BUILDING FLOOD RESILIENCE THROUGH INTERLINKING OF LAKES

- THE CASE OF AHMEDABAD

CASE STUDY: INTERLINKING OF LAKES | FOLDER - B

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PREFACE

Rapid urbanization and unplanned development have hindered the hydrology of urban water bodies. Incidents of severe Urban Flooding have become more frequent in the recent past owing to the high impact growth. The effect has been compounded because of extreme rainfall events owing to Climate Change. Cities worldwide have come up with initiatives to deal with pluvial flooding and sustainably manage the urban water cycle. Urban lakes and other water bodies have been integrated with infrastructure initiatives across the world to optimize the usage of water resource and provide co-benefits.

However, the conventional approach towards Urban Water Management in India works in silos. The Lake Redevelopment & Interlinking project of Ahmedabad is a rare case of city-level infrastructure development intended towards sustainable urban water management. The case study attempts to look at urban water bodies such as lakes as a crucial infrastructure system for the sustainable management of the urban water cycle and building resilience against flood. It includes the background, concept and the implementation of Lake Redevelopment & Interlinking Project. The study also dwells in understanding the impact of the project on the environment, society and economy of Ahmedabad.

The experience has been correlated with current legislations, regulations and statutory planning mechanisms concerning blue-green infrastructure development. The case study includes recommendations for strengthening the implementation of interlinking of lakes as a Sustainable Urban Infrastructure practice.

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ABBREVIATIONS

AMC	:	Ahmedabad Municipal Corporation
AMRUT	:	Atal Mission for Rejuvenation and Urban Transformation
AUDA	:	Ahmedabad Urban Development Authority
BGI	:	Blue Green Infrastructure
CGWB	:	Central Groundwater Board
CPCB	:	Central Pollution Control Board
CPHEEO	:	Central Public Health and Environmental Engineering Organization
DP	:	Development Plan
DSIR	:	Dholera Special Investment Region
DSIRDA	:	Dholera Special Investment Region Development Authority
DWDU	:	District Watershed Development Unit
EC	:	Environmental Clearance
EIA	:	Environmental Impact Assessment
GDCR	:	General Development Regulation
GSWMA	:	Gujarat State Watershed Management Agency
GTPUDA	:	Gujarat Town Planning & Urban Development Act
IMD	:	India Meteorological Department
IWMP	:	Integrated Watershed Management Program
JSA	:	Jal Shakti Abhiyan
JNNURM	:	Jawaharlal Nehru National Urban Renewal Mission
LAP	:	Local Area Plan
LRIL	:	Lake Redevelopment & Interlinking of Lakes
MCM	:	Million Cubic Metres
MOEF	:	Ministry of Environment, Forest & Climate Change
MOHUA	:	Ministry of Housing and Urban Affairs
MORD	:	Ministry of Rural Development
NAPCC	:	National Action Plan on Climate Change
NbS	:	Nature based Solution
NDMA	:	National Disaster Management Authority
NLCP	:	National Lake Conservation Plan
NPCA	:	National Plan for Conservation of Aquatic Ecosystems
NWCP	:	National Wetland Conservation Program
RWH	:	Rain Water Harvesting
RRR	:	Repair, Renovation and Restoration
SEIAA	:	State Environmental Impact Assessment Authorities
SFO	:	State Forest Office
SIR	:	Special Investment Region
SUI	:	Sustainable Urban Infrastructure
TPS	:	Town Planning Scheme
TPVD	:	Town Planning & Valuation Department
ULB	:	Urban Local Bodies
URDPFI	:	Urban & Regional Development Plan Formulation & Implementation

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1

AHMEDABAD CITY & TRIGGERS FOR LAKE REDEVELOPMENT AND INTERLINKING OF LAKES PROJECT

1.1 AHMEDABAD - EVOLUTION & WATER HERITAGE

1.2 AHMEDABAD CITY

- Demography and Spatial Extent
- Land use and Environs
- Climate

1.3 TRIGGERS FOR THE PROJECT

- Climate Extreme
- Groundwater Depletion
- Lake Encroachment
- Citizen Activism & Judiciary Intervention

1.1 AHMEDABAD – EVOLUTION AND WATER HERITAGE

Asaval was the town established on the banks of Shwabhramati. In 1411, close to this location, the city of Ahmedabad was founded by Sultan Ahmedshah I (Shastri, 1964). As Sabarmati was a seasonal river and could not be depended upon for year-round needs, the city's planning always incorporated water at the center of development. Conventionally, all around the Ahmedabad region, there were *Tekros* or mounds where settlements existed and *Talavadis*[1] or ponds which were situated near these settlements (Tayyibji, 2016). These *Talavadis* functioned as a rainwater harvesting and groundwater recharging mechanisms. The *Talavadis* were used for domestic purposes while the groundwater sources were used for drinking water. Fig. 1-1 presents the historic water bodies of the city in 1866. Large water bodies near village settlements of Paldi, Vastrapur, Ghatlodia, Thaltej and Vasna can be seen in fig.1-2. Other than the ponds or lakes, there were a series of reservoirs and gardens built by the Sultans for the water security of the city. The Sultans had constructed reservoirs such as the Hauz-i-Qutb (Kankaria Tank) (refer to fig. 1-3 & 1-5), Malek Saban Lake and Sarkhej Lake with a Roza adjacent to it (refer to fig. 1-4). Some of the *Hauzs*[2] were controlled through a supply sluice and were interlinked at surface level for rainwater harvesting as well as for stormwater (Biggs, Hope, & Fergusson, 1866).

Within the *Pols* or traditional housing clusters of Gujarat, at the household level, people constructed *Tankas*[3] or underground tanks for rainwater storage. The tiled roof was cleaned before the monsoon and the rainwater was diverted to these tanks through pipes. The *Tankas* would cover only partial demand owing to their limited size.

With the advent of technology and a quest for better water services, the British began to build modern reservoirs with piped water supply network. The dependency on the traditional mechanisms of *Talavadis, Hauzs* and *Tankas* reduced over the years. Gradually, such sustainable practices of rainwater harvesting, and stormwater management gradually waned and became a part of Ahmedabad's historical legacy.

[1]The term *'Talavadi'* in Gujarati means a pond or a lake. Some of the Talavadis situated inside the village or Gams were known as *Gamtalavs* because of its utility and close association with the village.

[2]The term *'Hauz'* in urdu means 'water tank'. In Architectural context, *Hauz* was a sub-structure dug up to access the groundwater and harvest rainwater.

[3]Tankas were underground water reservoirs that were constructed in traditional houses in Gujarat. These Tankas stored rainwater from rooftop through pipes and sufficed domestic water needs during the dry season.

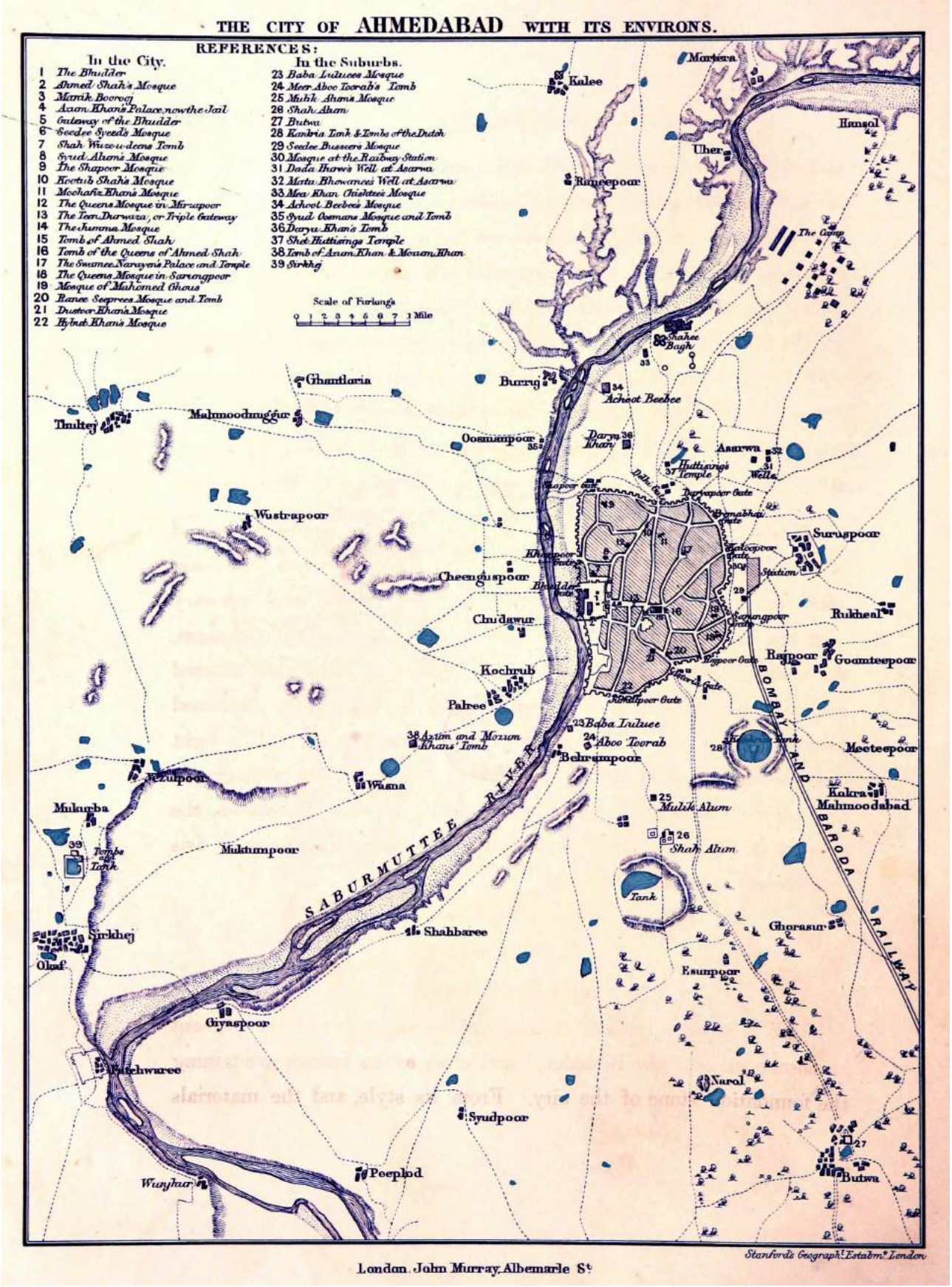

Figure 1-1: Historic Map of Ahmedabad with its environs (1866) exhibits numerous lakes that have been lost

Source: (Biggs, Hope, & Fergusson, 1866)

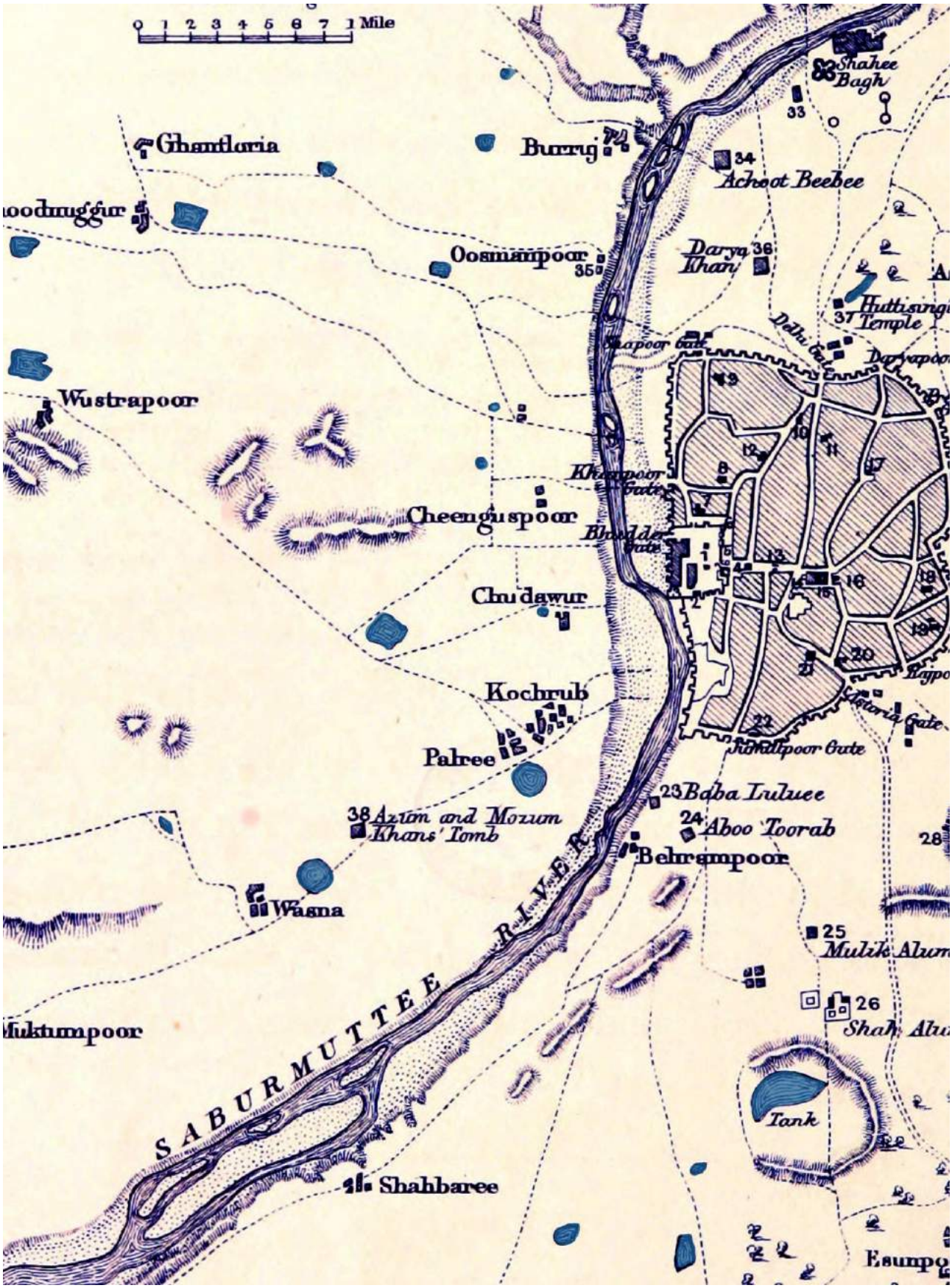

Figure 1-2: Enlarged Historic Map of Western part of the city exhibiting the erstwhile water bodies at Paldi, Vasna, Usmanpura, & Ghatlodiya

Source: (Biggs, Hope, & Fergusson, 1866)

Water Heritage of Ahmedabad through visuals

Figure 1-3: Howz-i-Kootub, or Kankaria Tank -The Supply Sluice
Source: (Biggs, Hope, & Fergusson, 1866)

Figure 1-4: Sarkhej Roza Complex
Source: (Sarkhej Roza Committee, 2021)

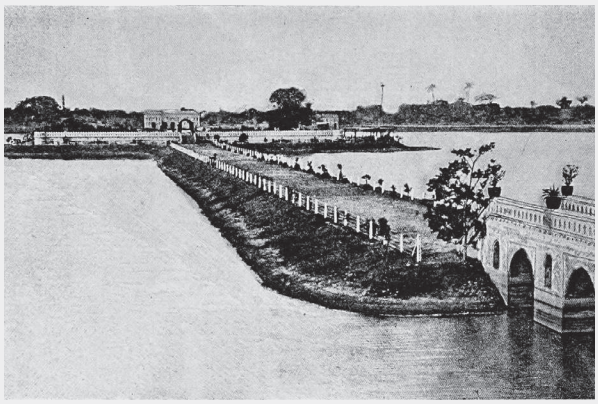

Figure 1-5: The Kankaria Tank
Source: (Arnold, 1891)

Figure 1-6: Riverbed Activities (Sabarmati)
Source: (Bresson H., 1966)

1.2 AHMEDABAD CITY

1.2.1 Demography and Spatial Extent

Ahmedabad is the largest city in Gujarat and is the seventh - largest metropolitan area in India. It serves as the administrative capital of the Ahmedabad district. The city is an important economic and industrial hub and is reported to be one of the fastest - growing cities in the 1991- 2011 period. The Ahmedabad Municipal Corporation (AMC), the city's administrative agency, covers an area of 465 sq. km. subdivided into 48 wards. The Ahmedabad Urban Development Authority region (AUDA) spans an area of 1,866 sq. km. comprising areas from the districts of Ahmedabad, Gandhinagar, Kheda, Kadi and Mehsana (refer to table 1-1). The Ahmedabad Municipal Corporation is the largest Urban Local Body (ULB) including five other Nagarpalikas and 169 villages in AUDA (AUDA, 2020).

Table 1-1: Population of AUDA Region

Year	AMC Population (in millions)	AMC Area (in Sq.km.)	AUDA Region Population (in millions)	AUDA Area (in Sq.km.)
1991	2.88	190	4.02	1295
2001	3.52	190	5.23	1295
2011	5.57	450	6.35	1866

Source: (Census, 2011), (AUDA, 2020)

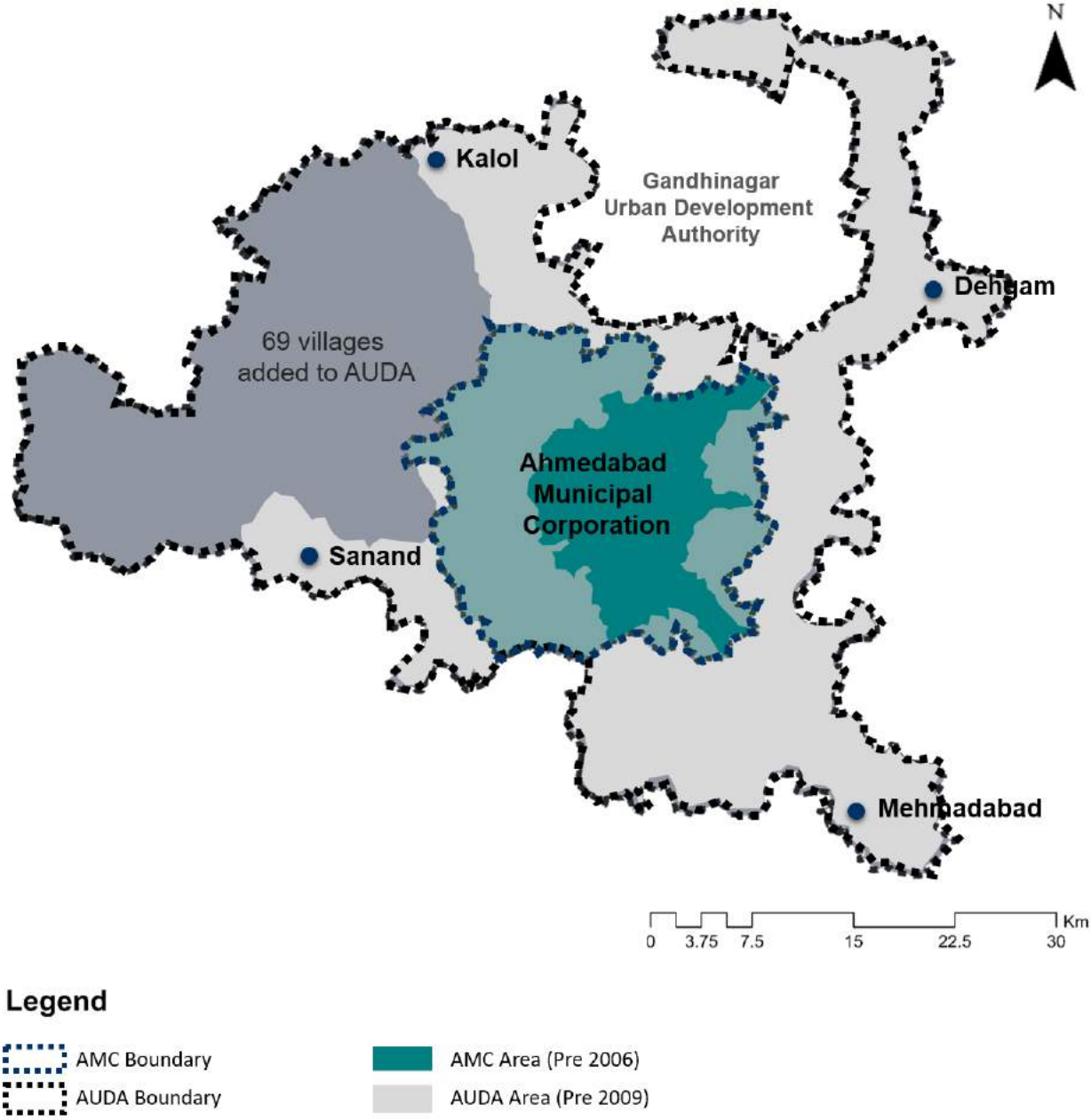

Figure 1-7: Map of AUDA & AMC Boundary (Expansion post 2006)

1.2.2 Land use and Environs

The predominant land use within the AUDA region is agriculture (refer to fig. 1-8 & 1-9). The built-up land area has increased from 250 sq. km. to 280 sq. km in the 1997-2011 period with intensified development and the addition of 69 villages. The area under water bodies has decreased from 3,854.53 ha (~3.85 sq.km.) to 3,500 ha (~3.5 sq.km.) in the AUDA region irrespective of its boundary expansion. Most of the lakes or ponds are smaller than 7.5 ha (refer to table 1-2).

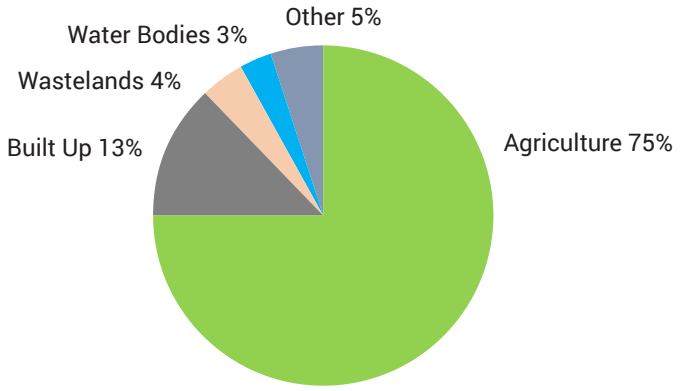

Figure 1-8: Land Use-cover distribution in 2011 (AUDA Region)

Source: (AUDA, 2001)

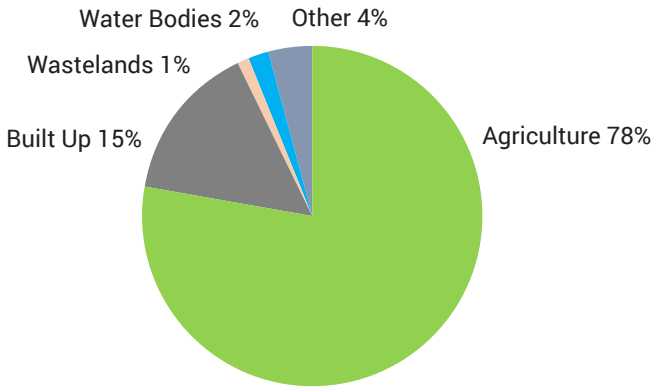

Figure 1-9: Land Use-cover distribution in 2011 (AUDA Region) exhibits decrease in area under water bodies irrespective of the expansion of AUDA boundary

Source: (AUDA, 2011)

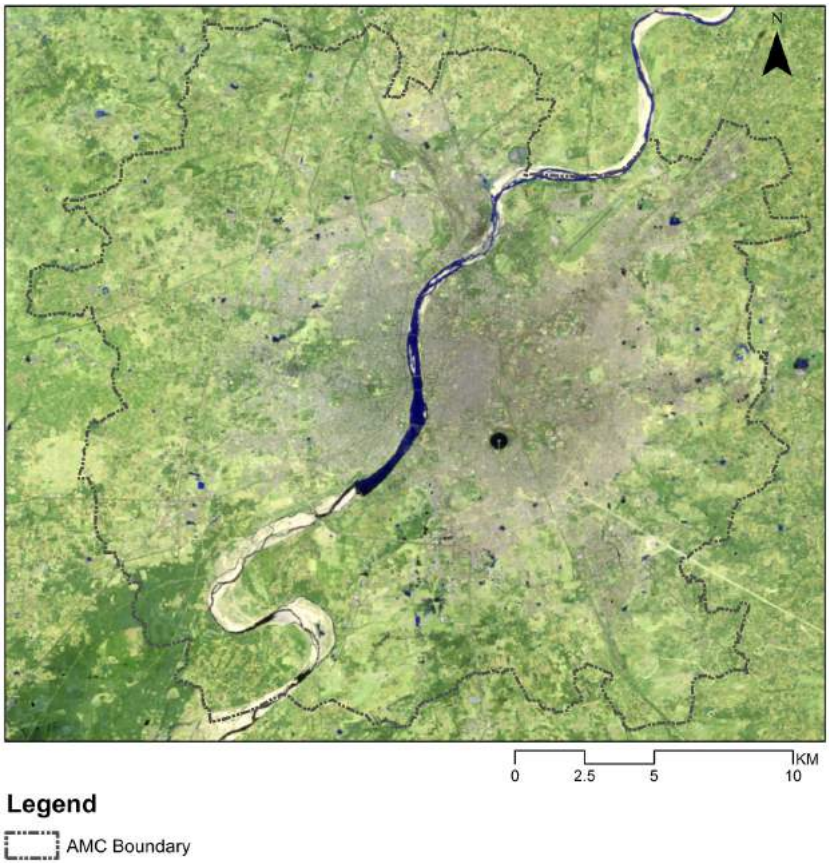

Figure 1-10: Land Cover of Ahmedabad (in 1991)

Source: Landsat 5

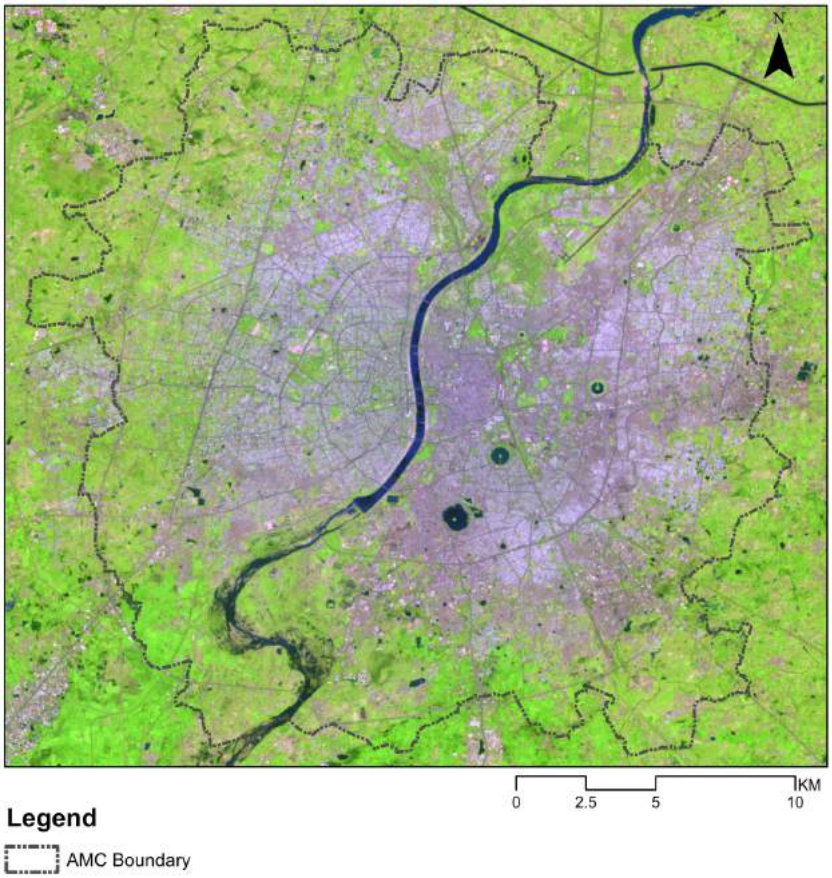

Figure 1-11: Land Cover of Ahmedabad (in 2019)

Source: Landsat 8

Table 1-2: Details of Water bodies in AUDA Region

	No. of Lakes	Area	<5 ha	5-7.5 ha	7.5-10 ha	> 10 ha
AMC	58	280.9	47	6	1	5
Old AUDA	723	1417.5	687	21	7	9
Added 69 Villages (New AUDA)	736	1883.6	677	15	14	30

Source: (AUDA, 2020)

In the AMC region, residential and mixed-use are the most prominent categories of land use. Industrial land use has decreased by 9%, owing to the expansion of boundaries in non-industrial areas (west Ahmedabad) and the closure of many of the city's industrial units. The city had 850.55 ha (~8.5 sq.km.) of land under the water bodies in 1997. In 2011, the combined area of the open spaces - lakes, ponds, gardens and parks had reduced to 497 ha (~4.97 sq.km.) (AUDA, 1997) (AUDA, 2011).

