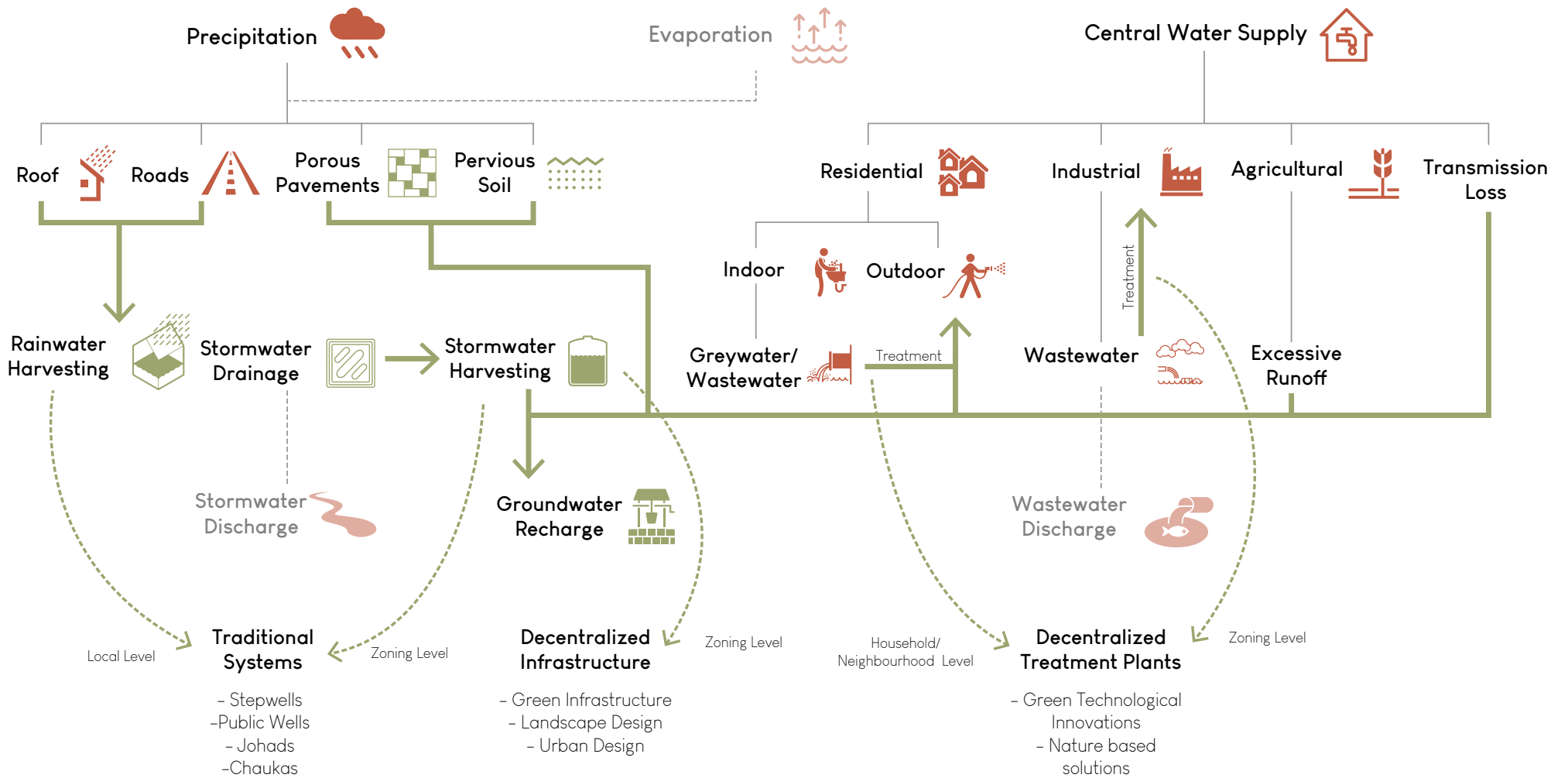
Principles of Water Sensitive Urban Planning and Design



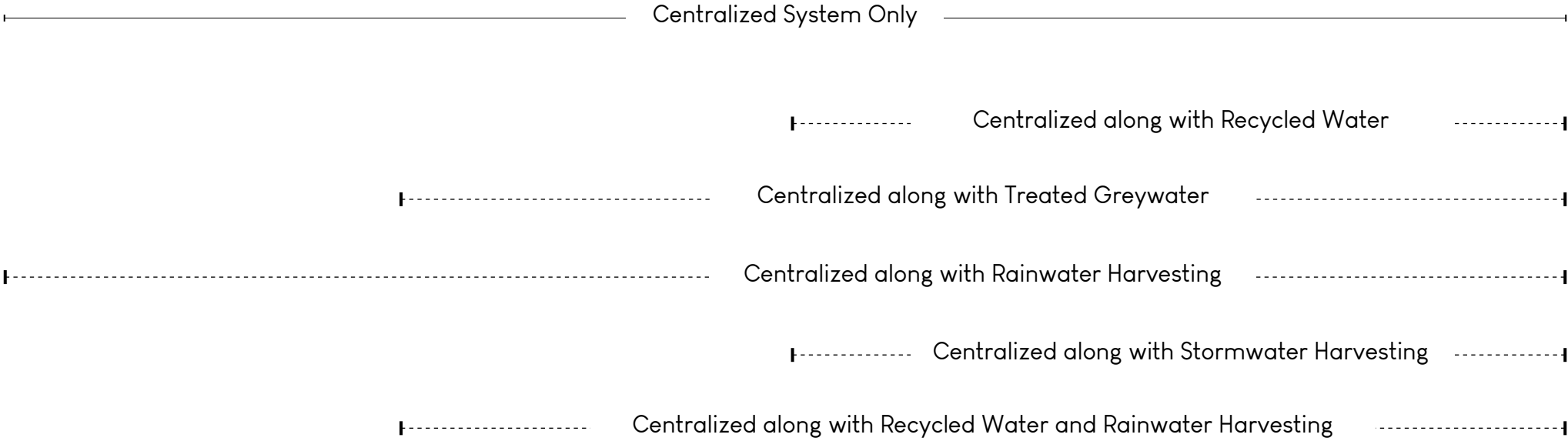
Current Water Management System of Jaipur



Proposed Hybrid System



Possible Scenarios



Multi Scalarity of the Hybrid System

Hybrid Water Management

[Planning]



Regional | City | Zonal

- Water Sensitive Urban Planning catering to ecological, economical, social and cultural demands
- Water Sensitive Land Use Planning (built vs open)
- Decentralized Infrastructure for water sewerage and drainage
- Integrated Watershed Management

[Governance]



Zonal | Neighbourhood | Local

- Decentralizing water management and treatment governance
- Community based water resource management
- Local Decision making for collective effort at rainwater harvesting and use

[Engineering and Design]



Neighbourhood | Local

- Adopting Nature based Solutions as green infrastructure
- Traditional water management systems and Innovation
- Water sensitive open/ green urban and landscape design
- Embrace sustainable new technologies

Characteristics of an urban plan in which spatial planning and urban water management are integrated?

Built vs Open

1. Open/Green space for water percolation
2. Increasing green surfaces for reducing urban runoff
3. Regulated land use with water conservation

Drainage

1. Stormwater management at public places through landscape
2. Integrate watershed management in designing
3. Buffer/Green areas along streets
4. Nature based solution for filtration

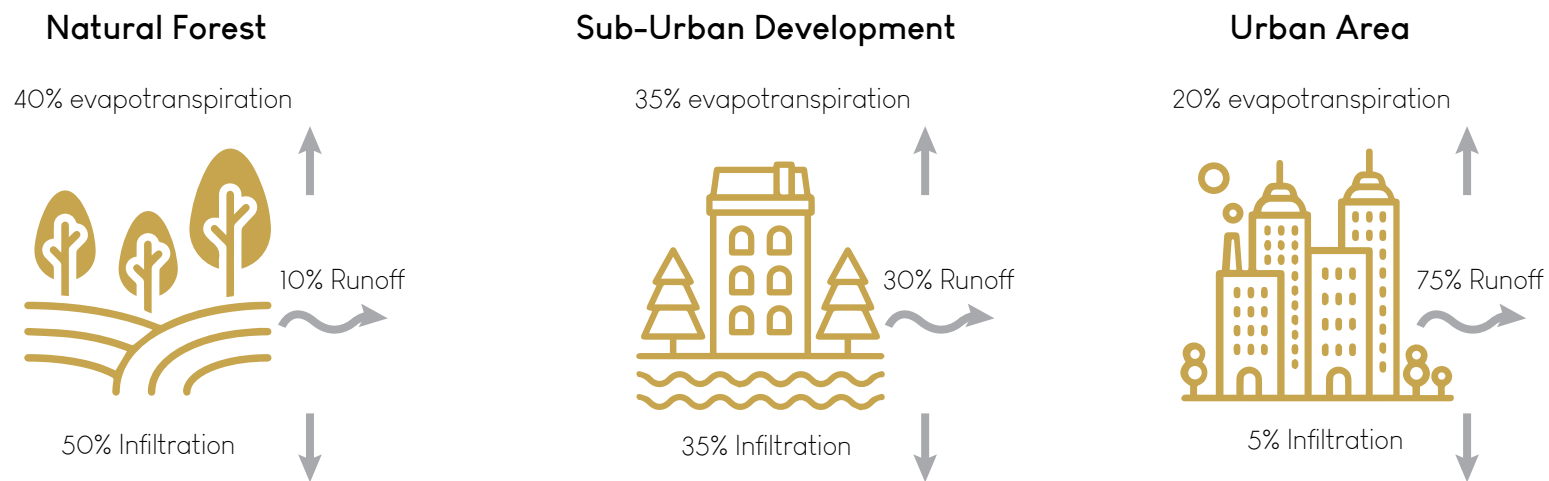
Sewerage

1. Recycling and Reusing wastewater
2. Reducing open drains to avoid pollution and health hazards
3. Low cost and low energy treatment solutions

Eco Zones

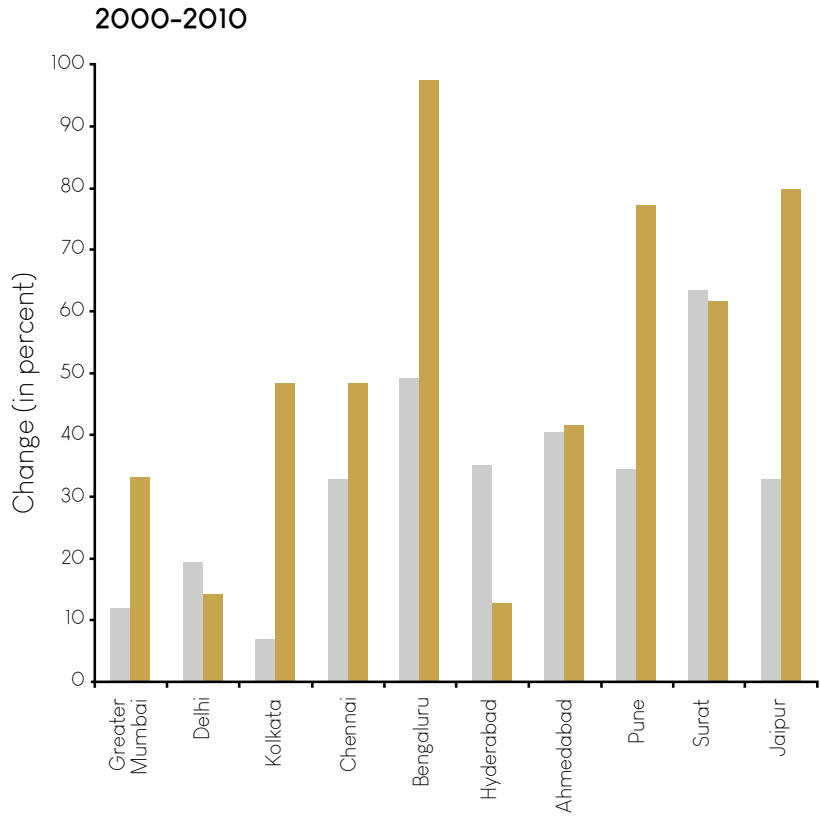
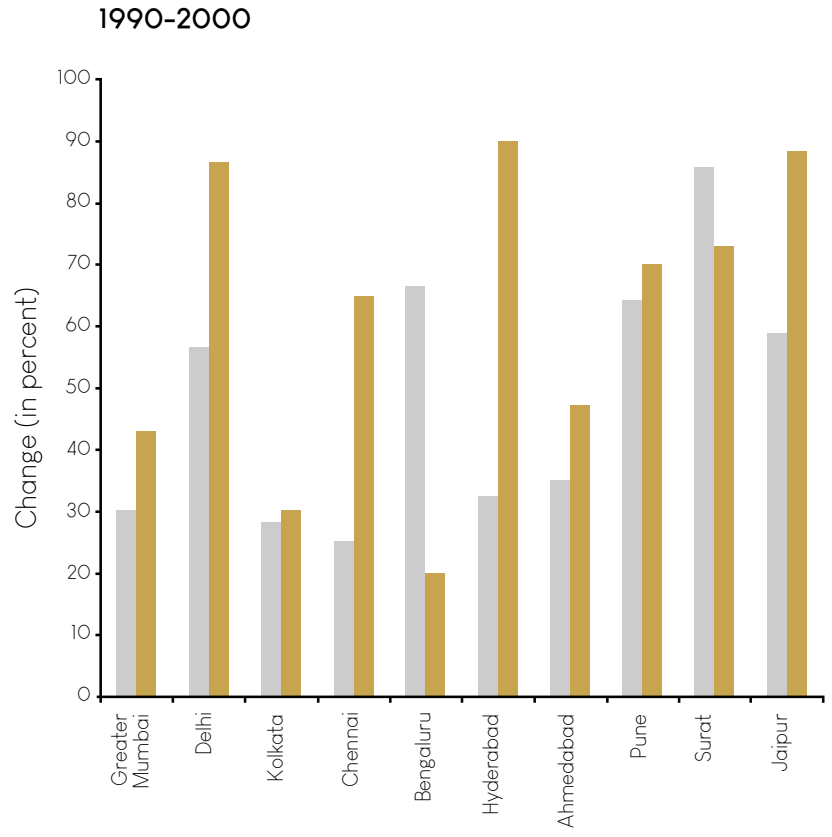
1. Protecting local waterbodies
2. Flood mitigation
3. Protecting forest cover
4. Promoting sustainable water sensitive agricultural practices
5. Restricting encroachment along reserved forest zones and waterbodies

Changes in Natural water Balance with Urbanization



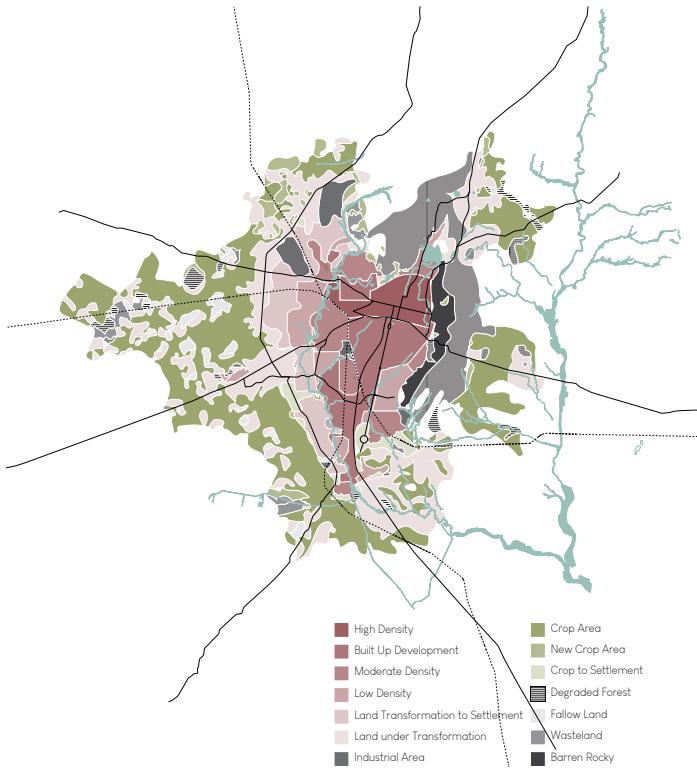
Urbanization increases surface stormwater runoff and modifies its quality as runoff volume is proportional to impervious areas

