# BUILDING FLOOD RESILIENCE THROUGH INTERLINKING OF LAKES

## - THE CASE OF AHMEDABAD

## CASE STUDY: INTERLINKING OF LAKES | FOLDER - A

A Case Study conceptualized as part of the GIZ
Sustainable Urban Development - Smart Cities (SUD-SC) initiative

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

CUPP CENTER FOR URBAN PLANNING AND POLICY | CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION | CEPT UNIVERSITY

## Case Authors:


**Principal Researchers**
Tushar Bose
Utkarsh Patel

**Research Associates**
Sarang Barbarwar
Fagun Rajkotia

**Copy Editor**
Nirmala Khadpekar

**Design and Layout**
Shashank Trivedi
Tarun Vataliya

# FOLDER-A

CASE STUDY: INTERLINKING OF LAKES

# BUILDING FLOOD RESILIENCE THROUGH INTERLINKING OF LAKES

- THE CASE OF AHMEDABAD

*This page is intentionally left blank.*

# CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# ACKNOWLEDGEMENTS

This case study research would not have been possible without the help of several people and organizations. The case authors would like to express their deep gratitude to all of them. Special gratitude is expressed to Dr. R. Parthasarathy, MEGA Chair and Director, Gujarat Institute of Development Research.

Furthermore, we would also like to acknowledge with much appreciation the crucial role of the following:

1. Mr. Ashwin Jagani, Deputy Town Planner, AUDA
2. Mr. Himanshu Thakkar, Ex-Town Planner, AUDA
3. Dr. Vatsal Patel, Ex-Chief City Planner, AMC
4. Dr. Mansee Bal Bhargav (Water Sector Expert & Activist)
5. Dr. Akshay Anand (Water Sector Expert)
6. Mr. A.B. Gaur, Chief Executive Authority, AUDA
7. Mr. Surendra Patel, Ex-Chairman, AUDA
8. Mr. Kamlesh Modi, Managing Director, Himalaya Buildcon Pvt. Ltd. (Real Estate Expert)
9. Mr. Rushi Pandya, Add. City Engineer, West Zone, AMC
10. Mr. P. L. Sharma, Chief Town Planner, Gujarat Industries Development Board
11. Mr. Sharvil Shridhar, Managing Director, A. Sridhar Group (Real Estate Expert)
12. Mr. N.K. Patel, President, ITPI & Founder Director, Sun Builders (Real Estate Expert)

# PREFACE

Rapid urbanization and unplanned development have caused hindrance to 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 by a few extreme rainfall events caused by Climate Change. Cities worldwide have come up with initiatives to deal with pluvial flooding and to 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 resources and to derive co-benefits.

However, the conventional approach towards Urban Water Management in India often works in silos. The Lake Redevelopment & Interlinking Project of Ahmedabad is a rare instance of city-level infrastructure development projected 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 floods. It includes the background, concept and implementation of the Lake Redevelopment & Interlinking Project. The study also dwells on understanding the environment and socio-economic impacts of the project.

The observed 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.

# 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 |

# EXECUTIVE SUMMARY

Asaval was a historic settlement adjacent to the Sabarmati River. The walled city of Ahmedabad was established near this location by Ahmed Shah in 1411. Sabarmati was a seasonal river and could not be depended upon for year - round needs. Hence, the city planning historically incorporated water at the center of development in the form of *Hauzs* or *Vavs*. The old houses in the city used *Tankas* or underground tanks to collect rainwater from the roof. All around the Ahmedabad region, there were *Tekros* or higher mounds where settlements were present and *Talavadis* or ponds were generally located near these settlements. These ponds were linked naturally through channels and collected the rainwater from their catchment areas. The dependence on traditional mechanisms of *Talavadis, Hauzs,* and *Tankas* reduced over the years. Gradually, the sustainable practices of rainwater harvesting and stormwater management waned and became a part of Ahmedabad's historic legends.

**Ahmedabad City:**

Ahmedabad city is now the largest city in Gujarat and the seventh-largest metropolitan area in India. The Ahmedabad Municipal Corporation (AMC), the city's administrative agency, covers an area of 465 sq. km. which is subdivided into 48 wards. The Ahmedabad Urban Development Authority region (AUDA) spans an area of 1,866 sq. km. The built-up land area under AUDA has increased from 250 sq. km. to 280 sq. km from 1997-2011 which saw intensified development with the inclusion of 69 villages. The area under water bodies decreased from 3,854.53 ha (~3.85 sq.km.) to 3,500 ha (~3.5 sq.km.) in the AUDA region regardless of its boundary expansion. The climate of Ahmedabad is hot semi-arid type with an average rainfall of about 782 mm with most of the rainfall occurring in the months of July and August.

**Project Triggers:**

The Lake Redevelopment & Interlinking of Lakes (LRIL) was a consequence of four triggers that made way for the project - climate extremes, groundwater depletion, lake encroachment, and civic activism & judicial intervention.