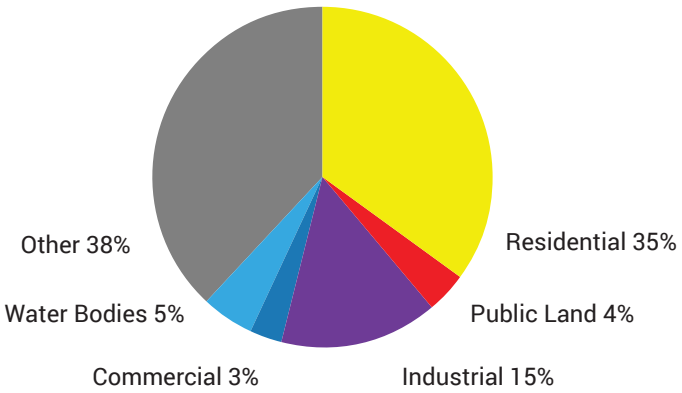

Figure 1-12: Land Use in AMC Region (1997)

Source: (AUDA, 1997)

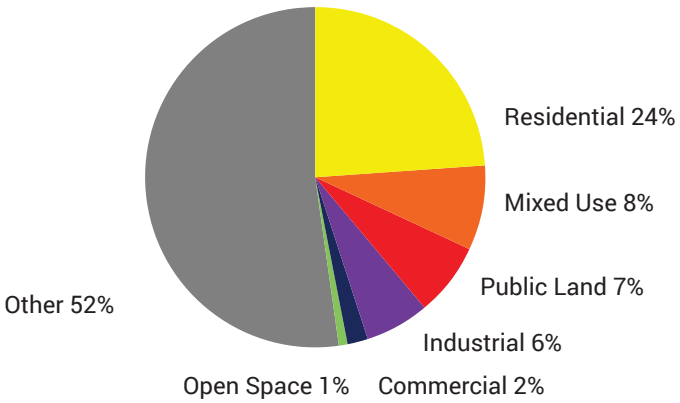

Figure 1-13: Land Use in AMC Region (2011)

Source: (AUDA, 2011)

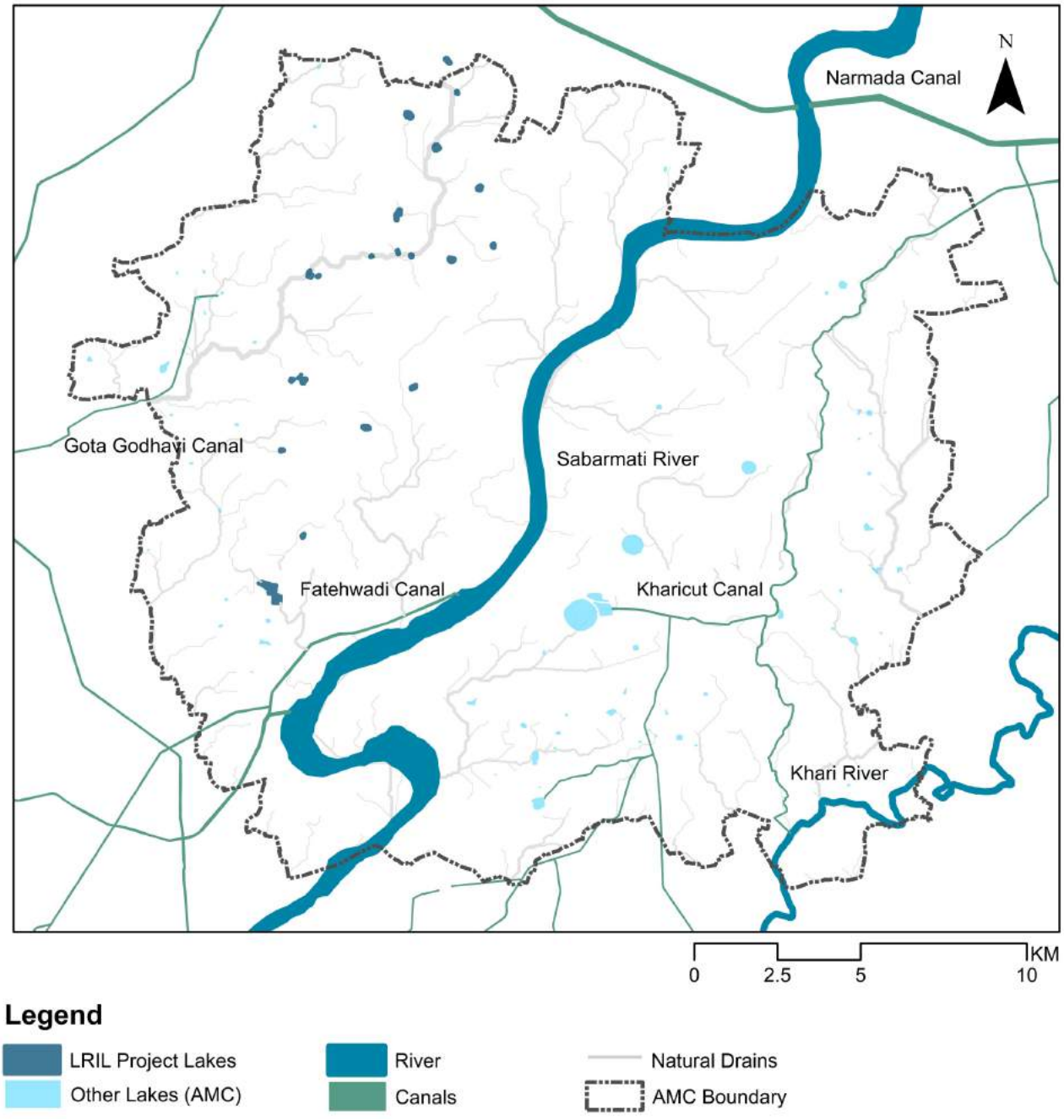

Figure 1-14: The blue map of Ahmedabad

1.2.3 Climate

The climate of Ahmedabad is hot semi-arid type. The average summer maximum is 41° C, and the average summer minimum temperature is 27°C. The winter temperatures range within an average maximum of 30°C and a minimum of 15°C. The average rainfall is about 782 mm with most of the rainfall occurring within the July-August period (AUDA, 2011).

1.3 TRIGGERS FOR THE PROJECT

A series of background events eventually led to the LRIL project. The next section details the four major triggers that played a key role in planning and implementation of the project.

1.3.1 Climate Extreme

Ahmedabad experienced heavy rainfall of 325 mm on 14th July 2000 (Adhyaru-Majithia, 2010) (India Water Portal, 2020). The city experienced its worst flood after 1927. Mobility and livelihood were disrupted badly at places after three hours of continuous rain. AUDA's housing at Vastrapur, Nirnay Nagar and Jodhpur were amongst the worst affected areas (Ray, 2005). The heavy downpour resulted in the death of 10 people and an approximate loss of goods worth INR 5,000 million[4] (Gujarat Samachar, 2000) (The Hindu, 2000). Such extensive destruction due to floods was "attributed in large part to unplanned, unregulated construction." As much as 75% of the buildings in AUDA were found to be violating the Gujarat Town Planning and Urban Development Act (GTPUDA) (Spodek, 2001).

This incident exposed the nexus of the Authorities and the Builders. An editorial published in The Times of India on July 15th 2000, blamed AUDA and builders for ignoring the natural slope and topography of the city (Spodek, 2001). The event led to a call for public transparency and accountability in city management. Three civic leaders - Mr. Manubhai Shah (from CERC - Consumer Education and Research Centre), Mr. Kirtee Shah (from ASAG - Ahmedabad Study Action Group) and Dr. R N (Rasubhai) Vakil (from Ahmedabad Citizen's Trust) of Ahmedabad called a public meeting on 6th August 2000. The purpose of the meeting was to file a PIL to establish public accountability of the government and public agencies (Spodek, 2001).

The onus on AUDA for greater accountability and improved city drainage system for flood mitigation led to the initiation of a stormwater plan overhaul for the city within the Authority. A resultant call for action and stormwater management led to the thought of developing a citywide stormwater management strategy. Mr. Surendra Patel, the then Chairman of AUDA, recalls this flood as "the single biggest trigger for the Lake Redevelopment and Interlinking of Lakes Project" (Patel S., 2020) (Thakker, 2020).

[4]~USD 67.13 million according to the exchange rate on 16th April 2021 retrieved from https://www.federalreserve.gov/releases/h10/current/

1.3.2 Groundwater Depletion

The state of Gujarat is one of the most water-stressed regions in India.[5] The per capita freshwater availability in the state was 1,137 m^3 per capita per annum and 830 m^3 per capita per annum in 2001 and 2011 respectively (Goswami, Parthasarathy, & Iyer, 2012).

The districts of Ahmedabad, Patan, Mehsana, Gandhinagar, Banaskantha and Patan were among the overexploited districts in terms of the level of groundwater development for 2002, 2004, and 2009 (CGWB, 2011).

The dependency on groundwater for municipal water supply was more than 20% in the period 2000-2006. Groundwater depletion was further aggravated due to groundwater extraction by private bore wells in Ahmedabad. Fig. 1-15 presents the groundwater level of Ahmedabad in different parts of the city. By 2006, the groundwater level across the city was more than 100m with a depletion rate of 2m/year from 1960 onwards (Goswami, Parthasarathy, & Iyer, 2012). The water stress and dwindling groundwater availability was one more trigger for the inception of the project.

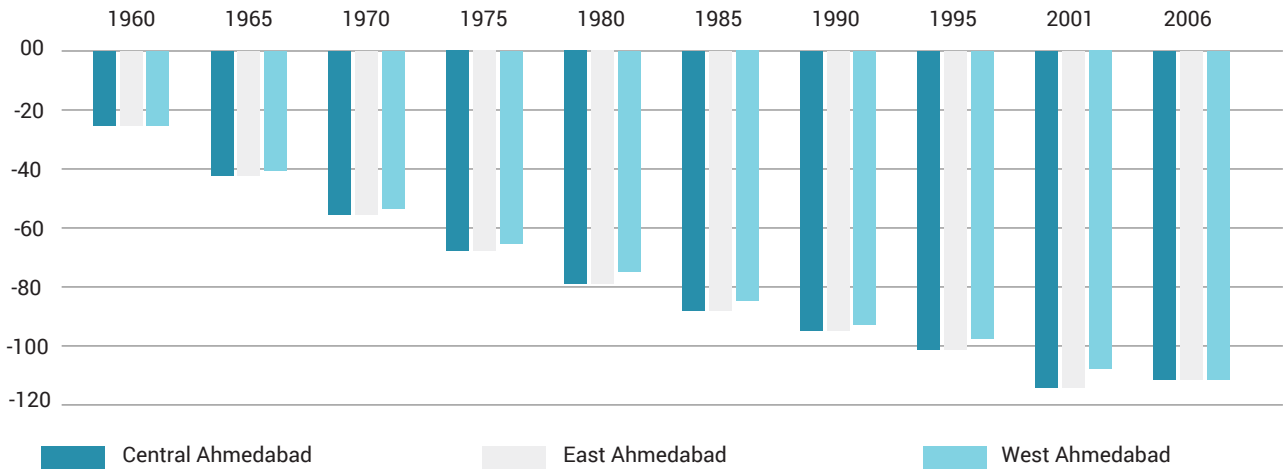

Figure 1-15 Ground water level data for Ahmedabad city (in mbgl) shows rapid decline in the ground water table in the 1960-2006 period
Source: (Goswami, Parthasarathy, & Iyer, 2012)

1.3.3 Lake Encroachment

Ahmedabad had lost 36 surface water bodies or *Talavadis* in the 1961-1996 period (Goswami, Parthasarathy, & Iyer, 2012). Urbanization and anthropocentric activities adversely affected the lakes in the city. The lakes became dry due to loss of catchment and disruption of their hydrological cycle. These dried up lake lands were converted to other uses under the guise of various formal and informal mechanisms. These approaches were analyzed at a few locations of these lakes across Ahmedabad through historical maps, expert consultation, and satellite imagery analysis (refer to fig. 1-1, 1-10 & 1-11). The subsequent section describes three mechanisms that led to the loss of the lakes.

[5]*F*alkenmark water stress index - This method defines water scarcity in terms of the total water resources that are available to the population of a region; measuring scarcity as the amount of renewable freshwater that is available for each person each year. If the amount of renewable water in a country is below 1,700 m^3 per person per year, that country is said to be experiencing water stress; below 1,000 m^3 it is said to be experiencing water scarcity; and below 500 m^3, absolute water scarcity (Falkenmark, Lundquist, & Widstrand, 1989).

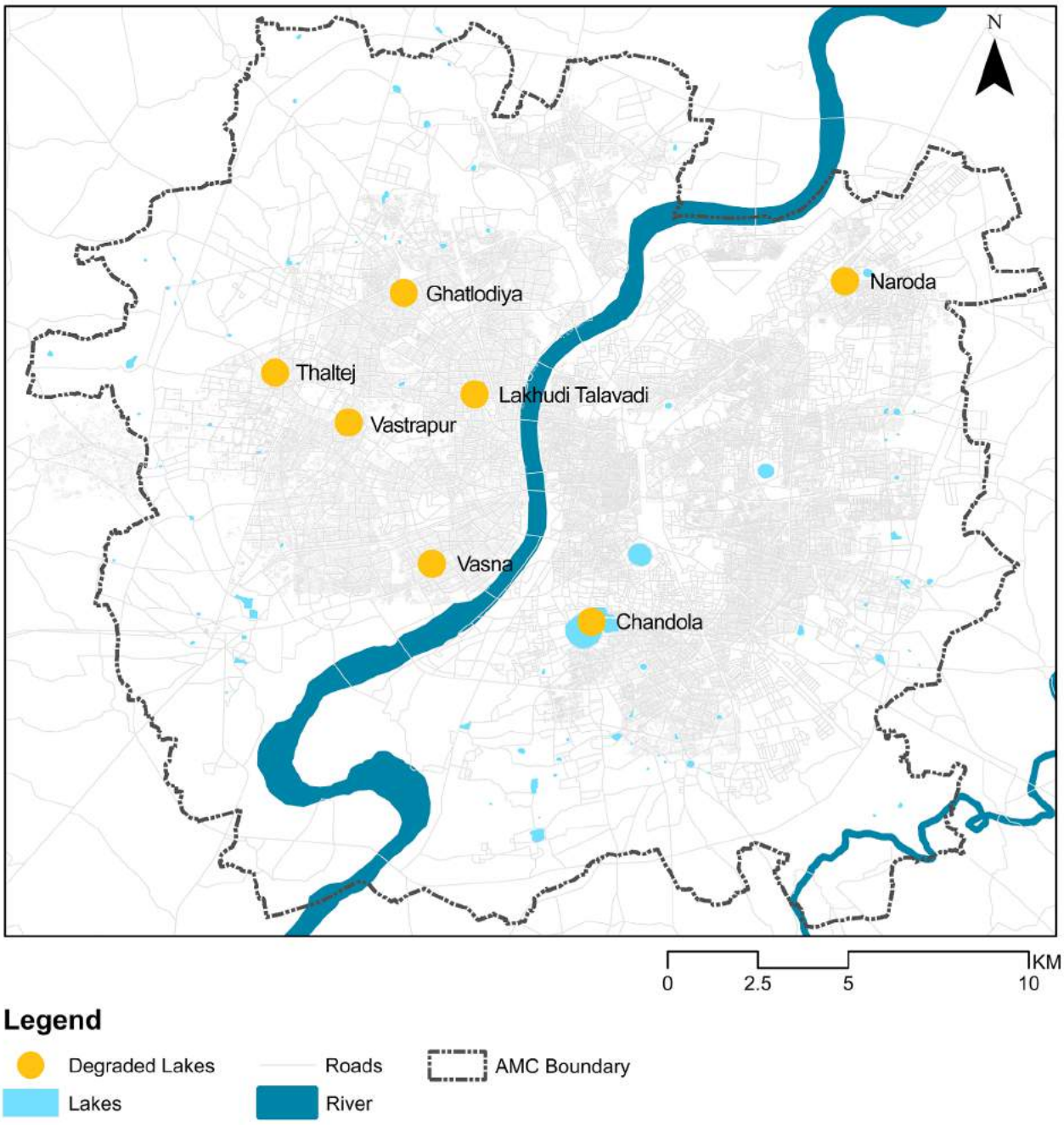

Figure 1-16: Map of Ahmedabad showing locations of degraded lakes that have been chosen for understanding the loss of lakes

Figure 1-17: Degraded and fragmented water body in Ghatlodiya (in 2000)

Source: (Google Earth, 2020)

1.3.3.1 Appropriation of Lake Land for other Purposes:

The first practice was the appropriation of land by the authorities for other uses such as neighborhood centers, waterworks, recreational space, or housing. The town planning schemes developed before 1990s did not emphasize on integration of the small lakes and ponds in the planning process (Patel V., 2020). This approach resulted in smaller fragmented water bodies eventually drying up. The resultant land was earmarked for other purposes. The neighborhood center at Ghatlodiya (T.P.S.-2) (fig 1-17 to 1-19); waterworks and garden at Vasna later developed as EWS housing (TPS - 26) (fig. 1-20 - 1-22); E.W.S. housing proposed and later developed as Ahmedabad Haat at Bodakdev (T.P.S.-1B) (fig. 1-23 to 1-25) were partially or completely built over a water body (TPVD, 2020).

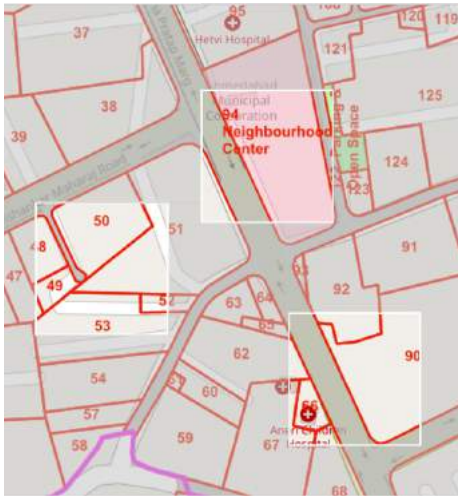

Figure 1-18: Land appropriated for public buildings and private development (T.P.S. - Ghatlodiya 2)

Source: (TPVD, 2021)

Figure 1-19: Public and private buildings have covered the Lake land (in 2020)

Source: (Google Earth, 2020)

Figure 1-20: Lake land encroached by informal settlements (in 2000)

Source: (Google Earth, 2020)

Figure 1-21: Lake land appropriated for garden and waterworks (TPS - Vasna North 26)

Source: (TPVD, 2021)

Figure 1-22: Public Housing on the Lake land that had been appropriated for garden and developed for EWS housing (2020)

Source: (Google Earth, 2020)

Figure 1-23: Lake land west of Vastrapur Lake (in 2000)

Source: (Google Earth, 2020)

Figure 1-24: Lake land appropriated for SEWS Housing (TPS Bodakdev 1B)

Source: (TPVD, 2021)

Figure 1-25: Ahmedabad Haat constructed on Lake l a n d (2020)

Source: (Google Earth, 2020)

Figure 1-26: Fragmented water body - Champal Talavadi (in 2000)

Source: (Google Earth, 2020)

1.3.3.2 Grant of Building Permission under TP Scheme

The second mechanism was the grant of permission for construction over lake land to private entities after land appropriation in TP scheme. Multistoried apartments and other structures were constructed on the lake land in Ghatlodiya (T.P.S. Ghatlodiya 2) and at Champal Talavadi (T.P.S. Naroda 1) (refer to fig. 1-19 & 1-28 respectively).

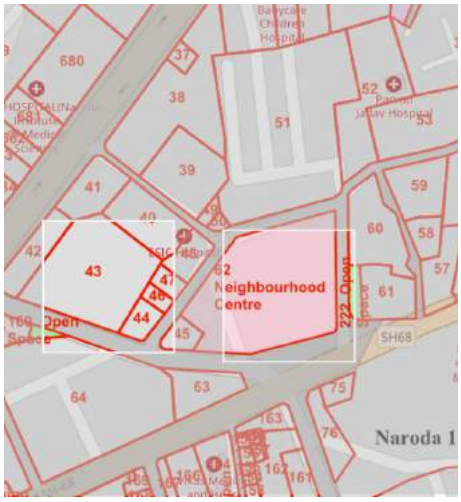

Figure 1-27: Lake land appropriated to private entities and public purpose (TPS Naroda 1)

Source: (TPVD, 2021)

Figure 1-28: Private and public buildings constructed on the Lake land (2020)

Source: (Google Earth, 2020)

1.3.3.3 Informal Settlements on Lake Land:

The last occurrence was the encroachment of the lake land by informal settlements. The lakes of Vasna, Chandola, Vastrapur, Memnagar, Thaltej, Isanpur and Asarwa were all infringed upon by informal settlements (refer to fig.1-20, 1-29 & 1-30 & 1-31). The Lakhudi Talavadi in Navrangpura had been completely encroached upon by slums. The land had been earmarked as a garden and playground in the earlier Town - Planning Scheme (J.S. Rajpurohit vs. State of Gujarat, 2014).

The loss of lakes had a domino effect which led to the triggering of citizen activism which in turn played a key role in the formation of the LRIL project.

Figure 1-29: Informal settlements on the lake land at Chandola Lake (in 2000)

Source: (Google Earth, 2020)

Figure 1-30: Informal Settlements over Lakhudi Talavadi before redevelopment

Source: (UNPSA, 2021)

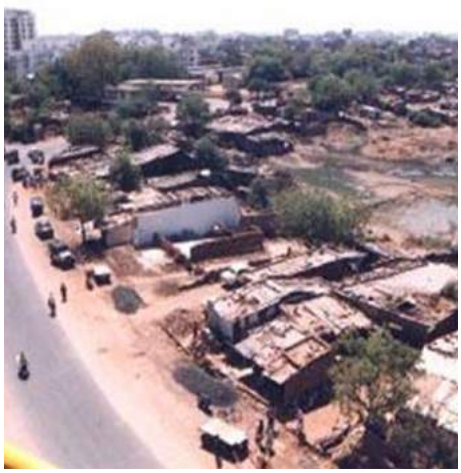

Figure 1-31: Informal Settlements along the periphery of Vastrapur Lake before redevelopment

Source: (AUDA, 2020)

1.3.4 Citizen Activism & Judicial Intervention

The final push to the project came in the form of community action followed by court orders. Citizens moved to court to file Public Interest Litigations (PIL) against the local authorities holding them accountable for water pollution and depletion of the city's lakes. In October 2000, Mr. Shailesh Shah filed a PIL against the state of Gujarat regarding the poor condition of Chandola Lake. The lake had completely dried up and informal settlements encroached over its land.

In a follow-up, the Gujarat High Court directed the state government and local authorities to inform it regarding the status and number of water bodies as a follow-up. The subsequent reply revealed that there had been a drastic reduction in the number of lakes in Ahmedabad in the past few decades. The court immediately ordered the local authorities to notify these lakes and check encroachments around them. It acknowledged that there was a crisis of water in the city and that conservation of the lakes was necessary (CSE, 2021).

The court directed AUDA and AMC to prepare plans to rejuvenate the lakes and rehabilitate the informal settlements around them. Mr. Surendra Patel (ex-Chairman, AUDA) was criticized by the court for allowing the violation of building permissions in the lake vicinity.
The PIL proceedings on Chandola continued for two years and in the final orders on 2nd August 2002, the bench of Justice R K Abichandani and Justice D A Mehta ordered the government to:

1. Notify all lakes and ponds within the state and to preserve them as is.
2. Undertake urgent measures for checking pollution, rejuvenating the water bodies and using them for recharging groundwater.
3. Remove encroachments and facilitate rehabilitation according to the existing norms.
4. Create a water resources council, headed by the chief minister, as laid out in the state's draft water policy, to oversee the program for rejuvenation of all water bodies. A water resources committee chaired by the chief secretary of the state will assist this committee (Shailesh Shah vs State of Gujarat, 2000).

Thus, these four triggers gave the necessary push for lake development and interlinking of the lakes policy. The next chapter covers the details of the project and the present status of interlinking of the lakes.

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2

LAKE REDEVELOPMENT AND INTERLINKING OF LAKES PROJECT (LRIL)

2.1 PROJECT INFORMATION

- Conceptualization of the Project
- Vision
- Aim and Objectives
- Components
- Interlinkage
- Funding
- Timeline
- Institutional Structure

2.2 CURRENT STATUS OF LAKES INTERLINKED UNDER LRIL

- Current Overview of the Lake Precincts
- Local Catchment Connection and Interlinkage
- Lake Development
- Green spaces and Recreational spaces
- Change in Land Cover
- Summary of the Current Status

2.1 PROJECT INFORMATION

In the following years, these triggers impelled AUDA to conceptualize the Lake Redevelopment and Interlinking of Lakes (LRIL) project as a solution to the water-centric issues of Ahmedabad. The authority focused on the Northwestern periphery of the city to establish a pilot that could be later scaled up. The growth in this region had outpaced infrastructure provision and it was a hotspot of triggers mentioned previously. This chapter contains information on different aspects of the project and the status of the interlinked lakes.

2.1.1 Conceptualization of the Project

The prevailing development in the Ahmedabad Urban Complex before the project ignored the natural gradient of water flow. Major roads such as Drive-In road, S.G. Highway and the Ring Road fragmented the old natural drains and catchment of lakes (Sharma, 2020) (Patel N., 2021). The stormwater within the AMC region was collected through a piped network and ultimately discharged into the Sabarmati River. Similar method of stormwater disposal was not practical for AUDA owing to the requirement of a mammoth-piped network for its large jurisdiction area. The technical team at AUDA came up with the idea to utilize the traditional *Gamtalavs* as natural retention basins for stormwater disposal after connecting them locally with its neighborhood. These lakes were to be interlinked to maintain the water level and discharge the excess water influx through the interlinking into the Sabarmati River (Thakker, 2020).

2.1.2 Vision

AUDA had envisioned the project to solve the dual water-related issues of Western Ahmedabad - flooding and water security (Patel S., 2020). The project's vision was also to leverage development in the region and develop the city as a 'Lake City' with vibrant public spaces around lakes for enhanced livability (Thakker, 2020).

2.1.3 Aim and Objectives

The aim of the LRIL project was to preserve and revive the lakes as water bodies while safeguarding them from encroachment and degradation. A set of objectives were defined for the project to achieve the goal:

1. To resolve the issues of waterlogging and strengthen flood resilience through lake interlinking
2. To ensure water security for Western Ahmedabad through lake rejuvenation and groundwater recharge

3. To improve the livability or quality of life of Western Ahmedabad through the creation of green and recreational spaces (AUDA, 2020) (Jagani, 2004) (Bal, Anthonie, & Jaap, 2011) (Thakker, 2020).

These objectives bring the project in juxtaposition with the objectives of any major Blue-Green Infrastructure project.[6] AUDA had identified 22 lakes for the project and selected 10 amongst them on a priority basis to implement the initiative (AUDA, 2020).

"To preserve, conserve and revive the lakes as waterbodies while safeguarding them from encroachment and solid waste dumping"

To resolve the issues of waterlogging and strengthen flood mitigation through lake interlinking

To ensure water security for Ahmedabad through lake rejuvenation and groundwater recharge

To improve the livability or quality of life of Ahmedabad through the creation of green and open spaces.

Figure 2-1: Project Objectives of Lake Redevelopment & Interlinking of Lakes Project

2.1.4 Components

AUDA adopted a comprehensive strategy that operated at a macro and micro scale integrating various urban infrastructure sectors. The project had two major components – Lake Redevelopment and Lake Interlinking. The interventions were to be implemented either on the lake land or in its vicinity. The interventions would look at curative measures for immediate impact and preventive measures for long-term impact on water quantity and quality. The interventions have been detailed here:

1. **Sewerage System:** Sewerage network was to be developed in the vicinity of the lakes to prevent raw sewerage disposal into the lake water.
2. **Construction of Public Toilets & Water Standposts:** The construction of public toilets would avoid open defecation around the lake land. A public standpost for drinking water was also to be provided.

[6] Blue-green infrastructure refers to the integrated systems approach of urban infrastructure towards the urban water resources (blue) and vegetation (green).

3. **Stormwater Network:** The immediate catchment of the lakes was to be connected to the lake through stormwater lines. The intervention would avoid flooding in the vicinity and recharge water within the lakes.
4. **Development of Roads:** Construction and widening of roads corresponding to the TP scheme to avoid congestion and improve the accessibility of lakes and simultaneously ensure the demarcation of the lake land.
5. **Rehabilitation of Informal Settlements:** The informal settlements encroaching on the lake land were to be relocated and rehabilitated. It was to ensure improved quality of life for the rehabilitated households.
6. **Land Reclamation:** The peripheral land was to be cleared of the encroachments and then used for the development of roads, gardens, and other recreational areas.
7. **Desilting & Excavation:** The lakebed was to be desilted and deepened for enhanced capacity to hold rainwater. The deepening of the water body would adjust the capacity reduced due to land reclamation.
8. **Construction of Percolation Wells:** Percolation wells up to 35m deep were to be constructed with a diameter of 300-600 mm for enhanced groundwater recharge.
9. **Architectural Landscape and Recreational spaces:** The architectural design was to be prepared for the lakes including landscape design and development of recreational activities on reclaimed land.
10. **Dry Season Recharge:** The lakes were planned to be filled with the Narmada Water in the dry season (AUDA, 2020).