Percentage change of Built Area vs Population in Indian Cities

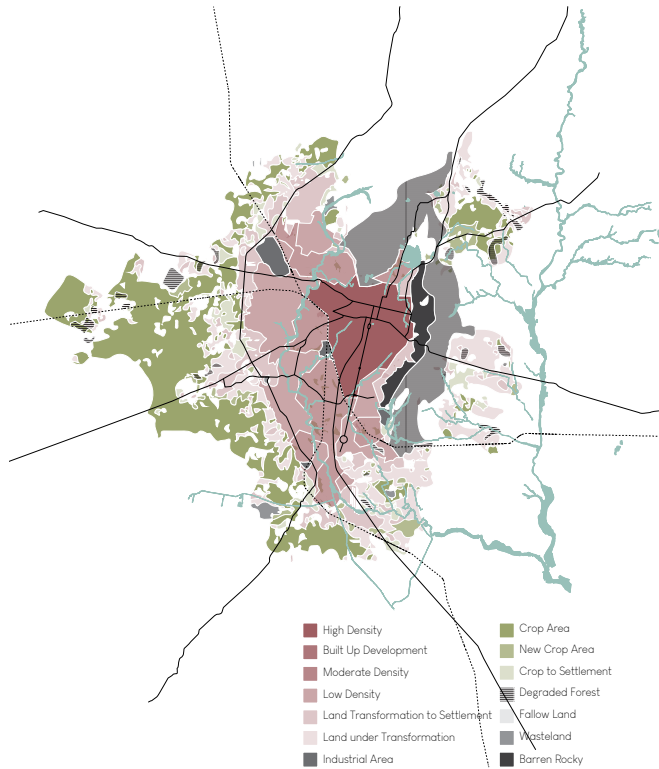


Land Transformation in the Jaipur Urban Area

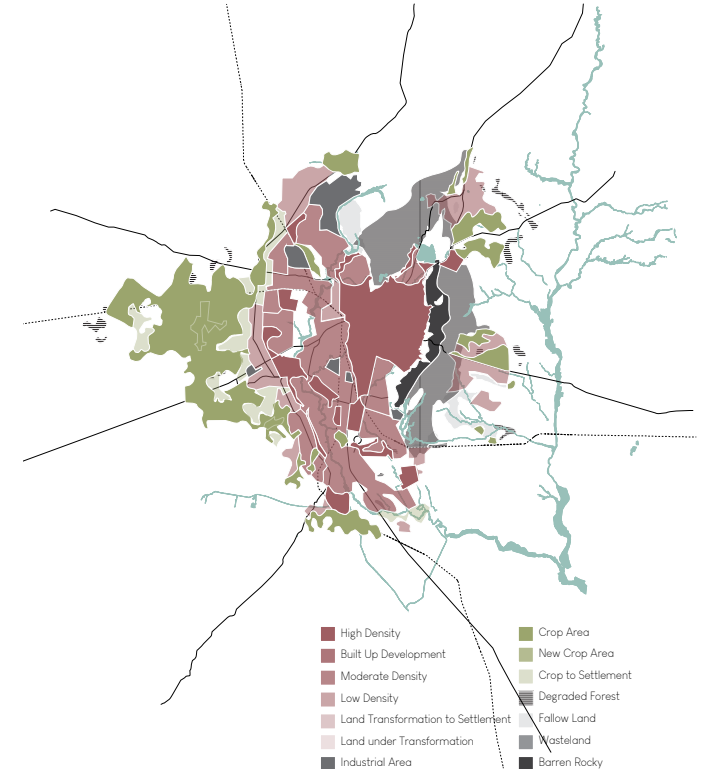
1986-1991



1991-2003

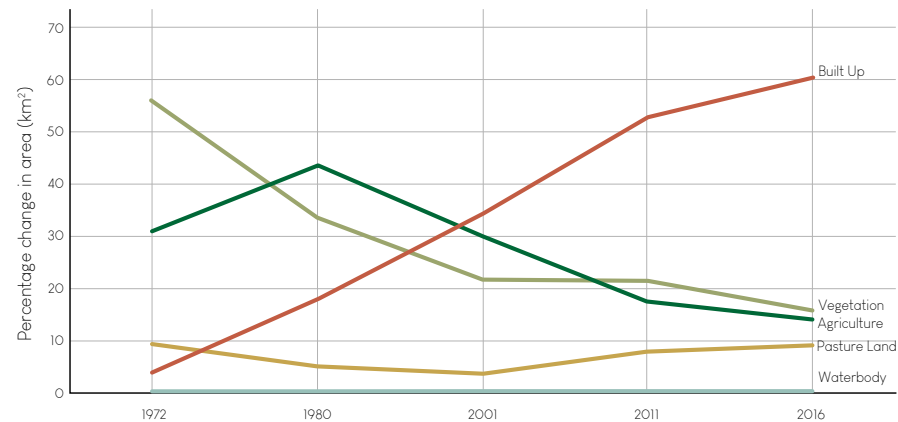


2003-2009

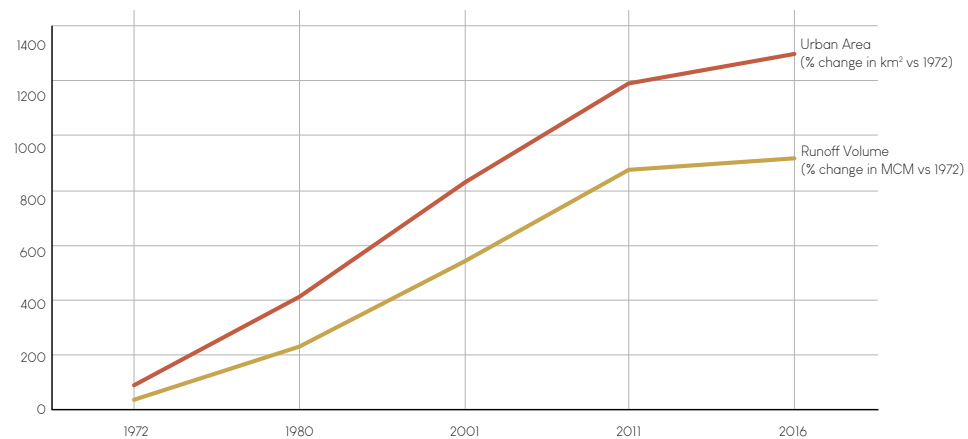


Effect of Land use Change on Urban Runoff in Jaipur

Change in Land use

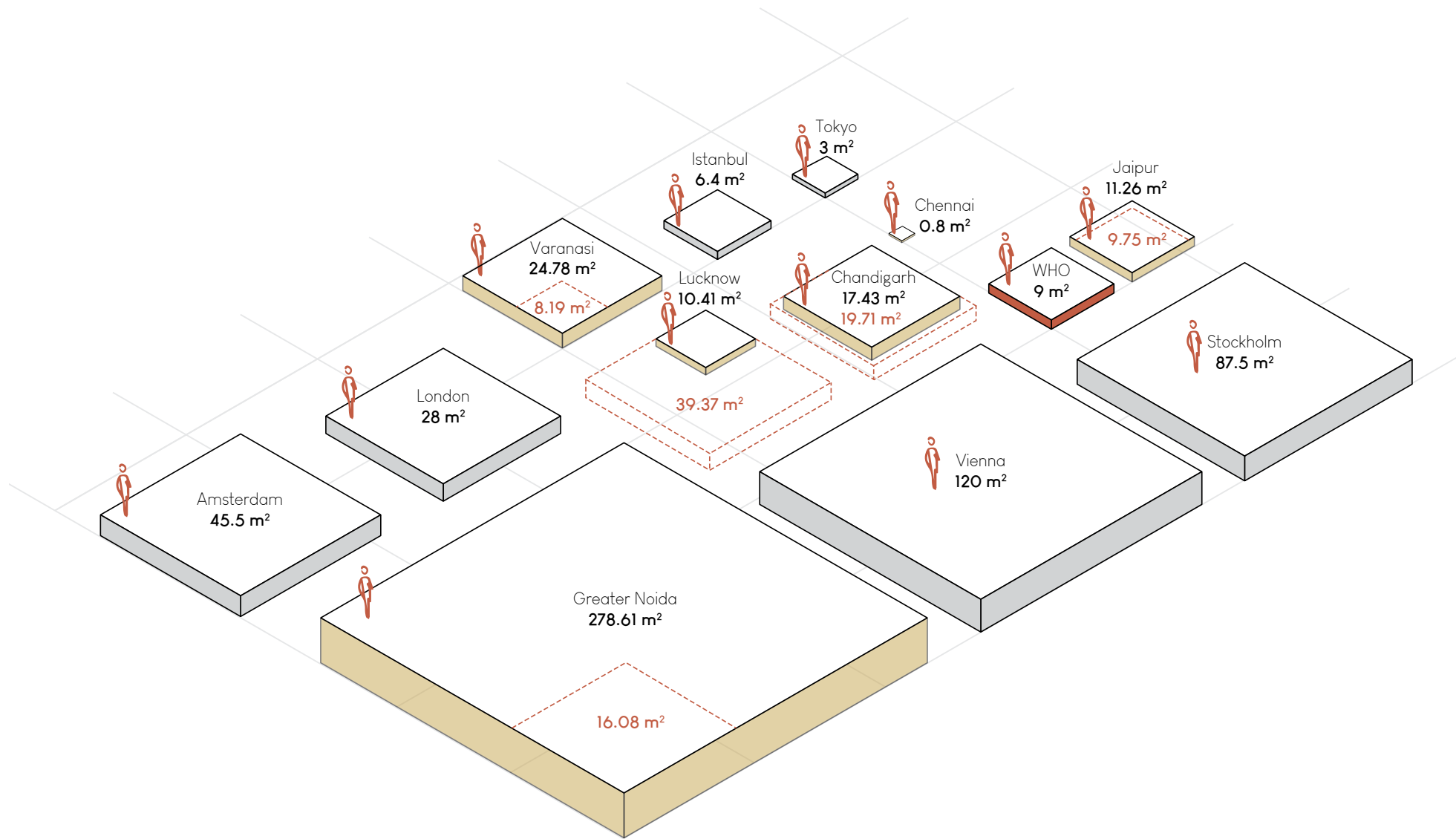


Land Use vs Urban Runoff in Jaipur

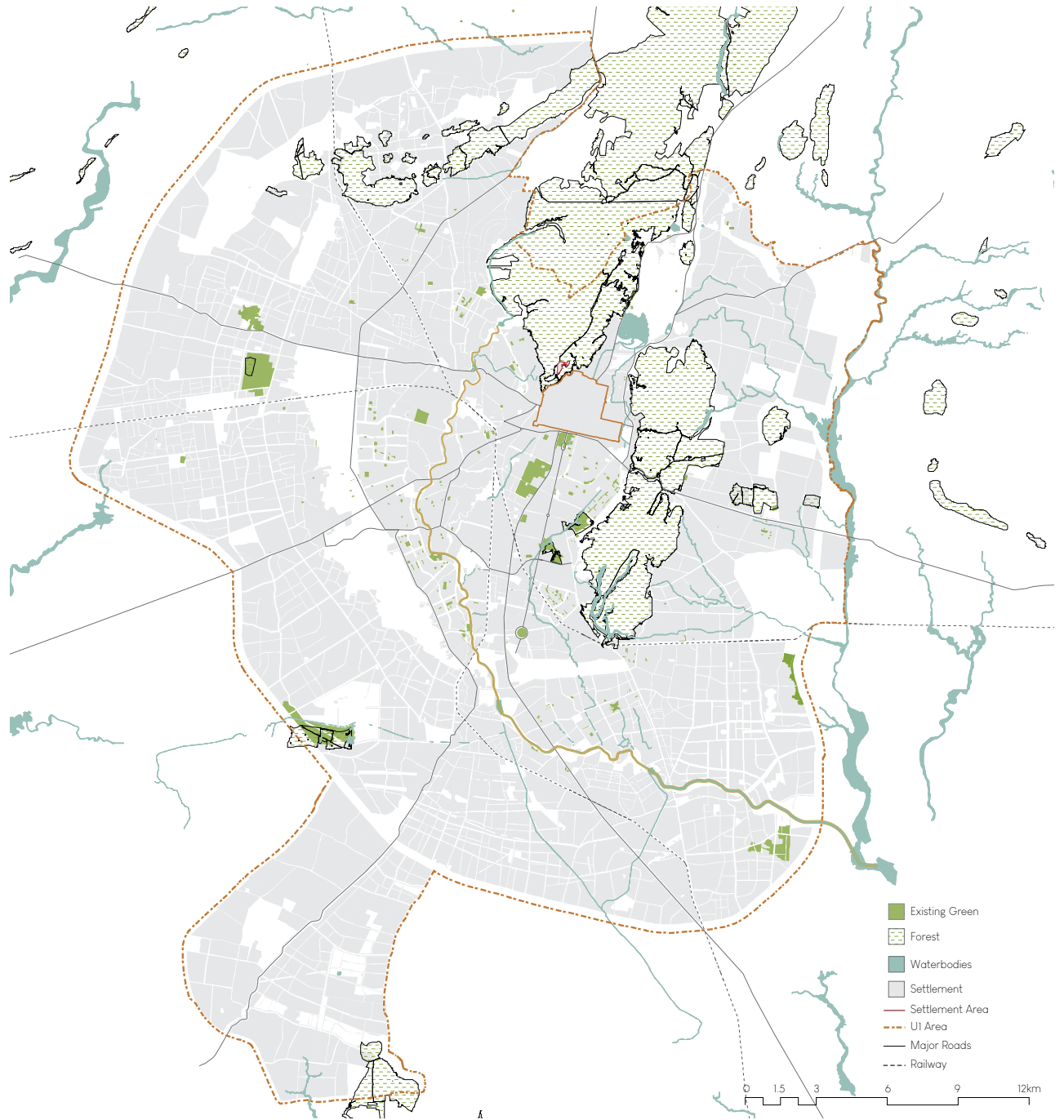


Source: Khare, D., Singh, L., & Jat, M. (2017). Impact of Landuse Change on Urban Runoff: A Case Study of Jaipur City, India. Paper presented at the 37th IAHR World Congress, Kuala Lumpur, Malaysia.
Graphic by Author

Per Capita Open Space in Cities



Green Areas- MDP 2011



Total open Space: 34.6 km²

Population: 3,073,350

Per capita space: 11.3 m²

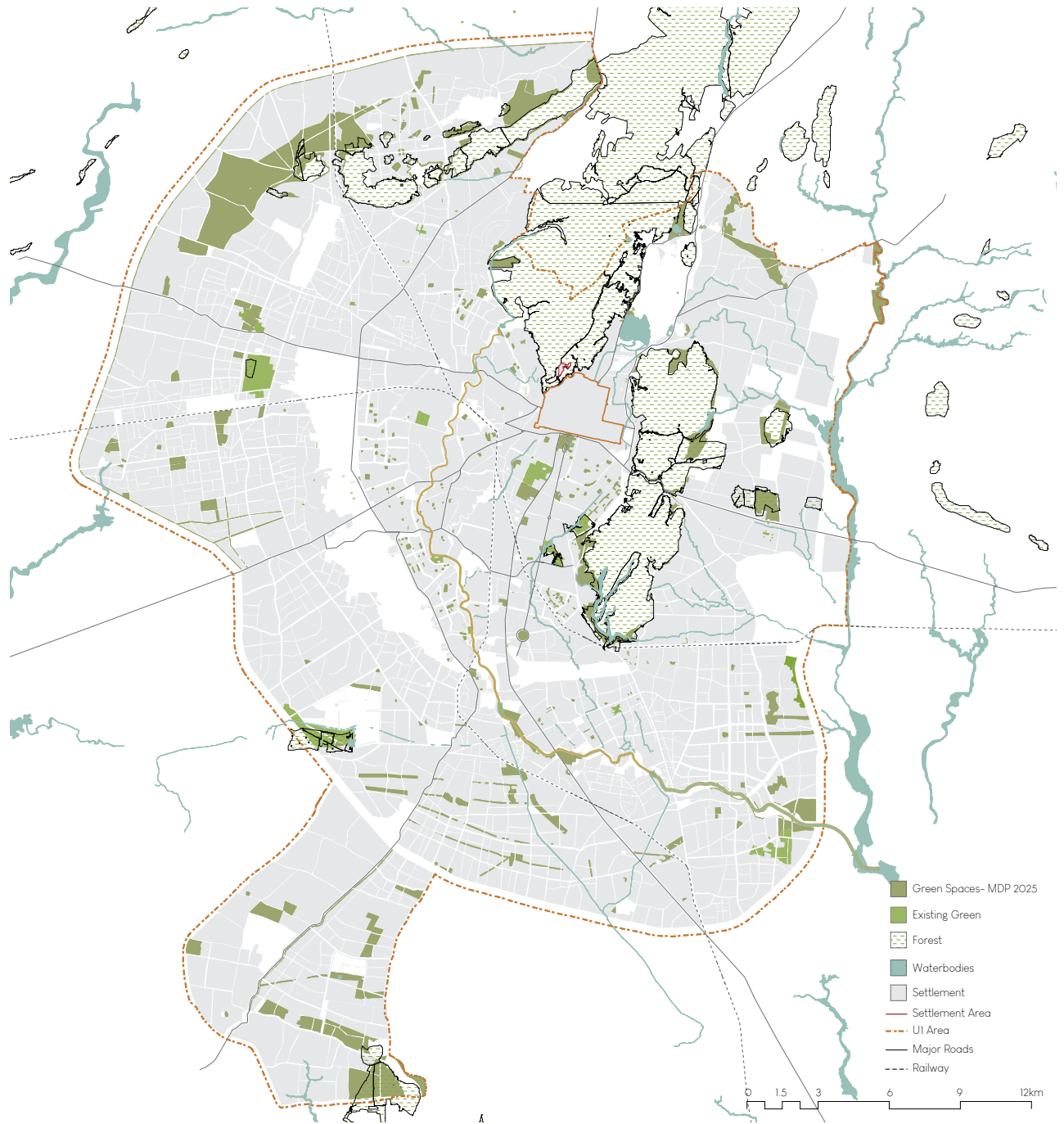
Green Areas- MDP 2025

Use	Area (km ²)	Percentage
Residential	457.46	48.39
Commercial	72.22	7.64
Public- Semi Public	52	5.5
Government Use	0.44	0.05
Army Area	10.42	1.1
Tourist Facility	10.32	1.09
Industries	26.38	2.79
Special Area	70.36	7.44
Circulation	100.30	10.61
Recreational	62.99	6.66
Nursery and Orchards	0.33	0.03
Water Bodies/ Drains	7.99	0.85
Open Forest	70.97	7.51
Open Space	0.35	0.04
Ecological	0.48	0.05
U3 Area	2.33	0.25
Total	945.34	

Total open Space: 63.34km²

Population: 6,495,000

Per capita space: 9.75 m²



Identifying Potential Urban Green

- District Parks
- Neighbourhood Parks
- Playgrounds
- Greenbelt [(buffers)]
- Green Strips
- Plazas
- Urban Canals
- Major Recreational Spaces
- Botanical Gardens
- Zoological Parks
- Traffic Parks
- Multipurpose Grounds

As per UDPFI Guidelines, per capita space should be 12-14m² in metropolitan cities

Required Space/Catchment:

90.93km²

Annual Rainfall: 600mm

Runoff Coefficient: 0.5

27,279,000 lit/year



Stormwater Management on Developmental Scale



Creating Stormwater storage spaces for maintaining landscape



Potential Harvesting Areas

Through Stormwater Management

Circulation:

100km²

Annual Rainfall: 600mm

Runoff Coefficient: 0.5

30,000,000 lit/year

Through On-Site Rainwater Harvesting

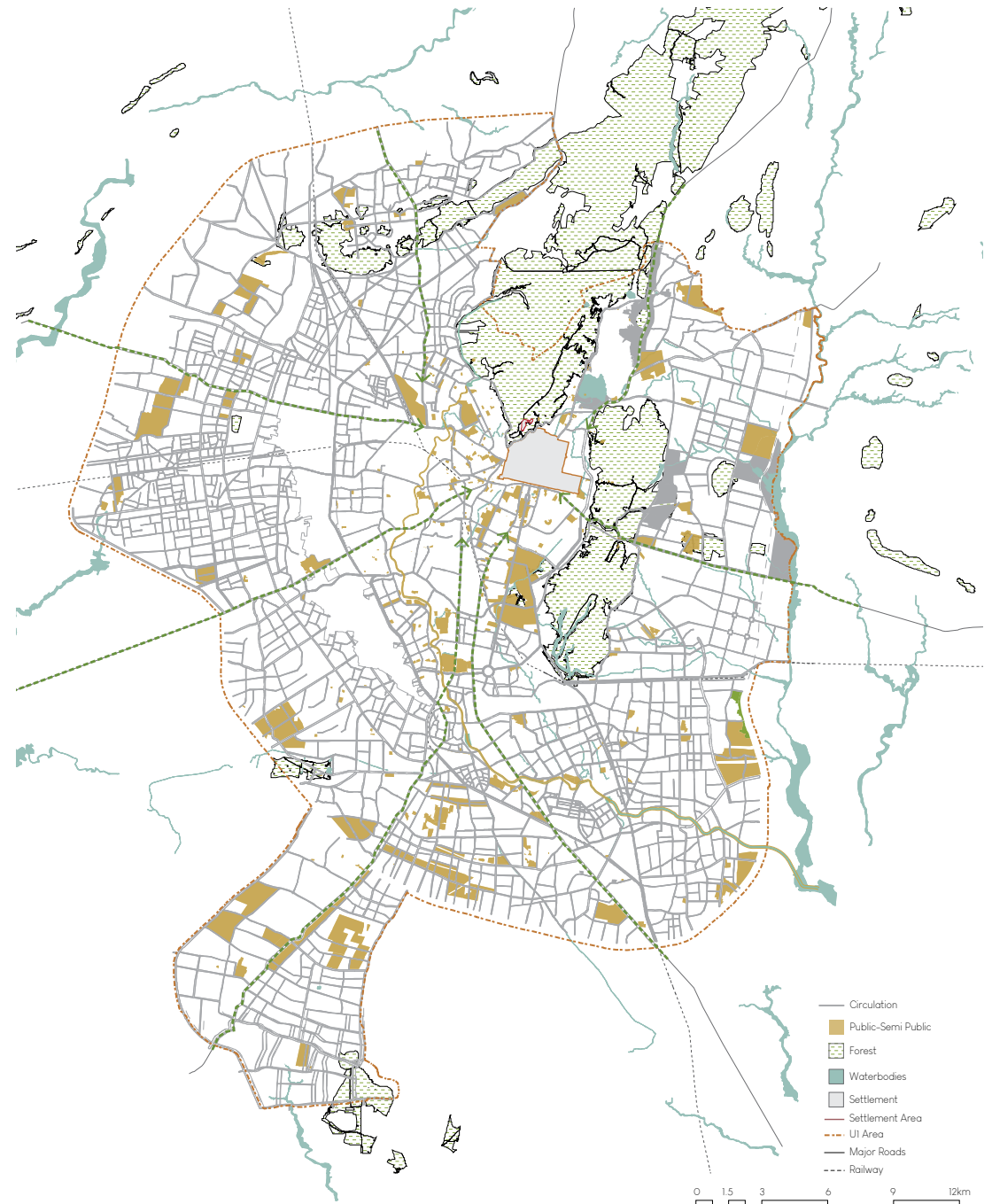
Public Semi-Public

773.84km²

Annual Rainfall: 600mm

Runoff Coefficient: 0.8

371,443,200 lit/year



Total Water Calculation:

428,722,200 litres/year

Per person consumption per day: 150 litres

Population 2025: 6,495,000

44% of the population can be served in a year

Climate Change Adaptation Technologies for 'TOO LITTLE WATER'

WATER ALLOCATION

1. Basin Level Modelling and Seasonal Forecasting
2. Seasonal Water Rationing
3. Water Re-allocation

WATER AUGMENTATION

1. Rainwater Harvesting for Infiltration
2. Urban Green Spaces
3. Conjunctive Use of Surface and Groundwater
4. Managed Aquifer Recharge (MAR)
5. Source Water Protection

WATER EFFICIENCY AND DEMAND MANAGEMENT

1. Water Efficiency in Industry
2. Improved Irrigation Efficiency
3. Water Metering
4. Reducing System Water Loss and Leakages
5. Public Water Conservation Campaigns
6. Progressive Pricing
7. Hydrological Zoning
8. Water Licencing and Permits
9. Shifting the timing of use
10. Water savings requirements in building codes

WATER STORAGE

1. Surface Reservoirs
2. Multipurpose Dams
3. Soil Moisture Conservation Techniques
4. Natural Wetlands
5. Rainwater Harvesting For storage

ALTERNATIVE WATER SOURCES

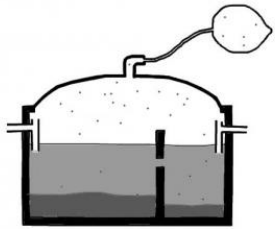
1. Sea water desalination
2. Soilar water Distillation
3. Fog Harvesting
4. Interbasin transfers
5. Groundwater prospecting and extraction
6. Boreholes and Tubewells
7. Water Recycling and Reuse