1. Ahmedabad experienced heavy rainfall of 325 mm on 14$^{th}$ July 2000. The heavy downpour resulted in the death of 10 people and an approximate loss of goods worth INR 5000 million. Such extensive destruction due to floods was "attributed in large part to unplanned, unregulated construction". Seventy five percent of the buildings in AUDA were found to be violating the Gujarat Town Planning and Urban Development Act (GTPUDA). The event led to a call for public transparency and accountability in city management.
2. The dependency on groundwater in Ahmedabad for municipal water supply was more than 20% from 2000-2006. By 2006, the groundwater level across the city was at a depth of more than 100 m with a depletion rate of 2m/year from 1960 onwards. The water stress and dwindling groundwater availability were the other triggers for the conception of the project.
3. Ahmedabad had lost 36 surface water bodies or *Talavadis* from 1961 - 1996. Urbanization and anthropocentric activities adversely affected the lakes in the city. The lakes became dry due to loss of catchment and disruption in their hydrological cycle. Three mechanisms were responsible for the flagrant loss of water bodies – i) appropriation of lake land for other purposes by the authorities; ii) grant of Building Permission under TP Scheme; and iii) growth of Informal Settlements on the lake lands.

4. The final push to the project came in form of community action followed by court orders. In October 2000, Mr. Shailesh Shah filed a PIL against the state of Gujarat regarding the poor condition of Chandola Lake. The scale of degradation of the city's lakes dawned on the public and the judiciary through this PIL. In a follow-up, the court immediately passed an order to the local authorities to notify these lakes and check the encroachments in the vicinity. The court directed AUDA and AMC to prepare plans to rejuvenate the lakes and rehabilitate the informal settlements around them. Thus, these four triggers gave the necessary push for the lake development and interlinking of lakes.

**Project Information**

The technical team at AUDA came up with the idea of utilizing the traditional Gamtalavs as natural retention basins for stormwater disposal after connecting them locally with their neighborhoods. These lakes were to be interlinked to maintain the water level and discharge the excess water influx through the interlinking eventually into the Sabarmati River.

Three objectives were defined for the project: i) to resolve the issues of waterlogging and strengthen flood resilience through lake interlinking; ii) to ensure water security for Western Ahmedabad through lake rejuvenation and groundwater recharge, and iii) to improve the livability or quality of life of Western Ahmedabad through the creation of green and recreational spaces.

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 included - development of sewerage network in the lake vicinity; construction of public toilets and water standposts; development of the stormwater network in the lake vicinity; construction and widening of roads according to the TPS in lake precincts; rehabilitation and resettlement of informal settlements; reclamation of land for recreational purposes; deepening and desilting of lakes; construction of percolation wells; architectural landscape & development of recreational spaces and dry season recharge with Narmada water.

The Interlinking of Lakes is aimed at harnessing the combined potential of the lakes as a collective system for water augmentation and flood mitigation. The approximate capacity of the Interlinkage system of the lakes in the first phase undertaken by AUDA was more than 3.3 MCM. The Interlinkages were conceived in two clusters based on topography and outfall. Cluster 1 comprised Sola, Thaltej, Bodakdev, Makarba, Memnagar, Vastrapur, and Prahladnagar lakes. Cluster 2 comprised Khoraj, Tragad, Chharodi, Jagatpur, Gota, R.C. Technical, Ranip, Chandlodia, Yadudi, Dev City lakes, and Chainpur was to drain in the Gota-Godhavi Canal.

The first phase of the LRIL project for nine lakes costing INR 440 million and was completed in 2006. AUDA utilized its internal resources for this phase of the project. Further, after boundary expansion, the AMC continued with the rejuvenation task for nine lakes under the project of 'Preservation of Water Bodies'. A fund of INR 1,040 million was approved under the JNNURM scheme for the purpose.

**Current Status of the 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 for 18 lakes.

All the lakes except for Memnagar, Vastrapur, Jagatpur, Chharodi, and Tragad were found to be connected to the interlinked network. A total of nine lakes were completely redeveloped with green recreational spaces around them, which were Vastrapur, Memnagar, Prahladnagar, Bodakdev, Chandlodia, RC Technical, Yadudi, Ranip, and Khoraj lakes. Only the lakes of Thaltej, Makarba, Chharodi, Gota, and Chainpur showed medium water levels. The lakes of Prahladnagar, RC Technical, Vastrapur, Yadudi, and Dev City had very low water levels consisting mostly of sewage inflow. Percolation wells were visible only at Bodakdev, Vastrapur, Khoraj, Ranip, and Chandlodia. The condition of such wells was seen as damaged at most of the lakes.

To sum up, the lakes were lacking in interventions meant for lake rejuvenation and water security. Many lakes were vulnerable to receiving sewage discharge and solid waste dumping. The redeveloped lakes were in better condition with green spaces. However, they were either dried up or had sewage discharge in them. Among all the three objectives of interlinking, groundwater recharge, and recreation of the green spaces, neither Cluster-1 nor Cluster-2 fully accomplished the objectives as of date.

**Impacts of the Project:**

1. **Environmental Impacts:**

   **A. Impact on Flood Resilience:**

   The project aimed at flood resilience through enhancement of storage capacity of the lakes and augmentation of flood capacity through interlinks. The flood resilience was assessed by studying urban flooding, extreme rainfall events, and system redundancy. The data on water stagnation points were collected from AMC. The analysis showed no major stagnation points on the west of Sarkhej-Gandhinagar Highway where the network had an elaborate coverage. The other water stagnation points were either near the missing links or the unmaintained lines. Therefore it could be said that the network needed to be maintained well and also expanded to the un-served areas.

   Ahmedabad has faced three extreme rainfall events in the last decade after the Cluster-1 and Gota arm of Cluster-2 had become functional. On 27$^{th}$ July 2017, the city recorded a rainfall of 180 mm. An uncontrolled heavy inflow of stormwater had spilled out the Chandlodia Talav flooding its nearby low-lying settlements. Similar flooding incidents had occurred in past at the lakes of Vastrapur, Prahladnagar, and Sola in 2010. There is no mechanism to monitor the water levels; nor is there a 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 in place for extreme events.