Figure 2-2: Sewerage network being laid near Vastrapur Lake
Source: (AUDA, 2020)

Figure 2-3: Slum clearance from the lake land at Vastrapur
Source: (AUDA, 2020)

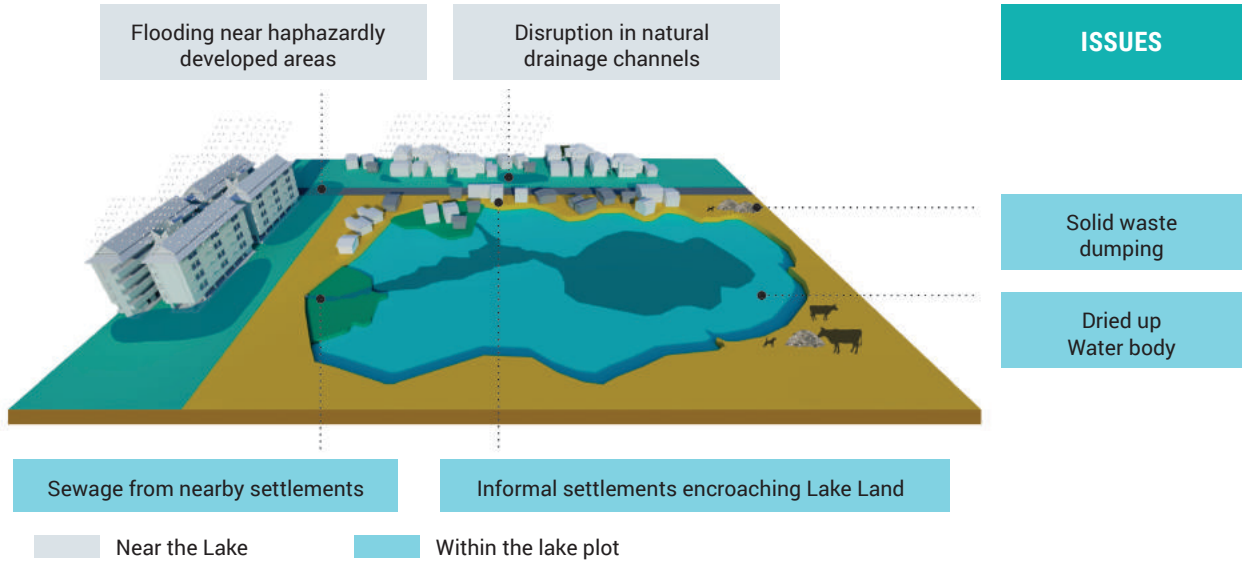

Figure 2-4: Prime issues faced by the lakes selected for LRIL project

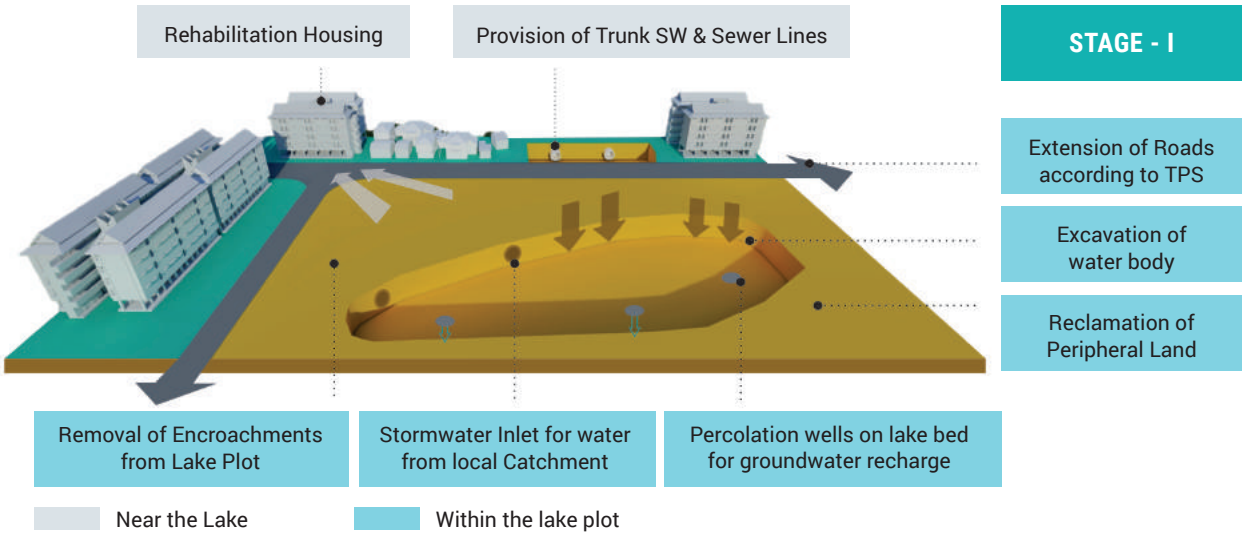

Figure 2-5: Project Components of LRIL project for Stage 1 (categorized as interventions within the lake plot and near the lake)

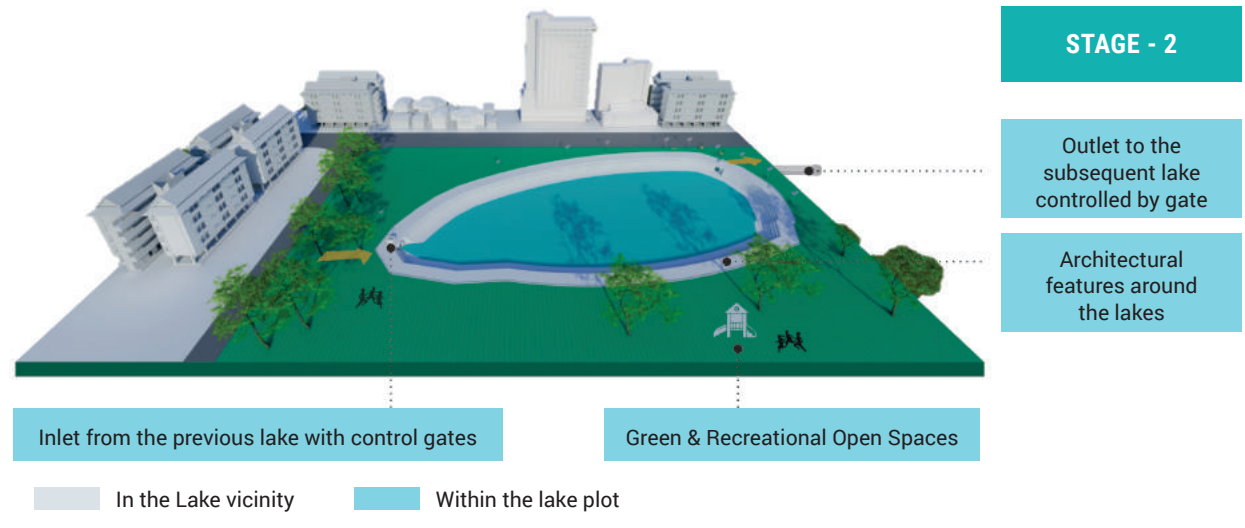

Figure 2-6: Project Components of LRIL project (categorized as interventions within the lake plot and near the lake)

2.1.5 Interlinkage

The interlinkages between the lakes were the crucial component envisaged in the LRIL project. Most of the lakes in Ahmedabad were smaller than five hectares, limiting their capacity to hold stormwater. Historically, lakes in Ahmedabad had been linked through natural drains and streams which maintained the water levels. Interlinkage was conceptualized for a system of small lakes that function together as a large urban hydrological system. The interlinkage would help fill the dried lakes and eventually divert the excess stormwater to the Sabarmati River via the series of lakes. The connections would work through a network of gravity lines following the natural slope of Ahmedabad from North to South. The linkages were to be controlled with the help of sluice gates and valves. Figure no. 2 - 7 presents the interlink network. Thus, the Interlinking of lakes aimed at harnessing the combined potential of the lakes as a collective system for flood mitigation and water augmentation (Thakker, 2020). The approximate capacity of the Interlinkage system of the lakes by AUDA was more than 3.3 million cubic meters in the first phase undertaken (AUDA, 2020).

The Interlinkages were conceived in two clusters based on topography and outfall.[7] Cluster 1 was to drain in the Sabarmati River with branches following this sequence:

- Sola to Thaltej to Bodakdev to Makarba to Sabarmati River
- Memnagar to Vastrapur to Makarba to Sabarmati River
- Prahladnagar to Sabarmati River

Cluster 2 was to drain in the Gota - Godhavi Canal with branches following this sequence:

- Khoraj to Tragad to Chharodi to Jagatpur to Gota to R.C. Technical to Gota - Godhavi Canal via RCC Duct
- Ranip to Chandlodia to Yadudi to Dev City to R.C. Technical to Gota-Godhavi Canal via RCC Duct

The Sola Lake was to be linked with R.C. Technical Lake where the latter would be functioning as a transition point for three branches and two clusters. The Khoraj Lake was to be connected to the Narmada Canal to supply water in the dry season to the clusters (AMC, 2020) (AUDA, 2020).

[7]AMC plans to expand the network in the Chandkheda region as a third cluster. The analysis does not include specifics of this cluster due lack of data availability.

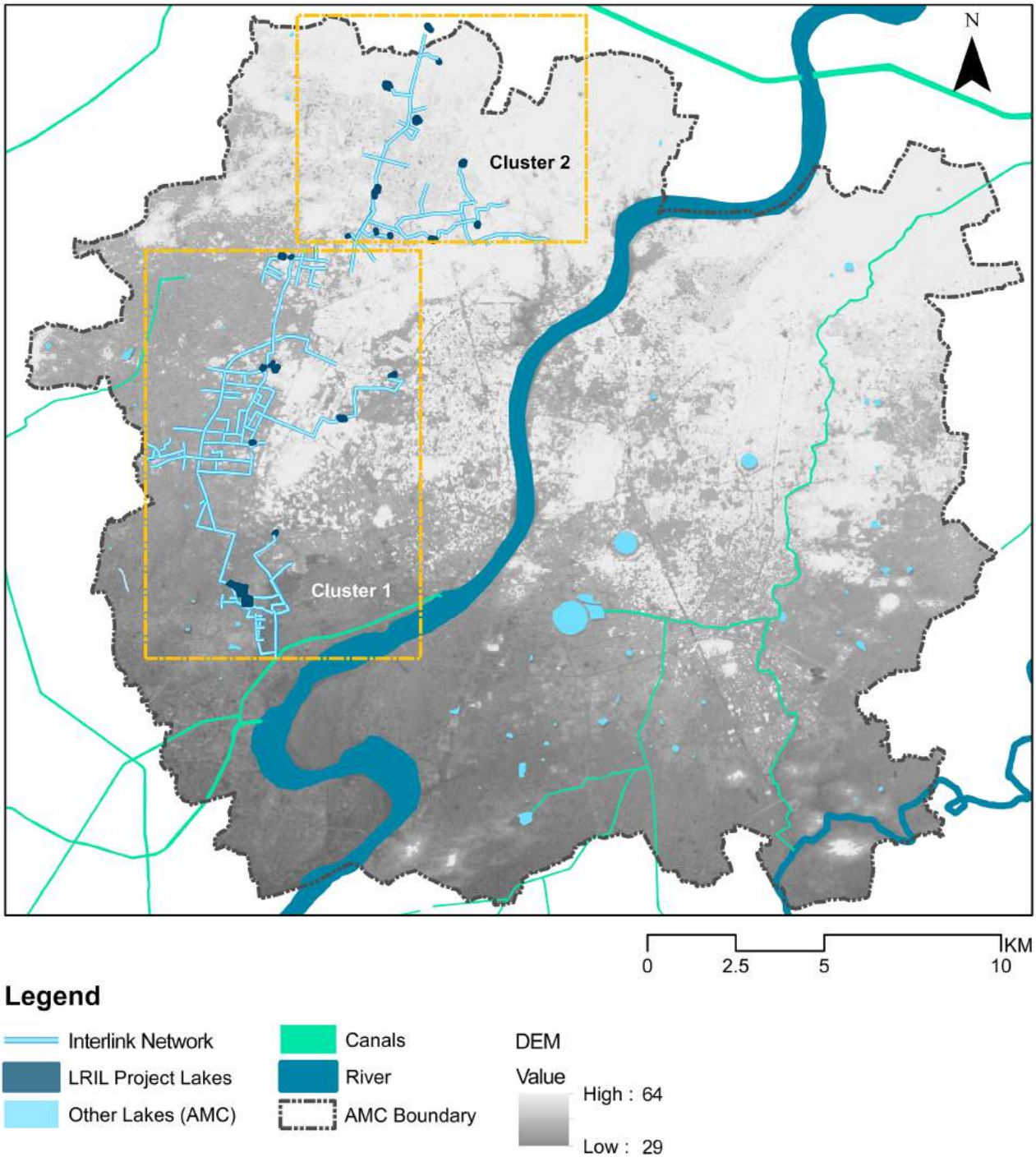

Figure 2-7: Interlink Network
Source: (AMC, 2020) (AUDA, 2020)

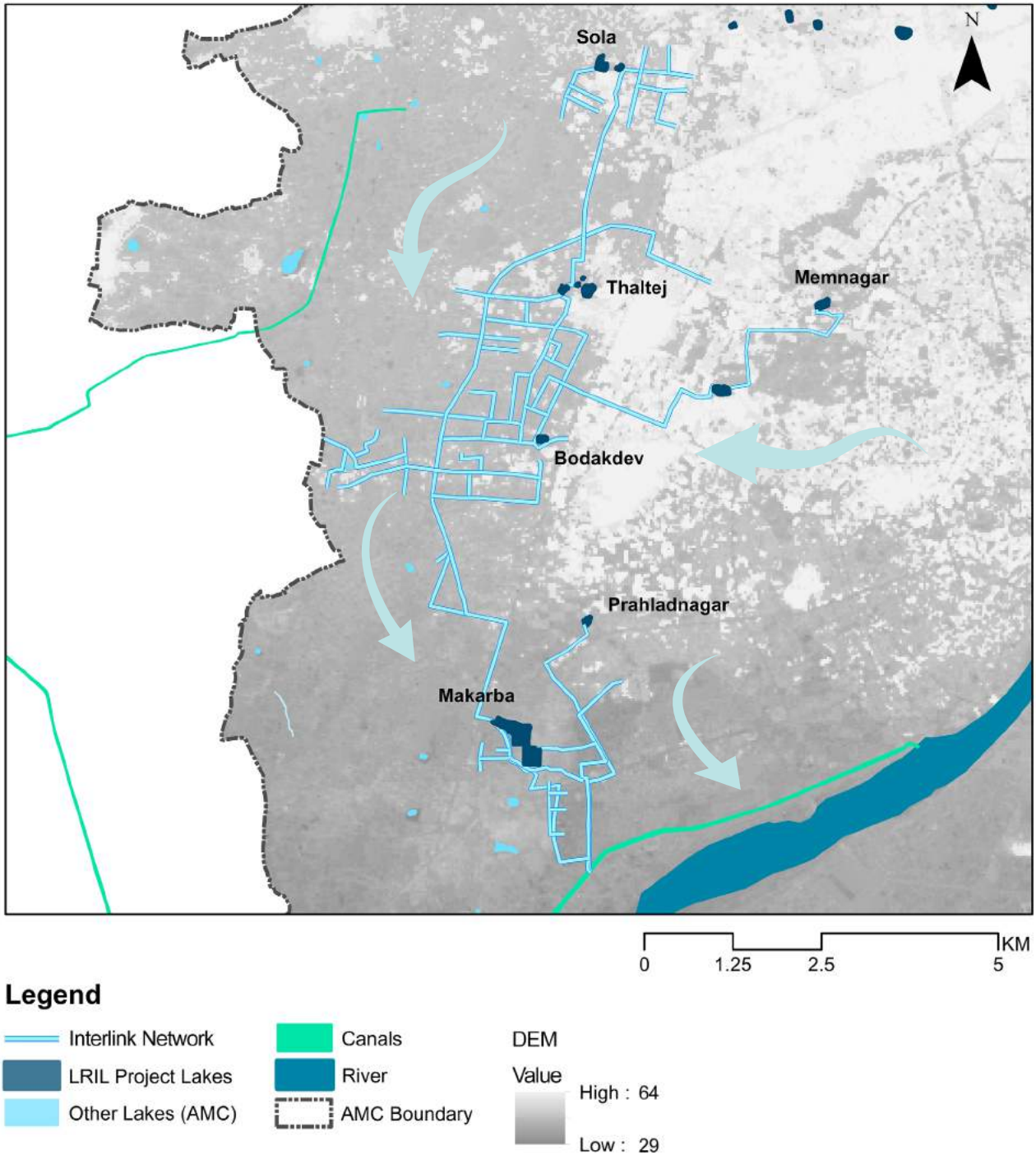

Figure 2-8: Cluster 1 under the Interlink Network of Lakes with outfall in the Sabarmati River

Source: (AMC, 2020) (AUDA, 2020)

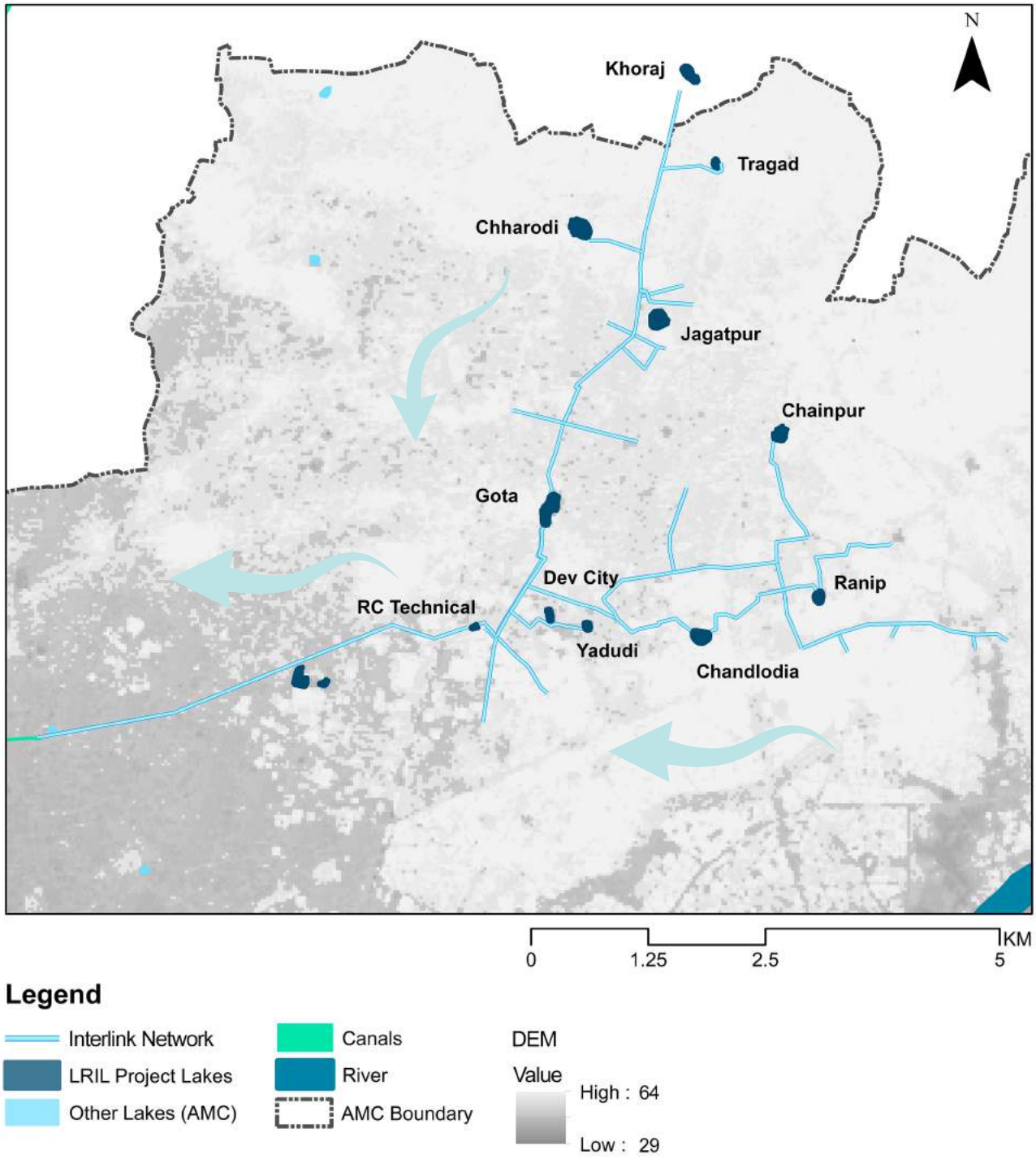

Figure 2-9: Cluster 2 under the Interlink Network of Lakes with outfall in the Gota Godhavi Canal

Source: (AMC, 2020) (AUDA, 2020)

2.1.6 Funding

The first phase of the LRIL cost INR 440 million[8]. AUDA utilized its internal resources for this phase of the project (AUDA, 2020). Table 2-1 exhibits the breakup of expenditure for the period 2002-2003 on the project. The Vastrapur Lake was being redeveloped as a pilot during this period. A major part of project expenditure (~45%) was spent on implementing the rehabilitation component of the project (Thakker, 2020). AUDA constructed dwelling units for 314 households. The cost of these units was to be paid by the beneficiaries while the Authority bore the expense of land and basic services (AUDA, 2020).

Table 2-1: Expenditure on LRIL project (2002-2003)

Sl. No.	Particulars	Cost in INR (million)
1	Excavation of lake	4.5
2	Stormwater drainage Network	5.0
3	Water recharging percolation wells	0.5
4	Stone pitching	5.6
5	Garden development and Landscaping	3.0
6	Amphitheater construction	3.0
7	Removal of Encroachments	0.5
8	Peripheral Road Network	5.0
9	Peripheral compound wall with decorative cast iron grill and paved parking area along with two-level walking track	3.0
10	Rehabilitation of slum dwellers	26.0
11	Design & Supervision	0.57
	Total	**57.57**

Source: (Thakker, 2020)

Further, after boundary expansion, the AMC continued with the task under the project of 'Preservation of Water Bodies' (Thakker, 2020). A fund of INR 1040 million[9] was approved under the JNNURM scheme for the purpose (Gupta, 2009).

[8] ~ USD 5.9 million according to the exchange rate on 16th April 2021 retrieved from https://www.federalreserve.gov/releases/h10/current/

[9] ~USD 13.96 million according to the exchange rate on 16th April 2021 retrieved from https://www.federalreserve.gov/releases/h10/current/

2.1.7 Timeline

The pilot project for Lake Redevelopment & Interlinking began in 2002 with the redevelopment of Vastrapur Lake. The first phase included the 10 lakes at Vastrapur, Makarba, Prahladnagar, Bodakdev, Thaltej, Memnagar, Sola, Chandlodia, Ambli and Gota.

The pilot and the initial phase for lakes except for Ambli were completed by 2006 (AUDA, 2020) (Pandya, 2020). The AMC had revised its boundary and added the western peripheral area as the New West Zone in 2006. It carried forward the implementation of the project on nine lakes under its jurisdiction. The AMC planned to expand the network of interlink with more than 40 lakes as part of the system. However, precise data on lakes interlinked to the network by AMC remains ambiguous due to limited data sources. In 2018, AMC began the revival of the lakes and interlinkages (Pandya, 2020).

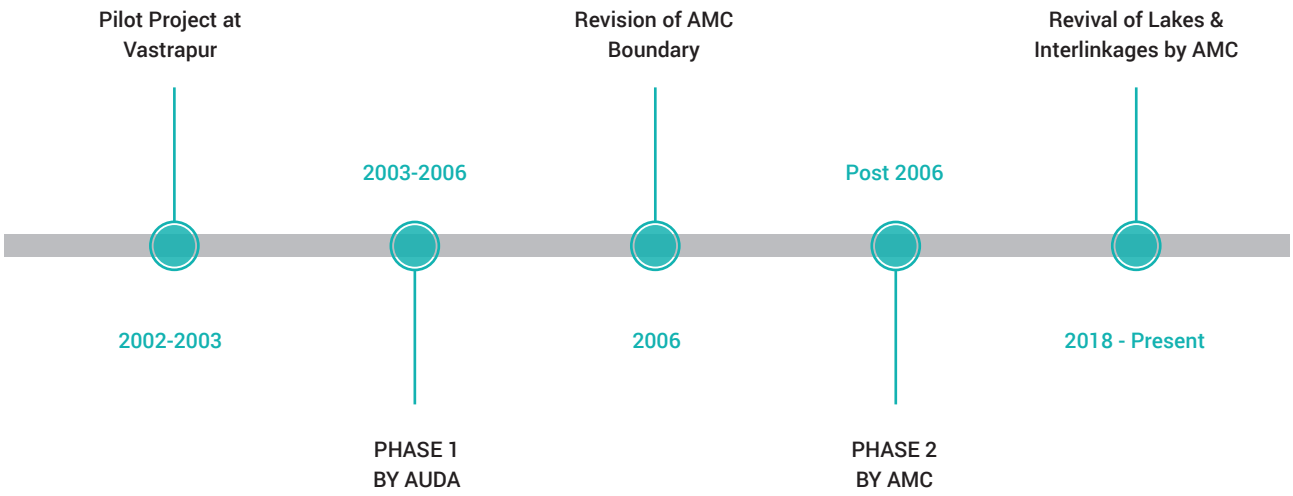

Figure 2-10: Project Timeline with reference to change in jurisdiction of the lakes

2.1.8 Institutional Structure

The LRIL involved multiple departments and agencies at various levels. The roles and responsibilities of these institutions in the implementation and operation of LRIL have been detailed in the following institutional matrix (refer to table 2-2) Most of the responsibilities lie with the Urban local bodies (ULB) and the Urban Development Authority (ADA). They are involved at every step from design to implementation partially or completely. The state-level agencies monitor the work of these ULBs or ADAs and ensure their compliance with the set standards.