+

Traditional Systems

Green Infrastructural Solutions for Water Management

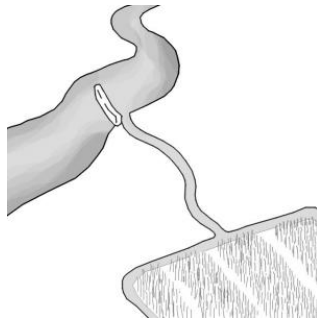
Anaerobic Biogas Settler



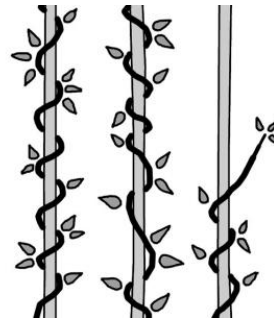
Non Planted Filters



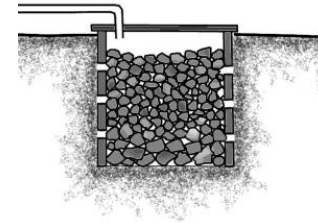
Sparte Irrigation



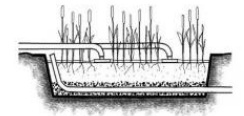
Vertical Gardens



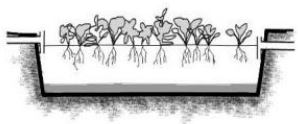
Soak Pit



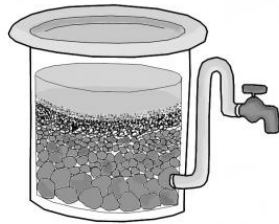
Vertical Flow Constructed Wetland



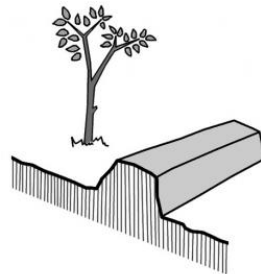
Aquaculture



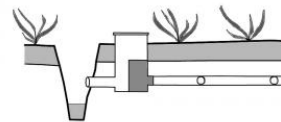
Bio Sand Filtration



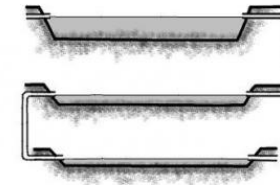
Bunds



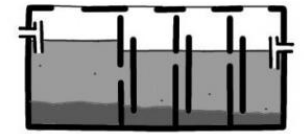
Controlled Drainage



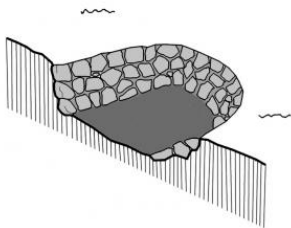
Waste Stabilization Ponds



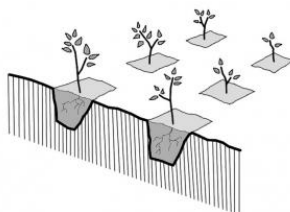
Anaerobic Baffled Reactor



Micro Basins



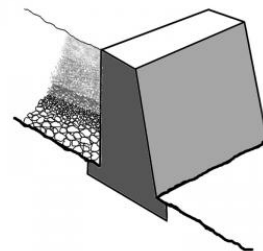
Planting Pits



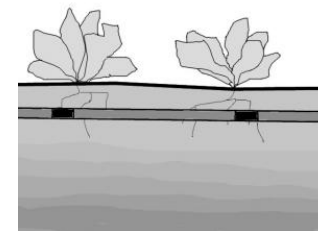
Retention Basins



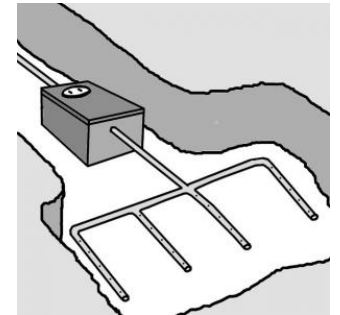
Sand Dam



Subsurface Drip Irrigation

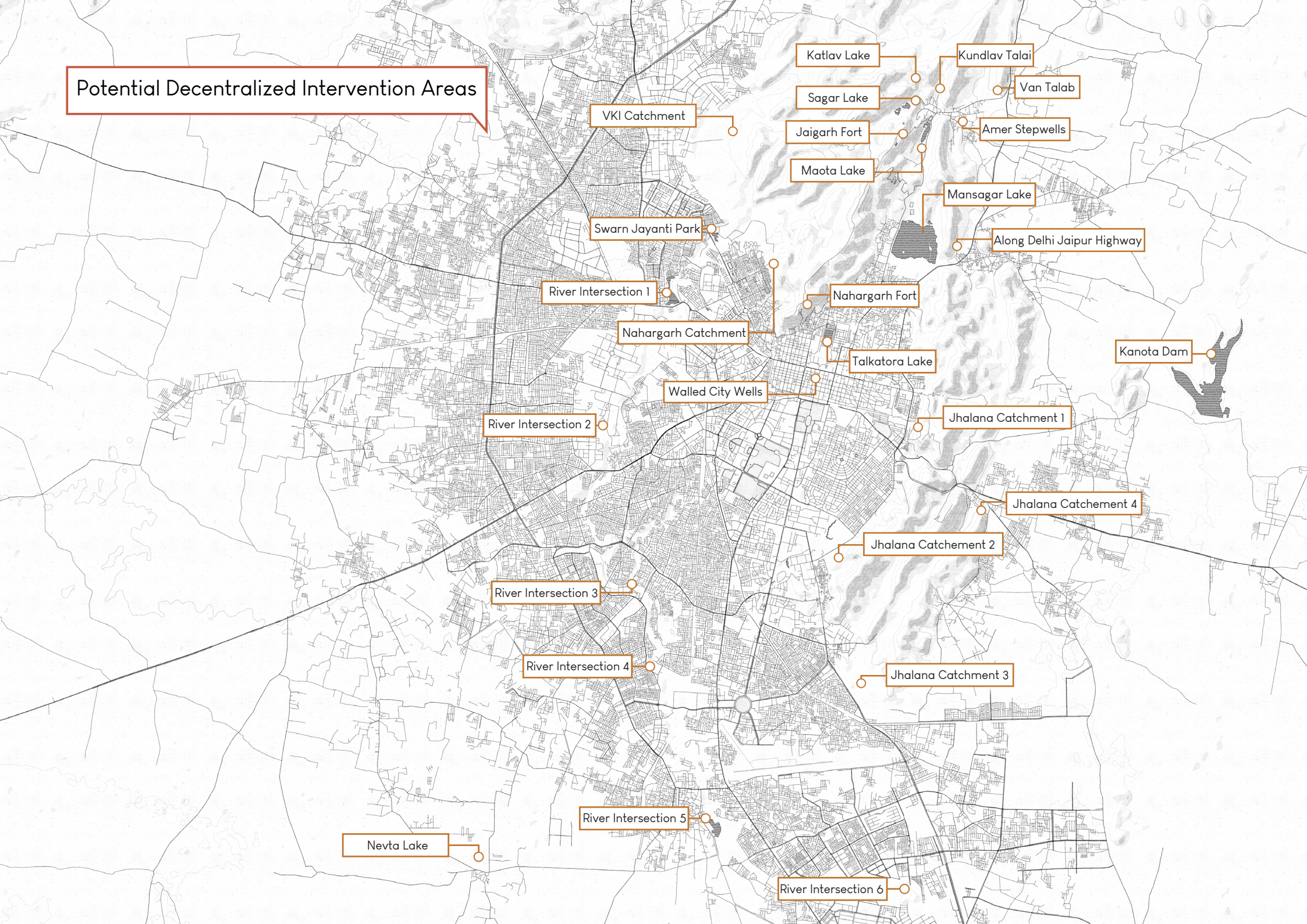





Leach Field













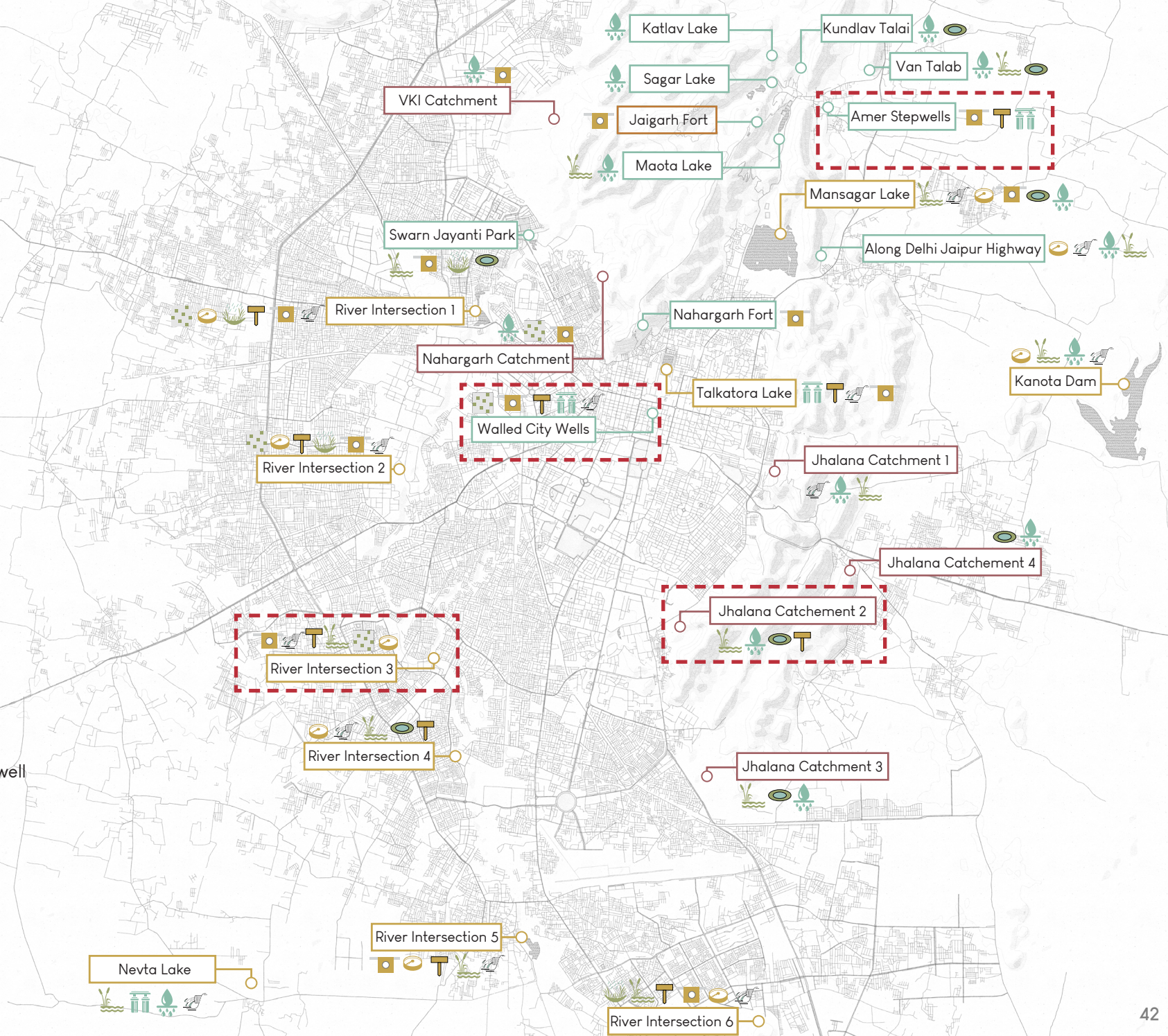
Source: Various (compiled at <https://sswm.info/>)

Potential Decentralized Intervention Areas



-  Rainwater Harvesting
-  Wastewater Treatment
-  Stormwater Management

-  Water Filtration
-  Reorganize Sewage Drain
-  Bio-retention area
-  Recharge through injection well
-  Filter Drains and Trenches
-  Water Treatment
-  Infiltration Basin
-  Bioswales
-  Wetlands
-  Porous Pavement

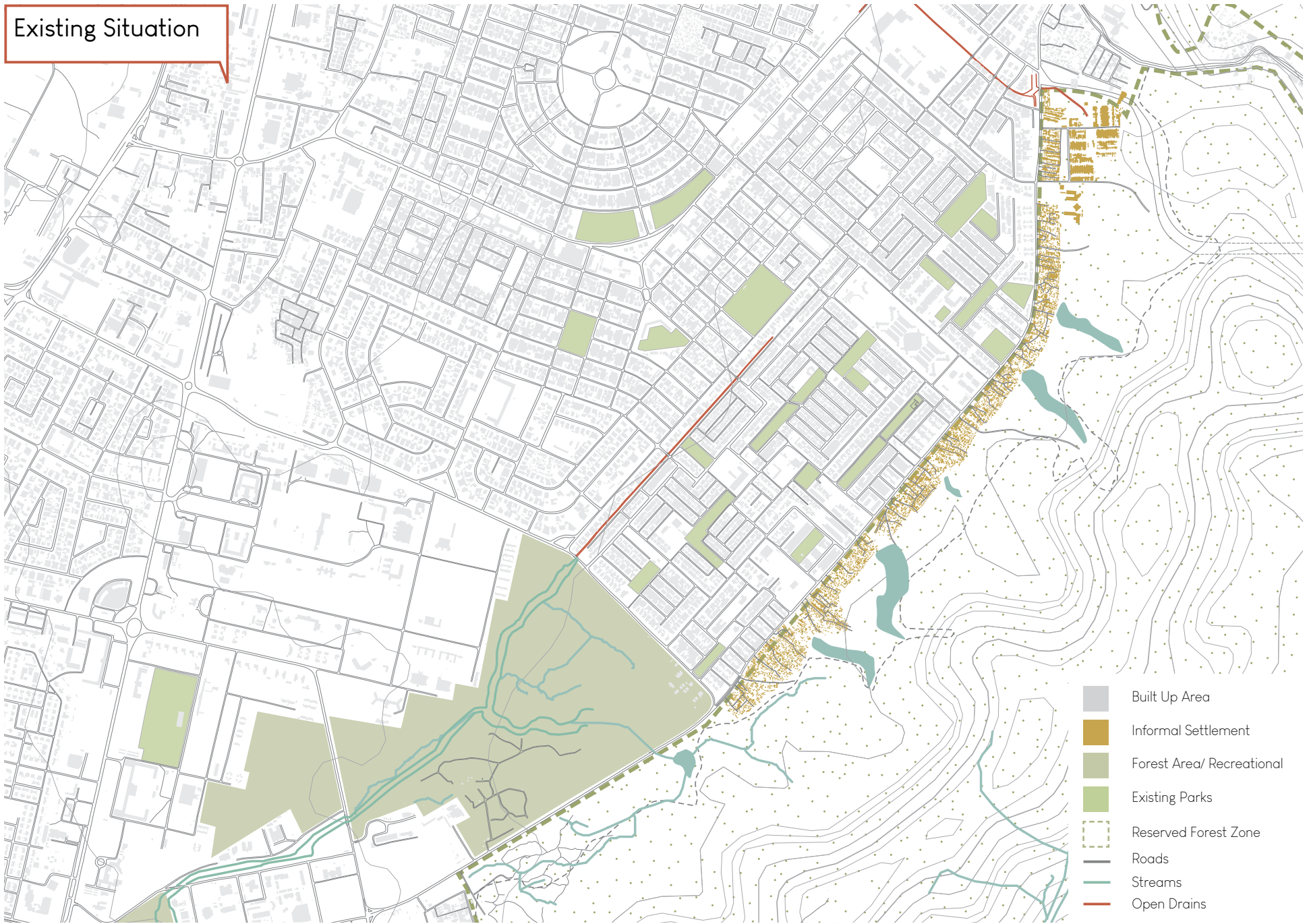


RE-NATURED INFORMALITY

Catchments of Jhalana Doongri



Existing Situation



Current Condition



" All the water during rains gets collected here on the streets, sometimes even fills inside our houses. It's a lot of trouble for the kids especially as the school has to shut down during rains.

*Rameshwar Meena
(Resident in the slum)*

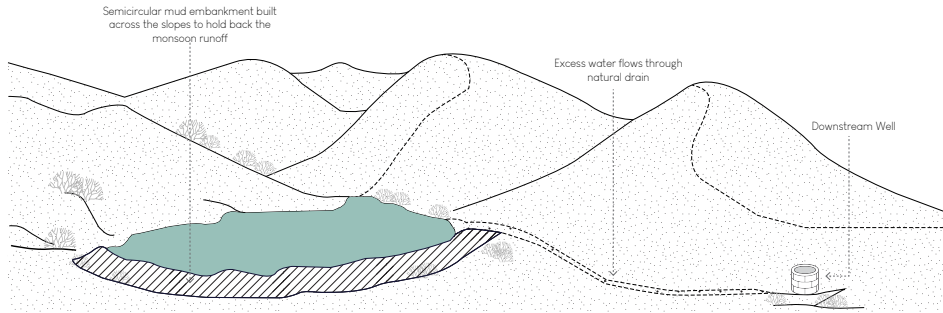
I have been living here for 5 years now and I have never seen it dry, the water from the hills and the streets collects here everytime. Since we don't get any water from the municipality so we have been using this dirty water for washing clothes and bathing.

*Anita Kavar
(Resident in the slum)*

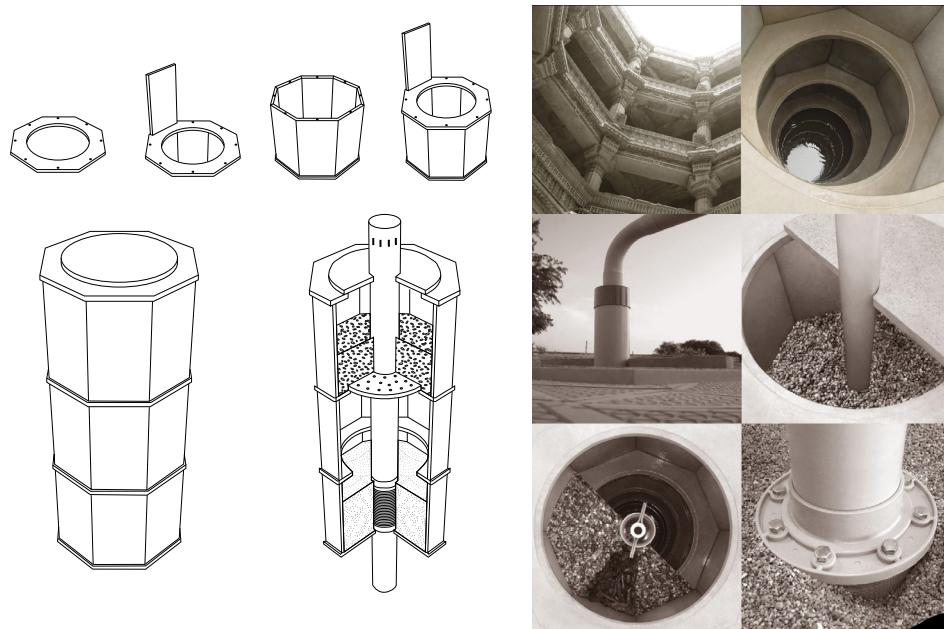


Components of the Proposed Strategy

1. Johad

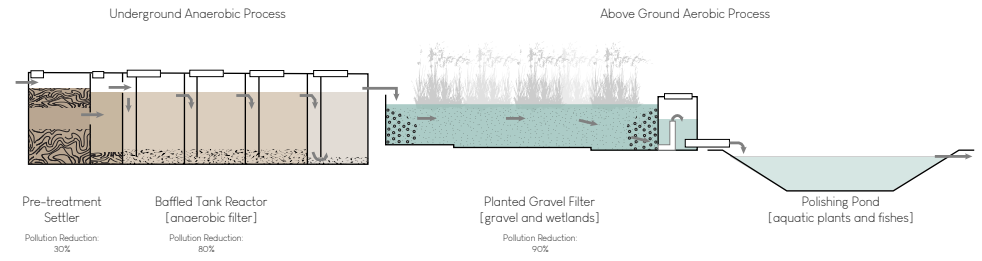


2. Furaat Precast Modular Stepwell

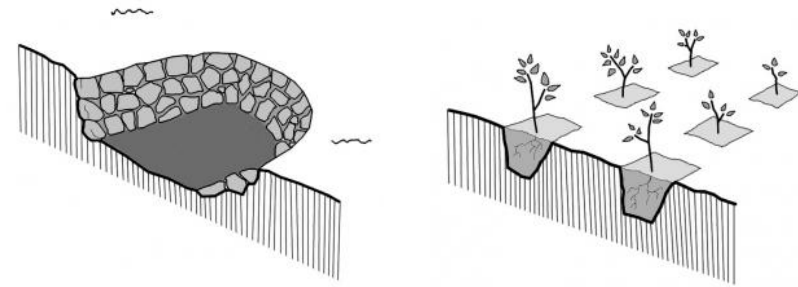


Source: Furaat Earth Pvt Ltd, Ahmedabad

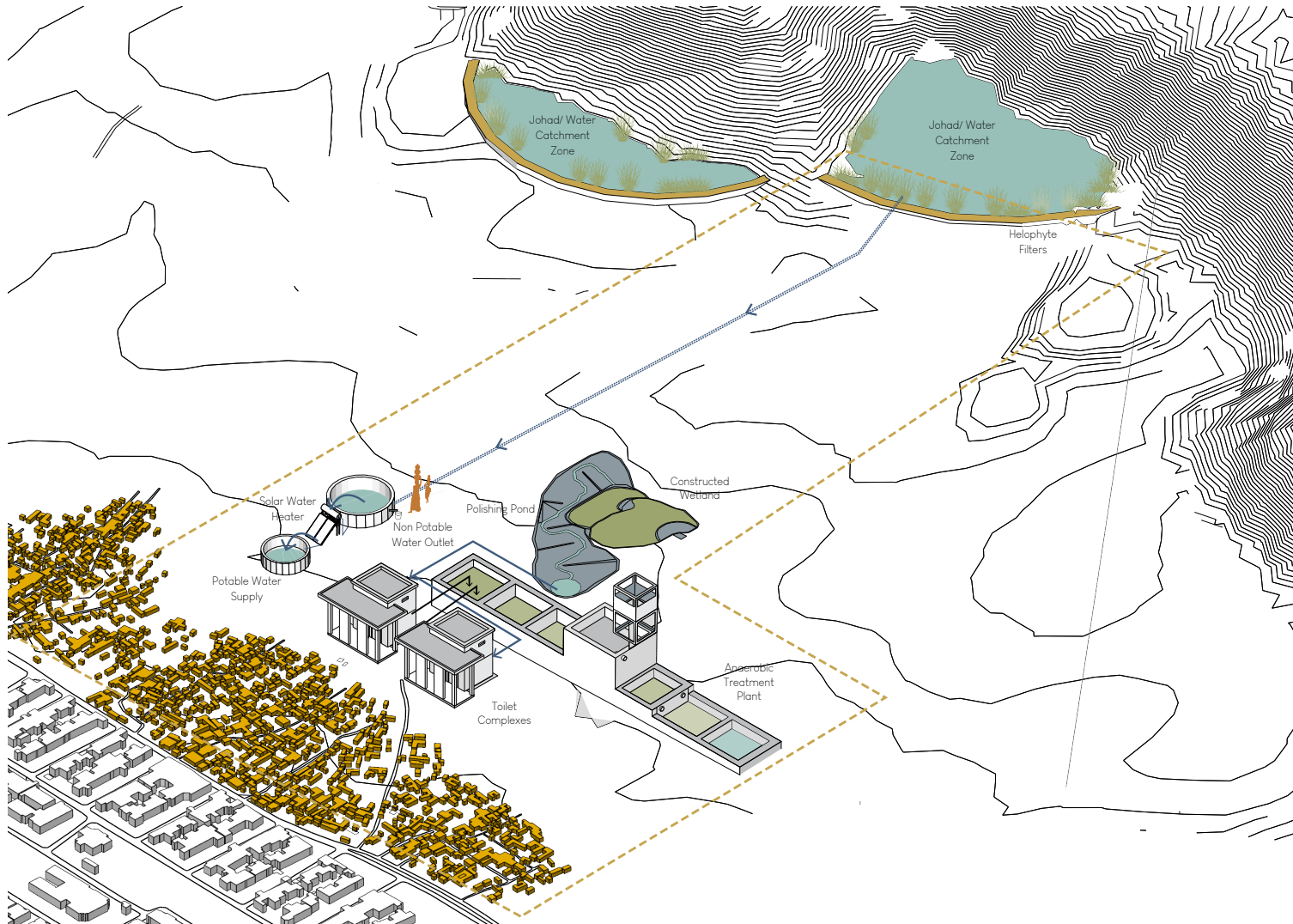
3. Underground Anaerobic Treatment Plant