   The current operational capacity of the interlinked lake network is about 3 MCM with 13 connected lakes out of 18 in the network. The addition of other unconnected lakes within the network would increase the capacity of the system by 1.05 MCM. 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 envisioned capacity.

   **B. Impact on Groundwater:**

   The project aimed at recharging groundwater to ensure water security for the city. The long-term data (2003-2019) for two groundwater stations near Vastrapur and Sola lakes shows an increase of 0.71 m per year and 2.2 m per year in the levels. The data from Ghuma station shows a decrease in the levels. The annual rainfall patterns of Ahmedabad from 2003-2019 do not exhibit any relation with this increase or decrease. The lakes of Vastrapur and Sola were intervened with under the project and the project could be credited for the increase of groundwater levels in those areas. However, no LRIL interventions and a real estate boom could be associated with the decrease in water level in the Bopal-Ghuma region.

**C. Impact on Land Cover:**

Four representative lake plots were analyzed to draw inferences on the impact of interventions on the lake land cover. The analysis of data suggests that the overall area of water bodies has decreased in the project lakes irrespective of the status of surrounding redevelopment. However, the redevelopment implemented under LRIL has been useful in preventing the growth of encroachments and controlled the intensity of solid waste dumping around the lakes. The redevelopment in most cases has happened by reclamation of lake land effectively reducing the overall water spread of the lake. The lakes like Thaltej and Sola were still under threat due to encroachment because of a lack of interventions.

**D. Impact on Water Quality:**

Water quality was monitored for 10 lakes through grab sampling. 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 Biochemical Oxygen Demand (BOD) of all the lakes was much higher than the acceptable range. The higher pH and BOD may be due to run-off characteristics from the surrounding areas and sewage disposal in the lakes. This exhibits lacunae in the LRIL project as it did not consider any strategy for the treatment of the runoffs as a component of the project.

**E. Green Cover:**

The creation of lake gardens had been one of the components under the LRIL impacting the urban vegetation cover. The vegetation has almost doubled in most of the redeveloped lake precincts while the lakes without interventions exhibited a decrease in vegetation cover. The burgeoning real estate, reduced agricultural activity, and solid waste dumping were the prime reasons for the reduction in green cover. Lack of maintenance resulted in a decrease of green cover at Ranip and Yadudi Lakes. It is evident therefore, that redevelopment under LRIL along with proper maintenance has a positive impact on the vegetation cover around the lakes.

**2. Socio-Economic Impacts:**

**A. Creation of Green Open Spaces and Recreational Areas**

Gardens were created during redevelopment around eight lakes. The lake gardens are in good condition and maintained on a Public-Private Partnership model by the Mother Dairy Company. The company gets a direct outlet for the sale of its products in the same garden. The gardens without maintenance agency were in poor condition like at Ranip and Yadudi. These lake gardens constitute 10% of the total green space within the AMC region. Hence, the LRIL project has contributed effectively to the augmentation of green open spaces in Ahmedabad.

**B. Rehabilitation & Resettlement:**

The 314 households living in slums at the periphery of lakes were rehabilitated to EWS Housing constructed by AUDA priced at INR 62,500 and INR 81,500 per unit. The rehabilitation resulted in improved housing conditions and access to basic services accompanied by a shift to formal housing. It minimized the risks of damage to life or property due to flooding and to health due to the degraded water body. However, the units came along with a loan from AUDA for the beneficiaries at an installment of INR 550 per month.

**C. Real Estate Prices**

The primary data from developers display an increase of 5-10% in the capital values and a premium of INR 50-150/ sq.ft. for lake-facing properties post the project implementation. However, the lack of maintenance of redeveloped lakes and no redevelopment at other lakes led to the normalizing of the increase in prices.

The impacts of LRIL are limited as the project was not completed and all the lakes were not redeveloped. Therefore, the potential of positive benefits have not been realized to the fullest.

**Mainstreaming Lake Redevelopment & Interlinking of Lakes project as a Sustainable Urban Infrastructure Practice**

The LRIL is a complex project that involves many aspects, including institutional and legislative support. The study suggests a comprehensive approach with regional level and city level interventions for successful planning and implementation of similar projects. The study suggests that it would not be prudent to look at the water bodies in isolation while working on mitigating the severe rainfall impact of the climate change. A comprehensive approach is necessary for environmental protection and safeguarding natural water resources. Hence, it is recommended that a regional level (district level) comprehensive Watershed Management Plan should be prepared. If LRIL-like 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 have the support of city level statutory and legal provisions.

The DP-TPS-LAP is a legislative mechanism that enables the development authority to plan at both the macro and micro levels. 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 implementation. Additionally, a regional level District Watershed Management Plan should be prepared for robust water resource management and mitigating climate change impacts. The authorities should incorporate the proposals and recommendations of the district-level Watershed Management Plan while preparing the DP, TPS and LAP.

# CASE BACKGROUND

## URBANIZATION IN THE INDIA AND WORLD

According to the UN report on Revision of Urbanization Prospects in 2018, 55% of the world population lived in urban areas. According to the projections in the report, the urbanization world over would increase to 68% by 2050. Interestingly almost 90% of the increase in urban population is projected to be taking place in Asia and Africa and that too in just a few countries. Together India, China and Nigeria would add more than 35% of the projected growth of the world's urban population from 2018 to 2050 (UNDESA, 2018).