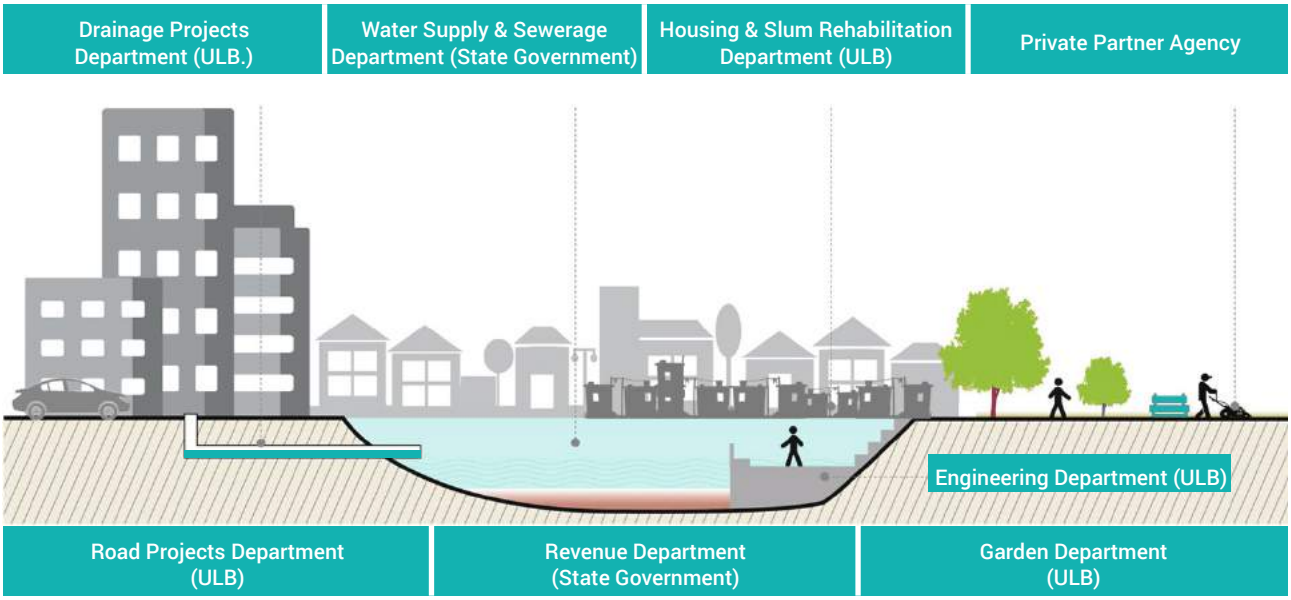

Figure 2-11: Representation of all the agencies involved with lake development

Table 2-2: Institutional Framework for implementation of LRIL

LEVEL	LOCAL BODIES										AREA DEVELOPMENT AUTHORITY			STATE								GOVERNMENT OF INDIA					
INSTITUTIONS			Ahmedabad Municipal Corporation								Ahmedabad Urban Development Authority			Government of Gujarat								Mo EF & CC	Mo JS		MoHUA		
	Gram Panchayat	Nagarpalika	Estate Department	Town Development Department	Engineering Department			Garden Department	Housing & Slum Networking	Fire Department	Planning Department	Engineering Department	Estate Department	Revenu Department	Forest & Environment Department	Department of Narmada, Water Supply, & Water		Climate Change Department	Gujarat Pollution Control Board	Gujarat Housing Board	Gujarat State Disaster Management Authority	Central Pollution Control Board	Central Water Comission	Gujarat Housing Board	Central Public Health & Environmental Engineering Organization	National Disaster Management Authority	Public-Private Partnership
					Drainage Project	Water Project	Road Project									Sardar Sarovar Nigam Limited	Gujarat Water Supply & Sewerage Board										
Regulations & Guidelines on waterbodies	■	■	■											●	■							■					
Lake Land Ownership				■									■	●													
Conservation of Waterbodies											●				■							■	■				
Transfer of the Lake Land				■										●													
Planning of Development around the lakes											●																
Storm water Management	The Local Bodies carry out the service provision within their jurisdiction. The Area Development Authority plans the network, which is then implemented by the engineering departments.																										
Guidelines																	■		■			■			■		
Planning of the network	■	■			■						●	■															
Designing of the network	■	■																									
Construction	■	■																									
Maintenance	■	■																									
Monitoring & Compliance					●							■							■			■					
																						In Case of Centrally Sponsored Schemes or eco-sensitive areas of national importance the compliance is met through central agencies						
Lake Gardens																											
Planning of Lake Gardens	■	■						■			●				■												
Designing of Lake Gardens	■	■						●				■															
Construction & Redevelopment	■	■			■			●				●															
Operation & Maintenance	■	■						●				●														●	
	The responsibility of developing and gardens is primarily done within Garden departments of the Local Bodies. Public Private Partnership are established to handover maintenance of gardens to the private sector entities																										
Sewerage Management																											
Guidelines																	■		■			■	■		■		
Planning of the network	■	■		■	■						■	■										■	■				
Designing of the network	■	■			●							●															
Construction of Sewerage Lines	■	■			●							●															
Construction & installation of STPs	■	■			●							●															
Maintenance of Sewerage Network	■	■			●							●															
Maintenance of STPs	■	■			●							●														●	

Legends: ■ Partial Responsibility ● Complete Responsibility

LEVEL	LOCAL BODIES										AREA DEVELOPMENT AUTHORITY			STATE								GOVERNMENT OF INDIA					
INSTITUTIONS			Ahmedabad Municipal Corporation								Ahmedabad Urban Development Authority			Government of Gujarat								Mo EF & CC	Mo JS		MoHUA		
	Gram Panchayat	Nagarpalika	Estate Department	Town Development Department	Engineering Department			Garden Department	Housing & Slum Networking	Fire Department	Planning Department	Engineering Department	Estate Department	Revenu Department	Forest & Environment Department	Department of Narmada, Water Supply, & Water		Climate Change Department	Gujarat Pollution Control Board	Gujarat Housing Board	Gujarat State Disaster Management Authority	Climate Change Department	Gujarat Pollution Control Board	Gujarat Housing Board	Gujarat State Disaster Management Authority	National Disaster Management Authority	Public-Private Partnership
					Drainage Project	Water Project	Road Project									Sardar Sarovar Nigam Limited	Gujarat Water Supply & Sewerage Board										
Monitoring & Compliance					■							■					■		■			■	■				
	The Local bodies undertake the construction and maintenance of the Sewerage network by involving private sector for STPs through public private partnership at places.															Compliance is primarily the responsibility within the Local bodies with GWSSB & GPCB as the enforcers											
Road Development																										
Planning of the network	■	■					■				■	■														
Designing	■	■					■					■														
Construction of new roads & Widening of existing roads	■	■					■					■														
Maintenance of Roads	■	■					■					■														
Rehabilitation Housing																										
Planning			■	■																■						
Designing																										
Land Provision			■	■																■						
Clearance of Informal Settlements				■																						
Construction of Dwelling Units																										
Provision of Basic Services																										
Transfer of ownership			■																	■						
	The local bodies undertake the rehabilitation within their jurisdiction. The intervention causing rehabilitation plays a decisive role in the onus of rehabilitation. GHB also develops Housing stock throughout the state irrespective of MC & ADA jurisdictions. Estate Departments play a major role in the transfer of the Housing of the beneficiaries.																									
Water Recharge to Lakes in Dry Season						■		■				■				■	■									
Flood Management																										
Planning Resilient Development				■							■	■				■	■	■								
Disaster Response Regulations & Guidelines																					■				■	
Preparation of Response Plans & Provision of equipment										■											■					
Emergency Operations										■																

Legends: ■ Partial Responsibility ■ Complete Responsibility

2.1.8.1 Leadership and Institutional Coordination

Projects like LRIL involving the coordination of multiple agencies with varied interests can be a challenge to implement. Leadership and political will are critical to ensure cooperation. The leadership and political will of Mr. Surendra Patel, ex-Chairman of AUDA, played a key role in the timely and successful implementation of the first phase of the LRIL project. He ensured cooperation across all departments within and outside AUDA (Modi, 2020) (Bal, 2020) (Pandya, 2020). He also engaged with local leaders such as Mr. Dharamsinh Desai, the ex-Sarpanch of Vastrapur village. Such involvement of local leaders and their engagement with the community helped in building acceptance for the project.

However, expansion of AMC boundary led to a transfer of the phase-2 of the project from AUDA to AMC. This process led to a series of issues with coordination of the project.

2.1.8.2 Administrative Procedure for Implementation

Figure 2-12 details the administrative procedures involved in the implementation of the project. The process begins with the approval from the state government for a proposal. The next step involves transferring of ownership of lake land to AMC or AUDA from the ownership of the revenue department to that of the state government. The estate department at AMC or AUDA coordinates with the State on this subject. The transfer of ownership enables the local authorities to create plans and implement them on the ground after floating tenders. The planning department and the engineering department plan and execute most of the work. Their subdivisions like water projects, drainage and road projects work in tandem according to their project domains. The lake gardens are handed over to the garden department post redevelopment and it oversees their maintenance (Patel V., 2020).

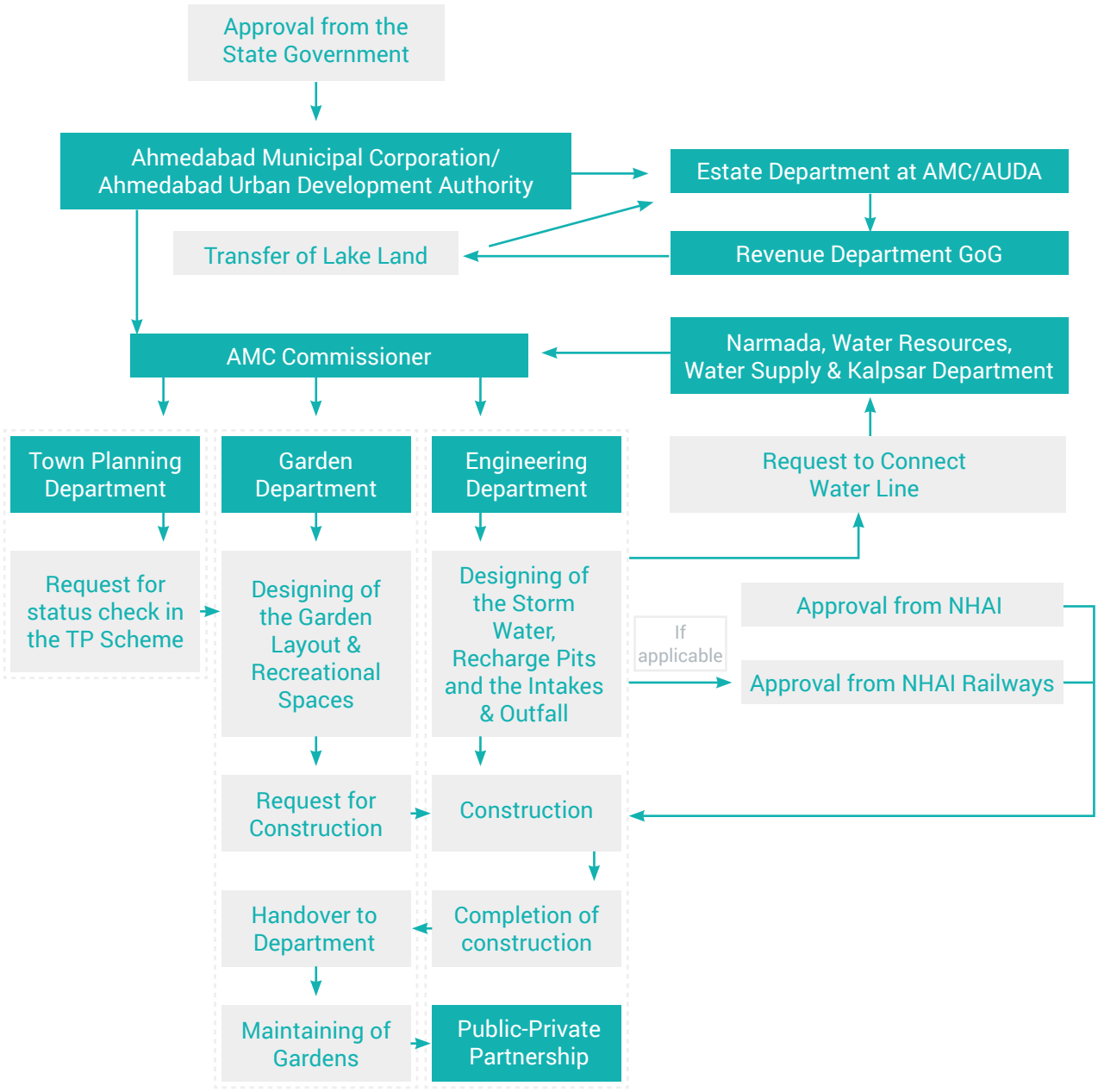

Figure 2-12: Administrative Procedures involved in the Redevelopment & Interlinking of a Lake

2.2 CURRENT STATUS OF LAKES INTERLINKED UNDER LRIL

The next section provides an account of the current status of the interlinked lakes concerning the achievement of the objectives of the project.[10] Eighteen lakes covered were part of the cluster 1 (7 lakes) and cluster 2 (11 lakes). The parameters applied for analyzing these lakes were derived from the objectives and the components of the LRIL project. The analysis is based on the data collected through site observations, satellite image analysis and consultations with the stakeholders. A considerable portion of the analysis has been done through site visits.[11]

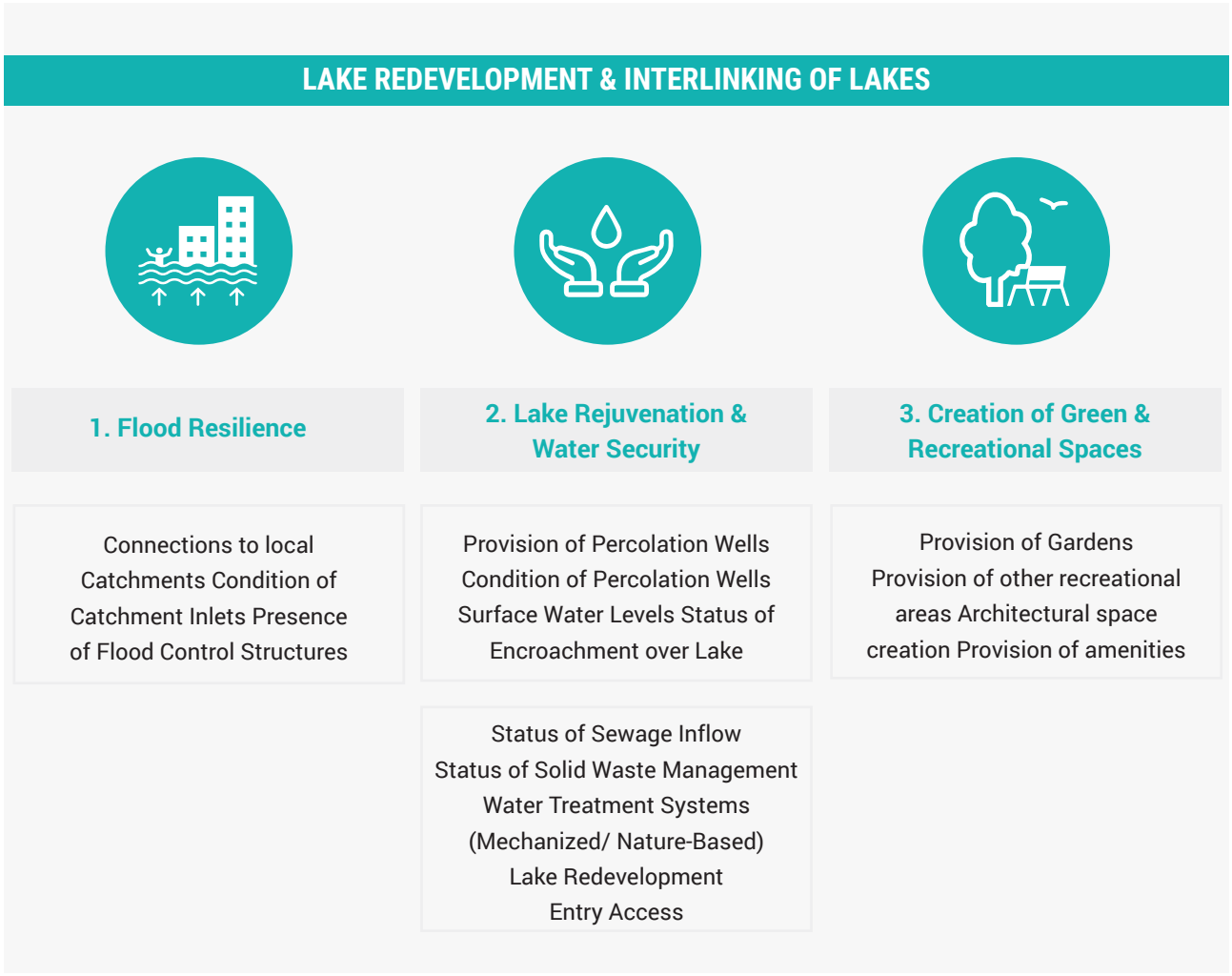

Figure 2-13: Parameters applied for the analysis grouped with their corresponding objectives

[10]The study covers 18 interlinked lakes that were consistent according to multiple and conflicting datasets provided by AUDA and AMC.

[11]The site visits were conducted in two stages - during monsoon (on 7th August 2020) and post-monsoon (on 11th & 12th November 2020)

2.2.1 Current Overview of the Lake Precincts

The existing land use and built fabric around the interlinked lakes was studied to understand the relationship of the lakes with their surroundings. Residential buildings along with support detail along the major roads formed the built fabric adjacent to most of the interlinked lakes. Multistoried apartments formed the residential component along the lakes of Vastrapur and Prahladnagar. Industrial activity was primary near the Sola and Gota Lakes. The residential built fabric was in the form of Gamtals adjacent to the lakes in the peripheral areas like Chainpur, Jagatpur, Chharodi and Tragad. The Dev City, Yadudi and Ranip lakes have row houses or bungalow schemes near them. Informal settlements were present along the edges of the Thaltej and Memnagar Lakes. A market operates along the edge of Thaltej Lake (opp. Govardhan Party Plot). Large organized commercial real estate was majorly present in the immediate catchment of Vastrapur and Bodakdev Lakes. The Lakes of Sola, Gota, and Thaltej are centers of religious activities in their respective areas. The Makarba Lake has heritage structures and upcoming apartment schemes in the vicinity apart from the Gamtal.

2.2.2 Local Catchment Connection and Interlinkage

The connections to local catchment and flood control structures were studied to understand the functioning of interlink network for flood resilience. The linkage of the lakes with local catchment was assessed through the provision and condition of inlet openings in the lake through site visit and data from AMC. The provision of an RCC stormwater duct and water control gates were used to assess the status of connection to the network. All the lakes were found to be linked with local catchment areas except for Tragad and Chharodi. The inlet openings were sealed off or reduced in diameter at Bodakdev, Yadudi and Vastrapur. The choked openings at Thaltej were being revived during the visits. The water-control gates for interlink to the network were visible at all the lakes of Cluster 1 while absent in Tragad, Jagatpur, Chharodi, and Chainpur lakes of Cluster 2.

Figure 2-14: Interlink Control Structures at RC Technical Lake

Figure 2-15: Prahladnagar Lake post Redevelopment

Figure 2-16: Damaged Percolation well at Ranip

Figure 2-17: Tube pulled out of percolation well at Bodakdev

2.2.3 Lake Development

The redevelopment status, condition of percolation wells, water level in lakes, solid waste and sewage dumping were studied to analyze the status of rejuvenation of lakes. Only nine lakes were redeveloped with hard lining on their embankments and had an architectural design of spaces around them. The Dev City Lake was partially redeveloped. The lakes that belonged to the village panchayats like Thaltej, Sola and Gota were not redeveloped.

Percolation wells were found at Bodakdev, Vastrapur, Khoraj, Ranip and Chandlodia lakes. The wells were in damaged condition except at Vastrapur and Khoraj. The tubes had been pulled out and well lining had been broken at places blocking them.

Visual site surveys contributed to the assessment of Lake water level. Visibility of lakebed and distance of water from the top of the lake land characterized the water level as low, medium or high. Water was absent in Sola, Bodakdev, Memnagar, Khoraj, Tragad, Jagatpur, Ranip and Chandlodia Lakes. The water level was at a very low and contained sewage in Vastrapur, Prahladnagar, RC Technical, Yadudi and Dev City Lakes. The Lakes of Chharodi, Thaltej, Gota, Makarba and Chainpur exhibited a medium level of water during both visits. Redevelopment had not happened in any of the lakes with medium water levels.

The lakes without boundaries had rampant solid waste dumping prevalent at their edges. Mounds of construction and municipal solid waste were present at the edges of Gota, Sola, Chainpur, and Thaltej Lakes.

Sewage inflow continues inside the lakes through local catchments at various proportions in all the lakes of Cluster 1 and most of the lakes of Cluster 2. Individual raw sewage outlets from informal settlements fall into the lake at the lake edge in Thaltej and Memnagar. Wastewater and sewage from the adjacent fabrication industry are discharged in Sola Lake. Unpleasant odorous environment prevails due to the lack of natural water and the inflow of sewage. Water treatment solutions were absent at every site except for Vastrapur Lake. The growth of water hyacinth had taken over the water body completely at Sola.

2.2.4 Green spaces and Recreational spaces

Gardens were evident adjacent to the redeveloped Lakes of Vastrapur, Prahladnagar, Bodakdev, Chandlodia, RC Technical, Memnagar, Yadudi and Ranip. The typical features at redeveloped lakes included promenades around the lakes, access ramps to the water body, aesthetical elements, and compound walls. The gardens at Yadudi and Ranip appeared neglected with dried vegetation and there was extensive open defecation. Recreational activities like an amusement park and boating facility were present only at Vastrapur Lake.

Figure 2-18: Poor condition of Sola Lake

2.2.5 Change in Land Cover

The land cover at Vastrapur, Memnagar, Thaltej and Sola were studied to understand the intensity of activities on the lake land.[12] The objective was to understand the land distribution in developed and undeveloped lakes. The water body occupies less than half of the area on all lake lands irrespective of their redevelopment status (refer to the table no. 2-3). Encroachments cover almost half of the Thaltej lake land. Memnagar and Sola also have a high level of encroachment on lake land.

Figure 2-19: Lake Garden besides Bodakdev Lake

Table 2-3: Existing Land cover on Lake Land exhibiting availability of green and recreational spaces only in redeveloped lakesv

Area Statement (in percentage of total plot area)								
Lake	Predominant Land Use in Lake Vicinity	Typology of Built Fabric around Lake	Redevelopment Status	Waterbody	Green Space	Other Recreational Areas	Encroachment	Other
Vastrapur	Commercial	Organized Retail	Yes	38.6%	29.5%	19.1%	-	12.7%
Memnagar	Residential	Informal Settlements & Gamtal	Yes	42%	9.1%	1.1%	17%	30.9%
Thaltej	Mixed	Informal Settlements & Gamtal	No	38.5%	-	-	48.6%	12.9%
Sola	Industrial	Small Industrial Workshops & Gamtal	No	46.1%	-	-	14.2%	39.7%

Source: (Google Earth, 2020), (TPVD, 2020)

[12]The four lakes were selected to bring a variety of context to the analysis. The predominant land use in lake vicinity varied from Commercial, Residential to Industrial. The built typology ranged from compact traditional village type G+1 structures (Gamtal typology) to large Organized Retail. The status of redevelopment interventions were varied as well.

2.2.6 Summary of the Current Status

The section below gives an overview of the status of all the interlinked lakes. The schematic representation of the status of all the interlinked lakes has been provided in the fig. 2-20 & 2-21. Data on the lakes interlinked in the first phase has been provided in the Snapshot section of the Annexure.

In addition, the fig. 2-20 and 2-21bring out these inferences on the status of the lakes:

1. The lakes were lacking in interventions meant for lake rejuvenation and water security. Many lakes were susceptible to sewage disposal and solid waste dumping.
2. The redeveloped lakes were in better condition with green spaces. However, they either were dried up or had sewage discharge in them.
3. Among all the three objectives of interlinking, ground water recharge and recreation of the green spaces neither cluster 1 nor cluster 2 have fully accomplished the objectives as on date.

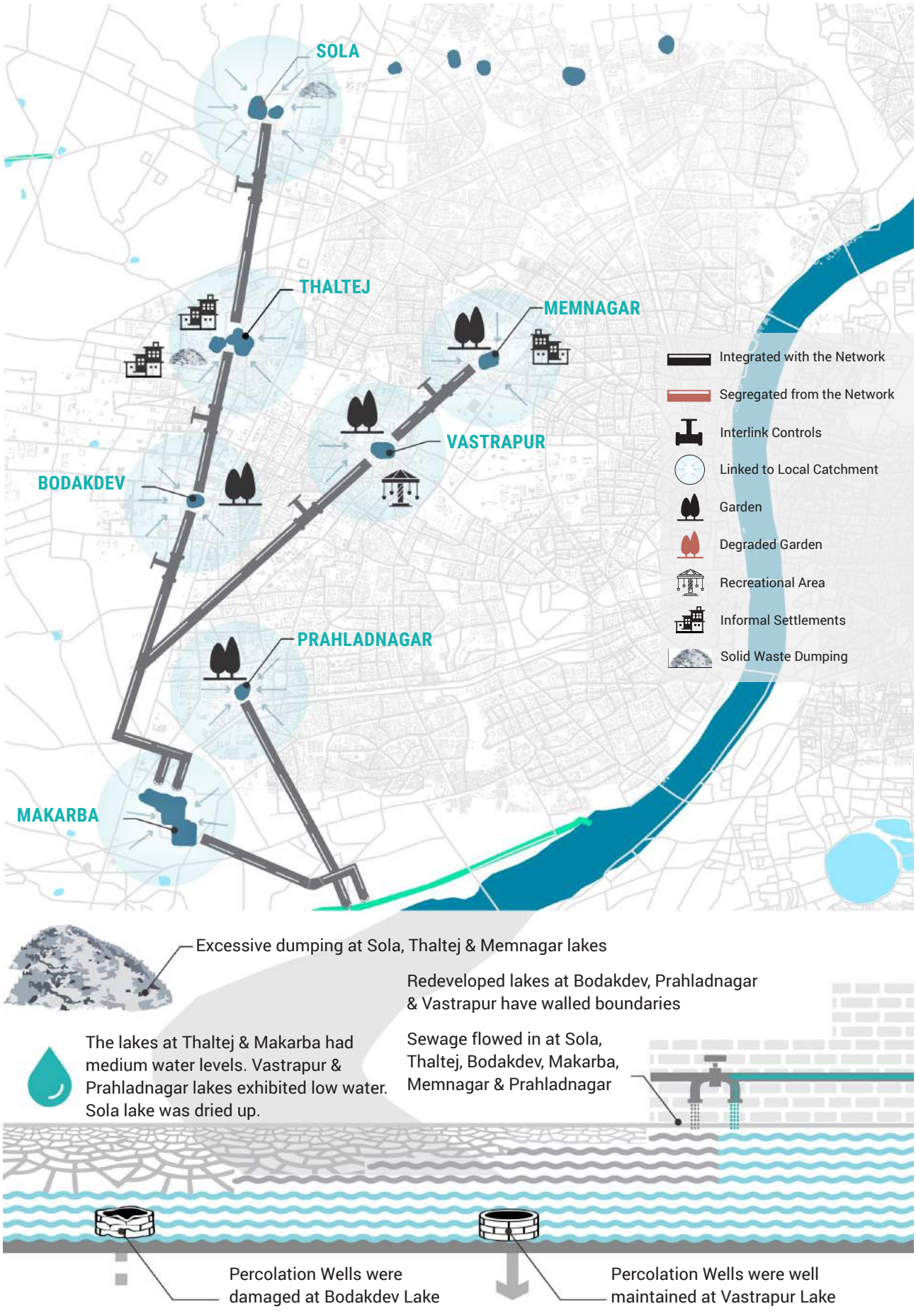

Figure 2-20: Representation of the current status of the lakes under Cluster 1

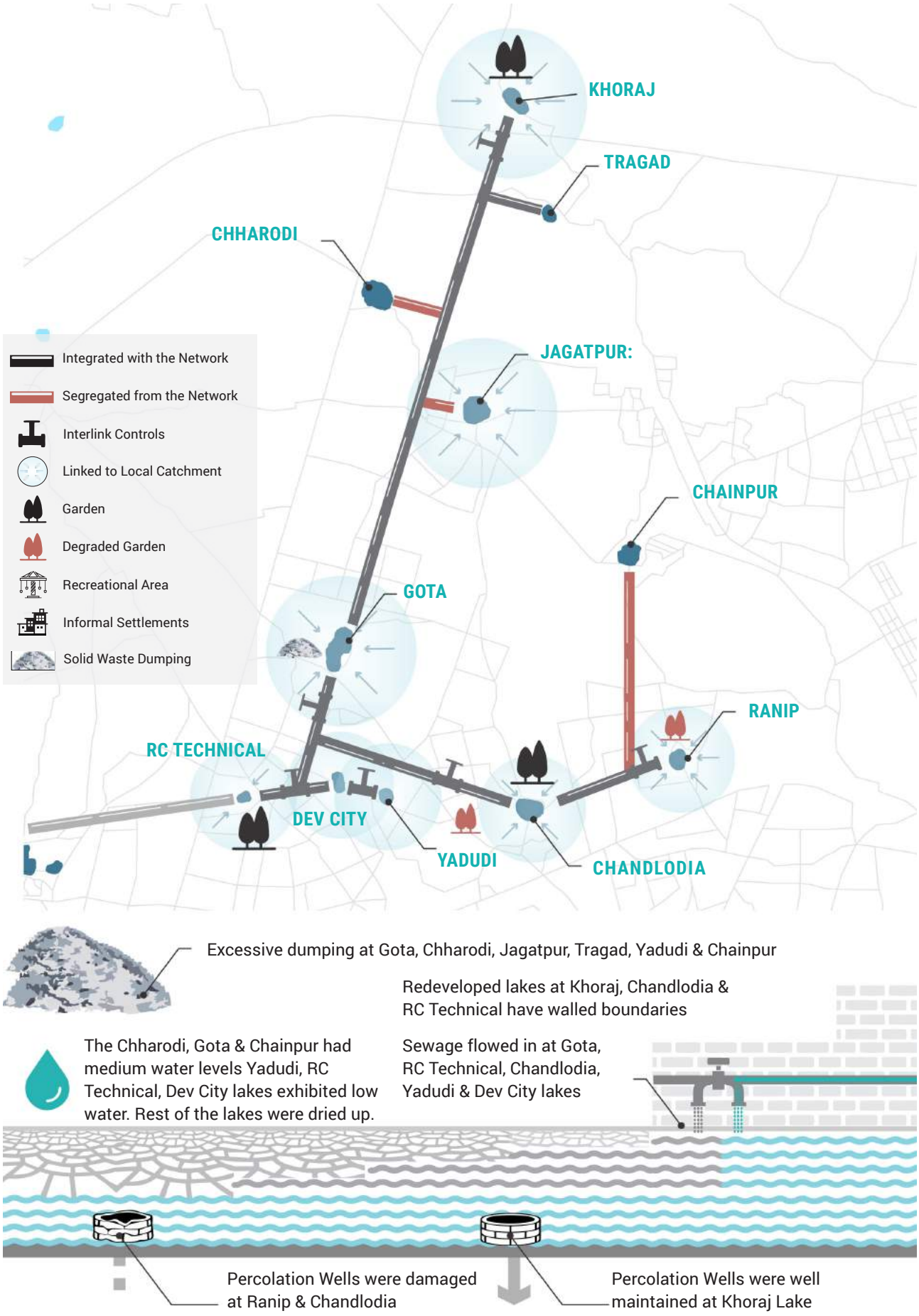

Figure 2-21: Representation of the current status of the lakes under Cluster 2

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3

IMPACT OF LAKE REDEVELOPMENT & INTERLINKING OF LAKES (LRIL) PROJECT

3.1 ENVIRONMENTAL IMPACTS

- Flood Resilience
- Groundwater level
- Changes in Lake land cover
- Lake Water Quality
- Green Cover

3.2 SOCIO - ECONOMIC IMPACTS

- Creation of Green Open Spaces and Recreational Areas
- Rehabilitation and Resettlement
- Real Estate Prices

3.3 SUMMARY OF IMPACTS

The LRIL project was a unique city-level infrastructure intervention for Ahmedabad. The project integrates the blue, green and grey infrastructure around the lakes. The objectives of LRIL were multifaceted with environmental and socio - economic aspects attached to them. The previous chapter analyzed the status of lakes. This chapter covers the impact of the project on Ahmedabad with regard to environmental and socio - economic values. The assessment has been over a pre-project and post - project timeline from 2002 - 2020. The impacts of the project included in the chapter are:

1. Environmental Impacts that include:
    - » Flood Resilience
    - » Groundwater level
    - » Changes in Lake land cover
    - » Lake water quality
    - » Green cover

2. Socio-Economic Impacts that include:
    - » Creation of Open Spaces and Recreational areas
    - » Rehabilitation & Resettlement
    - » Real Estate Market

Each of these parameters is explained and the impact has been assessed in the next section.