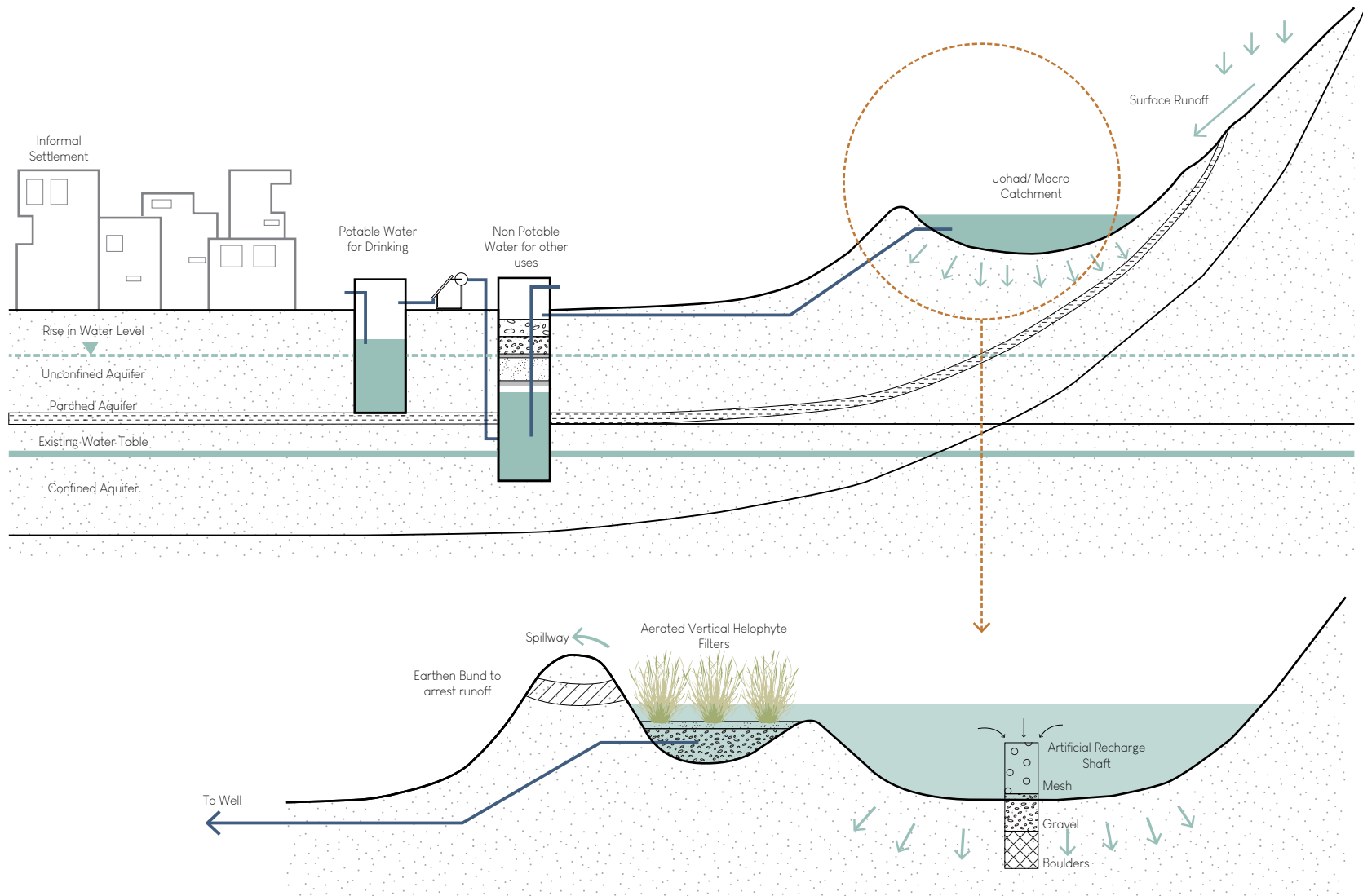
4. Micro Basins & Planting Pits



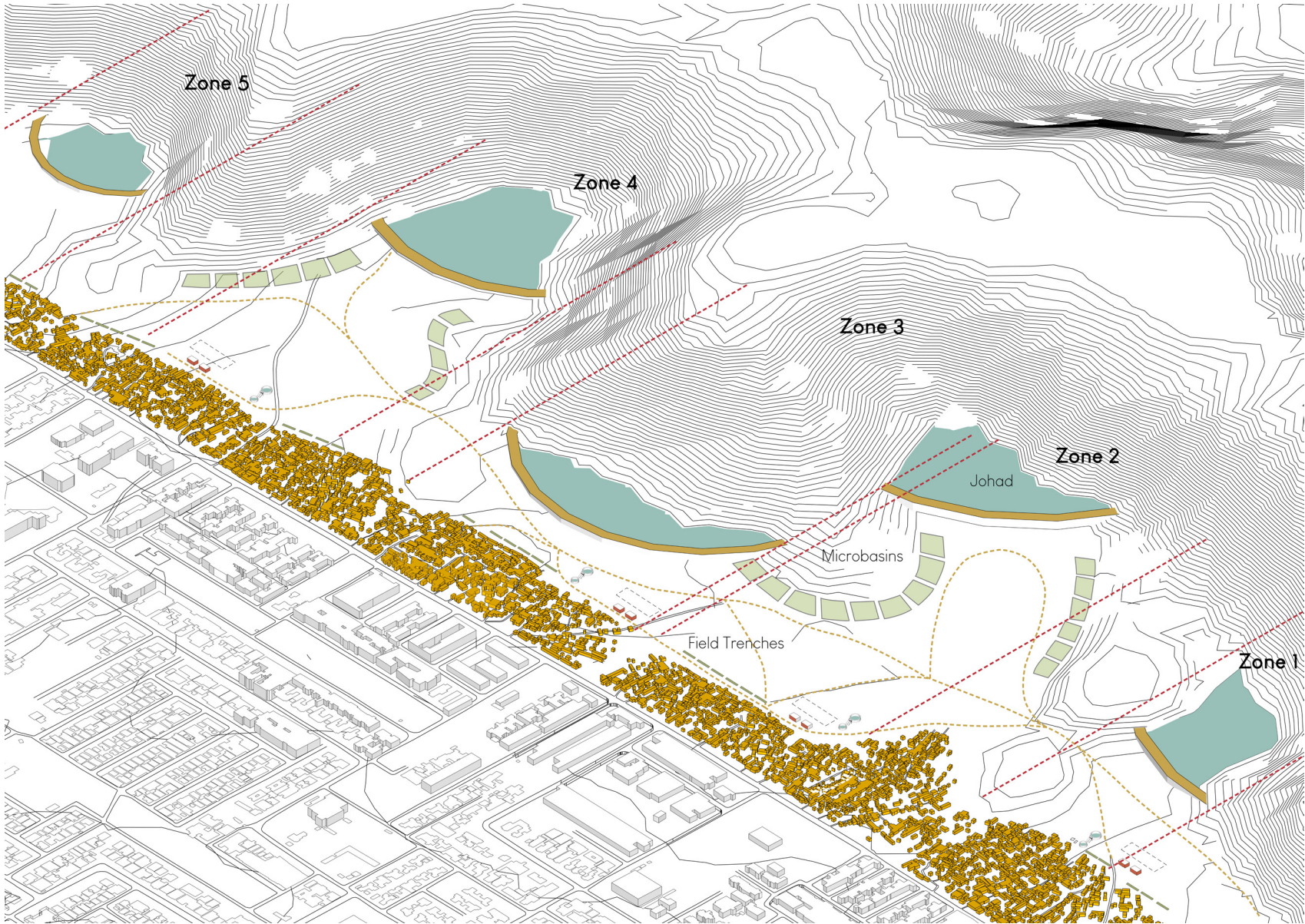
Conceptual Strategy



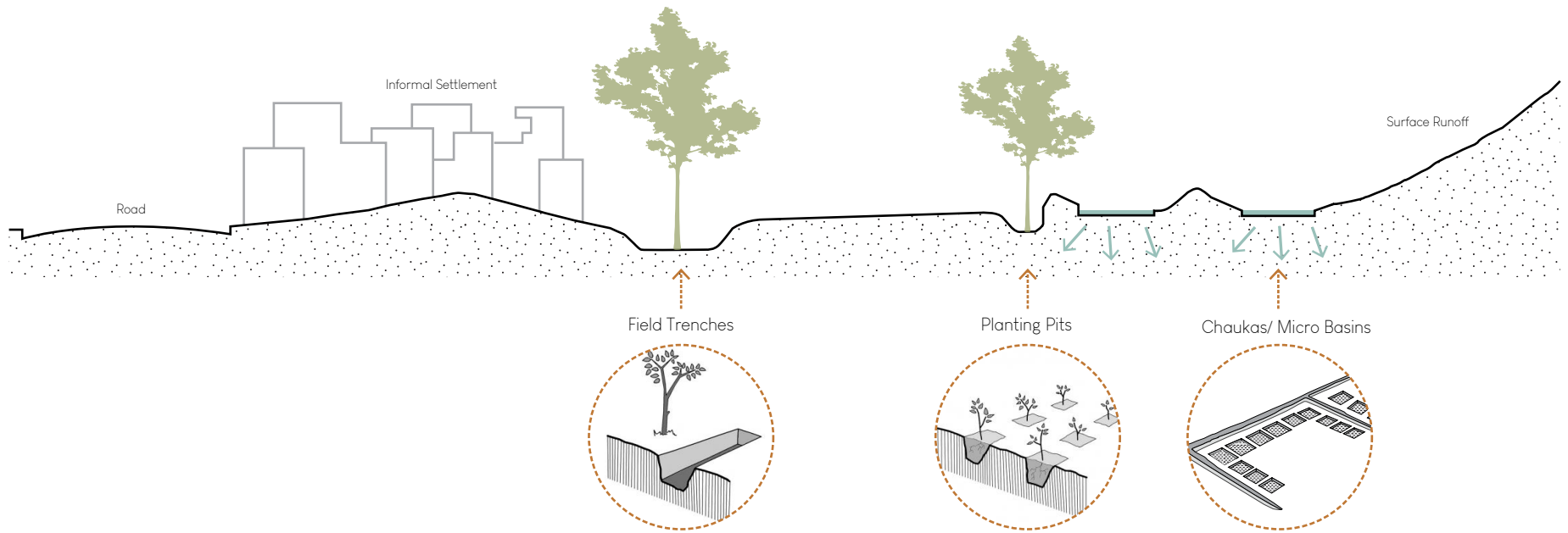
Conceptual Strategy



Conceptual Strategy

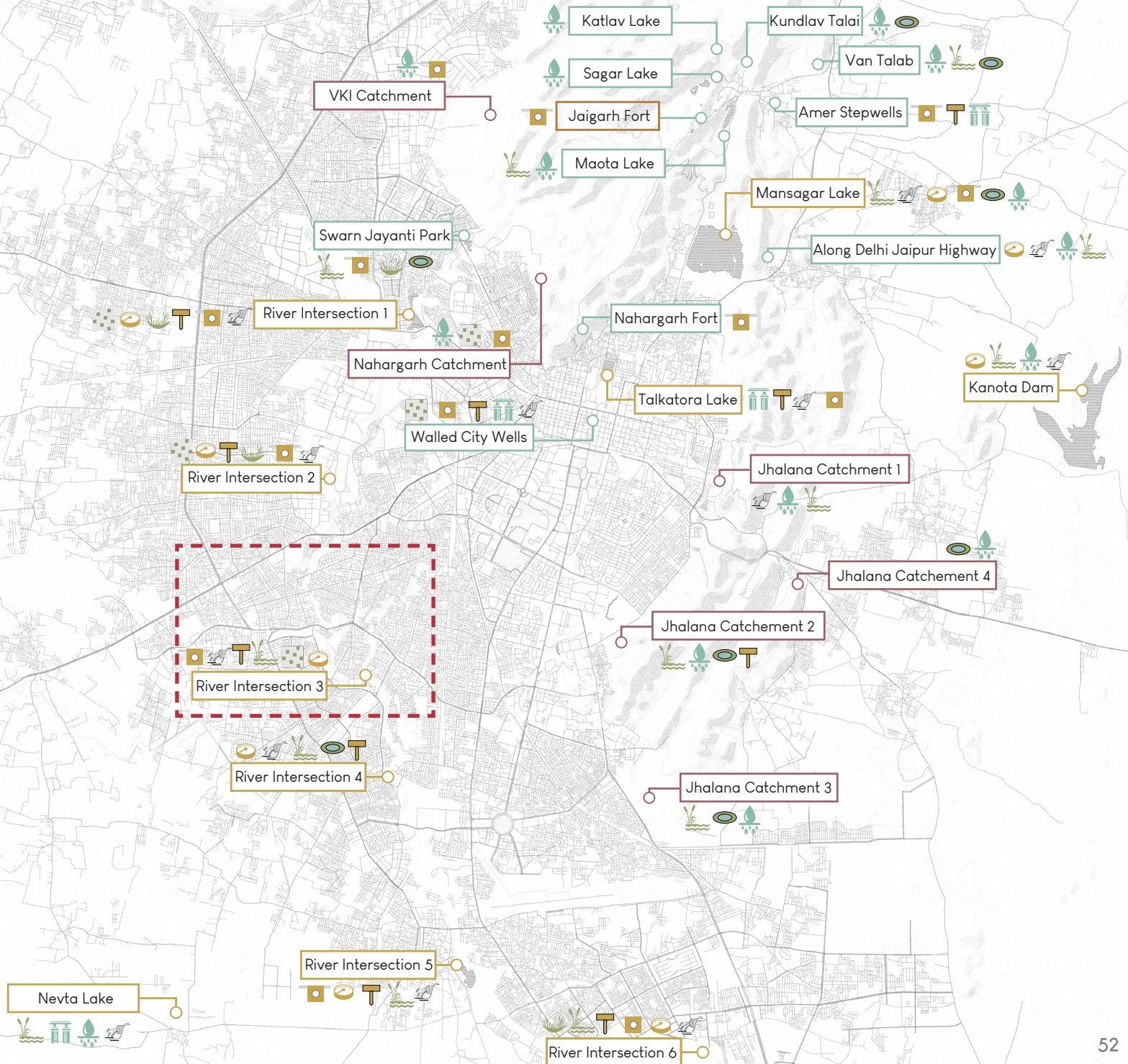


Conceptual Strategy



- Rainwater Harvesting
- Wastewater Treatment
- Stormwater Management

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- Porous Pavement

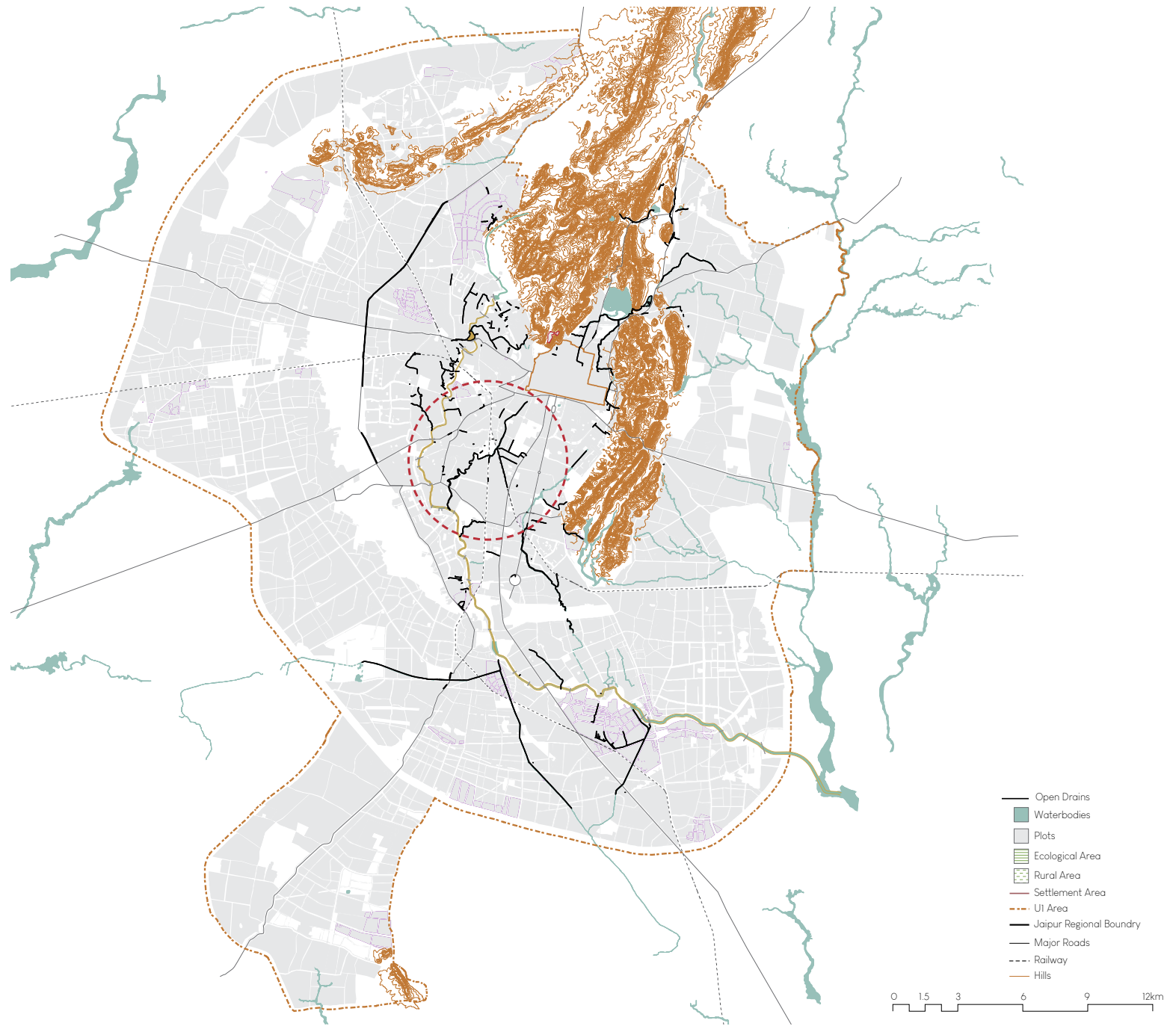


GREEN - BLUE GRIDS

Kartarpura Urban Creek



Open Drains in the City





Land use categorization



Institutional cum Residential Zone

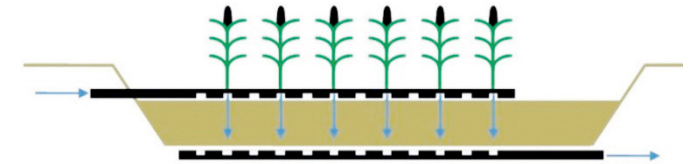
Infrastructural Zone

Eco-Sensitive Zone

Redefining the water course

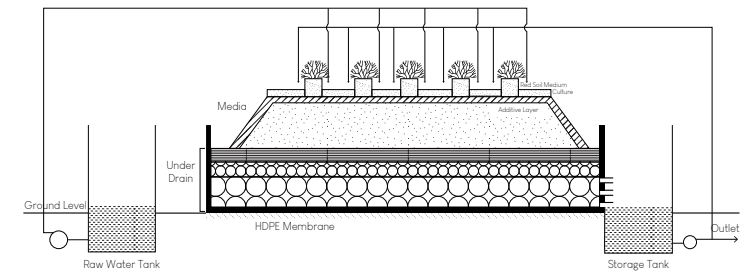


Helophyte Filter in Buffer Zone



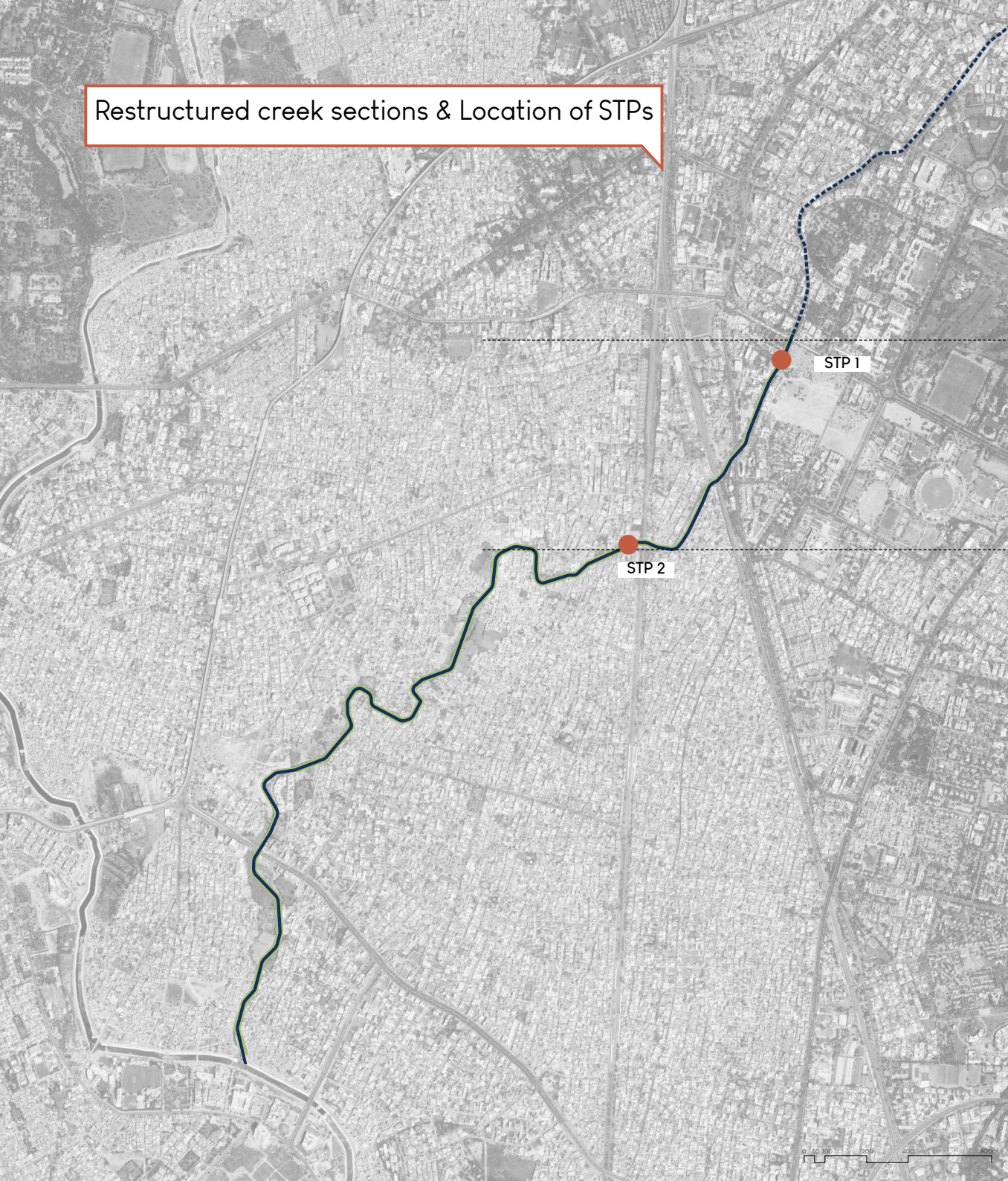
Source: atelier GROENBLAUW (<https://www.urbangreenbluegrids.com/measures/vertical-helophyte-filters/>)

Typical section of Soil Biotechnology Treatment (SBT) plant

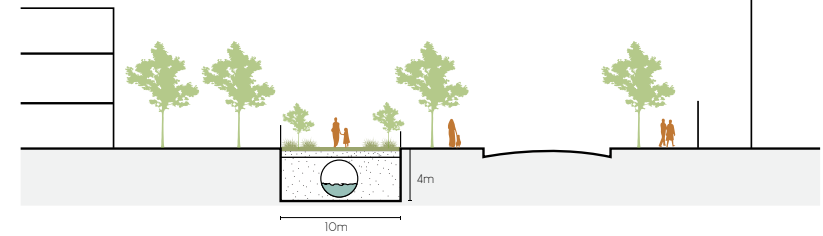


Source: <http://sugam.in/soilbiotechnology.html>

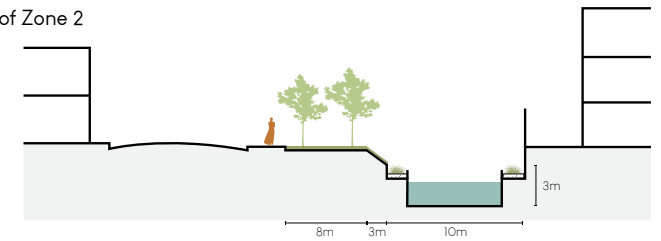
Restructured creek sections & Location of STPs



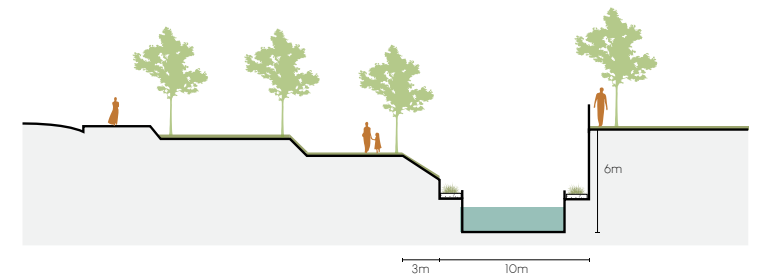
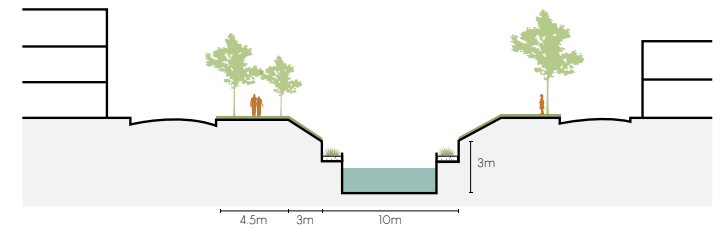
Typical Section of Zone 1