Urbanization in India is still low compared to the other developing nations of the world (31% in 2011 compared to other developing countries like China - 45%, Indonesia 54% Mexico 78% and Brazil 87% (Planning Commission, 2016). The rapid growth of the Indian cities is unprecedented. By 2050, India alone would have added 416 million urban dwellers more than any other country in the same period. Cities in India will also expand and six among the top 50 urban agglomerations would be located in the country (UNDESA, 2018).

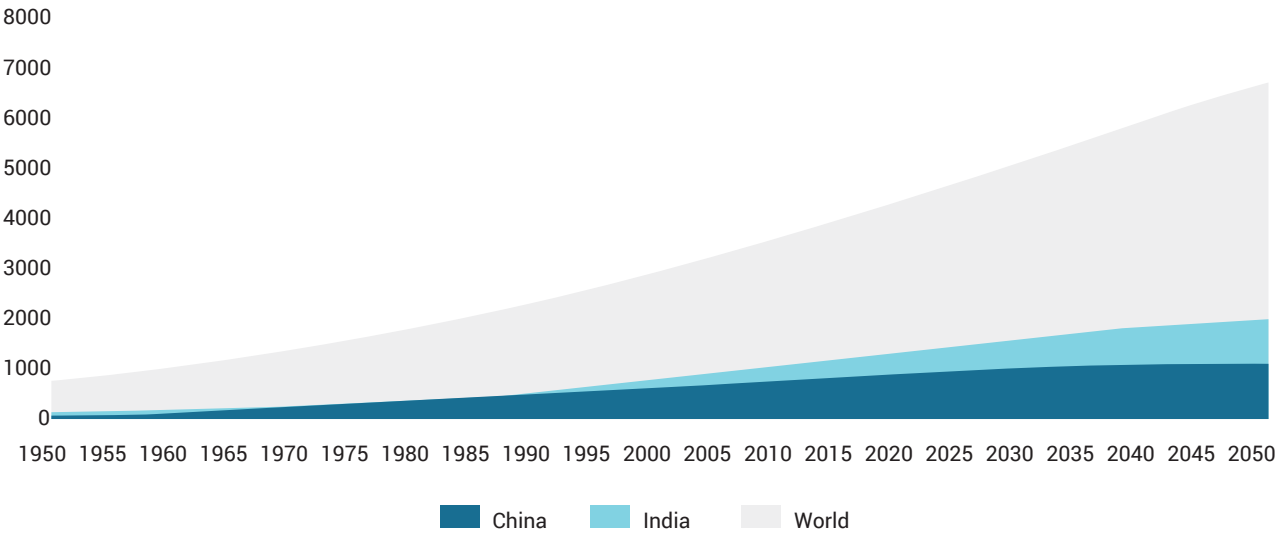


*Figure 1-1: India and China are projected to add dominant share in the projected world population worldwide*
*Source: (UNDESA, 2018)*

## CLIMATE CHANGE AND CITIES

This increase in urbanization and the size of the cities introduces fresh challenges for the sustainable management of cities. These challenges become more critical in the face of increased risks due to climate change. The fifth assessment report published by IPCC, apart from other risks identifies these major risks for Asia:

1. Increased flood damage to infrastructure, livelihoods, and settlements
2. Heat-related human mortality
3. Increased drought-related water and food shortage.

This is interesting because two of the three risks identified are directly associated with the management of water resources.

Furthermore, for the urban areas, the report identifies with very high confidence interval the risks from increase of storms and extreme precipitation, inland and coastal flooding, drought, water scarcity (IPCC, 2014). Therefore, urban areas are at the crossroads facing the pressure of climate change against the ever-increasing size of these areas especially in the context of cities in Asia, also with a challenge to grow sustainably.

In the global community, to respond to these pressures of urbanization against the backdrop of the emerging challenges, the United Nations introduced the Sustainable Development Goals. Goal number 11 of the SDGs is: “Make cities inclusive, safe, resilient and sustainable.” One of the targets of this goal of the SDGs is to develop policies and plans for adaptation to climate change and resilience to disasters.

# CLIMATE CHANGE AND DISASTER RISK IN INDIA

India faces a multitude of water-related risks induced by climate change with floods & droughts being the most common among these. The histograms below show the decadal frequency of drought and flood events in India from 1900 to 2020. There is a visible trend of an increase in droughts and floods from the beginning of the 20th century to the present decade.

Roxy et al. have also estimated a threefold increase in extreme events over central India from 1950 to 2015 (Roxy et al., 2015). Two different studies undertaken by IIT Gandhinagar on the future projection of precipitation and droughts, project an increase in flood and drought risk (Ali et al., 2019) (Aadhar, 2020).

Cities in India are at the forefront of these risks as discussed. In the last few years, both incidences of flooding and water scarcity have impacted many Indian cities. The table-1 shows the incidences of urban floods in the major cities in India. Interestingly all the megacities in India have faced multiple incidences of flooding in the last couple of decades. Also, the larger the cities the greater are the risks and induced losses due to flooding.

There is a connection visible here. Most of these cities which have faced the flood incidences are also some of the most water-scarce cities in India. According to the Niti Aayog report, 21 of the major Indian cities risk running out of ground water as early as 2020 (Niti Aayog, 2018).

Therefore, most of the cities in India face the problem of plenty during some months and scarcity of water during others. Sustainable management of water resources seems to be the only way out for Indian cities. The coming sections discuss the efforts of other countries the world over and how they deal with this conundrum of water management. The authors also discuss measures for water resources management adopted in Indian cities in the past.