3.1 ENVIRONMENTAL IMPACTS

The disruption in ecosystem services delivered by the urban lakes in Ahmedabad triggered the LRIL project (refer to section 1.3). All the objectives of the project have direct implications for the environment. The coming sections assess the impact of the project on the environment through the lens of flood resilience, water security and green cover.

3.1.1 Flood Resilience

The project aimed at achieving flood resilience through enhancement of storage capacity of the lakes and augmentation of flood capacity through interlinks. Enhancement of flood storage capacity is an established adaptation strategy in the cities. It facilitates a reduction in the volume of water to be disposed of, and reduction of the volume of peak discharge, thus reducing the requirement for a high capacity network. Further, the interconnection of the lakes augments the capacity through the linking of dried lakes. The next sections assess the impact of LRIL on flood resilience based on:

1. Urban Flooding
2. Extreme Events
3. System Redundancy

3.1.1.1 Urban Flooding

Urban Flooding incidents provide an insight into the functioning of the stormwater system in a conventional scenario through the water stagnation points in the city. It aids effective service delivery and reduces the disruptions in livelihood. The data sourced from AMC on the water stagnation points have been analyzed to understand the project impact on urban flooding. Fig. 3-1 demonstrates recurrent water stagnation points across the AMC region. These stagnation points are evident across the entire spread of Ahmedabad. There are no major stagnation points on the west of Sarkhej-Gandhinagar Highway where the interlinked network of lakes and stormwater has an elaborate coverage. This area had been severely affected in the past due to water stagnation. During an event of heavy rainfall, the S.G. Highway had to be dug to allow the stormwater to flow across it (Gujarat Samachar, 2000) (Sharma, 2020).

The locations of Shreenand Nagar and Sonali Cinema Road are yet to be connected with the local catchment of the nearby lakes. Helmet Crossroad, Manav Mandir, Valinath Chowk and AEC Crossroad are frequent stagnation points along the 132' Ring Road and Drive-In Road in the Western region. The locations lie in the close vicinity of Memnagar and Vastrapur Lake (refer to fig. 3-2), where interlinks

seem to be missing. There is also a lack of clarity on the layout of the interlink line in this area. Therefore, the AMC did not maintain the connections in this area. The ambiguity in the layout was an outcome of the improper transition of jurisdiction between AUDA and AMC (Ahmedabad Municipal Corporation, 2020) (Pandya, 2020).

The locations of Vandematram, Vishwas City (New Judges Bungalow Road), Janta Nagar and Chainpur are not linked to Cluster 2. It may be concluded that most of the water-logging points in the western Ahmedabad therefore are associated with the missing interlinks or which have not been maintained.

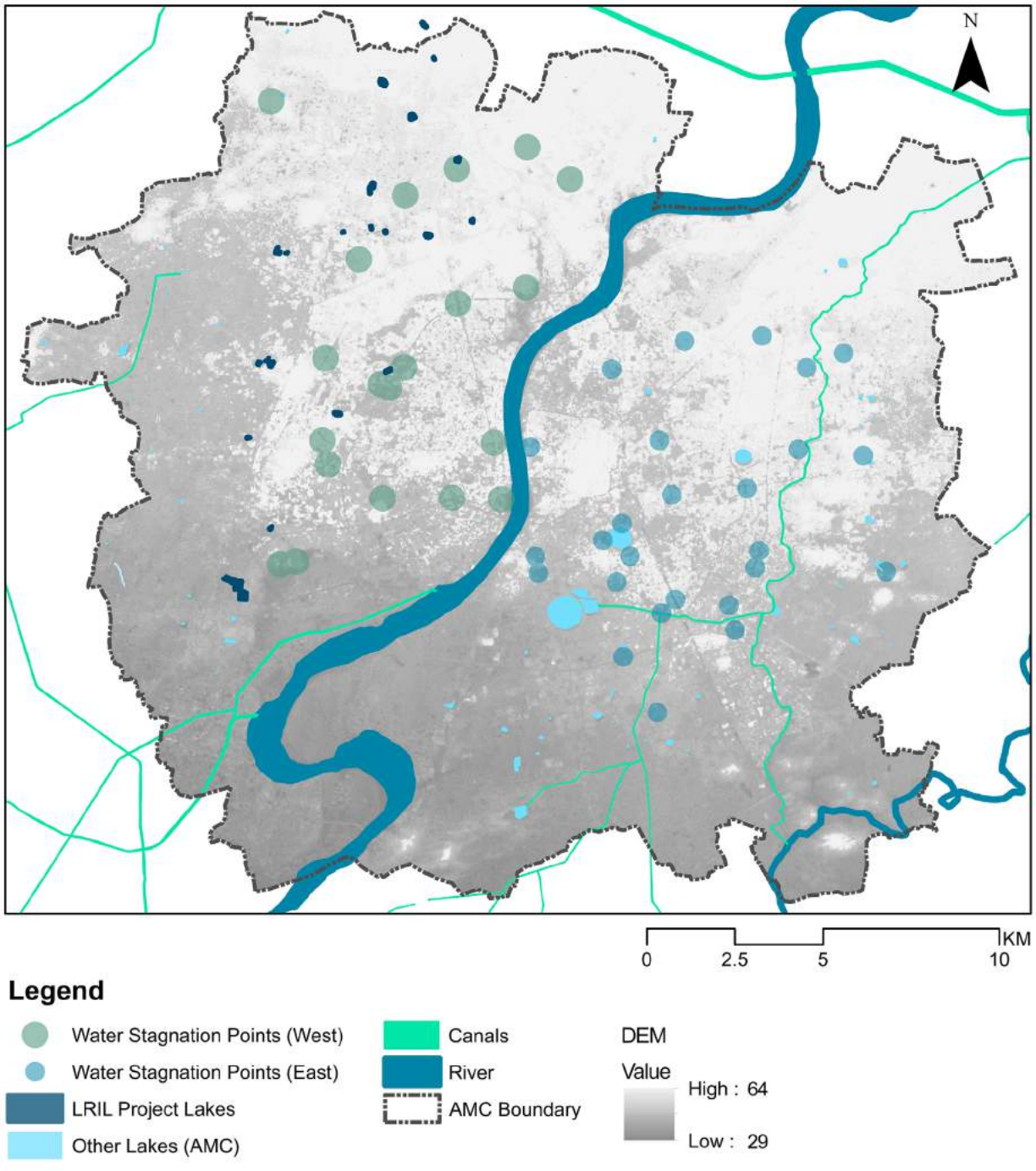

Figure 3-1: Water Stagnation Points in Ahmedabad
Source: (AMC, 2020)

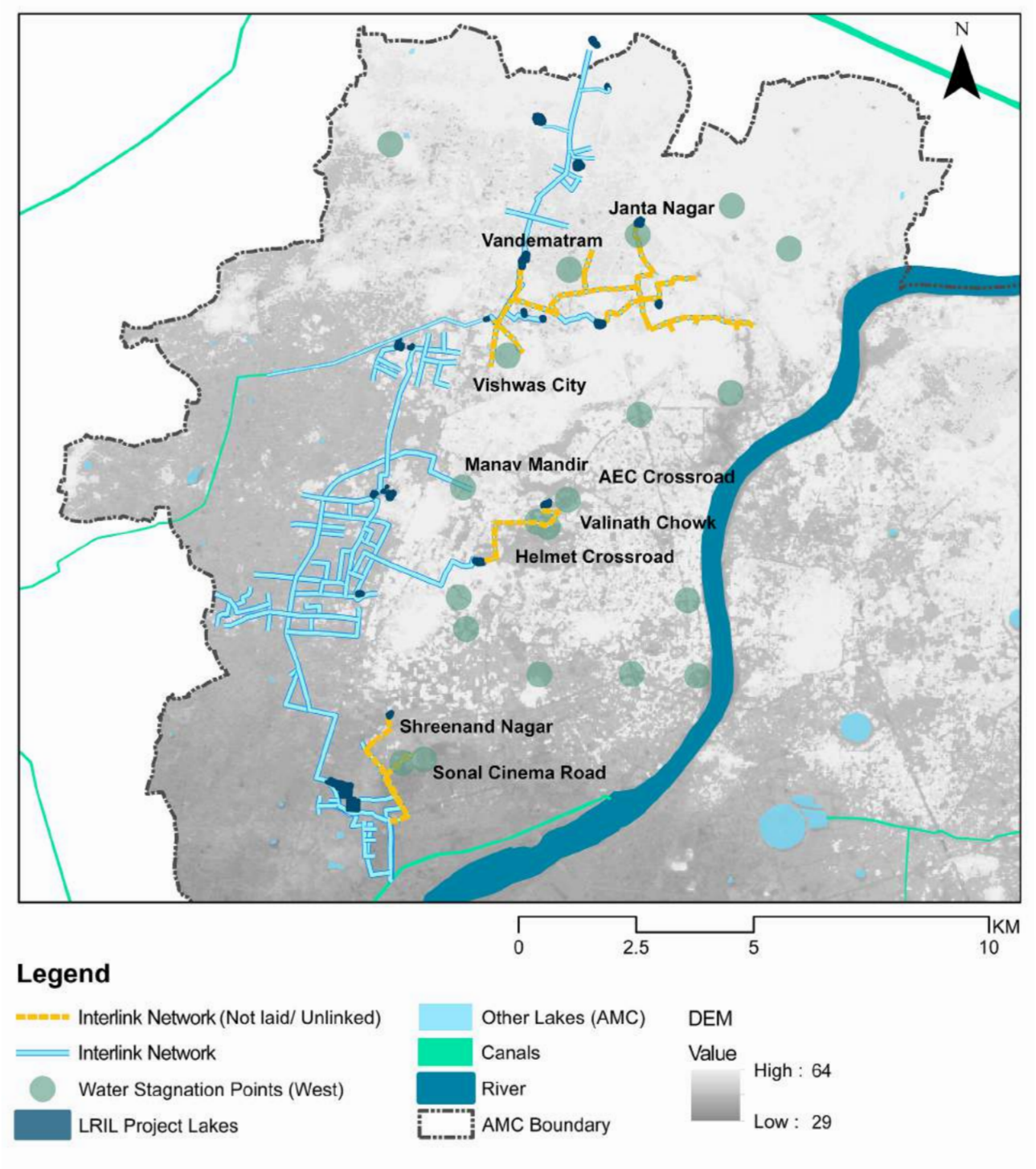

Figure 3-2: Water Stagnation Points and Interlink Network in Western Ahmedabad showcasing effective drainage in areas connected with the network

Source: (AMC, 2020)

3.1.1.2 Extreme Events

Extreme rainfall events need to be incorporated into the planning for stormwater management systems. The possibilities of such events have been on the rise due to the effects of climate change. Ahmedabad has faced three extreme rainfall events in the last decade after the Cluster-1 and Gota arm of Cluster-2 had become functional. The intensity of rainfall within 24 hours was higher than 134 mm.[13] The utility of the interlinked network has been challenged on such events. On 27th July 2017, the city recorded a rainfall of 180 mm within 24 hours (IMD, 2020). An uncontrolled heavy inflow of stormwater had dropped into the Chandlodia Talav, flooding its nearby low-lying settlements due to this event (VTV Gujarati News, 2017). The flood control mechanism had become the very cause of the flooding in the absence of monitoring and upkeep. Similar flooding incidents had occurred in past at the Lakes of Vastrapur, Prahladnagar and Sola in 2010 (DNA, 2010). There is an absence of any mechanism to monitor the water levels or warning system in case of flooding. Thus, while the system as a whole can reduce flooding when fully - operational, there needs to be an emergency plan for the extreme events.

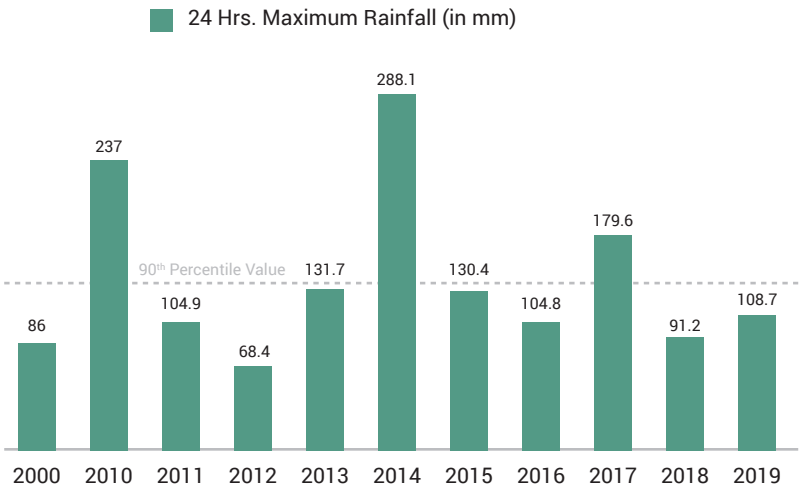

Figure 3-3: Year wise heaviest rainfall within 24 hours in Ahmedabad post LRIL.
Source: (IMD, 2020)

Figure 3-4 : Flooded Valinath Chowk along the 132' Ring Road
Source: (TNN, 2017), (TNN, 2020)

Figure 3-5: Flooded Helmet Crossroad on 26th July 2020
Source: (TNN, 2017), (TNN, 2020)

Figure 3-6: Flooded precincts of Chandlodia Lake
Source: (VTV Gujarati News, 2017)

Figure 3-7:Chandlodia Lake filled up to the adjacent road level on July 27th 2017
Source: (VTV Gujarati News, 2017)

[13]The analysis of daily maximum rainfall data from IMD suggested at a 90th percentile value of 134 mm that has been used as a benchmark to categorize the extreme events of rainfall.

3.1.1.3 System Redundancy

System redundancy is an important aspect to achieve resilience and adapt to climate change. The current operational capacity of the interlinked lake network is about 3 MCM with 13 connected lakes in the network. The connections between the Memnagar and Vastrapur Lakes have not been maintained and the lakes are not linked (Pandya, 2020). AMC has initiated the tendering procedure for de-siltation of connections among Tragad, Jagatpur and Gota Lakes that have reduced capacities due to siltation. The Lakes of Ranip and Khoraj have been redeveloped with flood control structures but remain unconnected to the lake network (AMC, 2020) (AUDA, 2020). The inclusion of these lakes would increase the capacity of the system by 1.05 MCM. The expansion of the network by AMC in Chandkheda region would further enhance their capacity. Therefore, it could be inferred that the project has increased the system redundancy for stormwater management in the city. However, it is yet to realize its envisaged capacity.

Table 3-1: Overview of storage capacity of lakes and the status of interlinkages

Sl. No.	Lakes Interlinked by AUDA	Capacity in MCM	Lakes Interlinked by AMC	Capacity in MCM
1	Vastrapur	0.15	Yadudi	0.09
2	Memnagar	0.22	Dev City	0.03
3	Gota	0.13	R.C. Technical Lake	0.02
4	Thaltej	0.21	Chharodi	0.11
5	Bodakdev	0.43	Jagatpur	0.28
6	Prahladnagar	0.17	Tragad	0.10
7	Makarba	1.42	Ranip	0.028
8	Sola	0.21	Khoraj (Nr. Vaishnodevi)	NA
9	Chandlodia	0.29	Chenpur	0.052
10	Ambli	0.11		
	Total	**3.34**	**Total**	**0.71**

Source: (AUDA, 2020) (AMC, 2020)

3.1.2 Groundwater level

Ahmedabad was at the crossroads of increased dependency on groundwater and depleting groundwater table (refer to section no. 1.3.2). The project aimed at recharging groundwater to ensure water security for the city. The Central Ground Water Board provided long-term data (2001 - 2020) for three groundwater monitoring stations near the lakes in Ahmedabad.[14] The map shows the location of these stations. Only three locations were selected that were near the lake here because of their long - term data availability from 2003-2020. Other stations from CGWB have limited data for the years 2003 - 2020.

[14]Only three locations were selected that were near the lake here because of their long-term data availability from 2003-2020. Other stations from CGWB have limited data for the years 2003-2020.

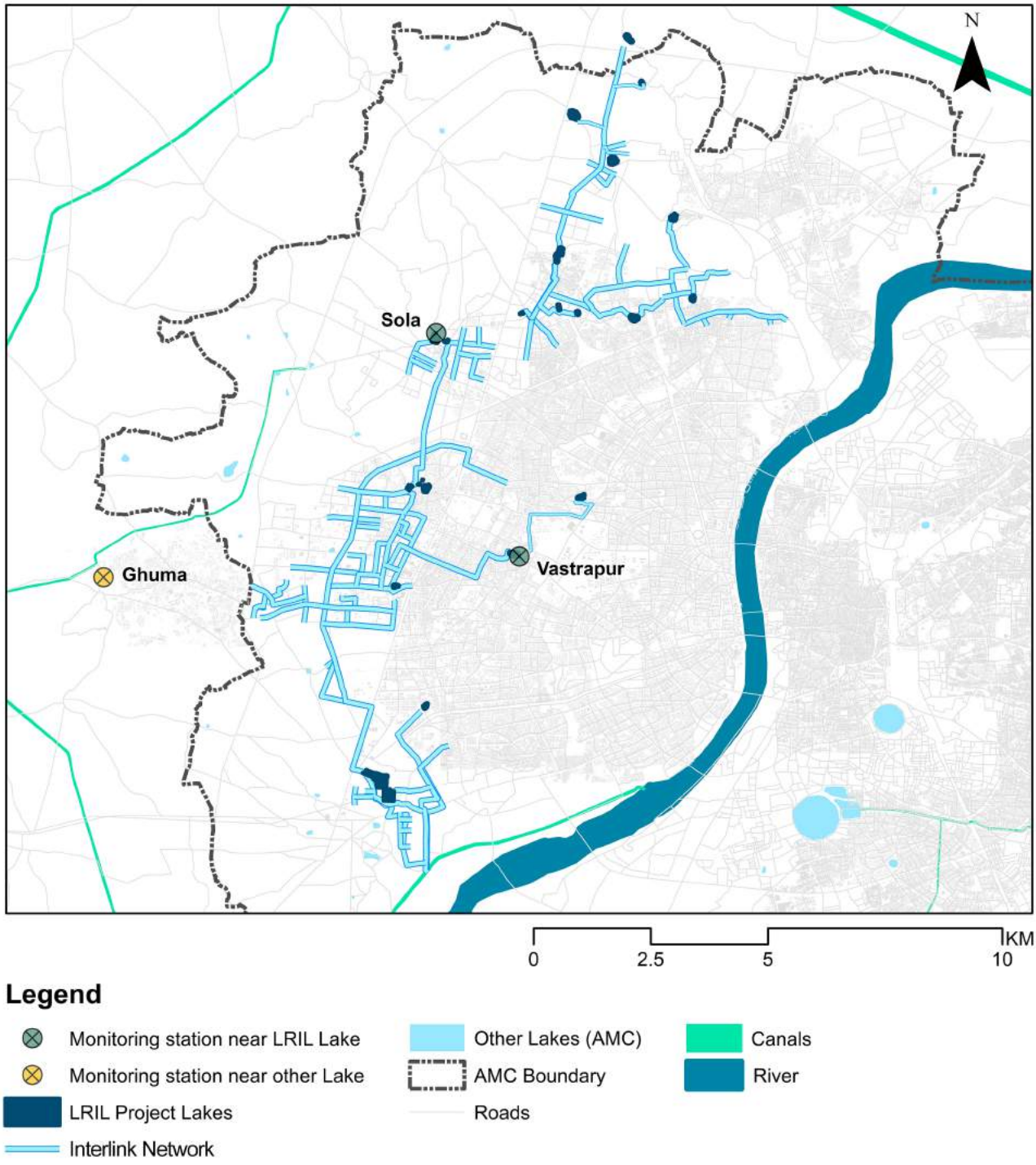

Figure 3-8: Groundwater Monitoring Locations at Ahmedabad near interlinked lakes (Sola & Vastrapur) and other lake (Ghuma)

Source: (CGWB, 2020)

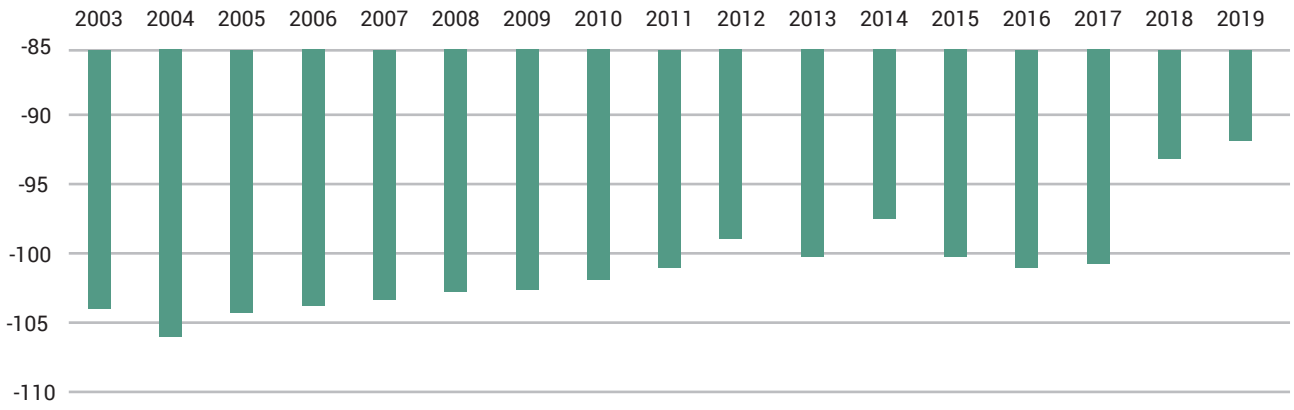

Figure 3-9: Increase in GW level (in mbgl) near interlinked Vastrapur Lake

Source: (CGWB, 2020)

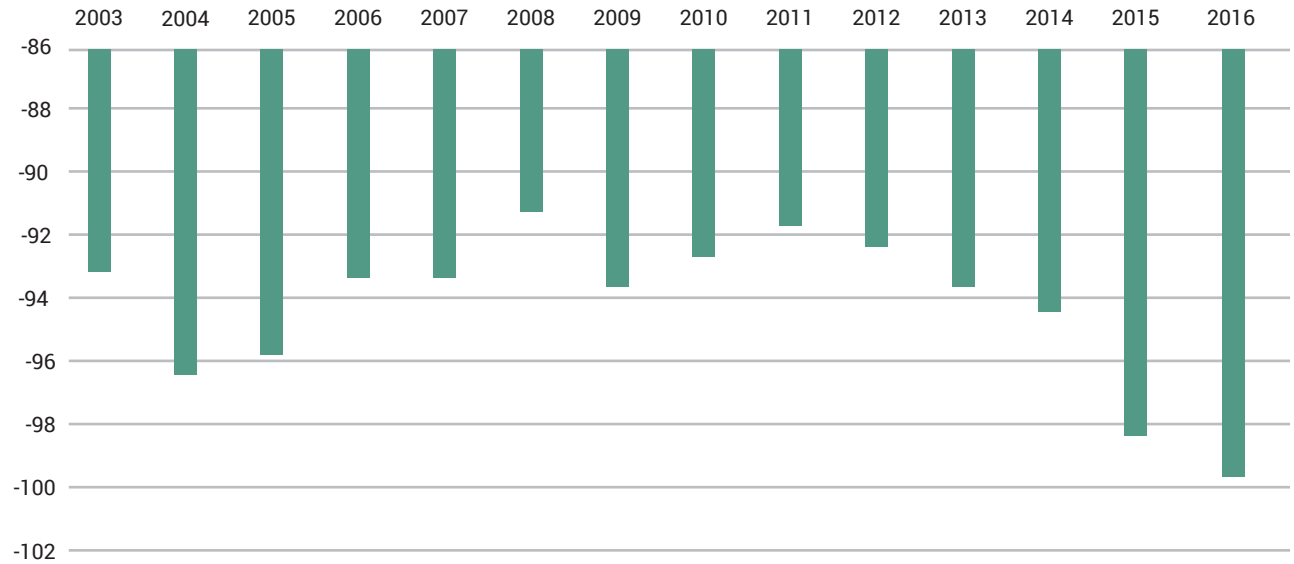

Figure 3-10: Decrease in GW level (in mbgl) near Ghuma Lake

Source: (CGWB, 2020)

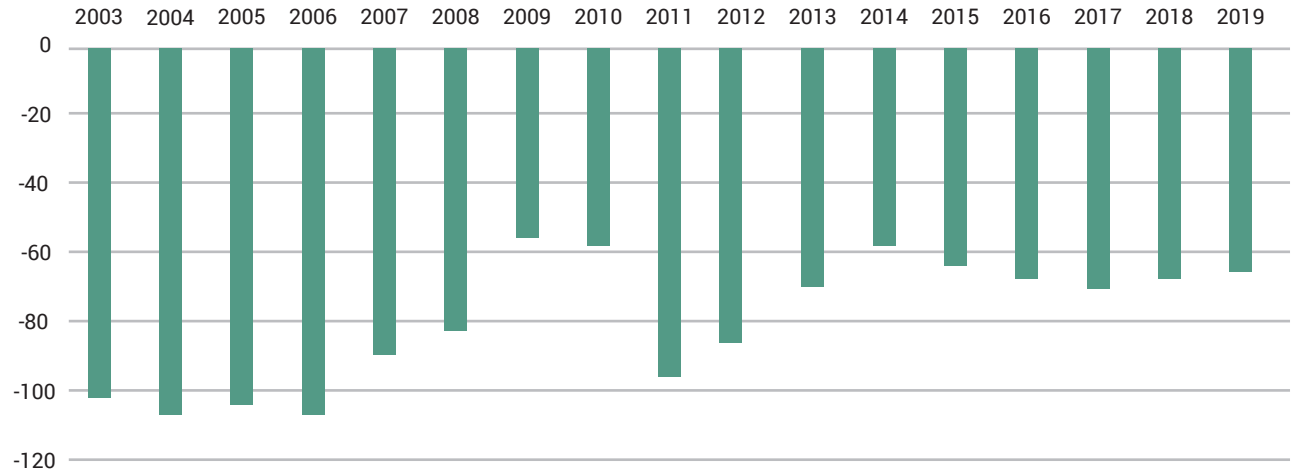

Figure 3-11: Increase in GW level (in mbgl) near interlinked Sola Lake

Source: (CGWB, 2020)

Analysis of the data suggests that there has been a positive impact on the groundwater level near two of the lakes. There was an increase in groundwater level at Vastrapur Lake at the rate of 0.71 per year for the period 2003-2019 (refer to fig. 3-9). This increase occurred despite the developments in its vicinity. Similarly, there has been a level increase at Sola Lake to the extent of 2.2 m per year for the same period (refer to fig. 3-11). There has been a reduction in groundwater level at the Ghuma Lake precincts. The Bopal-Ghuma area has rapidly become one of the most intensely developed residential areas in western Ahmedabad. Moreover, this lake has not been linked to the local catchment or the interlinked network. Hence, the reduction in groundwater level may be attributed to the increase in development and the non-implementation of LRIL interventions.

The rainfall data for Ahmedabad was collected from India Meteorological Department for the period 2001-2020. The intent was to analyze any links between the change in rainfall and the change in groundwater level. The presence of any links between the rainfall and the groundwater level would indicate that the increase in ground water level may be due to increase in rainfall and not the LRIL project. The graph (fig. 3 - 13) below presents the annual rainfall in Ahmedabad from the period of 2000-2020. [15]

There seems to be no significant change in annual rainfall during the project year. Therefore, it can be concluded that change in groundwater level may not be attributed to rainfall but the LRIL project.