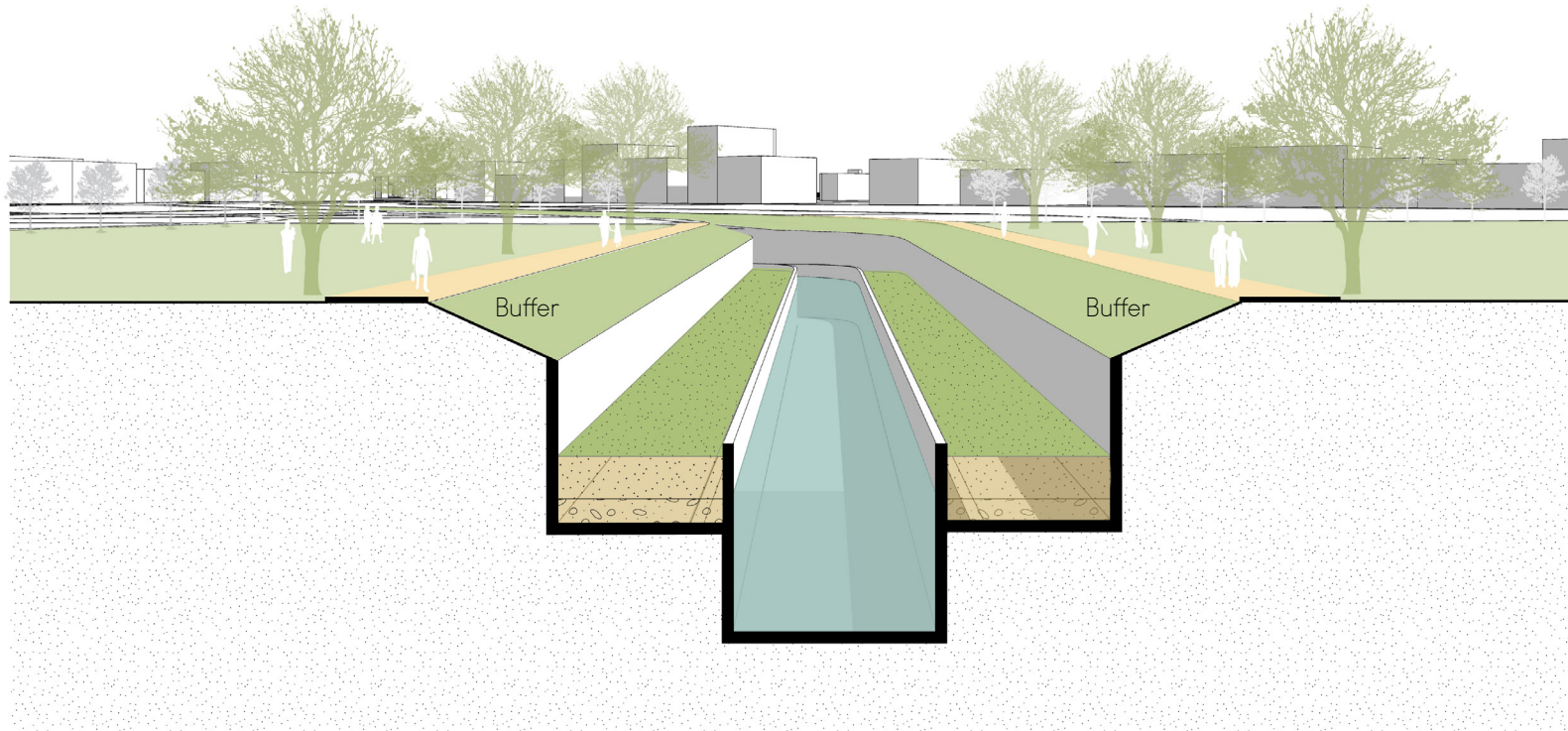
Typical Section of Zone 2



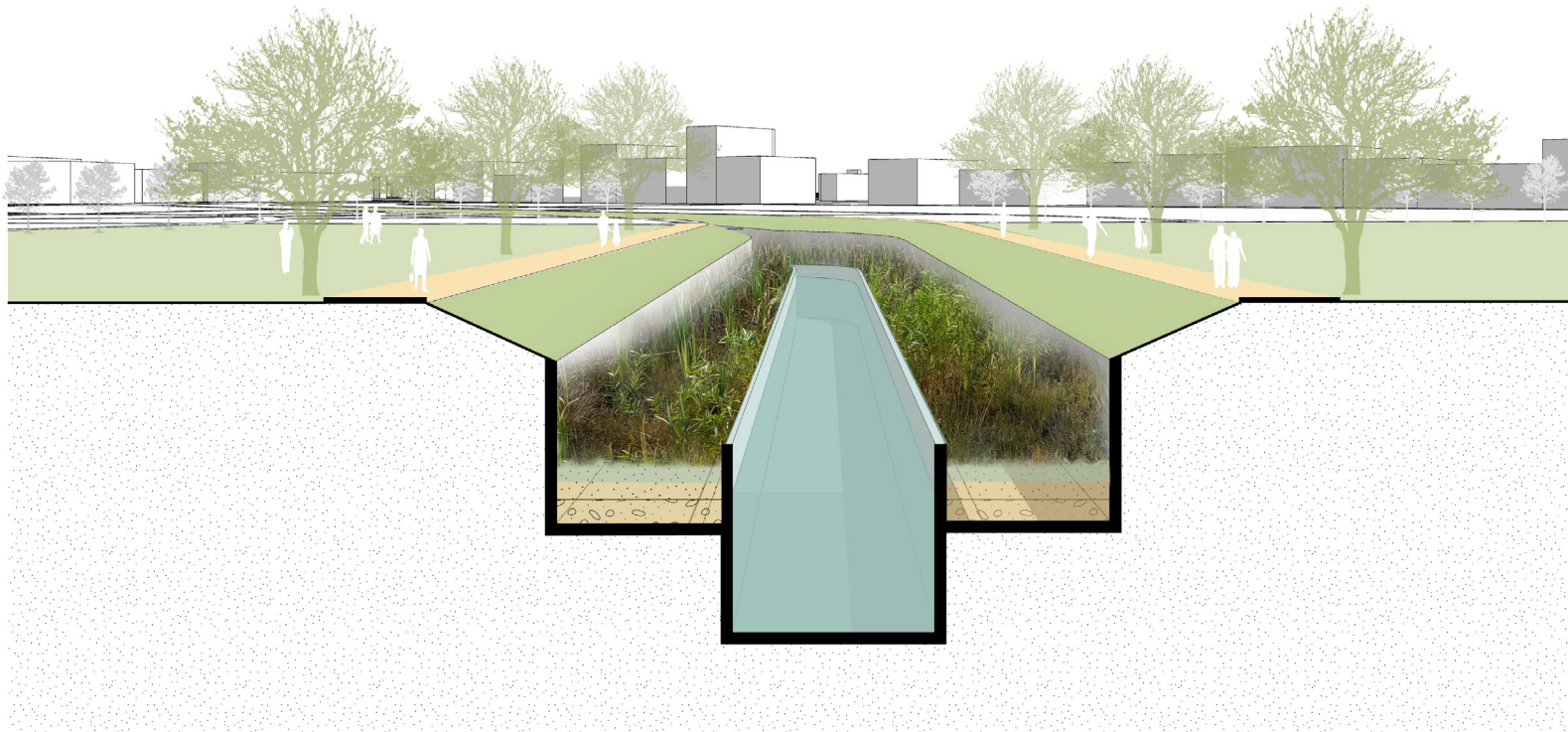
Typical Sections of Zone 3



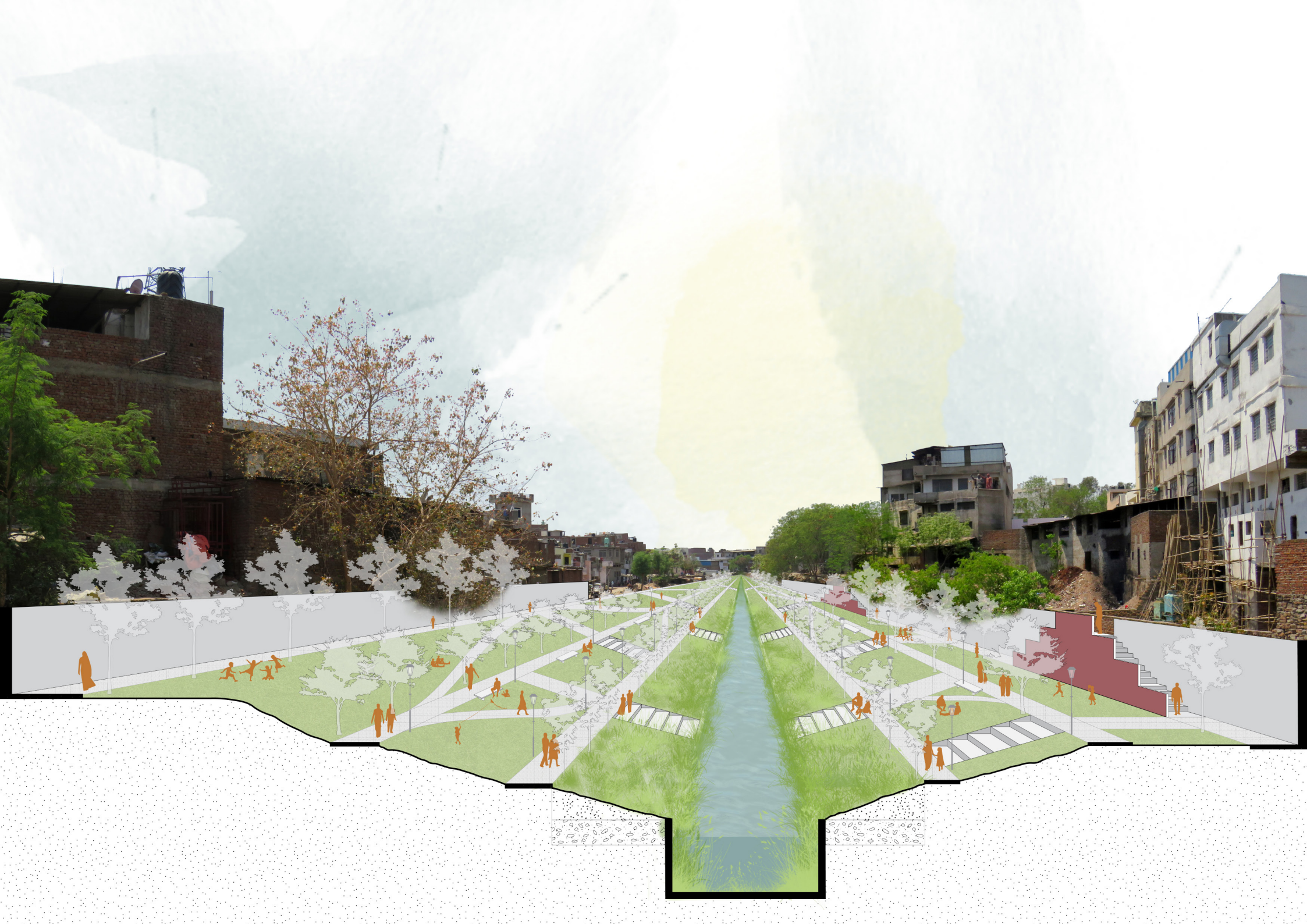
Summer Section



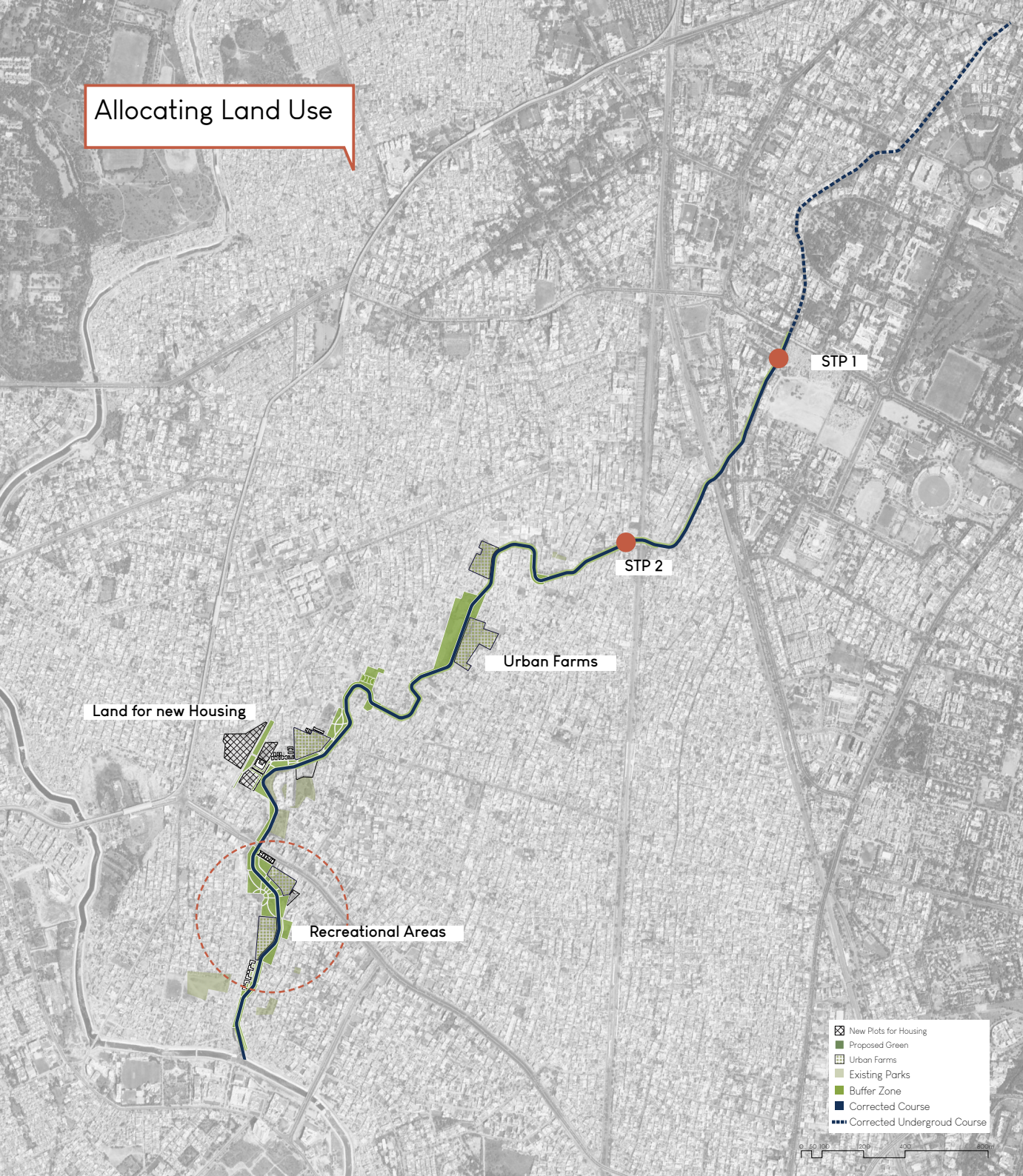
Monsoon Section





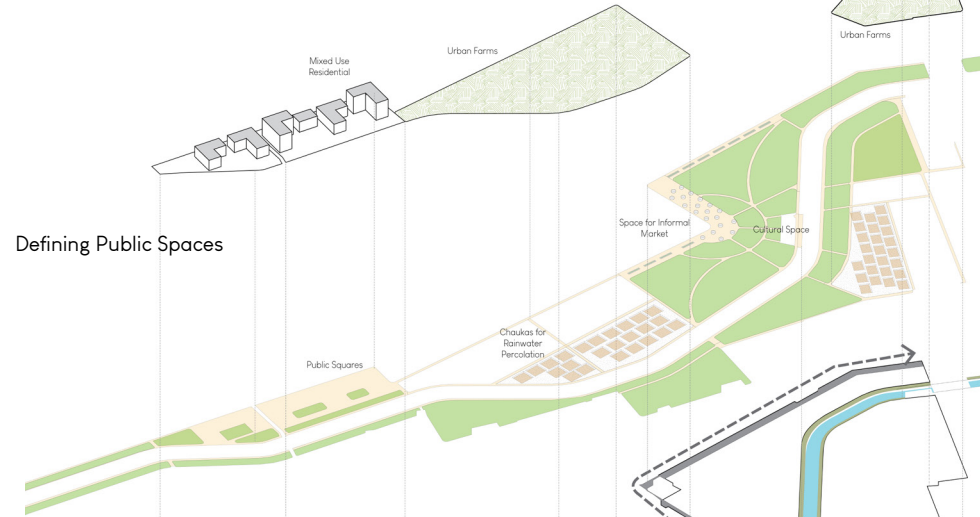


Allocating Land Use

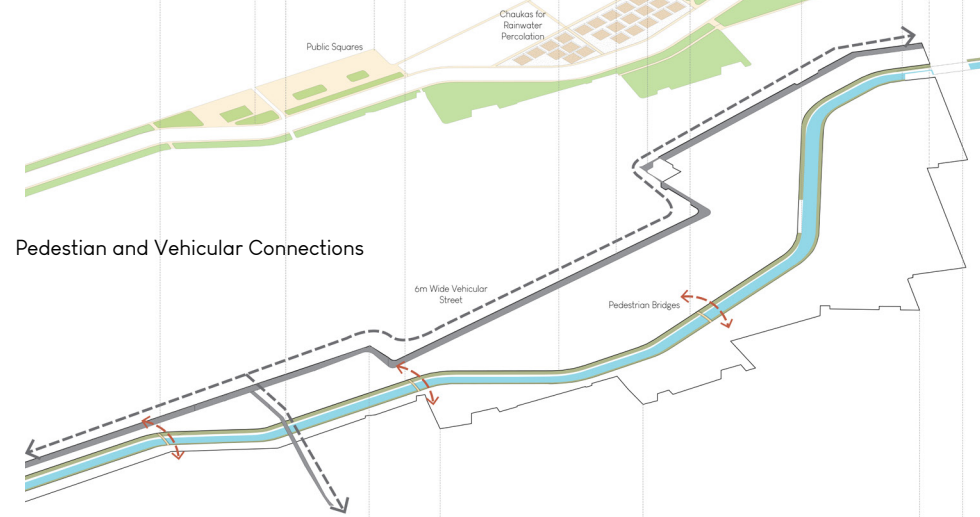


Design Layers

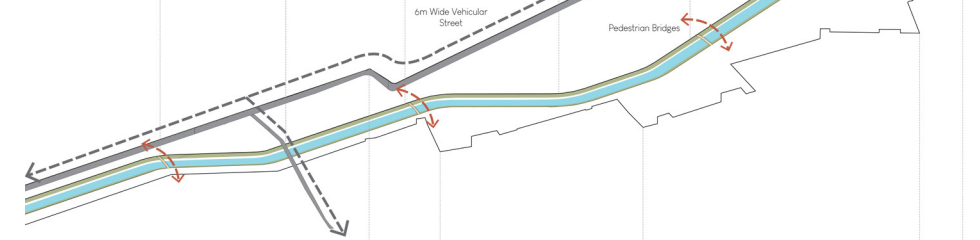
Allocating Land Use



Defining Public Spaces



Pedestian and Vehicular Connections



Stormwater Drainage Systems



Proposed Strategy

Mixed Use Residential
Housing with basic urban
amenities



Public Squares along the
water edge



Urban Farms



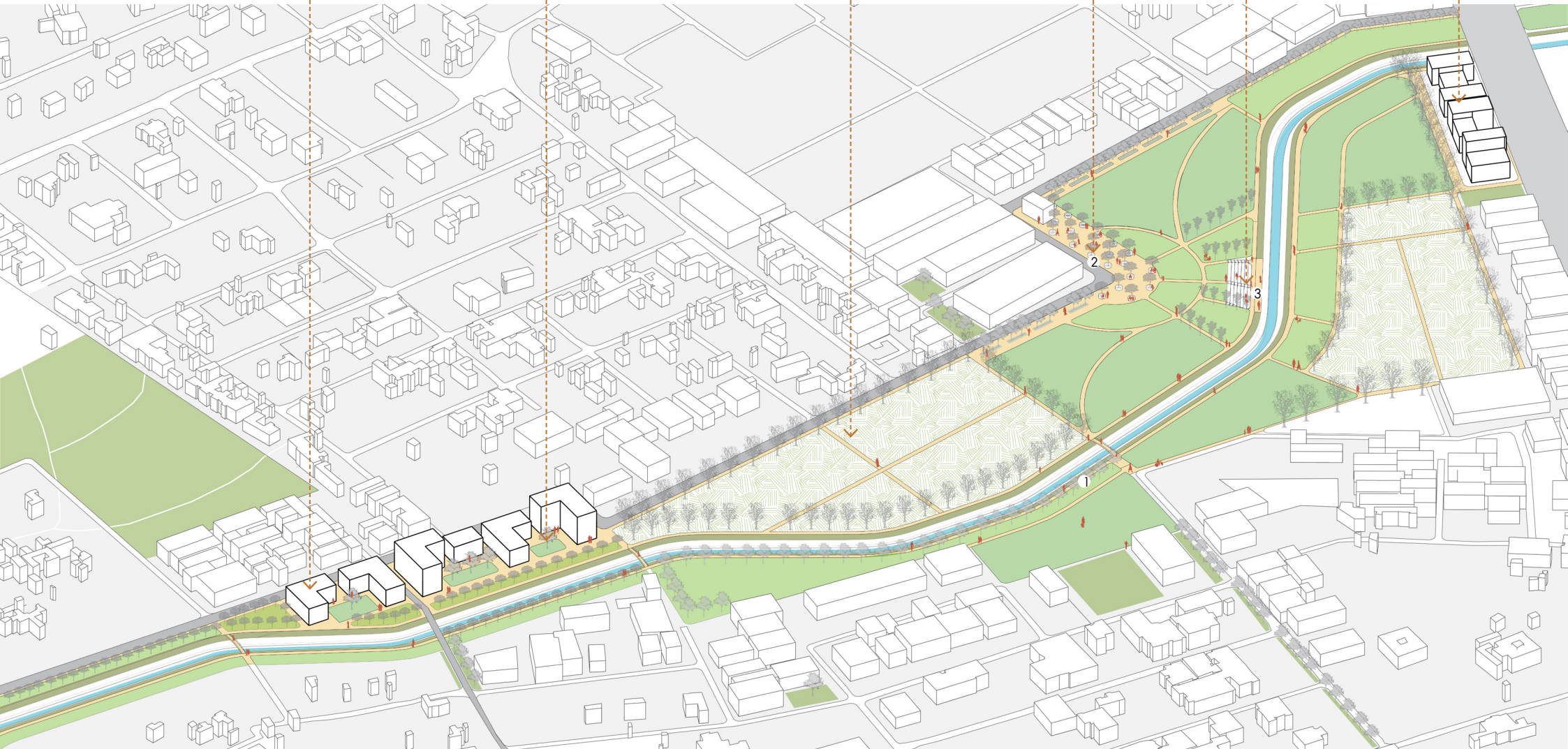
Space for weekly
Informal Markets



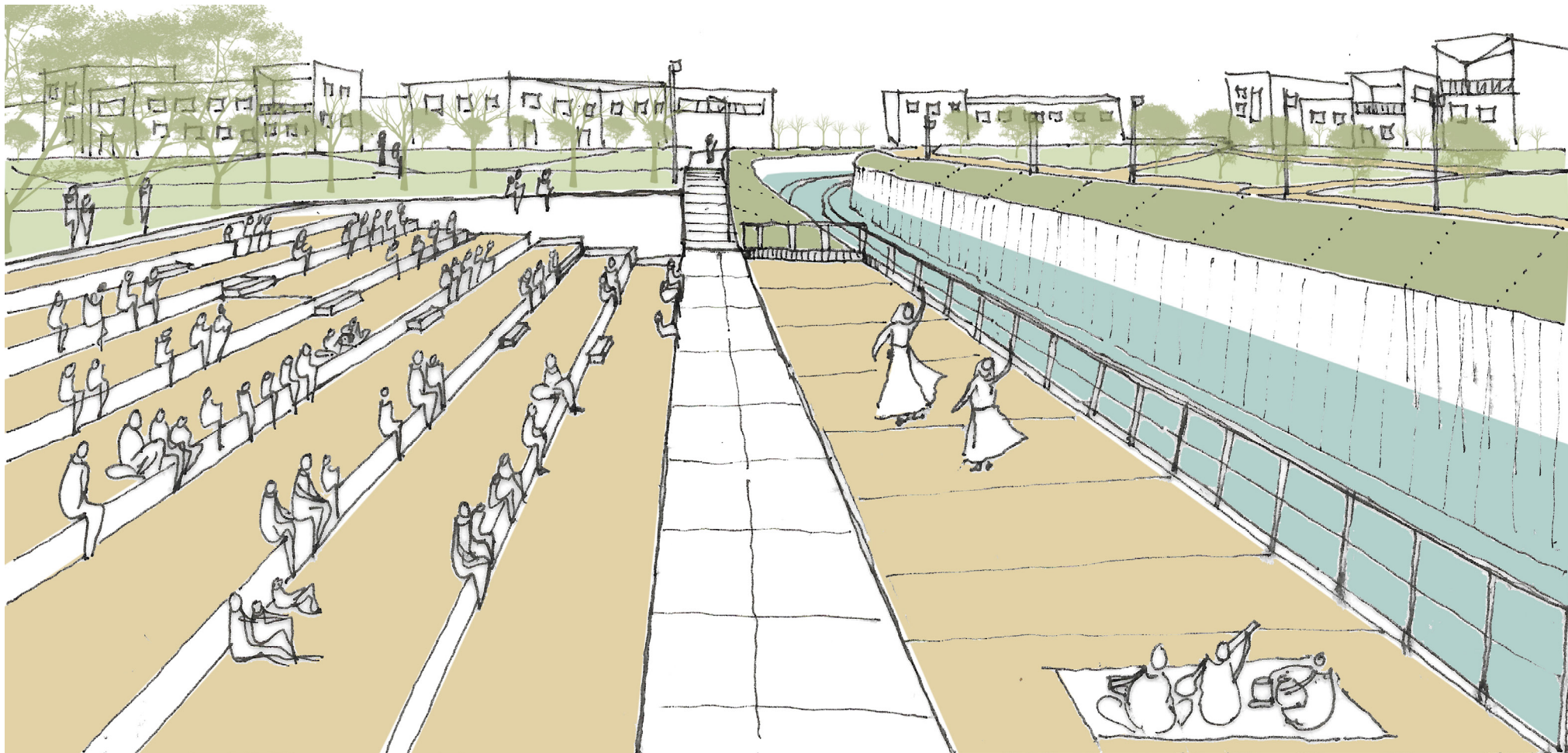
Multi-functional
public space for
events/ discussions



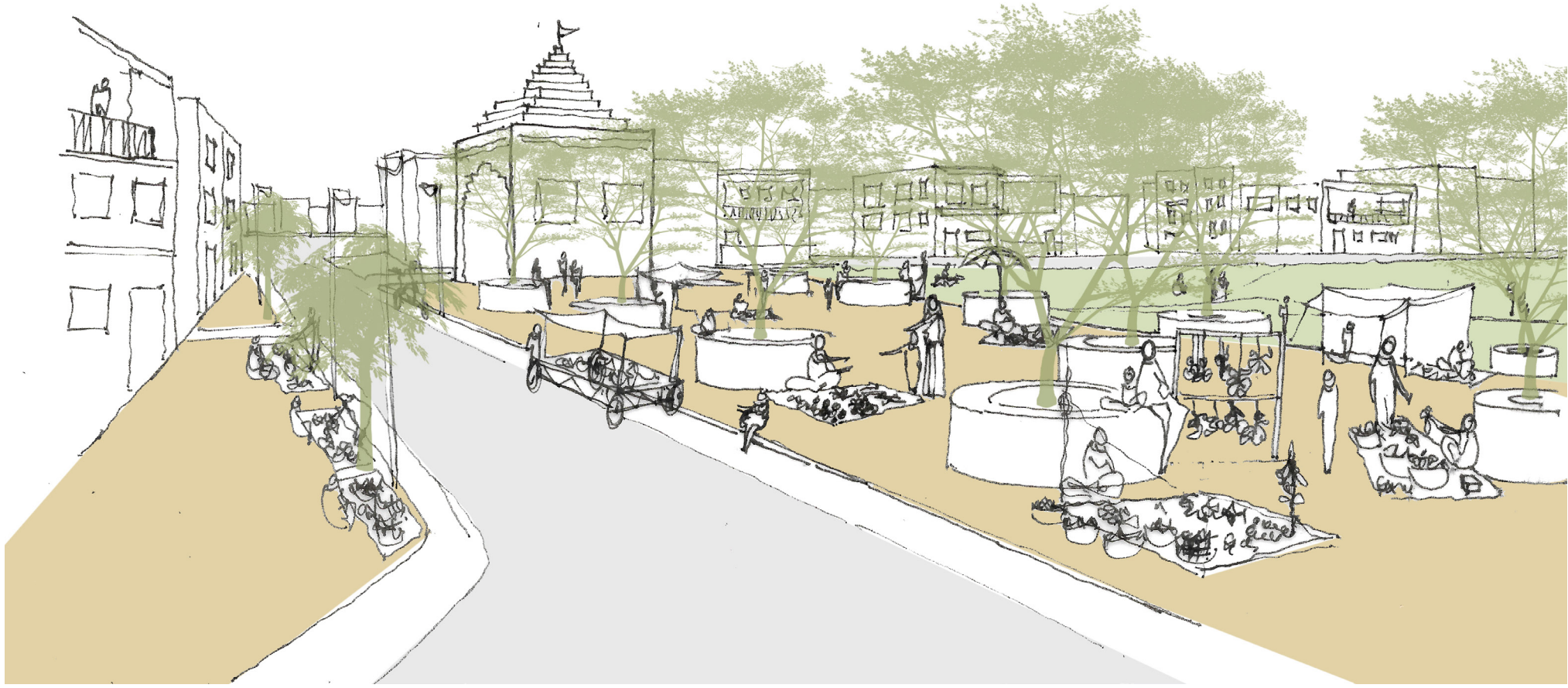
Commercial
landuse according
to Masterplan 2025