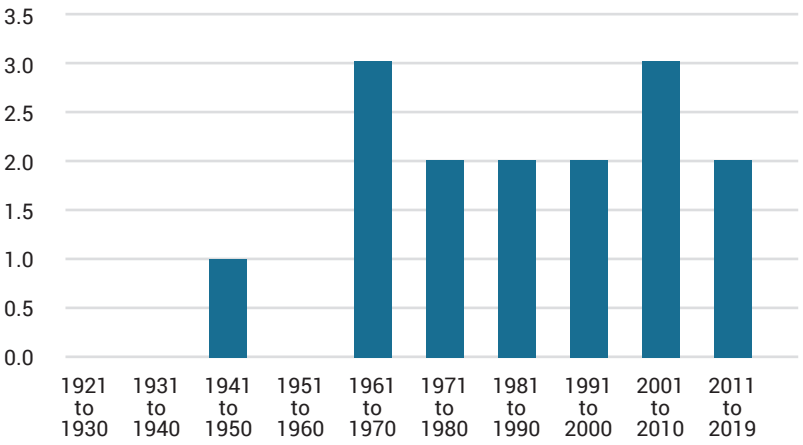


*Figure 1-2: Data on Decadal frequency of droughts in India shows increasing incidents of drought*

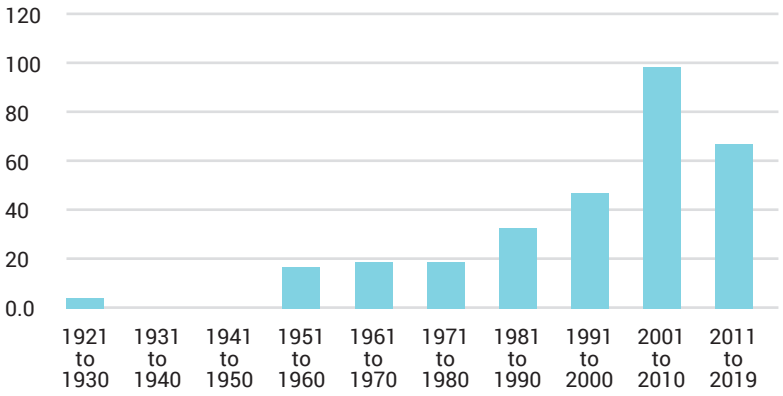


*Figure 1-3: Data on Decadal frequency of floods in India shows drastic increase in incidents of flood*

*Source: Authors' analysis with data from The International Disaster Database (https://www.emdat.be/)*

*Table 1-1: Incidences of flooding in major Indian cities*

| City | Year of flood incidence | Population (in Million) |
|---|---|---|
| Mumbai | 2005, 2007, 2015 | 18.41 |
| Delhi | 2002, 2003, 2009, 2010, 2013, 2016 | 16.31 |
| Kolkata | 2007, 2013 | 14.11 |
| Chennai | 2014, 2015 | 8.7 |
| Bengaluru | 2005, 2009, 2013 | 8.5 |
| Hyderabad | 2001, 2002, 2003, 2006, 2008 | 7.75 |
| Ahmedabad | 2001 | 6.35 |
| Surat | 2006, 2013 | 4.59 |
| Jamshedpur | 2008 | 1.34 |
| Srinagar | 2014, 2015 | 1.27 |

*Source: (Census, 2011) (NIUA, 2016)*

## SUSTAINABLE WATER MANAGEMENT IN CITIES - EXPERIENCES

Sustainable water resource management through linkages of green and blue infrastructure is becoming a go-to strategy for urban planners and managers for managing the water crisis. The next section discusses some of the strategies adopted by the cities the world over. These include a wide range from policy, governance to blue green infrastructure focused development plans. Table-2 provides a brief on strategies adopted for sustainable water management.

In international practice, an integrated approach of interlinking blue and green infrastructure is followed. In addition, in both these cases the urban local body or the city department has taken the lead in formulation, planning and implementation. Public Participation is encouraged in both cases but at different levels of the project lifecycle.

Community members and Citizen Based Organizations anchor the cases of sustainable water management in India. These approaches rely heavily on the presence of an active citizen network or enlightened community leaders.

The case of Ahmedabad Lake Interlinking is therefore unique. It is the first approach in India wherein an urban local body has adopted an integrated approach for water management and lake development. A deep dive into the case and drawing learnings from it would be useful for other ULBs in India.