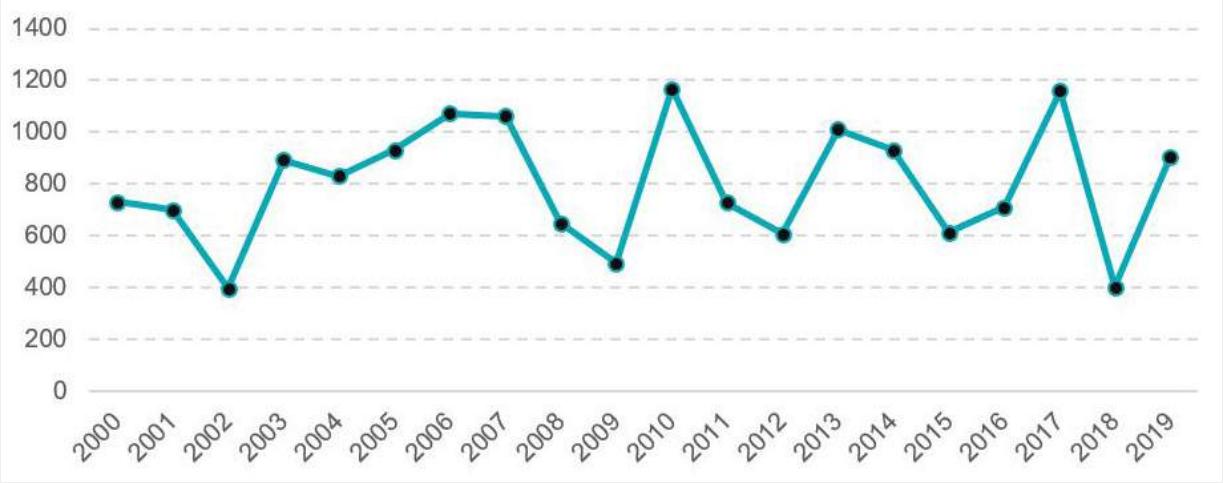

Figure 3-12: Annual Rainfall in mm recorded at Ahmedabad

Source: (IMD, 2020)

[15] The average annual rainfall during 2001-2020 was recorded as 800 mm with a standard deviation of 228.75.

3.1.3 Changes in Lake land cover

Rampant encroachments and solid waste dumping on the lake land were a major threat to the lakes (refer to section 1.3.3). This section analyzes the changes on the lake land cover due to LRIL. It is a continuation of section 2.2.4 in this document. The same four lakes have been studied on a temporal and spatial scale to analyze the impact through historical imagery and the data from the Gujarat TPVD. Table no. 3-2 shows the changes in lake land regarding the water body, encroachments and green spaces. The data suggests that the overall area of water bodies have decreased in the lakes under study, irrespective of the status of redevelopment.

Encroachments had been cleared off in Vastrapur making way for recreational spaces (refer to fig. 3-13 & 3-14). However, a road has been constructed dissecting the lake plot thereby reducing the effective area of the water body. The encroachments have neither been cleared off nor have they increased at Memnagar (refer to fig. 3-15 & 3-16). Thaltej has witnessed a decrease in cover of water bodies due to the intensification of encroachments around the lakes (refer to fig. 3-17, 3-18 & 3-19). The lake in Sola has been fragmented into two parts and a major part of the water body had been filled up (refer to fig. 3-20 & 3-21). Therefore, redevelopment implemented under LRIL has been useful in preventing the growth of encroachments and in de-escalation of solid waste dumping around the lakes. However, the redevelopment in most cases has happened by reclamation of lake land effectively reducing the overall water spread of the lake.

Table 3-2: Change in Land Cover on Lake Plot after the project exhibiting increase in green and recreational spaces in redeveloped lakes

Area Statement (in percentage of total plot area)										
Lake	Waterbody		Green Space		Other Recreational Areas		Encroachment		Other	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Vastrapur	48.6%	38.6% ↓	-	29.5% ↑	-	19.1% ↑	27.6%	-	23.8%	12.7% ↓
Memnagar	83%	42% ↓	-	9.1% ↑	-	1.1% ↑	17%	17%	-	30.9% ↑
Thaltej	60.2%	38.5% ↓	4.4%	-	-	-	14.5%	48.6% ↑	20.9%	12.9% ↓
Sola	100%	46.1% ↓	-	-	-	-	-	14.2% ↑	-	39.7% ↑

Source: (Google Earth, 2020)

Figure 3-13: Vastrapur Lake (pre-LRIL) with encroachments along the edges

Figure 3-14: Vastrapur Lake (post-LRIL) with green and recreational space

Figure 3-15: Memnagar Lake (pre-LRIL) with encroachments along the southern edge

Figure 3-16: Memnagar Lake (post-LRIL) with green space around the decreased water body

Source: (Bresson H., 1966)

Figure 3-17: Informal Settlements and market area at the edge of Thaltej Lake

Figure 3-18: Thaltej Lake (pre-LRIL) with encroachments

Figure 3-19: Thaltej Lake (post-LRIL) with increased encroachments and decreased water body

Figure 3-20: Sola Lake (pre-LRIL)

Figure 3-21: Decreased water body due to encroachment and dumping at Sola Lake (post-LRIL)

Source: (Google Earth, 2020)

3.1.4 Lake Water Quality

Water quality was monitored for all the lakes having water on 30/11/2020 by grab sampling. Water was available in 10 lakes out of the total 18 lakes in this study. For assessment of the water quality, the parameters were compared to IS: 2296 Class C (Drinking water with conventional treatment followed by disinfection).

The analysis of the water quality is presented in the next charts (refer to fig.3-26 to fig.3-29). The values of pH for most of the lakes were higher than 8.5. This pH range is harmful for the propagation of aquatic flora and fauna. The total dissolved solids (TDS) and DO are within acceptable limits (refer to fig. 3-27 & 3-28). The Biochemical Oxygen Demand (BOD) of all the lakes is much higher than the acceptable range (refer to fig. 3-29). The higher pH and BOD may be due to run off characteristics from the surrounding areas and sewage disposal in the lakes. The LRIL project did not consider any strategy for the treatment of the runoff as component of the project.

Figure 3-22: Water Samples collected for the testing

Figure 3-23: Sample testing process

Figure 3-24: RC Technical Lake filled with sewage inflow

Figure 3-25: Sewage inflow from inlet at Memnagar Lake

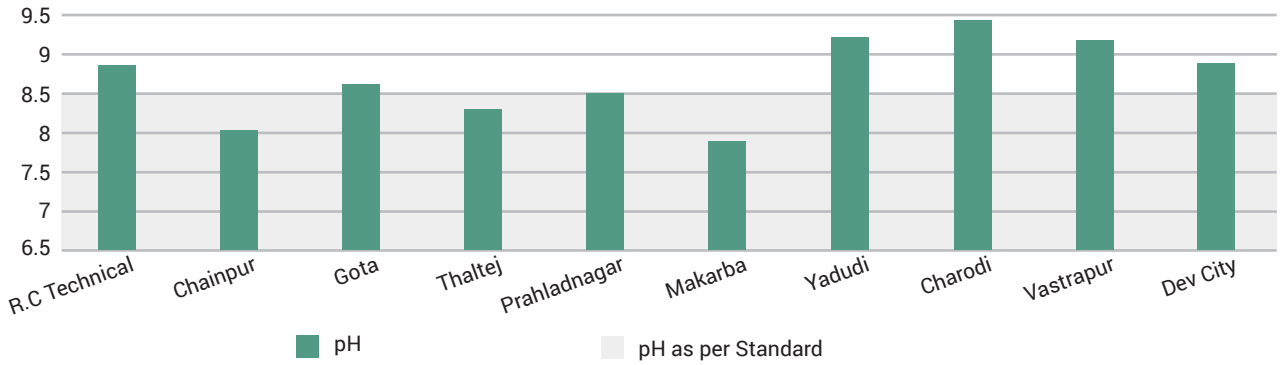

Figure 3-26: pH values for the collected samples exhibit higher values that does not allow the propagation of fauna and fauna

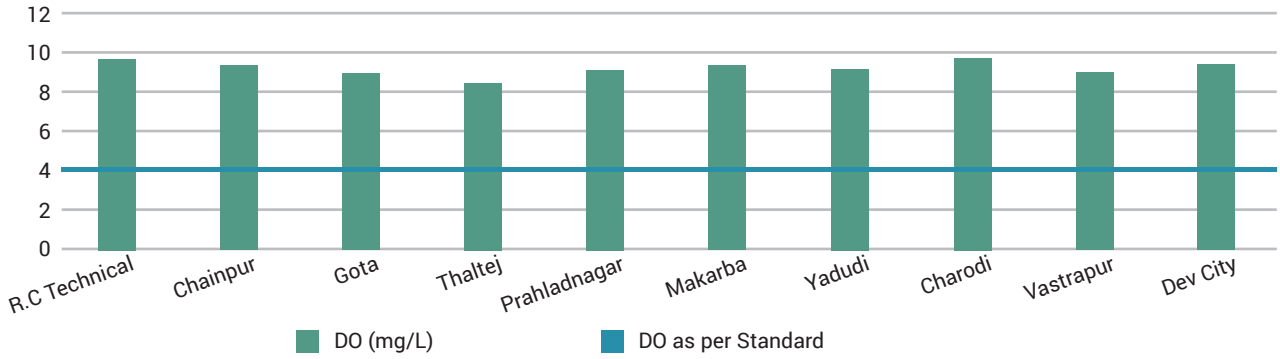

Figure 3-27: DO content of the collected sample exhibits that Dissolved oxygen content is within acceptable limits

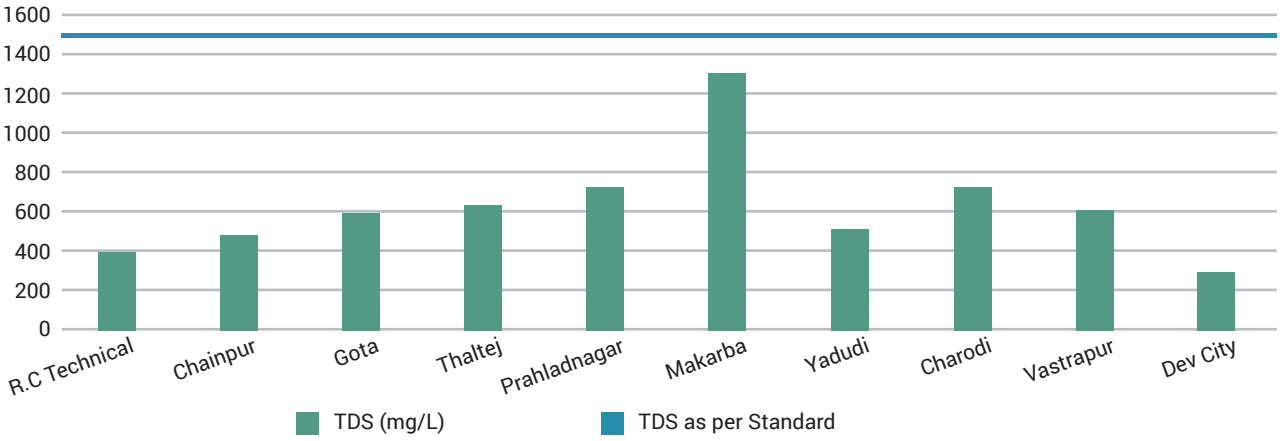

Figure 3-28: The TDS values of the collected samples in within the acceptable limits

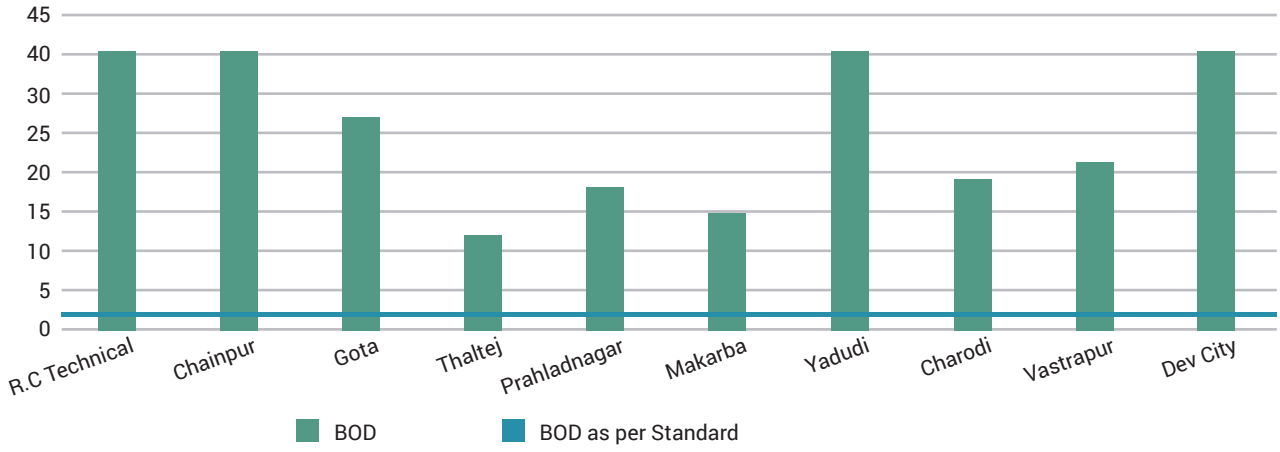

Figure 3-29: The gathered samples demonstrate high Biochemical Oxygen Demand exhibiting high pollution and hindrance to growth of fauna in the lake water

3.1.5 Green Cover

The creation of Lake Gardens had been one of the components under the LRIL affecting the urban vegetation cover. The change in vegetation cover post - implementation has been studied through an NDVI[16] analysis of 300m buffer around the redeveloped lakes or at locations where the activity has changed considerably[17]. The change in vegetation mentioned in this section analyzes the change in sparse vegetation that existed around these lakes.

The redeveloped lakes show a significant increase in surrounding vegetation cover while the lakes without interventions exhibit a decrease in vegetation cover (refer to table 3-3).[18] Vastrapur, Memnagar, Chandlodia, Bodakdev, Dev City and RC Technical Lakes belong to such increased vegetation precincts. The vegetation has almost doubled in most of the redeveloped lake precincts.

The NDVI analysis exhibits an increase in green areas in the periphery of lakes post-project (refer to Annexure B). Thus, the increase could be associated with the lake gardens developed during the LRIL project. The Sola, Chharodi, Makarba and Gota Lakes show decline in vegetation cover as they were not redeveloped (refer to Annexure B). The sharp decline observed near Gota Lake was due to decrease in agricultural activity in the area. The upcoming real estate projects near Khoraj and Makarba Lakes are responsible for the decline in vegetation in their buffer regions. However, the green cover at Khoraj has increased right at the periphery of the lake. The poor condition of lake gardens and lack of growth of natural vegetation was responsible for decrease in vegetation near Yadudi and Ranip Lakes. Therefore, redevelopment along with proper maintenance has a positive impact on the vegetation cover around the lakes.

Table 3-3: Change in Vegetation Cover at 300 m buffer around LRIL Lakes

Lake	Pre Project Cover (m²)	Post Project Cover (m²)	% Change	Lake	Pre Project Cover (m²)	Post Project Cover (m²)	% Change
Vastrapur	-	900	-	Prahladnagar	394,200	395,100	0%
Memnagar	-	7,200	-	Sola	203,400	139,500	-31.41%
Chandlodia	-	3,600	-	Charodi	103,500	83,700	-19.13%
Thaltej	5,400	6,300	16.67%	Khoraj	139,500	27,000	-80.65%
Bodakdev	16,200	40,500	150%	Ranip	50,400	-	-
Dev City	-	14,400	-	Yadudi	43,200	6,300	-85.42%
RC Technical	-	47,700	-	Makarba	66,600	17,100	-74.32%
Gota	19,800	900	-95.45%				

Source: Author's Analysis

[16]The Normalized Difference Vegetation Index (NDVI) is a geospatial tool-based index that provides information on the intensity of vegetation cover through satellite remote sensing data. The reflections from Near Infrared and Red bands are used as inputs for the calculation of NDVI. Higher positive values of NDVI correspond to dense vegetation while negative values correspond to built-up areas or barren soil.

[17]The Lakes of Jagatpur, Chainpur and Tragad have not been covered in the analysis as they have neither been redeveloped nor show any considerable change in activity around the lake.

[18]The analysis was undertaken for 2002 (pre-project year) and 2017 (post-project year) to avoid anomaly in the vegetation cover due to rainfall in the previous year.

3.2 SOCIO - ECONOMIC IMPACTS

3.2.1 Creation of Green Open Spaces and Recreational Areas

This section describes the significance of the LRIL project in creating green open spaces and recreational spaces at the city level. All of the fully redeveloped lakes have the provision for a garden and promenade adjacent to the water body as part of green space for public use.

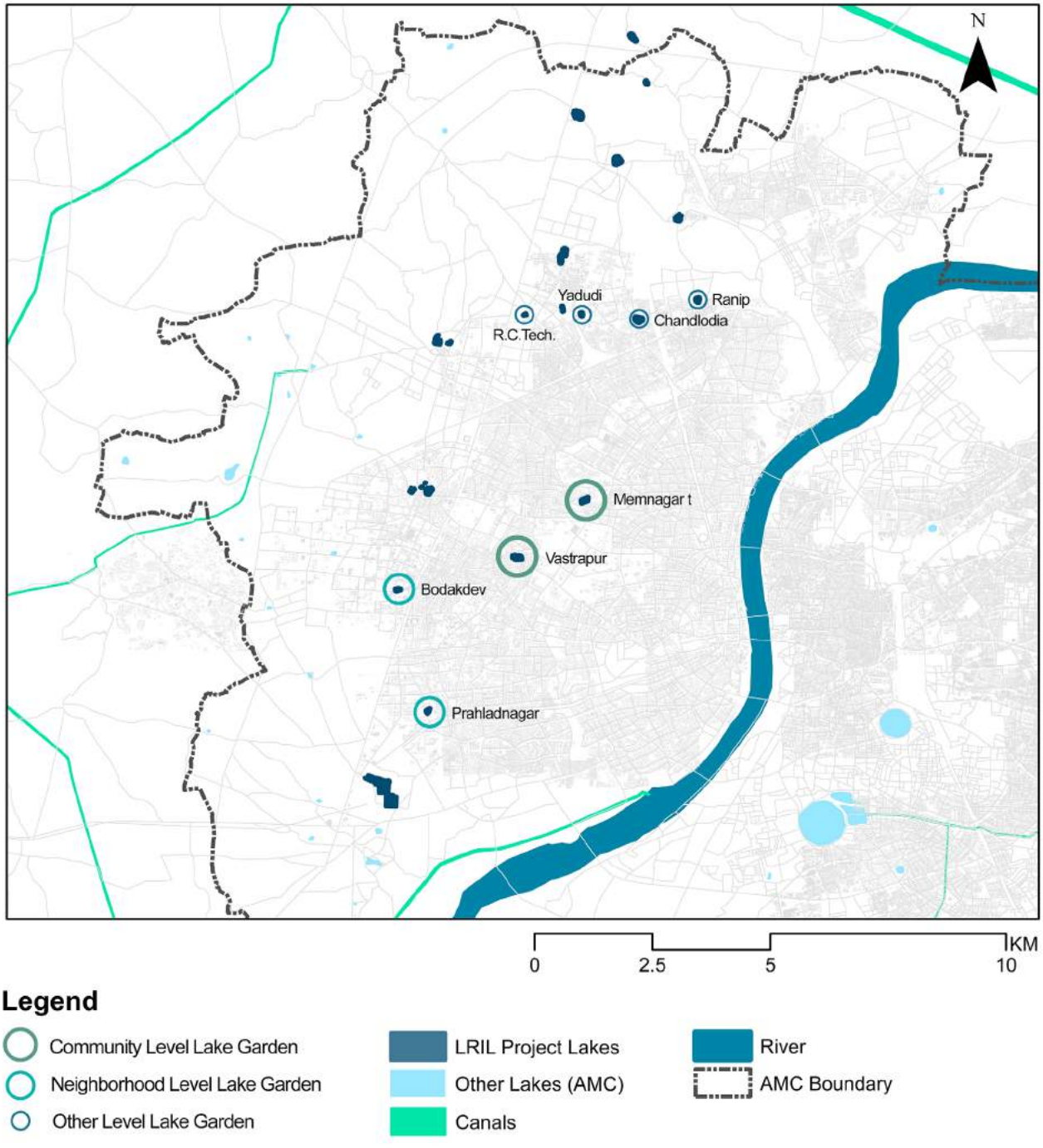

Figure 3-30: Location of LRIL Lake Gardens

The analysis of the data from Ahmedabad Municipal Corporation establishes the importance of LRIL as a city-level green initiative. There are 10 garden plots developed around eight redeveloped lake locations within AMC (refer to fig. 3-30).[19] However, these gardens constitute about 10% of the total green space under the AMC region (AMC, 2021). Hence, the LRIL project has contributed effectively to the augmentation of green open spaces in Ahmedabad. These lake gardens were found to be well maintained except for Ranip and Yadudi Lakes. The lake gardens are maintained on a Public Private Partnership model by the Mother Dairy Company. The company gets a direct outlet for the sale of its product in the same garden. No agency or organization was found to be maintaining the Yadudi and Ranip lake gardens.

Additionally, Vastrapur Lake has an amusement park, a boating zone and an open-air theater as a recreational space. These are alternative sources of revenue. Kariya Builders Pvt. Ltd. operates and maintains the boating services at the lake. The Amphitheater at the lake has a capacity of 2,500 and charges INR 40,000 for an event.[20] There are no alternative revenue sources at any of the other lakes.

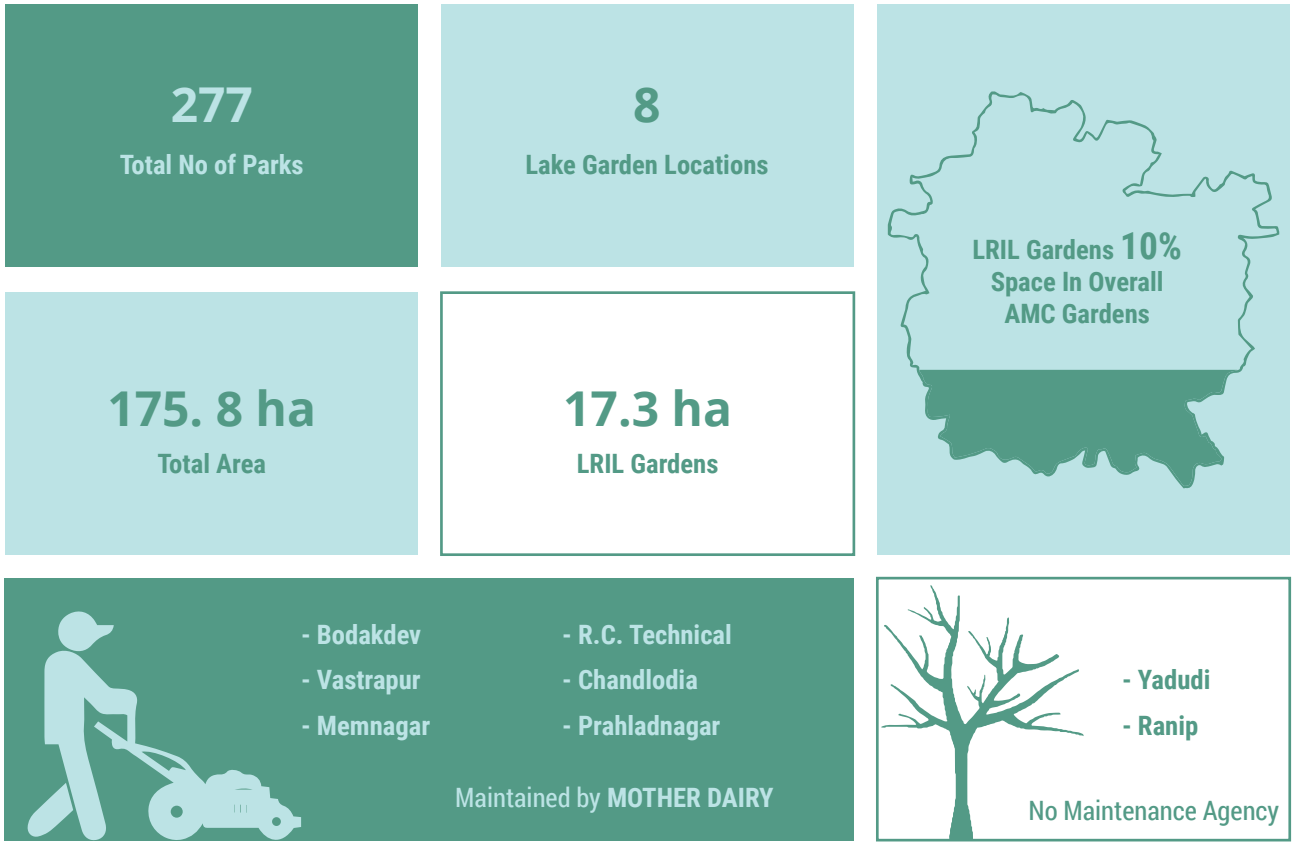

Figure 3-31: An overview of LRIL Gardens within AMC exhibiting importance of the LRIL project as a major contributor to Green Spaces in AMC

Source: (AMC, 2020), (TPVD, 2021)

[19]The analysis in the section has been conducted on data from AMC. The Khoraj Lake Garden was redeveloped under LRIL. However, it has not been included in the analysis as it falls outside the AMC Boundary.

[20]The details of the contracts or the financial arrangements were not furnished by any of the institutions involved in construction, operation and maintenance.

Figure 3-32: Location of Vrundawan Awas (Rehabilitation site) near Vastrapur Lake

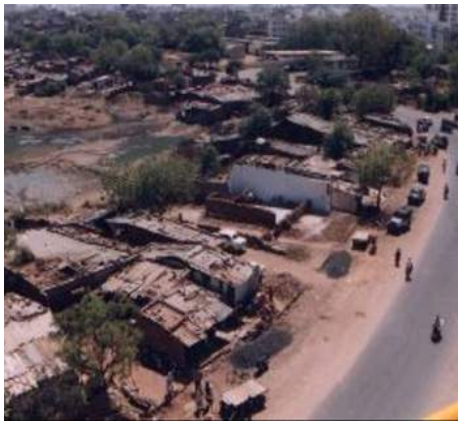

Figure 3-33: Informal Settlements around Vastrapur

Source: (AUDA, 2020)

Figure 3-34: Rehabilitation Housing at Vastrapur

Source: (AUDA, 2020)

3.2.2 Rehabilitation and Resettlement

The LRIL project also affected the quality of life of the rehabilitated slum dwellers around Vastrapur Lake. The households living in informal settlements around the Vastrapur Lake had been rehabilitated to the 314 EWS units constructed by AUDA. These dwelling units were G+1 structures with an area of 21 sq.m. at Vrundawan Awas Rehabilitation Site (refer to fig.3-32) (AUDA, 2020).

The project enabled a shift from informal housing (refer to fig. 3-33) to formal housing (refer to fig.3-34) for the beneficiaries. The rehabilitation offered the households better housing conditions and better access to basic services. It minimized the risks of damage to life or property due to flooding and to health due to degraded water body.

However, this shift from informal settlement to formal housing came with an impending debt to the households. Two types of dwelling units were constructed and priced at INR 62,500 and INR 81,500. AUDA provided soft loans to the beneficiaries post an initial payment of INR 5,000. The households had to pay an installment of INR 550 per month (AUDA, 2020). [21]

Also associated with such projects is the issue of gentrification. As the condition of these lakes improves, the poor are often shifted away making way for real estate development.

[21] ~Dwelling Unit prices - USD 839.15 & USD 1,094.25 respectively; Initial payment - USD 67.13 & Installment - USD 7.38 according to the exchange rate on 16th April 2021 retrieved from https://www.federalreserve.gov/releases/h10/current/

3.2.3 Real Estate Prices

The land and real estate market have been studied to analyze changes in capital or rental values and product mix in properties around the LRIL lakes. These values are proxy indicators of social and environment value around a location and can be used to interpret the livability of an area. The primary data collected from Developers indicates an increase of 5-10% in the capital values of properties adjacent to the lake post redevelopment. As Ahmedabad lacks any significant natural feature, the lakes provide an aesthetic anchor to the real estate projects. Therefore, these lake-facing properties were priced at a premium of INR 50-150/sq.ft. (Patel N., 2021).

The redevelopment also triggered an alteration in the product mix of upcoming residential schemes around the lakes. The schemes started to incorporate more commercial components to capitalize on the speculated footfall (Modi, 2020). The increase in land values also helped AUDA to leverage its land parcel near Vastrapur Lake to generate funds later.

However, due to lack of maintenance around some of the lakes and no development around some, the increase in value got diminished by issues of maintenance. Poor maintenance of the lakes caused unhygienic condition coupled with non-aesthetical views in some locations (Shridhar, 2020). For the others, the increased commercial activity and recreational activities post redevelopment increased footfalls as well as vehicular movement which normalized or decreased the desirability of lake precincts as a residential area (Shridhar, 2020).