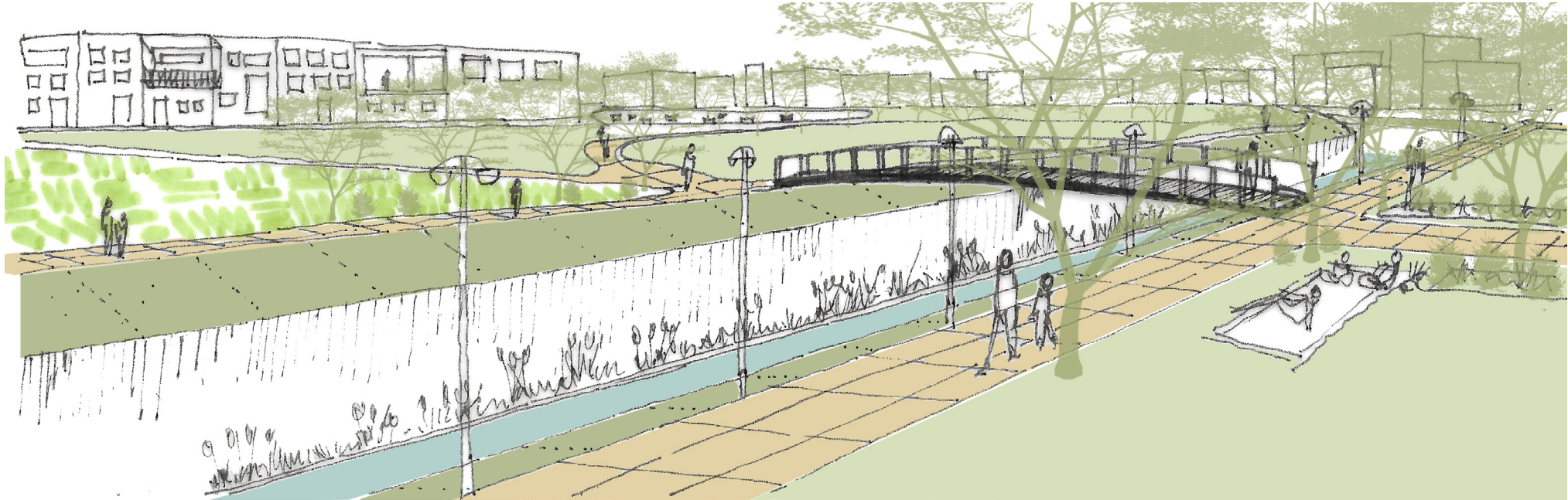
Multifunctional Cultural Space



Informal Market Area

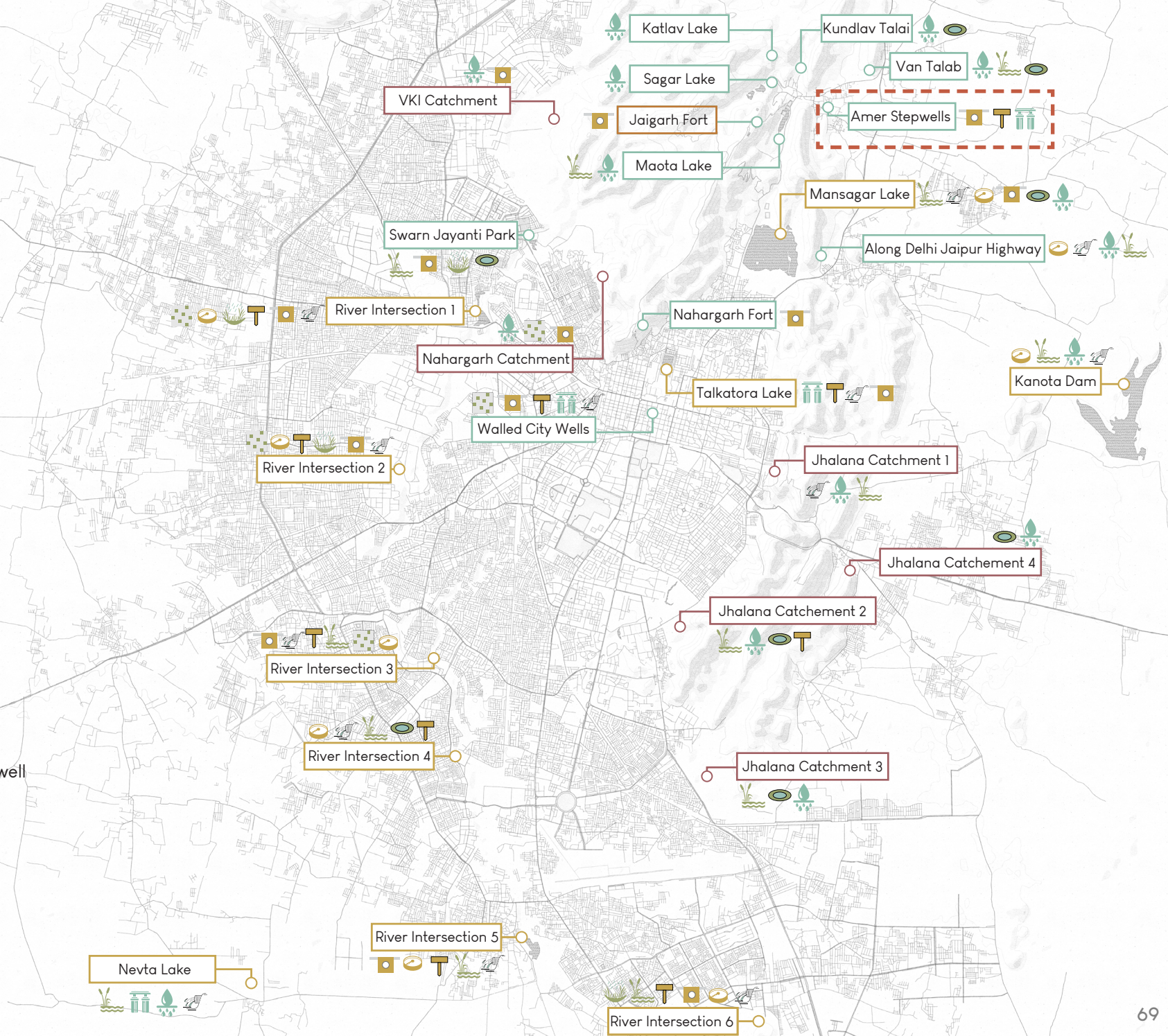


Recreational Space along the river



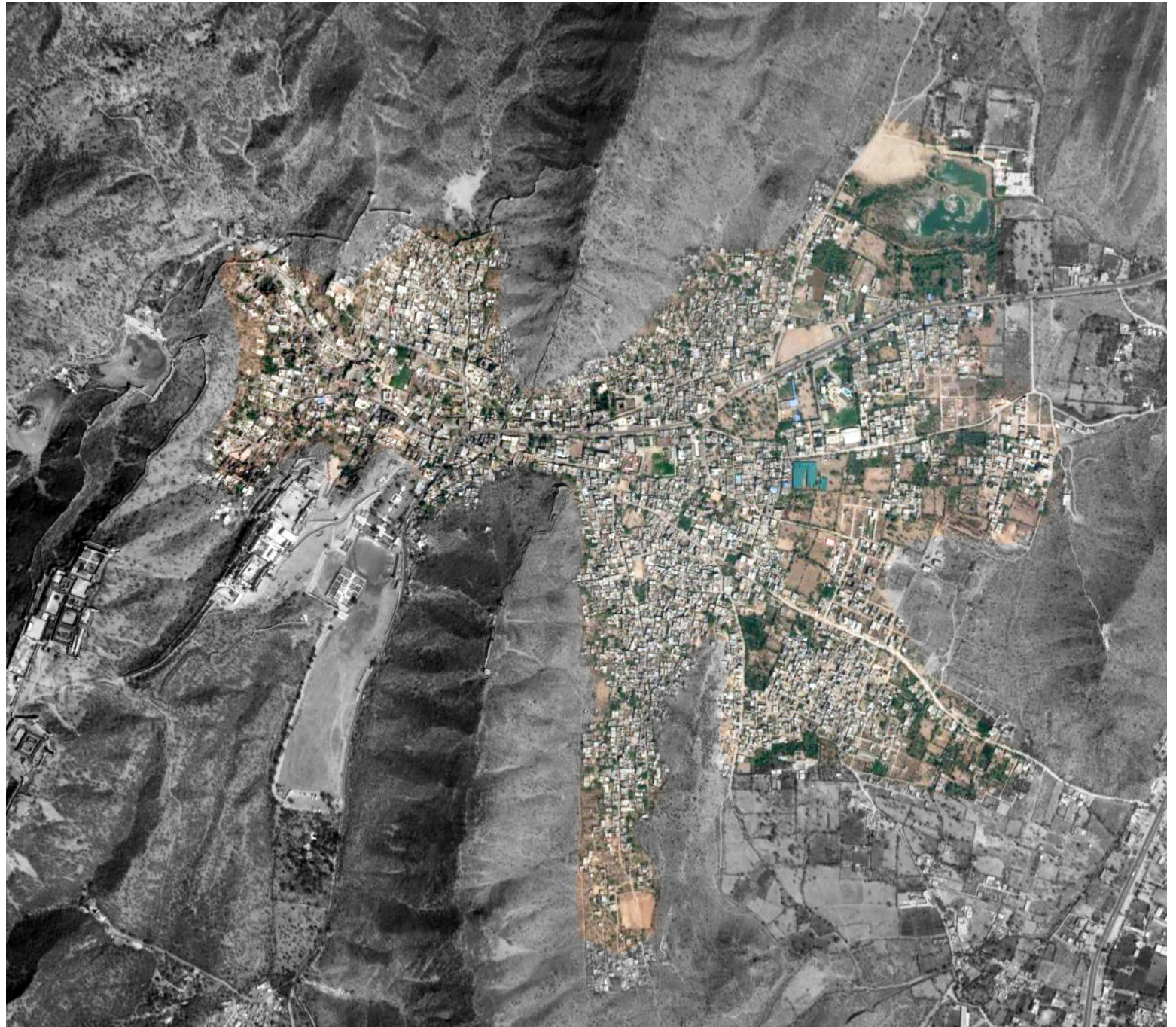
- Rainwater Harvesting
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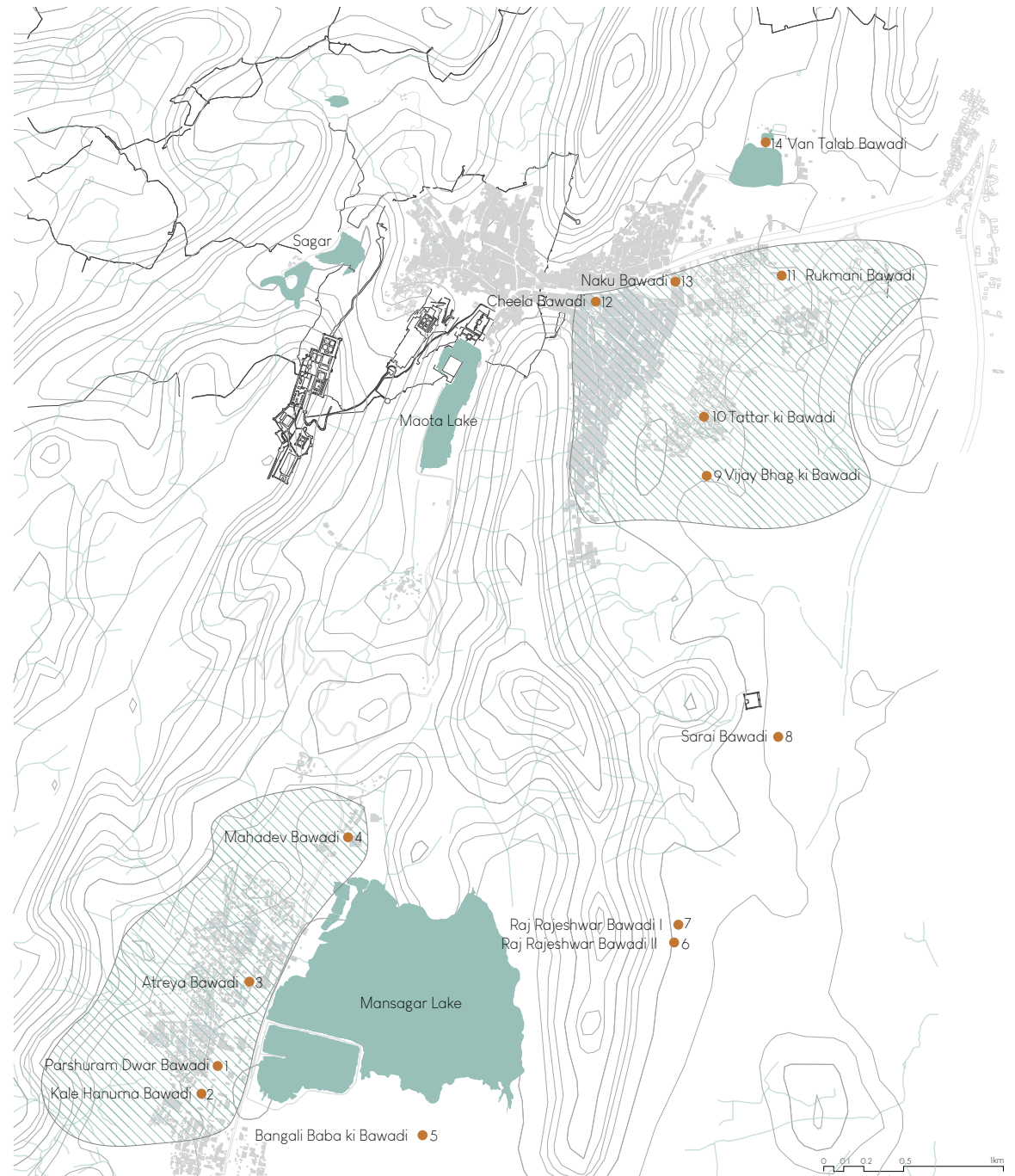
REVIVING ANCIENT WISDOM

Stepwells of Amer



Location of Stepwells

There are approximately 50 stepwells in the city of Jaipur which have been identified, but only a few have been mapped and conserved to some extent.



Typologies of Stepwells

Typology 1



Typology 2



Most of them have either dried up due to overuse or inadequate recharge through rain or contain water which is polluted owing to lack of maintenance and ignorance of the government.

Typology 3



Typology 4

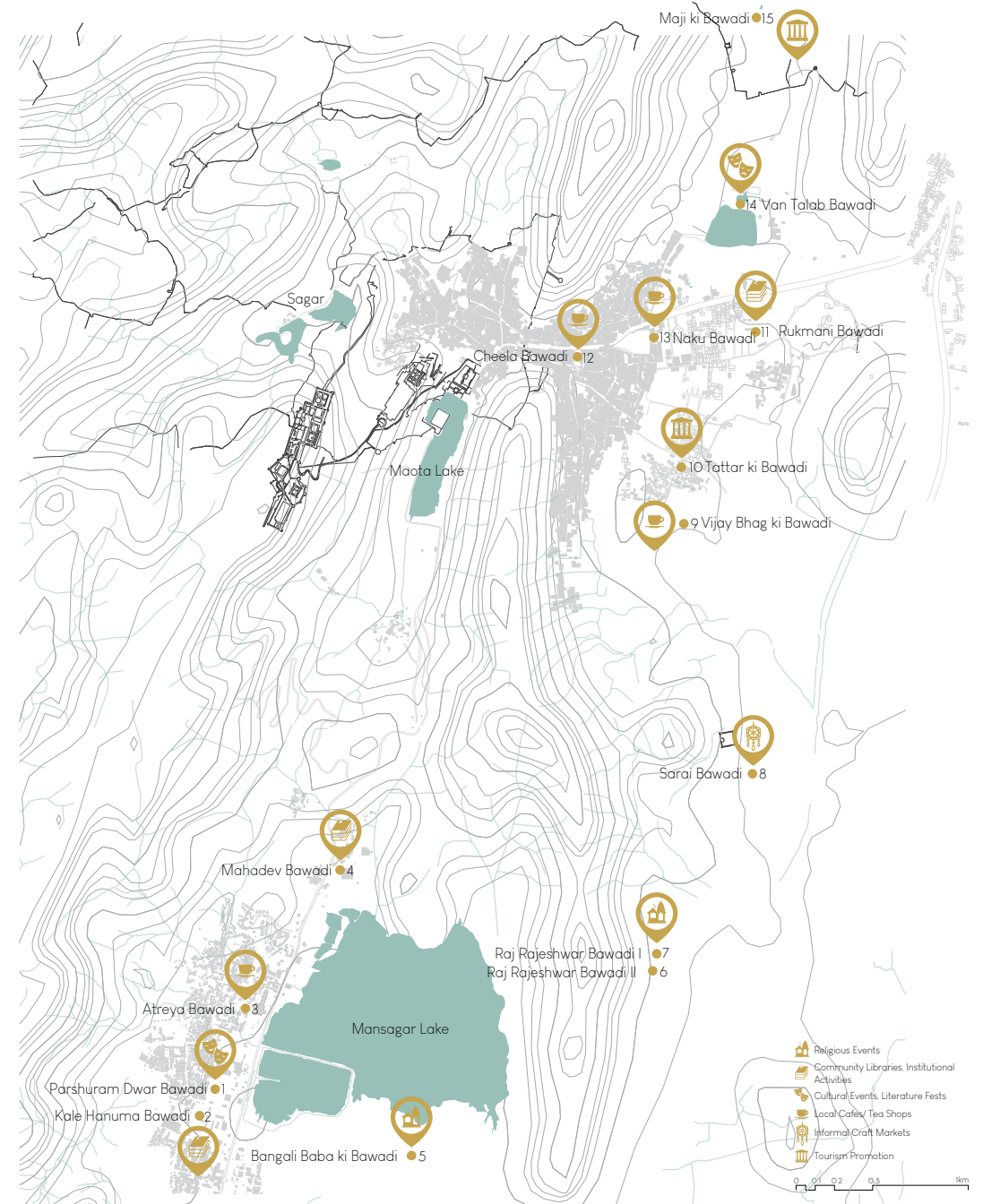


Typology 5

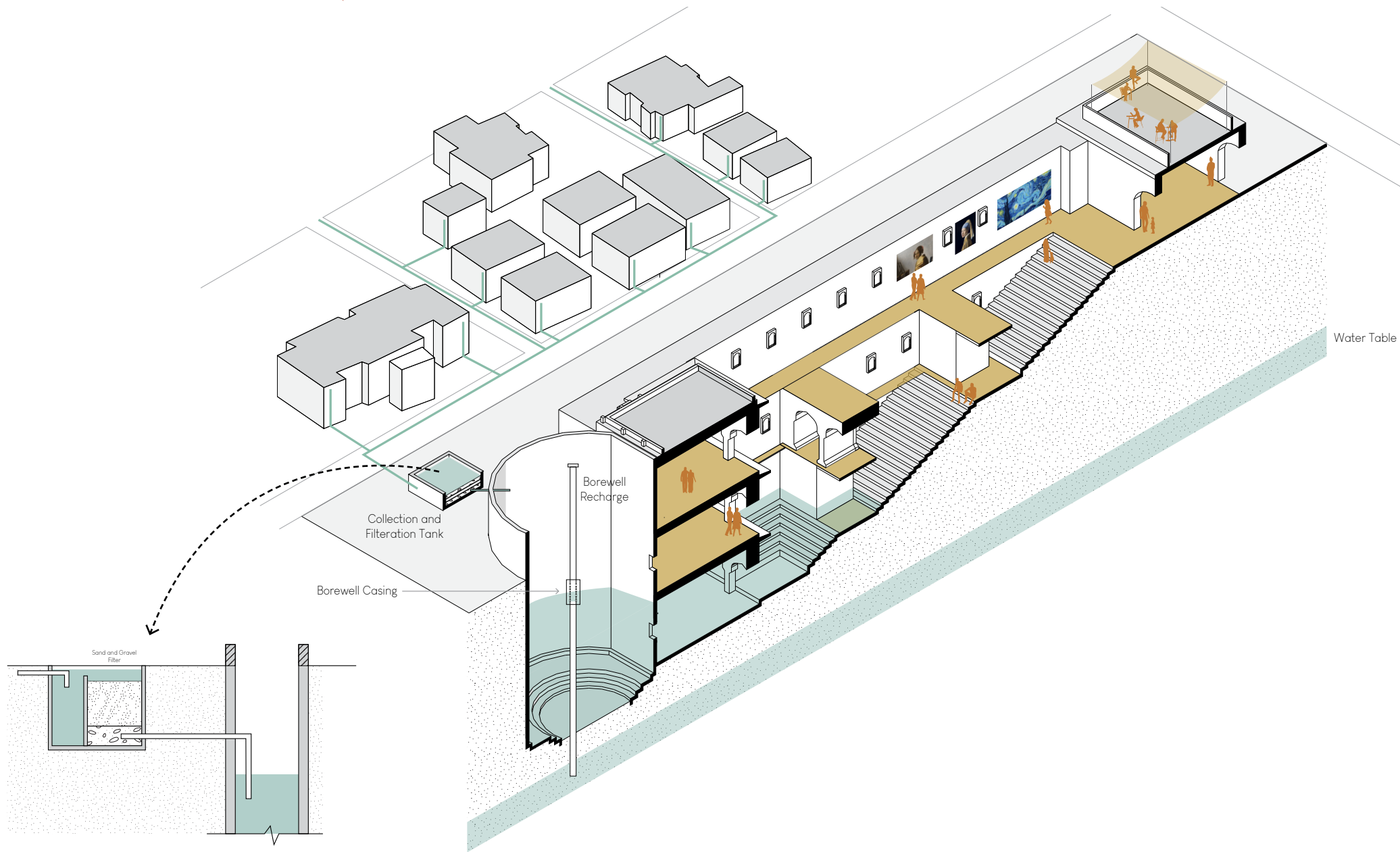


Revival Strategy

1. Rejuvenation of Stepwells through an effective stormwater drainage system
2. Creating public and recreational spaces in an around the stepwells through PPP model