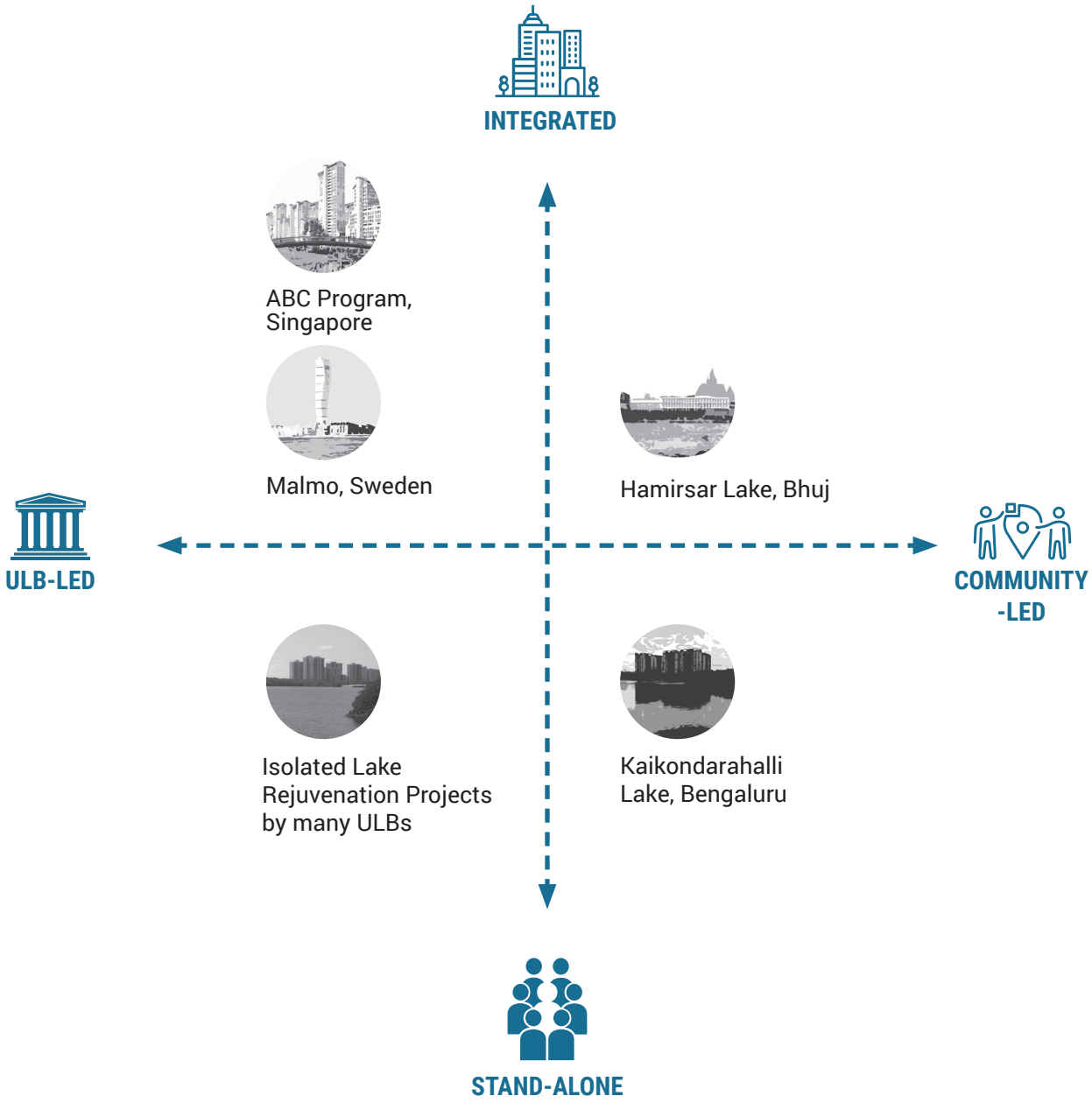


*Figure 1-4: SUWM experiences with respect to the leading institution and implementation approach*

*Table 1-2: Key Details of Sustainable Urban Water Management Experiences*

| Sr. No. | City Country Year of Implementation | Primary Focus | Policy, Regulation | Development Plan | City wide approach | Public Participation | Lead Driver | Key Actions |
|---|---|---|---|---|---|---|---|---|
| 1 | ABC Program, Singapore (2006) | Master Plan Approach for Water Management | Direct - Through ABC Water Design guidelines issued by PUB | The city nation divided onto three major watersheds. A development plan approach for all the watersheds | All the elements of watershed tributaries, reservoirs and canals are integrated | Indirect public participation through demonstration projects | Public Utilities Board, Singapore | - Creation of Watershed Managers<br>- Integrated approach<br>- Design Guidelines<br>- Demonstration Projects |
| 2 | Augustenborg, Malmo, Sewden (1998) | Sustainable Drainage Management for Flood Control | Indirect | SuDS is part of the Development Planning Process | This small project is part of Sustainable Urban Draingage Project | Public Participation was ensured during the design stage of the project | The Service Department, City of Malmö | - System of green roofs<br>- Creation of retention ponds<br>- Creation of micro catchments forstorm water management<br>- Development of Botanical Gardens |
| 3 | Kaikondarahalli Lake, Bangalore India (2008) | Ecological Lake Rejuvenation | Indirect | Indirect | The lake is part of a chain of lakes in Bangalore which was developed to provide water to the city of Bnaglore | This initiative was public led and resulted into development of Trust for Lake the Mahadevpura Parisara Samrakshane Mattu Abhivrudhi Samiti. | Local citizens who later developed Mahadevpura Parisara Samrakshane Mattu Abhivrudhi Samiti | - Ecological lake restoration plan<br>- Diversion of sewage<br>- Creation of public open spaces<br>- lake Festivals |
| 4 | Hamirsar Lake, Bhuj, India (2001) | Water Recharge and Availability for Arid Region of Bhuj | Indirect | Groundwater recharge and watershed management integrated in development planning process | Traditional linkages of all lakes with watershed revived and lakes desilted and redSoeveloped | Creation of Jalsrot Sneh Samvardhan Samiti for Public Participation | Arid Communities and Technologies, NGO | - Recreation of old linkages of lakes with catchment<br>- Diversion and treatment of sewage<br>- ICT activities for connecting the lake to the people<br>- Extensive studies of lake ecosystem |

*Source: (Centre for Liveable Cities, 2017), (Climate Adapt, 2017), (Stahre, 2005), (Nagendra, 2016) & (Mehta & Mehta, 2016)*

# OBJECTIVES AND METHODOLOGY

The key question that has been addressed in the case is the impact of innovative projects like the Lake Redevelopment and Interlinking of Lakes Project (LRIL) on building flood resilience for the city of Ahmedabad. The main objectives of the case are:

1. To understand the triggers that led to the Lake Redevelopment and Interlinking of Lakes Project (LRIL).
2. To study the project's conceptual, technical, and financial details along with the present status of the lakes.
3. To analyze the environmental and socio-economic impacts of the project.
4. To suggest recommendations for implementation of such projects involving blue and green infrastructure.