3.3 SUMMARY OF IMPACTS

The assessment of the environment and socio-economic impacts suggests that, wherever the lakes have been developed and maintained along with the interlinks, there were positive environmental impact in terms of decrease in incidences of flooding, increase in ground water, and green cover.

In terms of socio-economic parameters apart from increase in green spaces for the residents it is difficult to make inferences about the positive impacts. This is mainly due to issues of gentrification that are associated with development projects. While there is rehabilitation, it is in most cases away from the lakes. Secondly, the proxy indicator of change in real estate values shows that in most places the values have stabilized as the maintenance of the lakes is an issue.

These impacts however are limited as the project was not completed and all the lakes were not developed. Therefore, the potential of positive benefits has not been realized to the fullest.

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4

MAINSTREAMING LAKE REDEVELOPMENT & INTERLINKING PROJECTS AS A SUSTAINABLE URBAN INFRASTRUCTURE PRACTICE

4.1 REGIONAL LEVEL INTERVENTION

4.2 CITY LEVEL INTERVENTION

- Sustainable Infrastructure Project - Legal Approval through Development Plans
- Land reservation through Town Planning Scheme and Local Area Plan
- Land Reservation through Local Area Plan

4.3 SUMMARY

The LRIL is a complex project that involves many aspects, institutions and legislative support. This chapter suggests a comprehensive approach with regional level and city level interventions for successful planning and implementation of similar projects as a Sustainable Urban Infrastructure Integrated Planning tool.

4.1 REGIONAL LEVEL INTERVENTION

It would not be prudent to look at the water bodies in isolation while mitigating the incidents of severe rainfall due to the impact of climate change. A comprehensive approach is needed for environmental protection and safeguarding natural water resources. Hence, it is recommended that the regional level (district level) comprehensive Watershed Management Plan should be prepared. It should cover all water bodies regardless of the sizes, identifying the eco - sensitive areas essential to be preserved and conserved, high flood levels, full - tank levels, flood points and catchment areas. Moreover, the plan should include the proposals and recommendations to manage water bodies, waterlogging and developing green and blue infrastructure. Further, the recommendations and proposals of the plan should be incorporated by ULBs while preparing DP and TPSs.

State level Watershed Management Agency should prepare the Watershed Management Plan for each district in association with the respective District Watershed Development Unit (DWDU). For Gujarat State, it is Gujarat State Watershed Management Agency (GSWMA).

4.2 CITY LEVEL INTERVENTION

If LRIL projects are planned with the support of statutory provisions, the project realization would be much higher. Therefore, at the city level macro and micro scale interventions should be backed up by the state and city level statutory and legal provision.

4.2.1 Sustainable Infrastructure Project - Legal Approval through Development Plans

Most states in the country have enacted the Act (Town and Country Planning Act) for urban planning and development within their jurisdiction. The Act usually provides for the constitution of urban development or area development authorities and empowers them to prepare the Development Plan (DPs), Zonal Development Plans, Town Planning Schemes, Area Development Schemes and Local Area Plans.

The Development Plans are sanctioned by the state government. Resultant, the projects identified under the DP also get sanctioned. Hence, it is recommended that a DP must identify a city-level sustainable infrastructure project like the LRIL as essential. With legal endorsement, the project implementation becomes feasible for the city administration.

The DP should be in line with the District Watershed Management Plan. Proposals and suggestions of Watershed Management Plan should be incorporated in the DP to identify water bodies, waterlogging areas, flood-prone zone, catchment areas and eco-sensitive areas that should be conserved and preserved. Further, before conceptualizing the proposed land use zoning for the city, the responsible authority/agency should undertake surveys and analyses of the city's topography, conditions of water bodies and their catchment areas, stormwater drainage network, hydrological system, and sewerage network. These surveys and analysis would help to plan the LRIL project with the identification of lakes for redevelopment and likely lake linkages. However, a comprehensive project report should be prepared before implementing the project. Along with this, a land suitability analysis should be carried out to identify non-developable areas and areas with low development suitability. These non-developable areas are required to conserve/ preserve include water bodies, steep slope, stormwater channels, forest area, dense vegetation areas and other eco-sensitive areas. The catchment areas of the water bodies and low-lying areas should be conserved by providing green or recreation uses.

DP should propose the identified non-developable areas as a conservation zone or park and open spaces with no development allowed. Further, the water bodies should also be conserved by not allowing any activities within their immediate vicinity, which can be done by delineating non-developable conservation/green buffer surrounding the water bodies. The size of the buffer can vary depending on the size of the water bodies. Moreover, the DP should permit either no development or low-intensity development for the identified catchment, waterlogging, and flood-prone areas. The development intensity and activities permitted should be controlled through the GDCR (General Development Control Regulations). For example, urban forestry or a public garden could be permitted in the conservation zone. Only low-intensity nonpolluting development may be allowed in the catchment areas. Further, the catchment areas should be connected with the water bodies with the network of stormwater channels, following the natural contours.

The DP road network and stormwater network should be proposed with considering the natural contours/drainage pattern of the city; this would help increase the efficiency of the stormwater channels. In Gujarat, Urban Development Authorities constituted under the GTPUDA prepares the development plans; Gujarat Urban Development & Urban Housing Department sanctions the plans. At the same time, the municipal corporations implement the plan within the corporation areas. Further, within the corporation area, various departments are responsible for implementing various proposals of the DP. The Engineering Department is responsible for developing the road network, water supply, drainage and stormwater work. The Garden Department is responsible for developing and maintaining the park and open space. Hence, for successful planning and implementation of the LRIL project, integration and coordination between the departments are vital.

4.2.2 Land reservation through Town Planning Scheme and Local Area Plan

Once the DP is sanctioned, the implementing authority/agency can implement the proposal by reserving land through acquisition or using a land pooling mechanism. The authority can preserve/ conserve the land for non-development buffer surrounding the water bodies and natural stormwater channels through the Town Planning Scheme mechanism. The road network for the Town Planning Scheme (TPS) area should follow the natural contour/ drainage line. The authority may provide a stormwater network along with the road network.

In Gujarat, the GTPUDA, 1976, provides an effective two-stage mechanism of Development Plan and Town Planning Scheme. The

DP being sanctioned, the urban development authorities prepare and implement TPSs to execute the development plan proposals by dividing the DP area into smaller areas to develop and implement the TPSs. The Act provides for reserving at least five per cent of the TPS area for the park and open space activities.

4.2.3 Land Reservation through Local Area Plan

The Local Area Plan (LAP) is a statutory tool available to implement the DP proposals, especially for brownfield areas. LAP creates a framework to enhance public spaces, improve infrastructure and road network by enabling the redevelopment of the existing development. With the LAP mechanism, the DP implementing agency can strengthen the lake by providing reservations for gardens and open spaces (within lake vicinity), proposed under the LRIL project. In Gujarat, urban development authorities can prepare LAPs according to the provisions under GTPUDA.

EXAMPLE 1: Reservation of Land for Green Buffer through DP-TP Mechanism (DHOLERA SIR)

Dholera Special Investment Region (DSIR) is a Greenfield Industrial City planned and located approximately 100km southwest of Ahmedabad City. The DSIR spans approximately 920 sq.km, covering 22 villages of the Dholera Taluka of the Ahmedabad District. The Dholera Special Investment Region Development Authority (DSIRDA) has prepared the Development Plan for DSIR. For implementation purposes, the implementing authority/agency has adopted the TPS mechanism to deliver serviced land. Dholera DP conserves the water bodies by proposing Green Space Zone surrounding the water bodies, and through the TPS mechanism, for which the land is carved out for the proposed zone.

Dholera SIR Master Plan

Proposed Land Use Zoning Map | **Dholera SIR TPS Plan** | **TPS No.3**

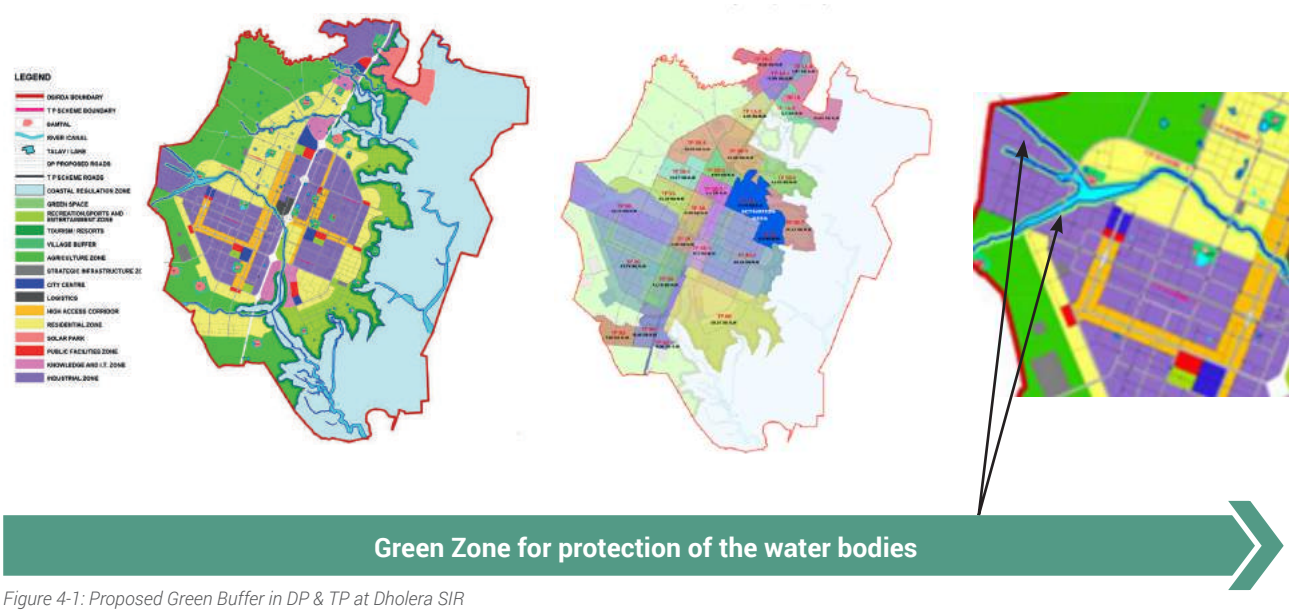

Figure 4-1: Proposed Green Buffer in DP & TP at Dholera SIR

Source: Special Investment Region Development Authority, Dholera; http://dholerasir.com/

EXAMPLE 2: Reservation of Land for Green Buffer through TP Mechanism (Ahmedabad City)

Yadudi Lake in 2001 | Original Plots | Yadudi Lake in 2020 | Final Plots of lake in T.P. Scheme

Figure 4-2: AMC adopted TPS mechanism to amalgamate plots to reserve land for the proposed park and garden development surrounding Yadudi Lake

Source: (Google Earth, 2020), (TPVD, 2021)

4.3 SUMMARY

DP-TPS-LAP is a legislative mechanism that enables the development authority/agency to plan at both the macro and micro level. It allows the development authority to envision city-level projects and then undertake very detailed planning/implementation through TPS and LAP. If sustainable infrastructure projects like LRIL are incorporated in a city DP, the project will get the required legal support for the implementation.

Both TPS and LAP are land pooling tools to appropriate land for the projects without any acquisition and thus provide financial sustainability to the project finances. With the TPS & LAP, the delivery of service land for the implantation of the projects would become viable; hence, chances of implementation of the projects would be higher.

A District Watershed Management Plan should be worked out for robust water resource management and adaptation to climate change impacts. The authorities should incorporate proposals and recommendations of the district-level Watershed Management Plan while preparing the DP, TPS and LAP.

REGIONAL LEVEL INTERVENTION

Agency Involved

Gujarat state Watershed Management Agency District Watershed Development Unit

District Watershed Management Plan

A comprehensive plan for environment protection and safeguarding Natural Water Resources

Proposals and Recommendation

Background Study

Identify and Map

- All water bodies
- Storm water Channels
- Catchment areas
- Watershed areas
- Flood points
- Low laying area
- Eco-sensitive area

GIS Based Plan
Superimposed with the DP

CITY LEVEL INTERVENTION

Agency Involved

State Development
Urban Development Authority / Area Development Authority
Agency

City Development Plan

Legal Approval - If LRIL is a DP proposed project then gets statutory endorsement along with the sanctioned DP

Statutory Implementation
Tool to implement DP

Agency Involved

State Government
Urban Development Authority / Area Development Authority
Urban Local Governing Body

Town Planning Scheme (TPS)
Local Area Plan (LAP)

LRIL- DP Proposed Project

Base for LRIL

Survey & Thematic Maps

- Water Bodies & their Catchment Area
- Flood Prone Areas
- Topography
- Hydrological Map
- Aquifer System
- Water Sheds
- Storm water channels
- Sewage network
- Green and blue map

Land Suitability Analysis
To identify

- Non-Developable Area for conservation
- Low Development Suitability Area

DP Proposal & GDCR- supporting LRIL

Land Use Zoning Proposal
Non - Developable Area

- Conservation Zone - no development allowed
- Park & Open Space - low intensity recreational activity allowed
- Low Development Suitability Area
- Low intensity residential activities
- Park and open spaces for recreational activities

GDCR

- Controls intensity of development as per the DP proposals
- Impose no-development green buffer surrounding all water bodies

Land Reservation for LRIL

TPS

Tool to plan greenfield area of the DP

- Carve outs land for parks and gardens
- Preserve water bodies
- Delineate no-development green buffer surrounding water bodies
- Delineate natural storm water channels & preserve them

LAP

Tool for redevelopment I brownfield area of the DP

- Enable redevelopment of the existing developed area
- Create framework enhancing public spaces
- Improvement of infrastructure
- Improve road network
- Reclaim land for development of lake gardens

Figure 4-3: Recommended structure for Planning and Implementation of LRIL projects as a Sustainable Urban Infrastructure LRIL Project - within the existing Institutional Framework and State Level Statutory Mechanism in Gujarat

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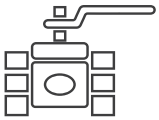
LEGENDS FOR ANNEXURES

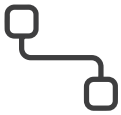


Interlink Controls

Predominant Land Use

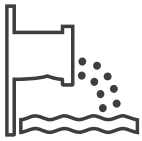
Interlink to Network

Groundwater Percolation Mechanisms



Interlink to Local Catchment

Solid Waste Dumping



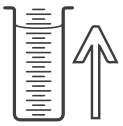
Sewage Disposal

Gardens / Parks

Lake Capacity

Recreational Areas

Built Vs. Open



Water Level

Lake boundary

Status of Redevelopment

Lake Catchment

Status of Encroachment

ANNEXURES

ANNEXURE A - SNAPSHOT: VASTRAPUR LAKE

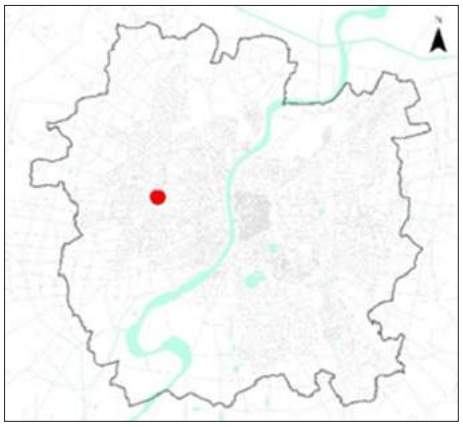


Figure A-1: Vastrapur Lake Key Map

Figure A-2: Vastrapur Lake

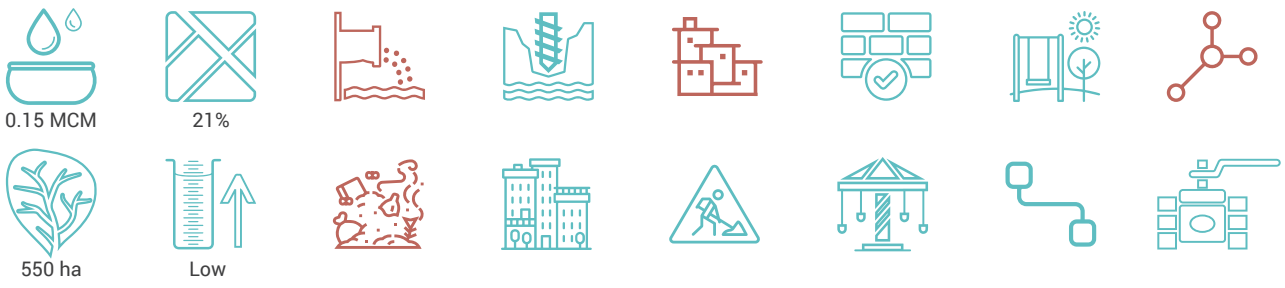
Figure A-3: Existing Land Use around Vastrapur Lake

Figure A-5: Landscape area and Promenades at Vastrapur Lake

Figure A-4: Built vs. Open Areas around Vastrapur Lake

Figure A-6: Percolation Wells at Vastrapur Lake

Figure A-7: Amusement Park at Vastrapur Lake.



ANNEXURE A: SNAPSHOT (MEMNAGAR LAKE)

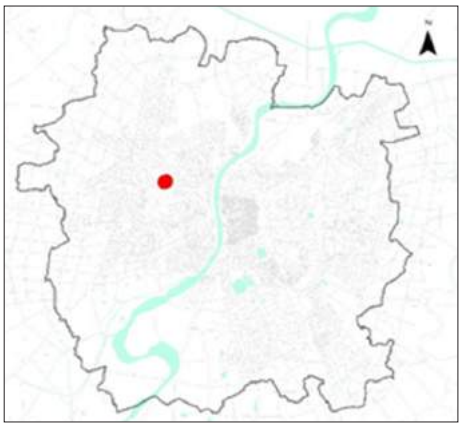


Figure A-8: Memnagar Lake Key Map

Figure A-9: Memnagar Lake

Figure A-10: Existing Land use around Memnagar Lake

Figure A-12: Garden & Lakeside Promenade on the lake's Northern edge

Figure A-11: Built Vs Open Areas around Memnagar Lake

Figure A-13: Solid waste dumping on eastern edge of the Lake

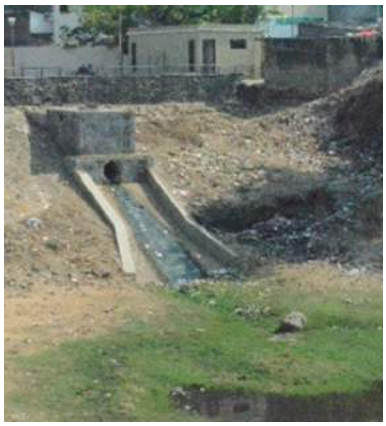
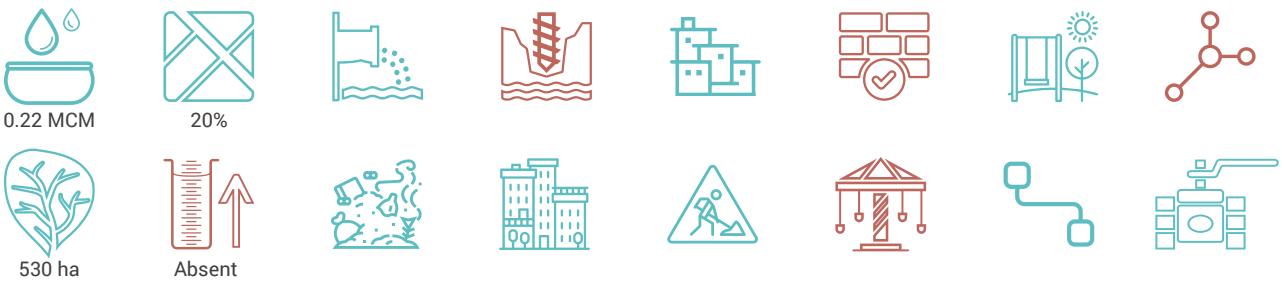


Figure A-14: Untreated Sewage disposal at Memnagar Lake



ANNEXURE A: SNAPSHOT (SOLA LAKE)

Figure A-15: Sola Lake Key Map

Figure A-16: Sola Lake

Figure A-17: Existing Land Use around Sola Lake

Figure A-19: Lake being encroached with solid waste dumping

Figure A-18: Built Vs Open Areas around Sola Lake

Figure A-20: Solid waste dumping in between the Sola Lakes

Figure A-21: Interlink control structure next to the Lake

ANNEXURE A: SNAPSHOT (THALTEJ LAKE)

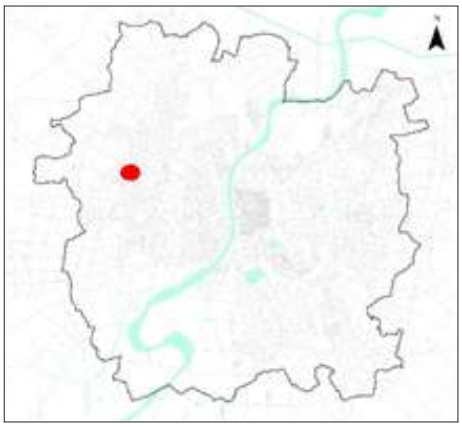


Figure A-22: Thaltej Lake Key Map

Figure A-23: Thaltej Lake (Opp. Govardhan Party Plot)

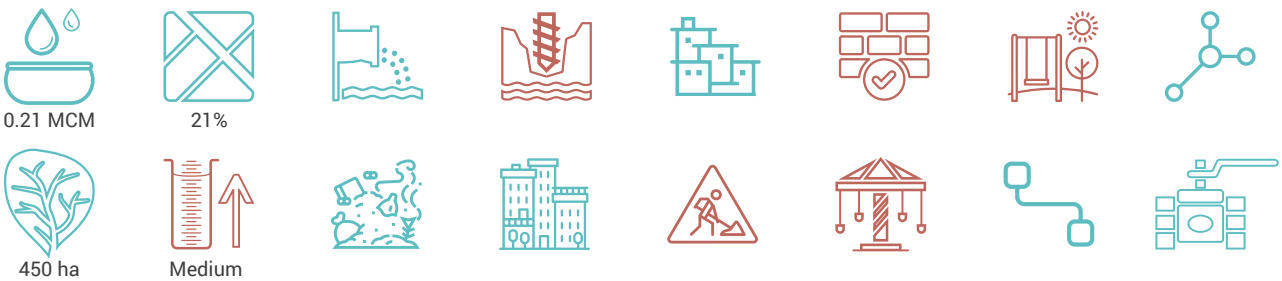
Figure A-24: Existing Landuse around Thaltej Lakes

Figure A-26: Thaltej Lake being encroached with solid waste dumping

Figure A-25: Built Vs Open Areas around Thaltej Lakes

Figure A-27: Rampant Sewage disposal and Solid Waste dumping

Figure A-28: Market at the southern edge of the lake



ANNEXURE A: SNAPSHOT (BODAKDEV LAKE)

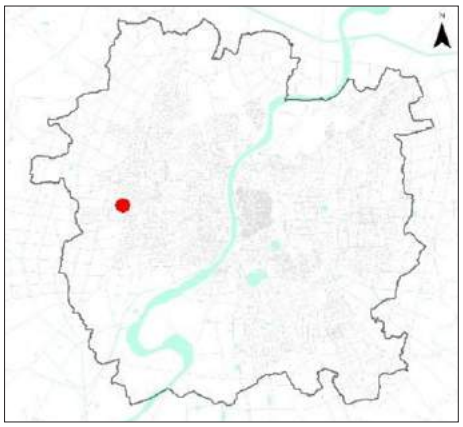


Figure A-29: Bodakdev Lake Key Map

Figure A-30: Bodakdev Lake

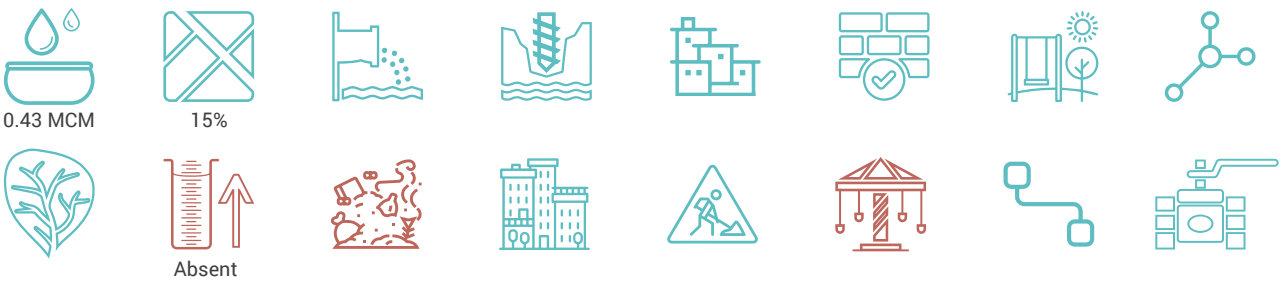
Figure A-31: Existing Land use around Bodakdev Lake

Figure A-33: Garden adjacent to the Bodakdev Lake

Figure A-32: Built Vs Open Areas around Bodakdev Lakes

Figure A-34: Damaged percolation well

Figure A-35: Sewage disposal in the Bodakdev Lake



ANNEXURE A: SNAPSHOT (PRAHLADNAGAR LAKE)

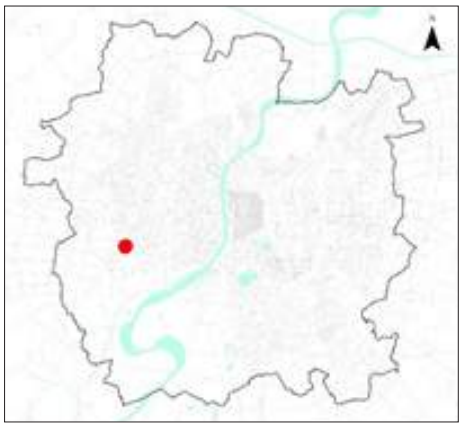


Figure A-36: Prahladnagar Lake Key Map

Figure A-37: Prahladnagar Lake

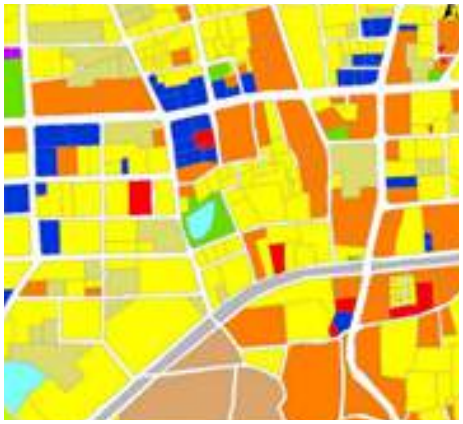


Figure A-38: Existing Land use around Prahladnagar Lake

Figure A-40: Lakeside Promenade and garden at Prahladnagar Lake

Figure A-39: Built vs. Open Areas around Prahladnagar

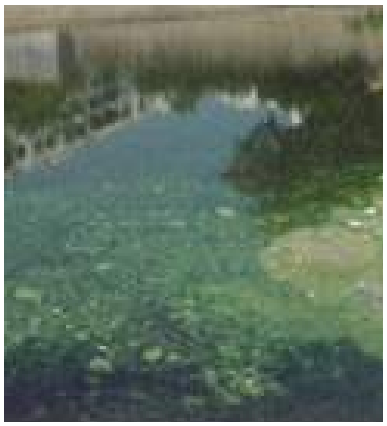


Figure A-41: Algae bloom in the lake water

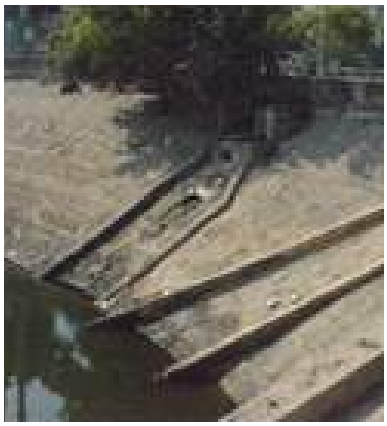
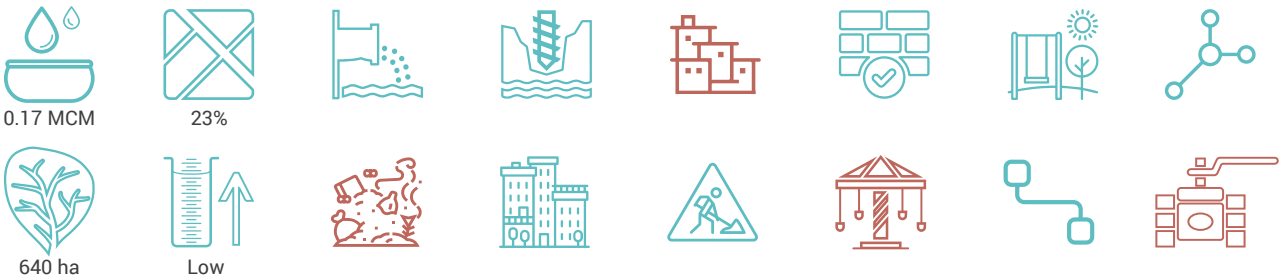