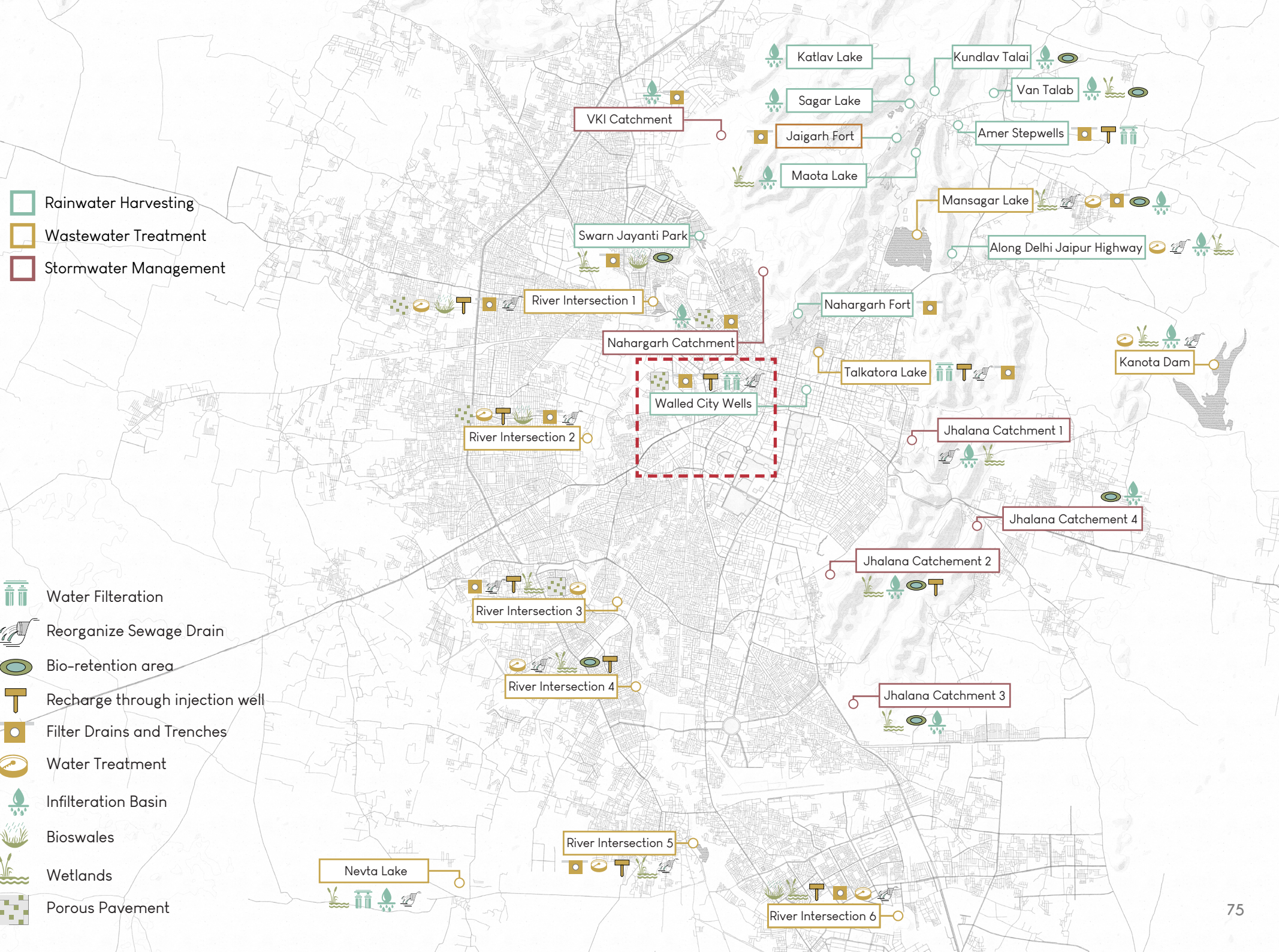


Water as part of Public Space



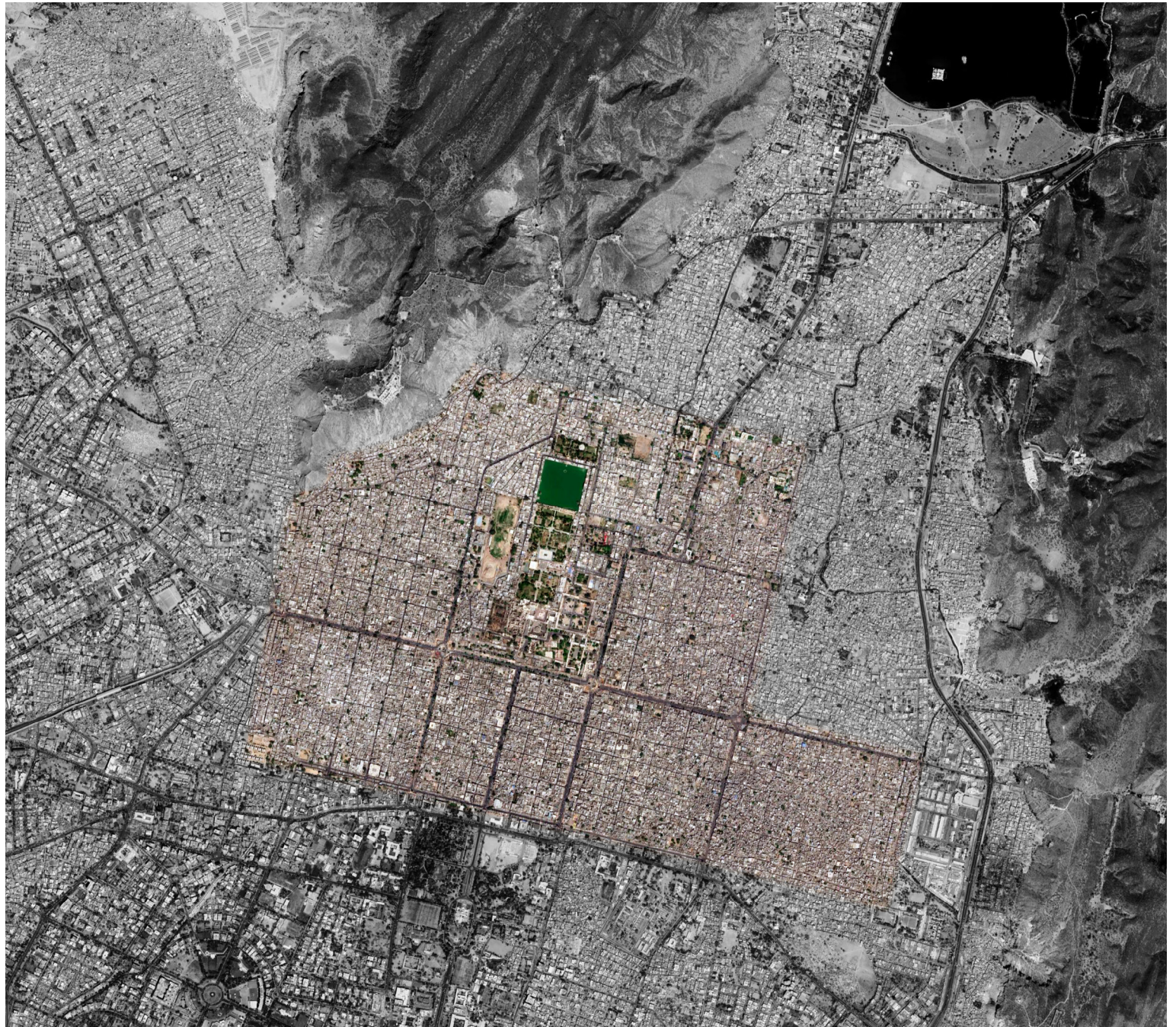
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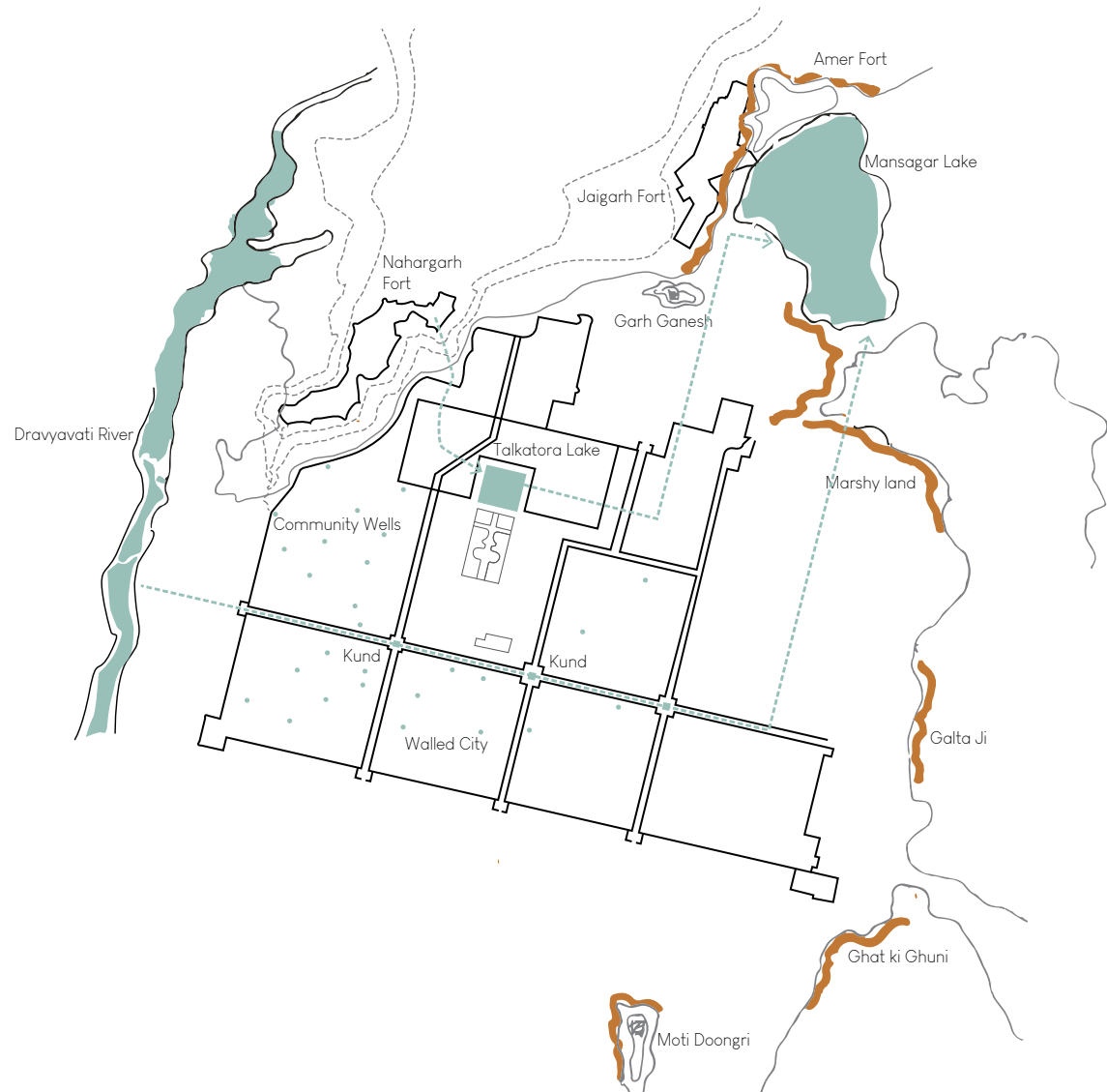
MAKING WATER EVERYBODY'S BUSINESS

Public Wells in the Walled City



Research Gap

What happens to a city's traditional foundations of service delivery when it expands boundaries and enhances its infrastructure? Does the city still concern itself with the maintenance of the supply structures that were once essential for the city?

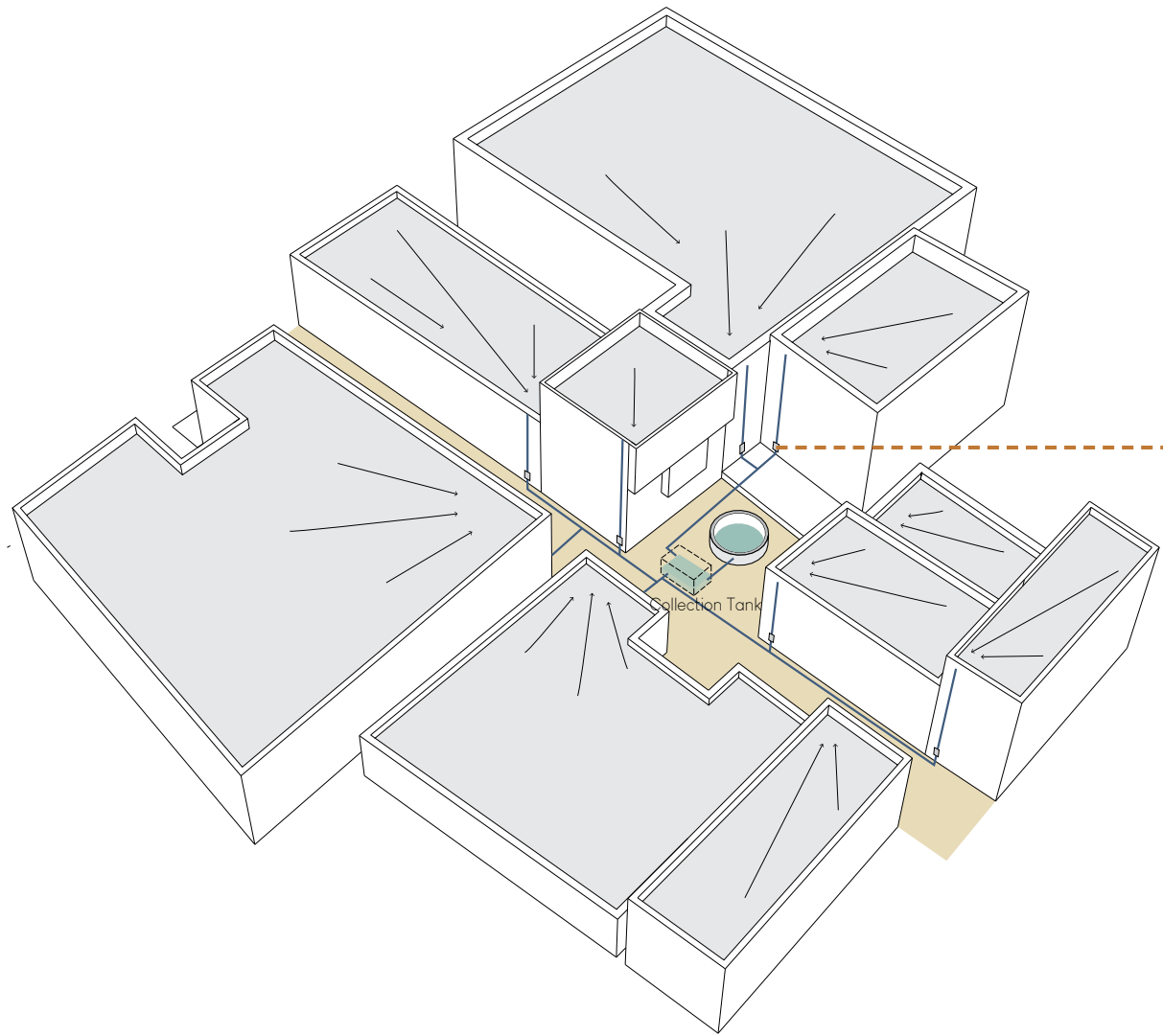


Existing Situation

820 Wells



Rooftop Rainwater Harvesting

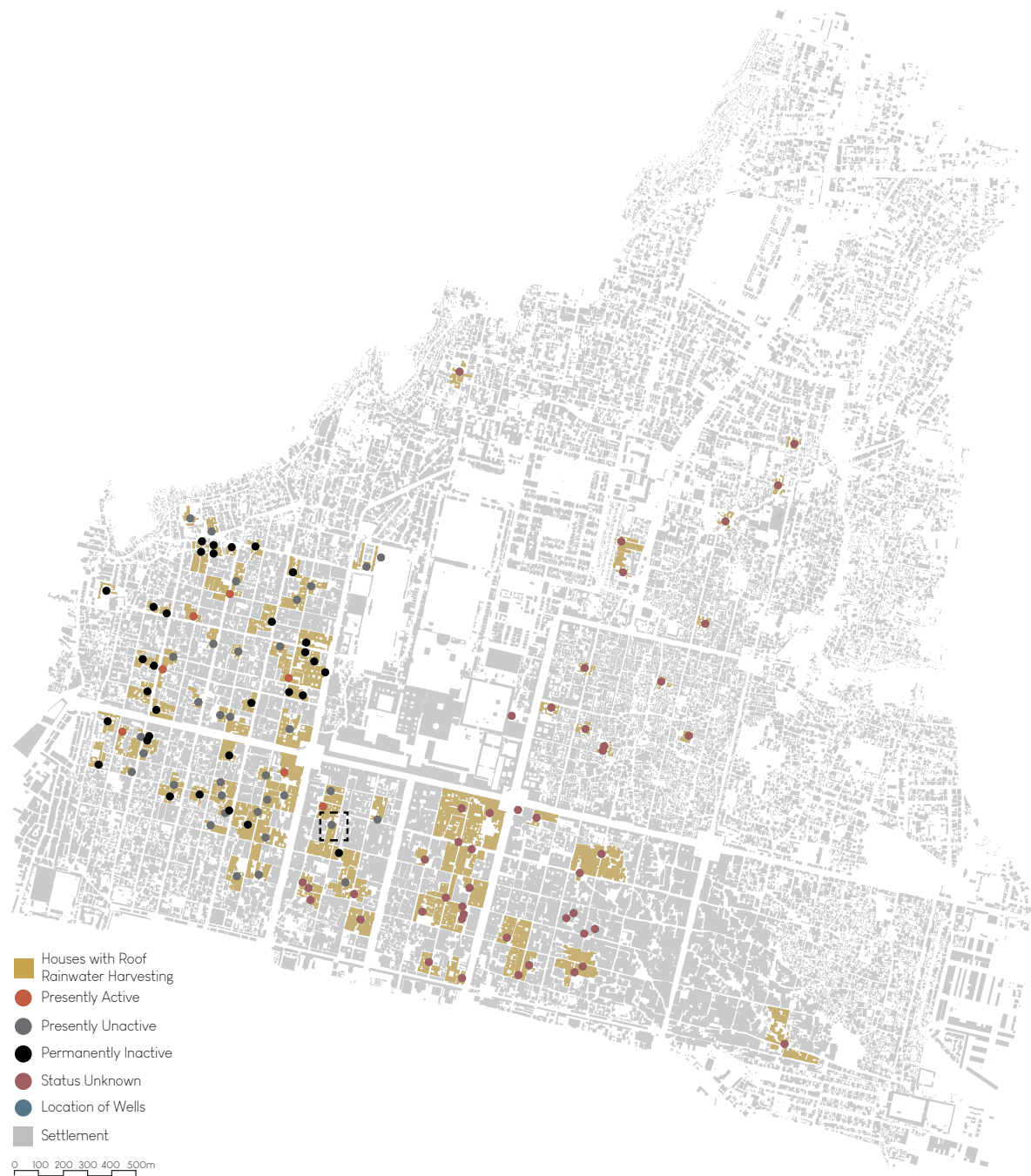


Collective Effort at Rooftop Rainwater Harvesting to recharge existing wells



Pop Up Filter

Identified Public Wells



Bordi ka Kua

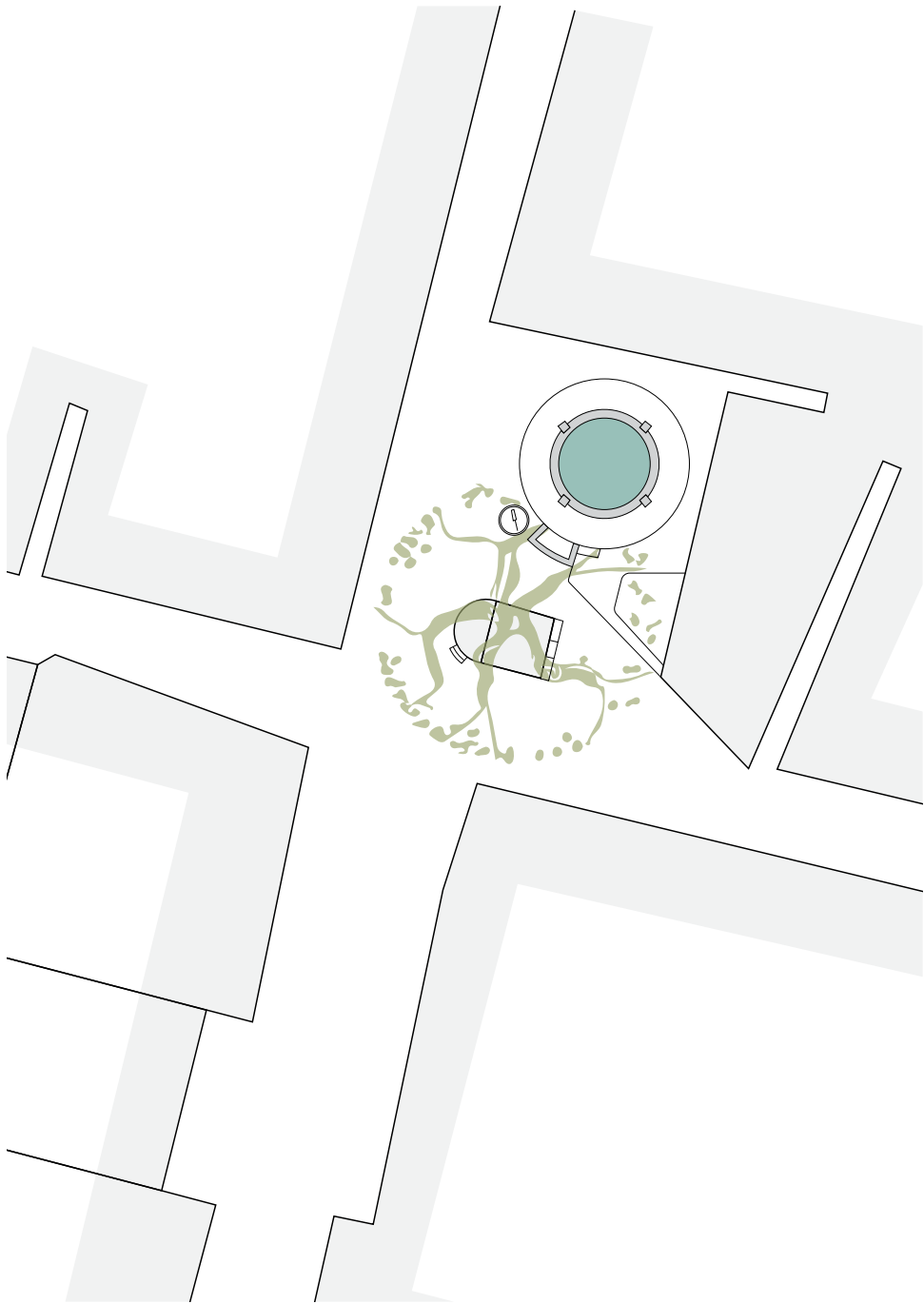


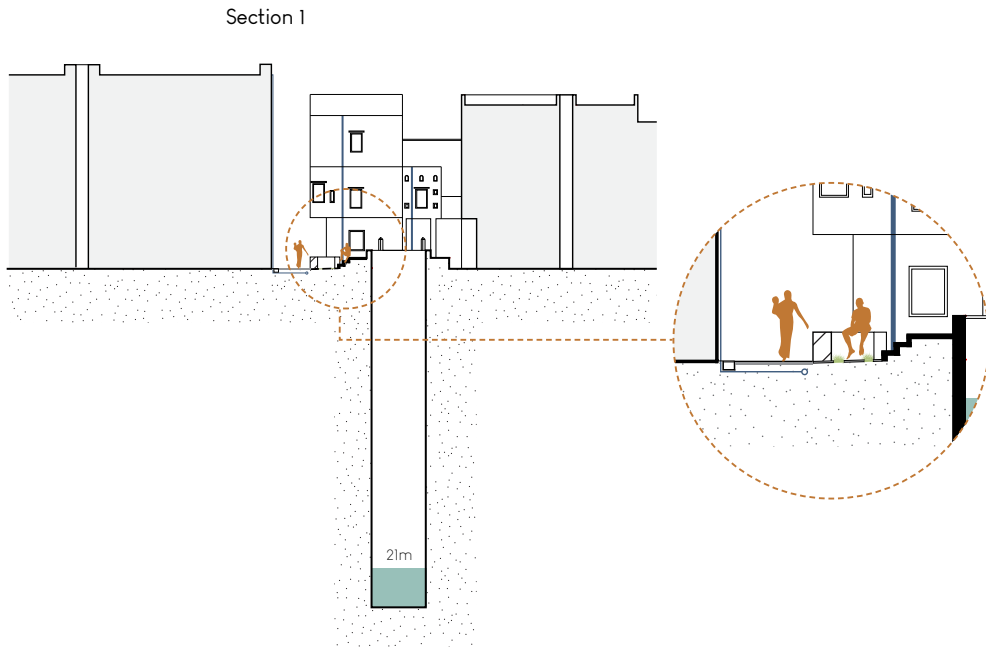
Well in a Residential Area: Existing Situation



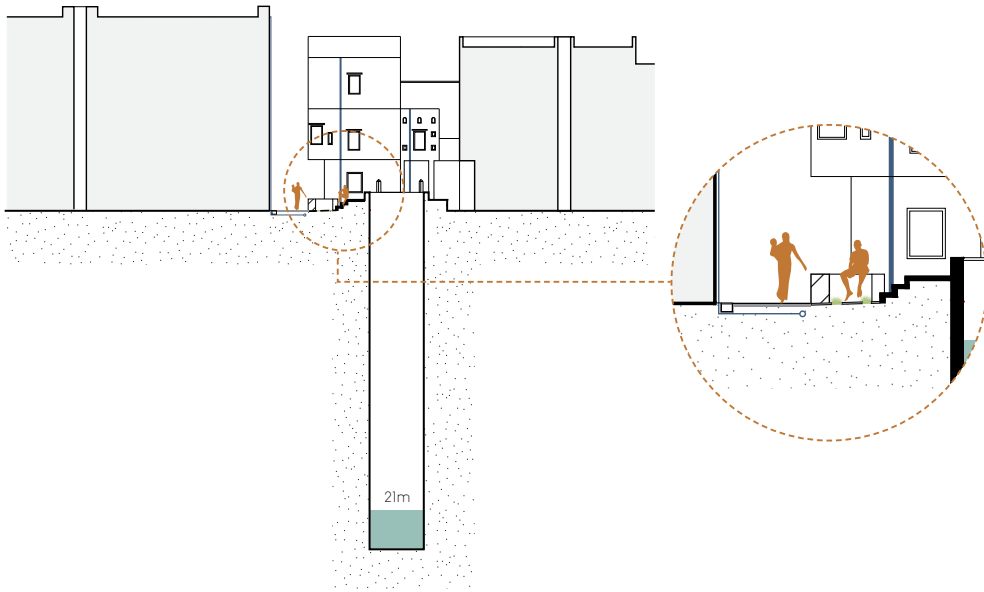
"This well was supplying very sweet water until the last 15-20 years. Later, together as a community, we spend 30-40 thousand rupees and got it cleaned. We even connected a pipe from the temple to the well so that clean water from the offering doesn't get wasted. The government has shown no interest in reviving it."