The methodology involved primary and secondary research supported by both qualitative and quantitative data. These included literature review through research papers, government documents and reports, relevant legislations, field observations, stakeholders' interviews, and online surveys as well as the collection of water samples to support comprehensive case-based teaching material.

The literature review indicated what the events of the triggers were and who were the stakeholders involved with those events. Consultations with the state actors from Ahmedabad Urban Development Authority (AUDA) & Ahmedabad Municipal Corporation (AMC) and non-state actors (Researchers & Activists) helped in developing the understanding of the supply side and demand side issues concerning the infrastructure provisions in Ahmedabad. Media reports and interviews with key ex-officials of the Ahmedabad Urban Development Authority (AUDA) provided information on Climate Extreme as a trigger. The role of Groundwater Depletion as a trigger was understood with the help of data from the Central Ground Water Board (CGWB), Expert Interviews, and Media Reports. The lost water bodies were identified through historical maps, Google earth satellite imagery, and geospatial analysis tools. A few lost lakes were selected within the geographical extent of Ahmedabad. Their records from the Town Planning & Valuation Department (TPVD) and timelines of Google Earth were studied to derive prevalent market and administrative mechanisms that led to lake encroachment. The consultations with planning professionals and ex-officials in local administration strengthened the knowledge on these mechanisms.

Published and non-published research was referred to in order to understand the project specifics. The consultations and the secondary data provided by key officials at AUDA and AMC augmented the information regarding the project. Various site visits and collection of primary data helped in understanding the status quo of the lake sites across Ahmedabad. Historical imagery and mapping of physical characteristics were undertaken to study the evolution over time. The environmental impact was assessed with the help of primary and secondary data. The impact on flood resilience, groundwater table, water quality along with impact on vegetation has been considered. The impact on flood resilience was studied by triangulating the data from IMD, AUDA & AMC, and media reports. The state of water quality was determined through lab testing of samples collected from the sites. The long-term secondary data from CGWB helped in understanding the impact on groundwater. The impact on vegetation was studied through an NDVI analysis of lake-buffer area in a pre-and post-project timelines through remote sensing satellite data.

The environmental and socio-economic influences were analyzed as part of the impact of the LRIL project. The impact on flood resilience was studied through the aspects of urban flooding, climate extremes, and system redundancy. The data from AMC and media reports on water stagnation points were cross-referenced with the coverage of interlinked networks to locate the urban flooding close to the interlinked system. The water stagnation points were then checked with the functioning status of the links to derive inferences. The daily rainfall data from IMD (1901-2020) was analyzed to understand the extreme rainfall events in Ahmedabad after the implementation of the project. Literature resources and audio-visual media contributed to understanding the performance of the interlinked system during such events. The lake capacity data from AUDA & AMC provided information on the system capacity. The achieved capacity was analyzed with the help of consultations with AMC officials and site visits to the lakes. The impact on groundwater was analyzed through long-term data on groundwater levels from CGWB from stations near the lakes. The data was compared to the annual rainfall of the city to draw inferences on the crosslinks. Further, the change in levels was linked to the qualitative data from the site to analyze the impact. The impact on lake land was analyzed through the comparison of land cover at lakes before the project and after the project. Four lakes at different stages of implemented interventions were studied to draw inferences on the impact on the lake lands. Water samples were collected from the lakes to study the impact on the water quality of the interlinked lakes. The impact on vegetation cover was analyzed through NDVI analysis of the lake-buffer areas in a pre-project (2002) and post-project (2017) timeline.

The socio-economic impacts included - the creation of green & recreational spaces, rehabilitation & resettlement of households and impact on real estate prices. The creation of public green space was studied from the data provided by the Garden Department under the AMC. Site visits and consultations helped in analyzing the maintenance and management of the lake gardens. The impact on the rehabilitated households was studied through data from AUDA and media reports. Data regarding project cost and funding mechanism was gathered from AUDA. The change in land and property prices was studied through consultations with real estate professionals and by conducting an online survey.

Consultations with key officials and sector experts were conducted for the implementation and inclusion of sustainable infrastructure projects that involved the Interlinking of Lakes across Indian cities. Legislations and statutory planning mechanisms were reviewed for suggesting inclusions or recommendations. The ongoing COVID-19 pandemic restricted the collection of data from relevant households.

# DETAILED CONTENTS OF THE CASE STUDY

The Case Study has been organized into three folders. The contents of the folders are:

## FOLDER A: INTRODUCTION TO THE CASE

Terms of Use and Agreement; Foreword; Acknowledgements; Preface; Abbreviations; Background; Objectives and Methodology; Detailed Table of Contents; Executive Summary

## FOLDER B: MAIN CASE

### Chapter 1: Ahmedabad City & Triggers for Interlinking of Lakes Project

The chapter begins with the water heritage of Ahmedabad and gives a general overview of the city - its demographics, spatial extent, environs and the climate. The latter half of the chapter describes the backgrounds triggers that led to the Lake Redevelopment and Interlinking of Lakes (LRIL) project. The sections detail the role of Climate Extremes, Groundwater Depletion, Lake Encroachment, Citizen Activism and Judicial Intervention as the milestones leading to the project conceptualization by AUDA.