Figure A-42: Sewage and waste dumping from the road side has caused pollution



ANNEXURE A: SNAPSHOT (GOTA LAKE)

Figure A-43: Gota Lake Key Map

Figure A-44: Gota Lake

Figure A-45: Existing Land Use around the Gota Lake

Figure A-47: Lake being filled up with construction waste from the edge

Figure A-46: Built vs Open Areas around Gota Lake

Figure A-48: Informal settlements at the lake edge

Figure A-49: Unsecured road side edge of G o t a Lake

ANNEXURE A: SNAPSHOT (CHANDLODIA LAKE)

Figure A-50: Chandlodia Lake Key Map

Figure A-51: Chandlodia Lake

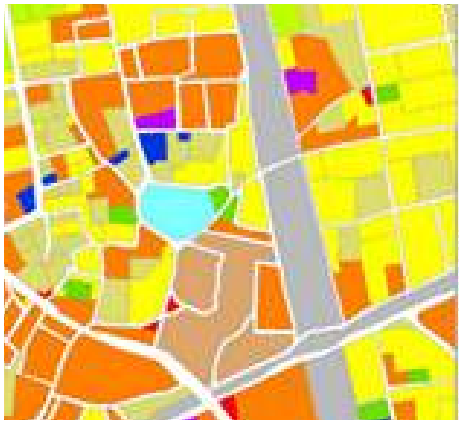


Figure A-52: Existing Land Use around Chandlodia Lake

Figure A-54: Lakeside Promenade and adjacent garden

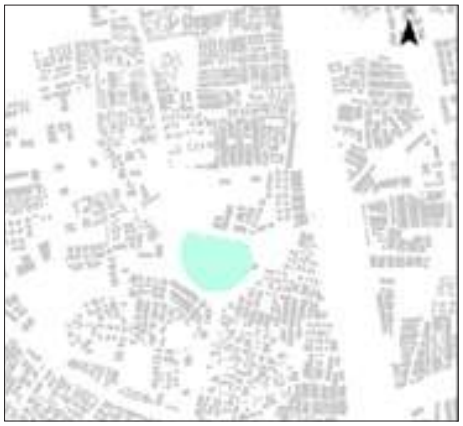


Figure A-53: Built vs. Open areas around the Chandlodia Lake

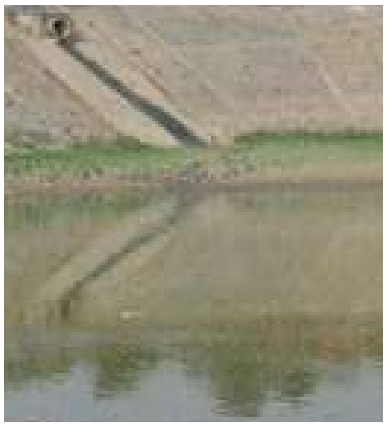
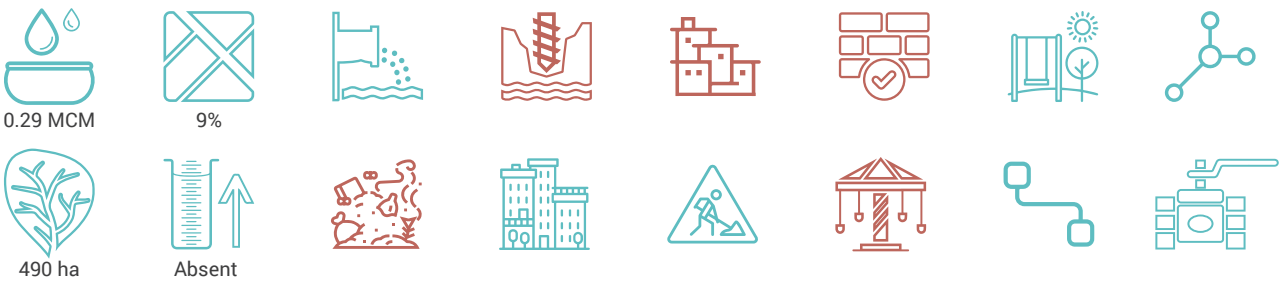


Figure A-55: Sewage flowing into the Chandlodia Lake

Figure A-56: Interlink Control Structure at Chandlodia Lake



ANNEXURE A: SNAPSHOT (MAKARBA LAKE)

Figure A-57: Makarba Lake Key Map

Figure A-58: Makarba Lake

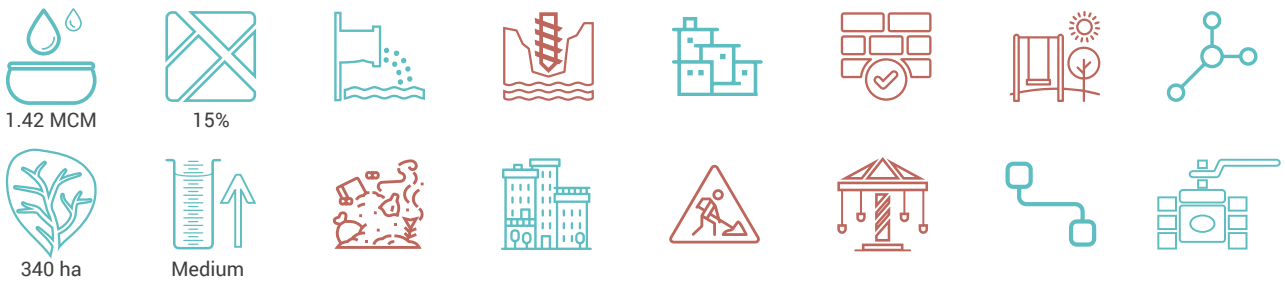
Figure A-59: Existing Land Use around the Makarba Lake

Figure A-61: Upcoming Residential properties adjacent to Makarba Lake view

Figure A-60: Built vs. Open areas around the Makarba Lake

Figure A-62: The natural bund lining around the Makarba Lake

Figure A-63: Interlink Control Structure at Chandlodia Lake



ANNEXURE B - NDVI ANALYSIS OF LAKE BUFFER AREA

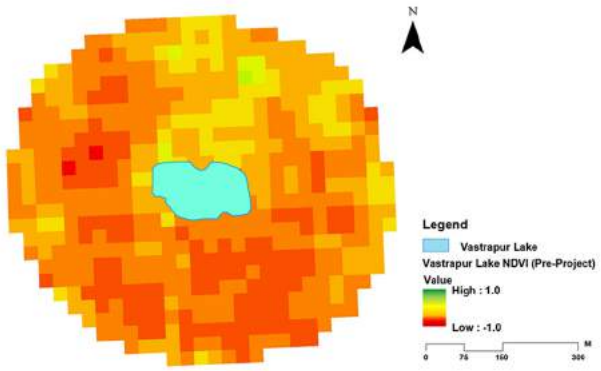


Figure B-1: Vastrapur Lake NDVI Analysis (pre-LRIL)

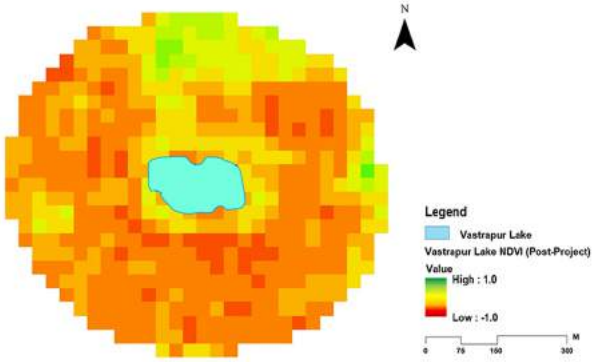


Figure B-2: Vastrapur Lake NDVI Analysis (post-LRIL)

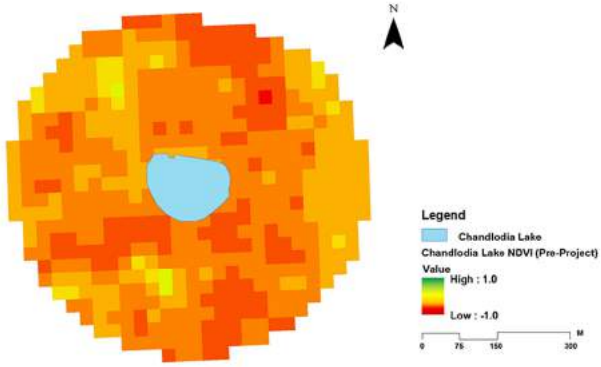


Figure B-3: Chandlodia Lake NDVI Analysis (pre-LRIL)

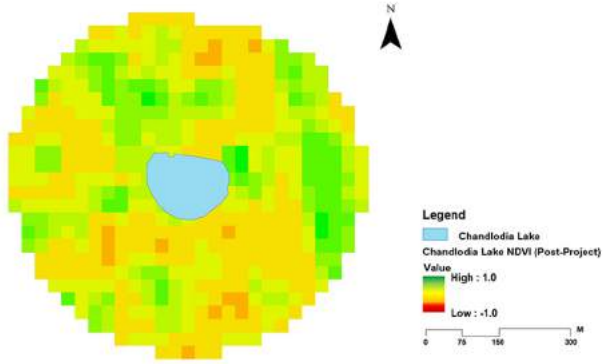


Figure B-4: Chandlodia Lake NDVI Analysis (post-LRIL)

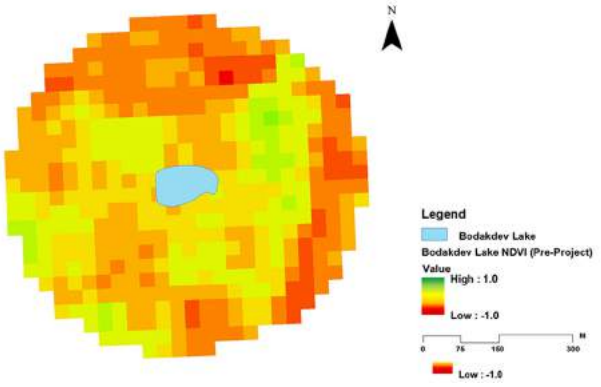


Figure B-5: Bodakdev Lake NDVI Analysis (pre-LRIL)

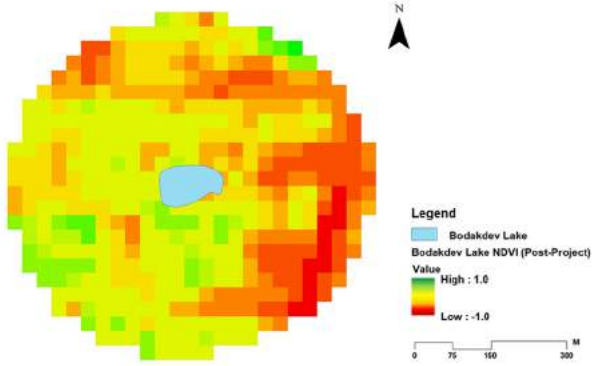


Figure B-6: Bodakdev Lake NDVI Analysis (post-LRIL)

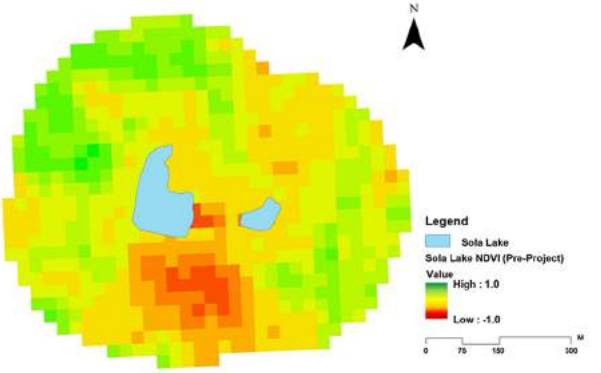


Figure B-7: Sola Lake NDVI Analysis (pre-LRIL)

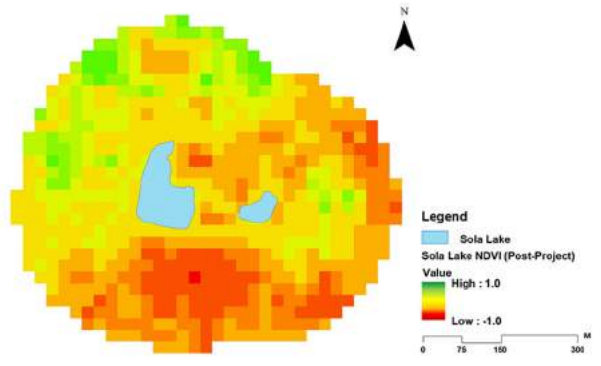


Figure B-8: Sola Lake NDVI Analysis (post-LRIL)

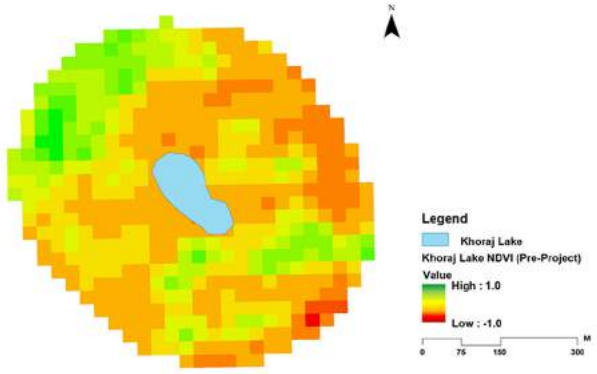


Figure B-9: Khoraj Lake NDVI Analysis (pre-LRIL)

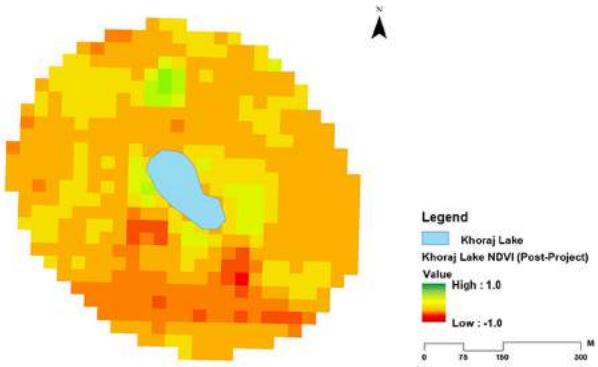


Figure B-10: Khoraj Lake NDVI Analysis (post-LRIL)

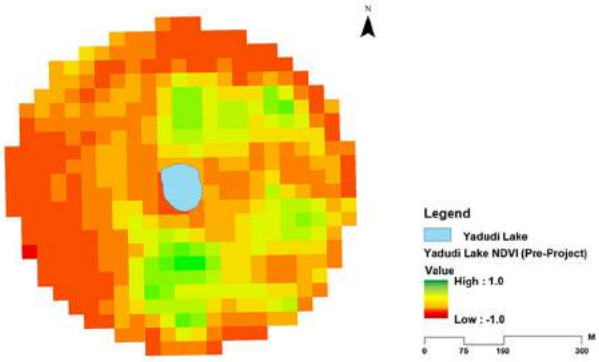


Figure B-11: Yadudi Lake NDVI Analysis (pre-LRIL)

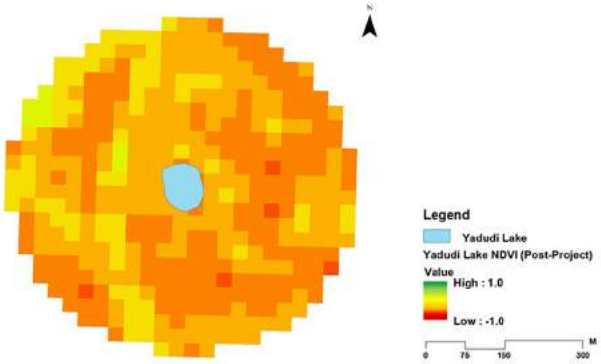


Figure B-12: Yadudi Lake NDVI Analysis (post-LRIL)

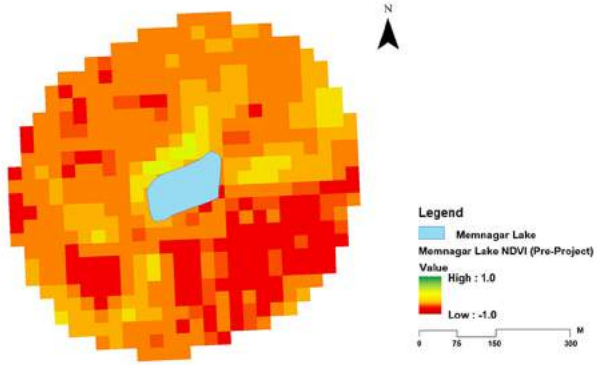


Figure B-13: Memnagar Lake NDVI Analysis (pre-LRIL)

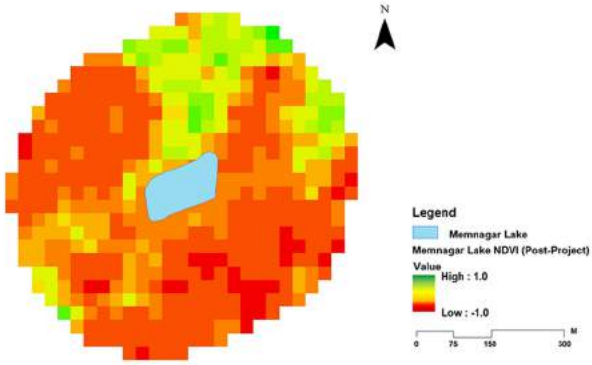


Figure B-14: Memnagar Lake NDVI Analysis (post-LRIL)

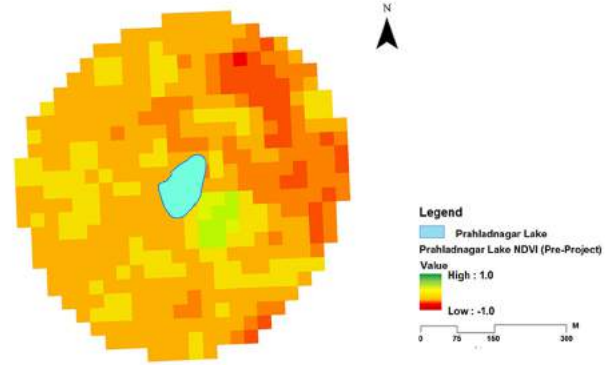


Figure B-15: Prahladnagar Lake NDVI Analysis (pre-LRIL)

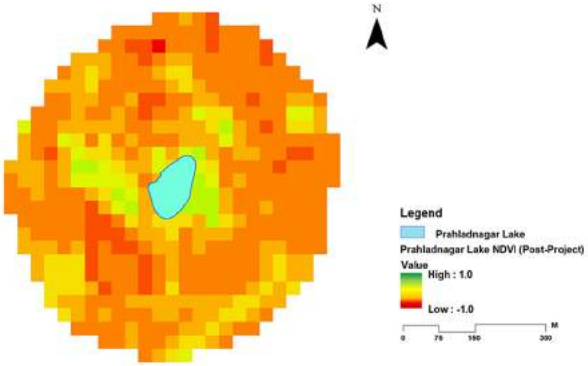


Figure B-16: Prahladnagar Lake NDVI Analysis (post-LRIL)

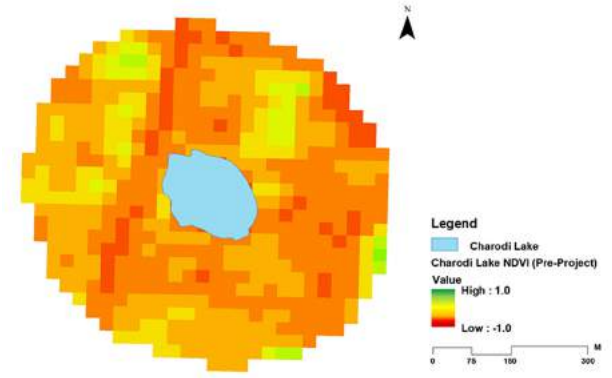


Figure B-17: Chharodi Lake NDVI Analysis (pre-LRIL)

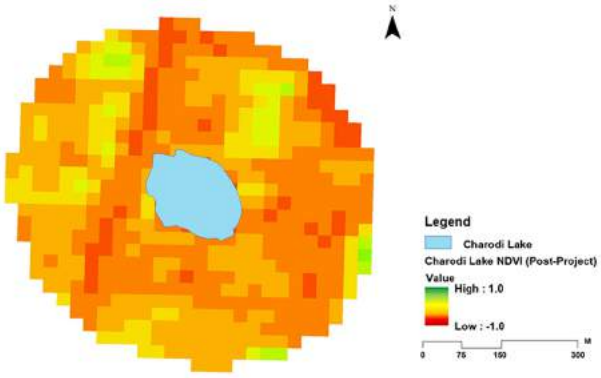


Figure B-18: Chharodi Lake NDVI Analysis (post-LRIL)

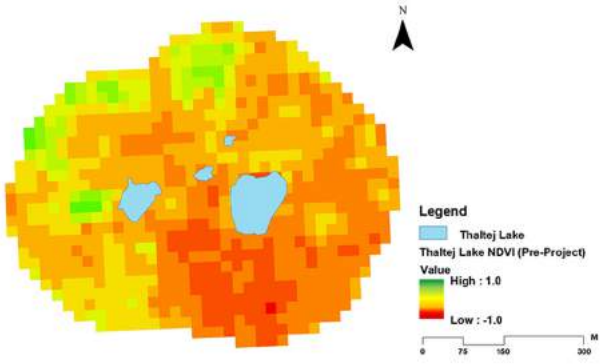


Figure B-19: Thaltej Lake NDVI Analysis (pre-LRIL)

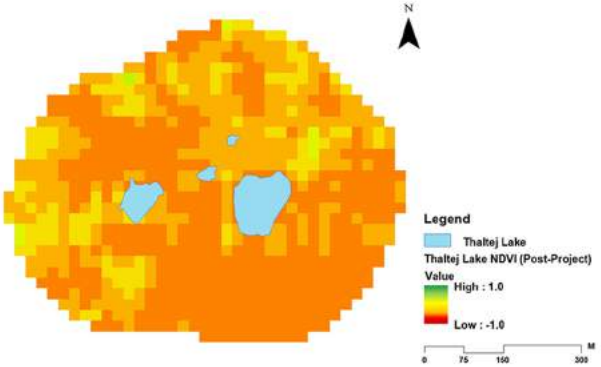


Figure B-20: Thaltej Lake NDVI Analysis (post-LRIL)

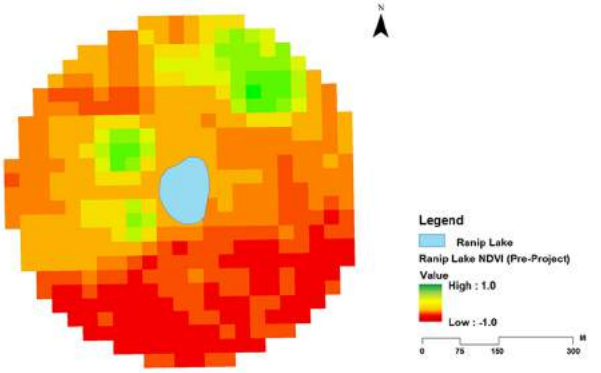


Figure B-21: Ranip Lake NDVI Analysis (pre-LRIL)

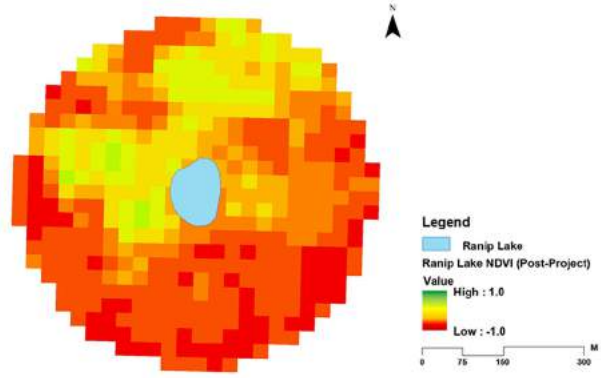


Figure B-22: Ranip Lake NDVI Analysis (post-LRIL)

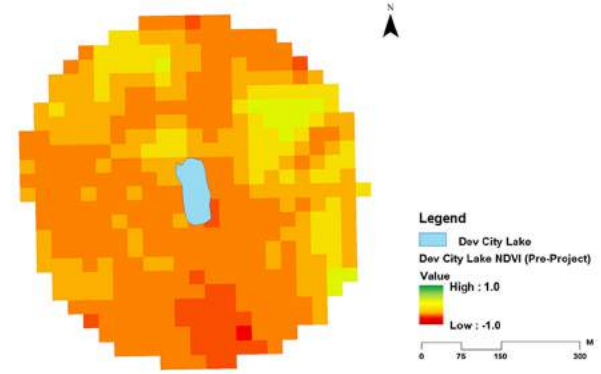


Figure B-23: Dev City Lake NDVI Analysis (pre-LRIL)

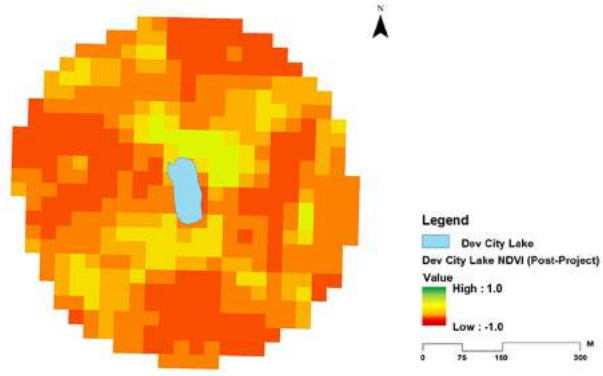


Figure B-24: Dev City Lake NDVI Analysis (post-LRIL)

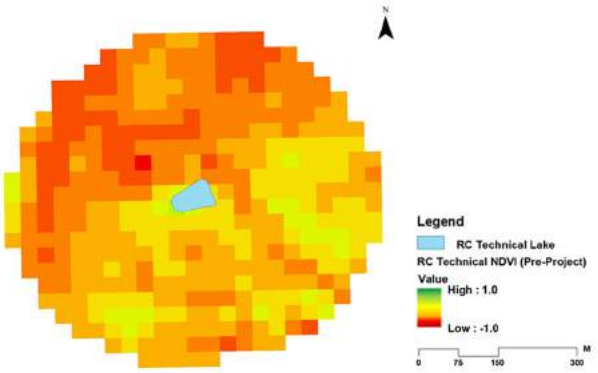


Figure B-25: RC Technical Lake NDVI Analysis (pre-LRIL)

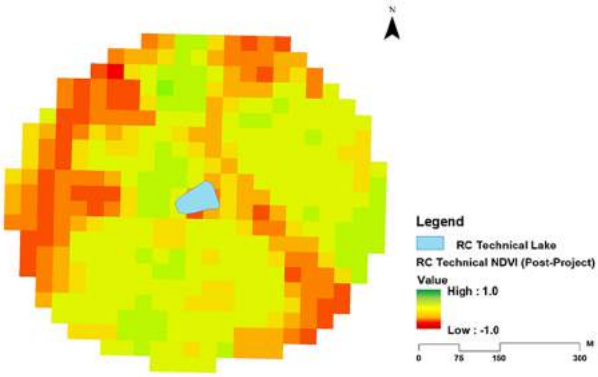


Figure B-26: RC Technical Lake NDVI Analysis (post-LRIL)

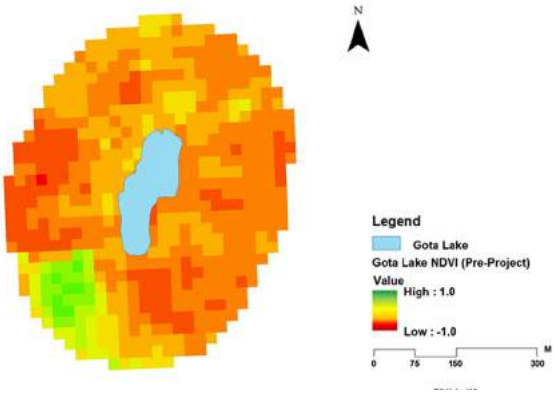


Figure B-27: Gota Lake NDVI Analysis (pre-LRIL)
Source: Author's Analysis

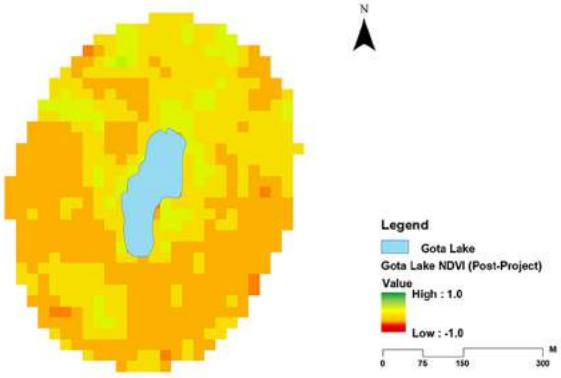


Figure B-28: Gota Lake NDVI Analysis (post-LRIL)

Notes

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