Roshan Lal Sen
(Resident in the community)

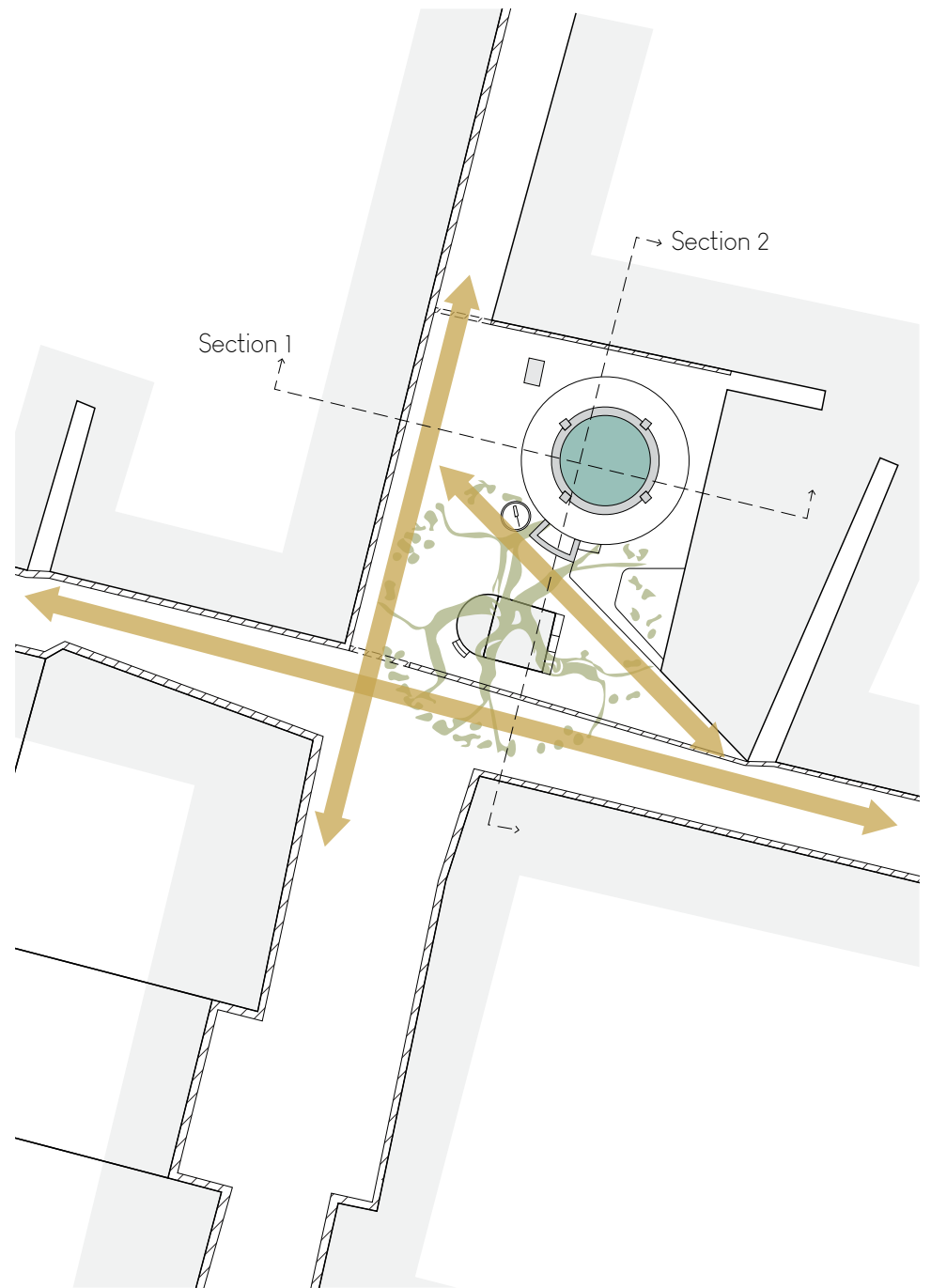
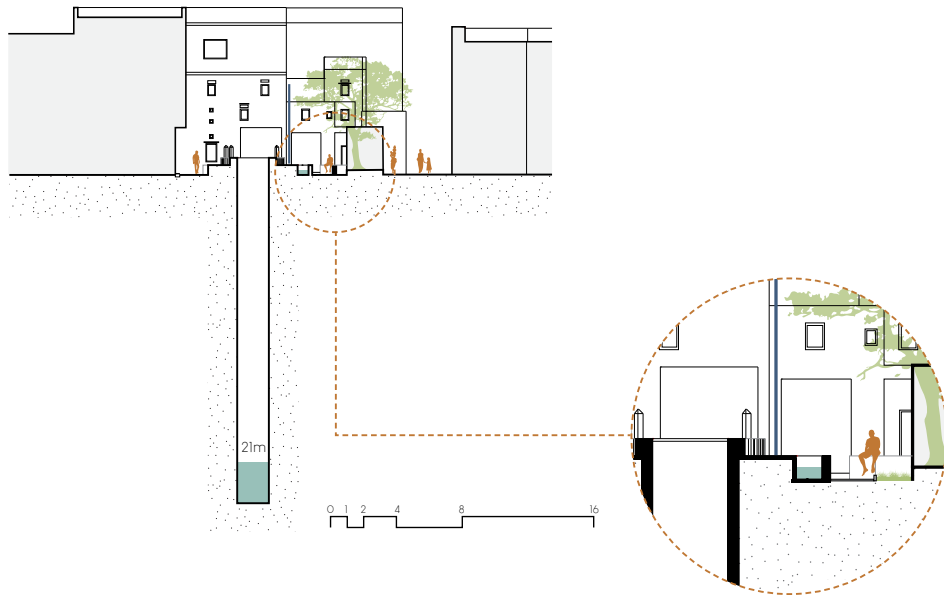




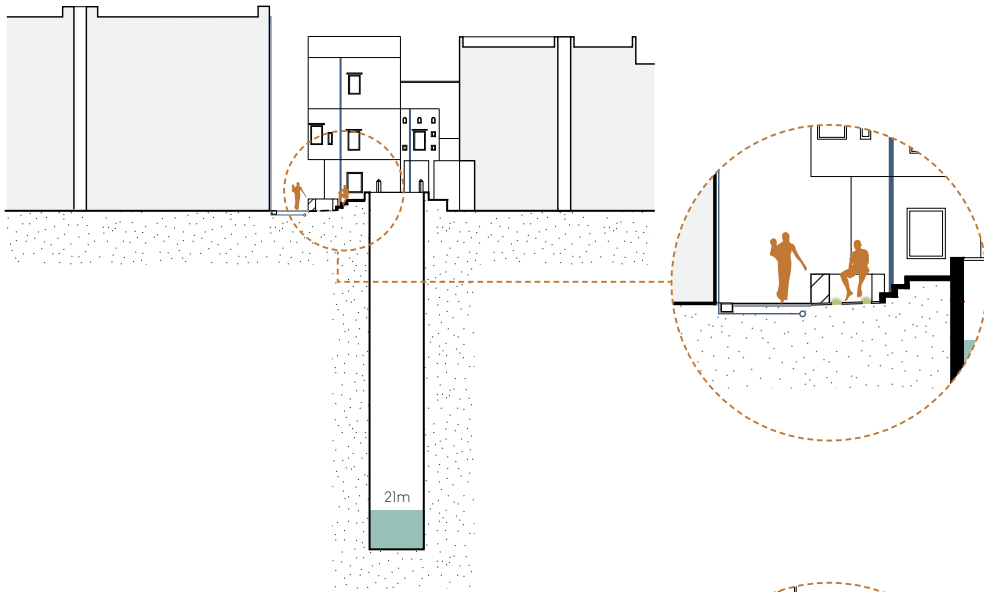
Section 1



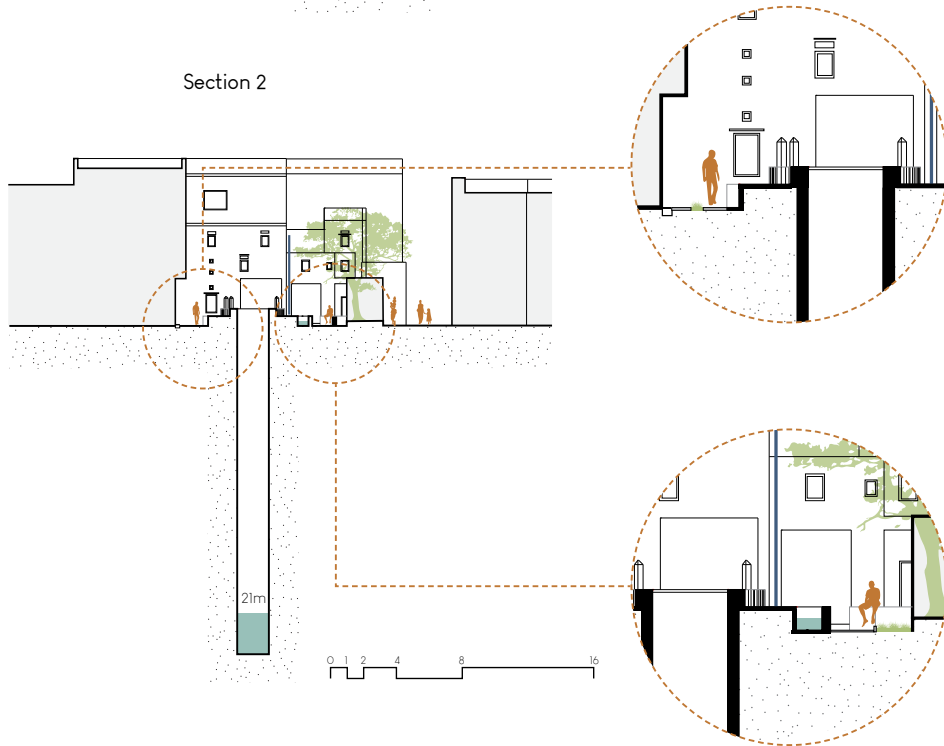
Section 2



Section 1



Section 2



Existing



Proposed



Average Depth of Wells: 14m

Average Diameter: 3m

Average Volume of Well: 98.96 m³ (98,960 litres)

Average Area of 1 house: 100 sq mt

Total Surrounding Houses: 4=400 sq mt (catchment area)

Average Rainfall 600mm

Volume of Rainfall over terraces: 400 X 0.6= 60 cum mt (60,000 lit)

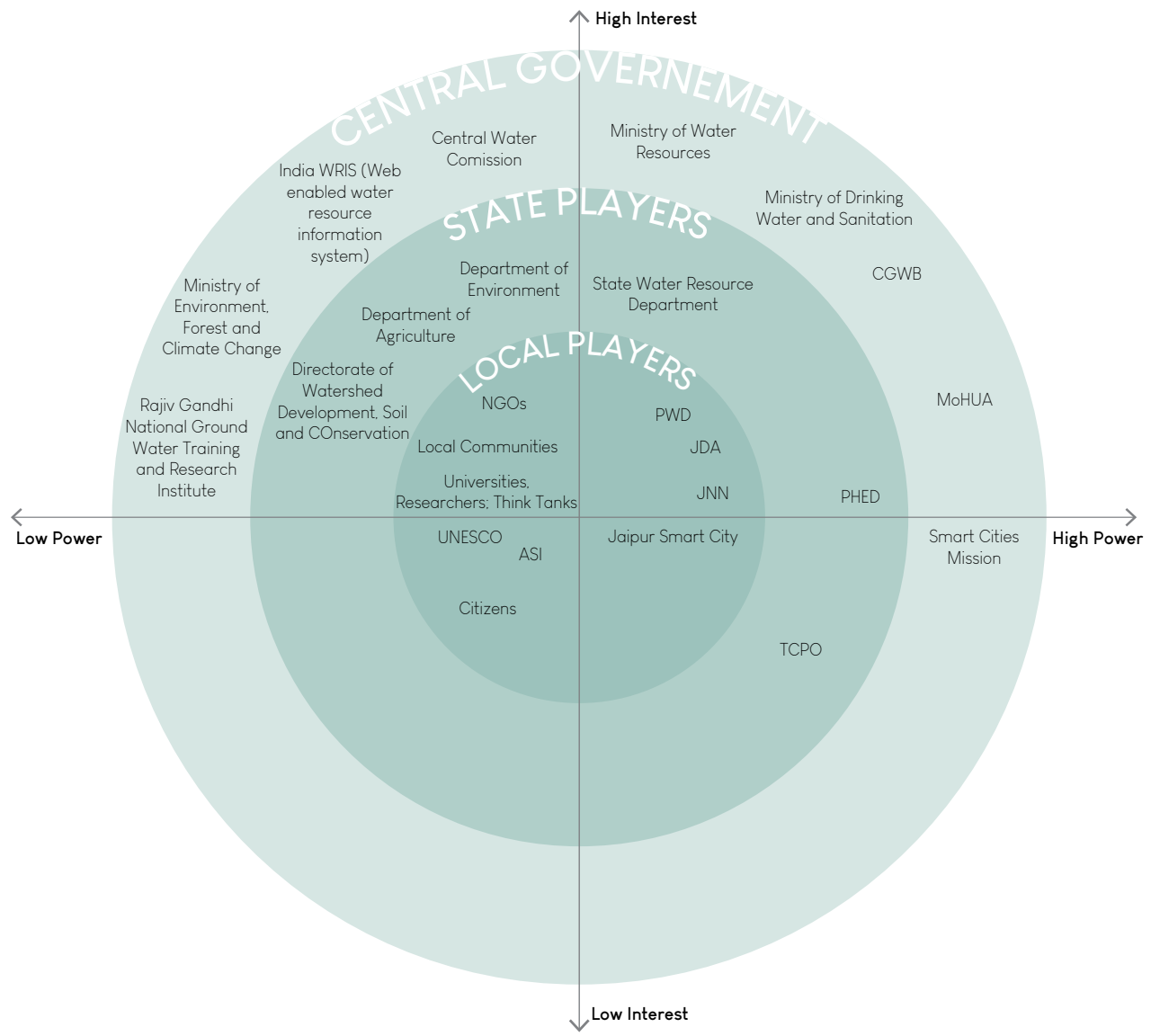
Assuming only 60% is harvested in Urban Areas

Total Water Harvested in one well: 36,000 litres

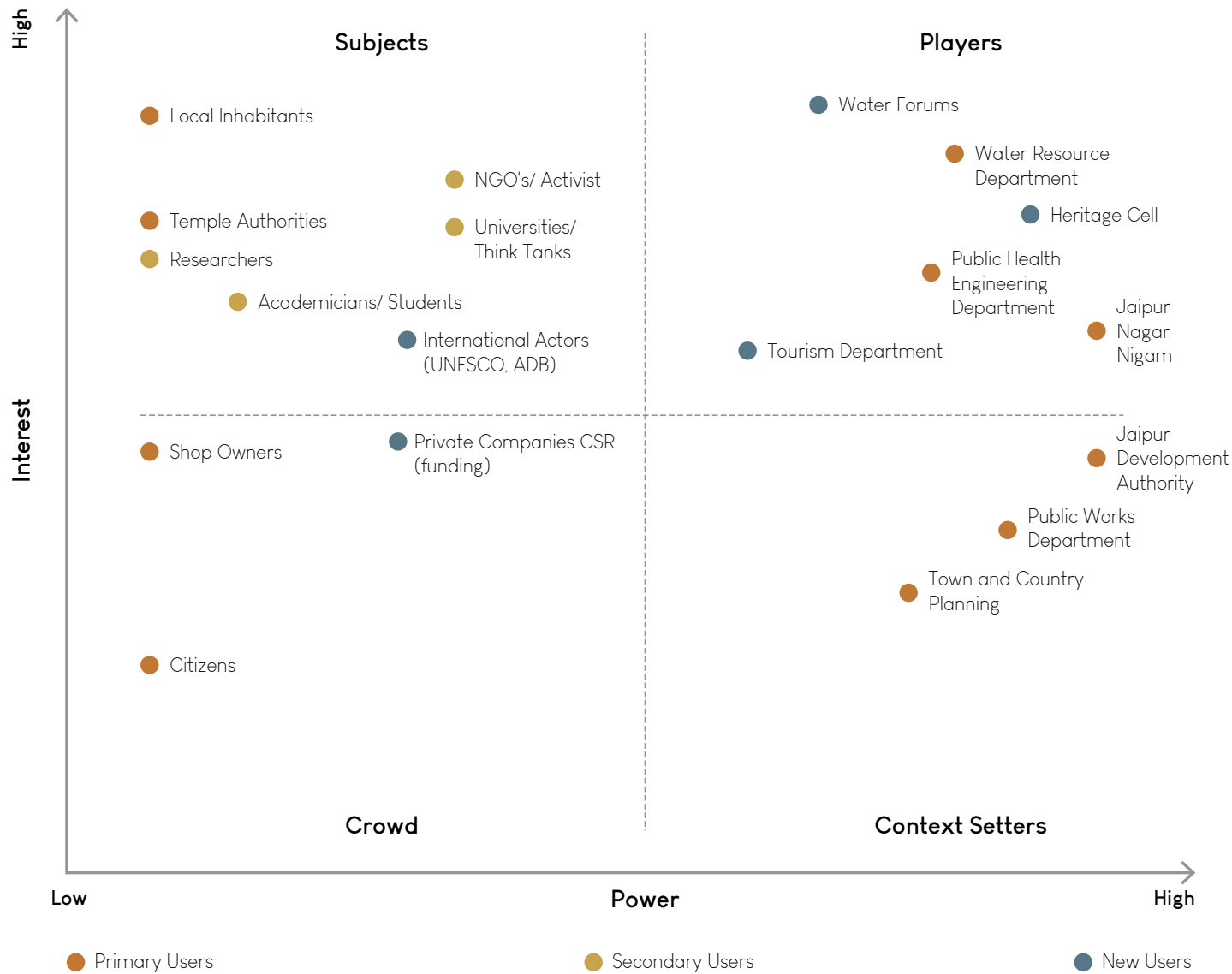
Total Water Calculation for 820 wells:

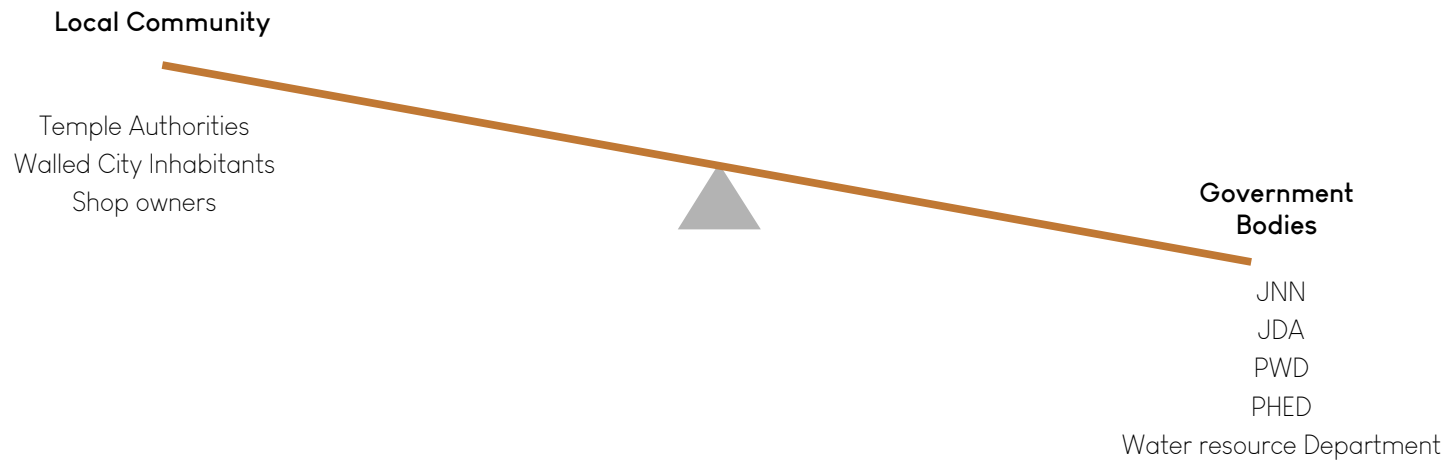
29,520,000 litres/year

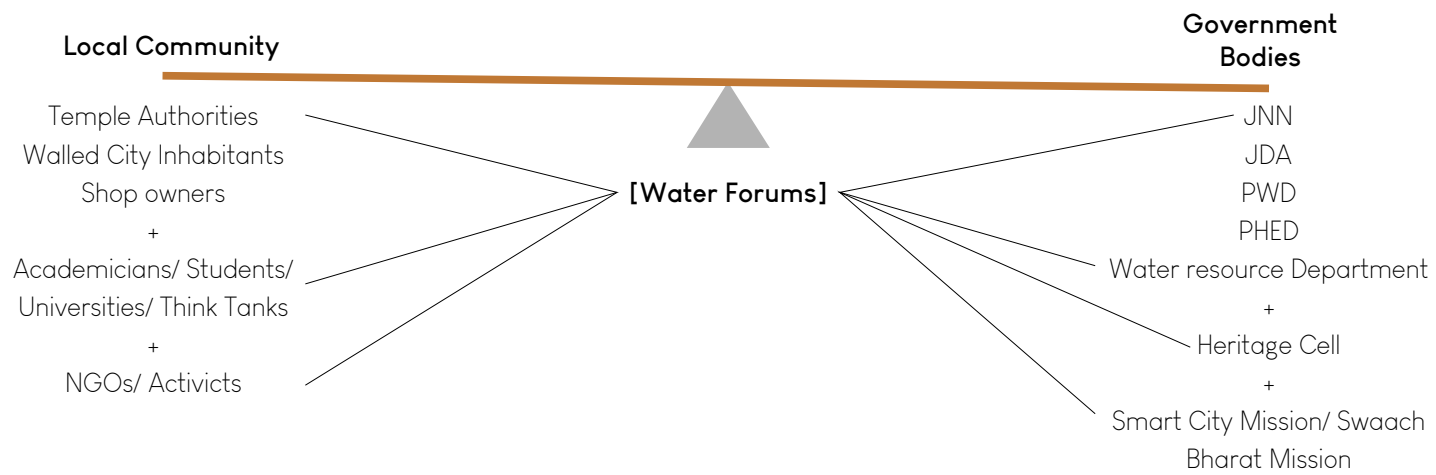
Stakeholders involved in Water Management in India



Stakeholders involved in reviving walled city public wells









JAIPUR WATER FORUM

User Engagement



Local Community Representative from each ward



Academicians/ Researchers/ Universities/ Think Tanks



Ngos/ Activist Group

Operation and Execution



Heritage Cell



Engineers, Urban and Landscape Designers, Architects



Planners, Project Managers



Bureaucrats



Jaipur Smart City Mission

Maintenance



Jaipur Nagar Nigam



Local Community



Jaipur Development Authority



Engage local users through community meetings, discussions and participatory initiatives



Collaborate with academicians/ practitioners/ universities/ architecture students through waterwalks, workshops, awareness drives for the local, tourists and citizens



Planning and design by government agencies, architects, planners, smart city, funding through government schemes/ corporate CSR



Public Review of proposals through the forum



Project Planning, Management and execution by Jaipur Nagar Nigam, Smart City and Jaipur Development Authority, PWD.



Collective effort for maintenance by locals and municipality



GOT MORE?