### Chapter 2: Lake Redevelopment & Interlinking of Lakes Project

This chapter describes the conceptualization, vision and objectives of the LRIL project. Further, it details the components, funding, implementation timeline, institutional structure and the administrative procedures of the project. The unique component of interlinking has been included in the chapter along with the information on clusters within the interlinked network. The subsequent sections describe the current status of the lakes in relation to the project objectives. The chapter concludes with a detailed graphical analysis of the current status of all the interlinked lakes.

### Chapter 3: Impact of Lake Redevelopment & Interlinking of Lakes Project

The environmental and socio-economic impacts of the LRIL project have been described in this chapter. The effect on flood resilience of the city regarding urban flooding, climate extremes and system redundancy has been analyzed here as part of the environmental impact. The influence on the groundwater table, lake land, water quality and vegetation cover too are covered under the environmental impact. Further, the socio-economic impacts have been analyzed in terms of creation of green & recreational spaces and rehabilitation & resettlement. The impact on the real estate market is also part of this section as it is an indicator of the existent physical and social infrastructure within and around a location.

### Chapter 4: Mainstreaming Lake Redevelopment & Interlinking of Lakes (LRIL) projects as a Sustainable Urban Infrastructure Practice

This chapter suggests a comprehensive approach with regional level and city level interventions for successful planning and implementation of similar projects involving blue and green infrastructure.

## FOLDER C: TEACHING NOTE AND CASE ARCHIVE

### Teaching Note

The purpose of this folder is to communicate to the user/ instructor the possibilities of utilizing the case study. However, it should be treated as guiding principles and the users might develop their own way of teaching.

### Possibilities of Use

This section is a note providing guidance on using the case as a module in various courses or as an independent teaching module. The case could be useful as a part of a course or training program covering - Environmental Resources in Urban Planning/ Socio-Ecological Systems; Cities and Climate Change; and Integrated Infrastructure Planning/ Green Infrastructure.

### Pedagogical Possibilities

This section discusses the pedagogical possibilities as an independent module. It prescribes the ways in which the case study can be delivered as part of a Classroom Discussion, Classroom Debate, Research and Analysis, Environmental Cost Benefit Analysis/ Ecosystem Services, or Site Exposure session.

## Probing questions

This section provides probing/ guiding questions to encourage discussion on case chapters.

## Way Forward

This section explains the utilization of this case study for future research on - how cities can plan climate change strategies around the blue and green spaces; developing an integrated approach for mainstreaming blue and green infrastructure projects; and exploring the valuation of ecosystem services of infrastructure projects.

## Case Archive

This section comprises the data sets that were used for analysis in this case study. The intent is to provide the tutor with raw data for reference and value addition. The case archive includes interviews, maps, matrices, infographics, a list of the raw data referred, and relevant water management legislation of the country and Gujarat state.

The Archives also contain a folder for complementary reference material on Folders A & Folder B.

# REFERENCES

AUDA. (2020, August 14). Interlinking of Lakes - AUDA. Ahmedabad, Gujarat, India.

Centre for Liveable Cities. (2017). Urban System Studies- The Active, Beautiful, Clean Waters Programme: Water as an Environmental Asset. Singapore: Centre for Liveable Cities.

Climate Adapt. (2017, June 27). Urban stormwater management in Augustenborg, Malmö. Retrieved from Climate ADAPT: Sharing adaptation information across Europe: https://climate-adapt.eea.europa.eu/metadata/case-studies/urban-storm-water-management-in-augustenborg-malmo

DNA. (2010, August 10). Overflowing lakes in Ahmedabad a health hazard: Residents. Retrieved from DNA INDIA: https://www.dnaindia.com/india/report-overflowing-lakes-in-ahmedabad-a-health-hazard-residents-1421284

Goswami, S., Parthasarathy, R., & Iyer, M. (2012). State of the Environment Report - Gujarat. Gandhinagar: ENVIS.

Gujarat Samachar. (2000, July 15). Intense Rains kill at least 10 people in Ahmedabad. Gujarat Samachar.

Gujarat Tourism. (2021, April 26). Hamirsar Lake Bhuj. Retrieved from Gujarat Tourism: https://www.gujarattourism.com/kutch-zone/kutch/hamirsar-lake--bhuj.html

Malmo stad. (2021, April 26). Malmo stad: population. Retrieved from Malmo stad: https://malmo.se/Fakta-och-statistik/Facts-and-statistics-in-english/Population.html

Mehta, D., & Mehta, M. (2016). Moving Bhuj towards Water Security. Ahmedabad: CEPT University.

Nagendra, H. (2016). Restoration of the Kaikondrahalli lake in Bangalore: Forging a new urban commons. Pune: Kalpavriksh.

Pandya, R. (2020, June 26). Consultation on Impact of Interlinking of Lakes Project in Ahmedabad. (T. Bose, Interviewer)

Sheth, D., & Iyer, M. (2021). Local water resource management through stakeholder participation: case study, arid region, India. Water Practice & Technology, 333-343.

Spodek, H. (2001). Ahmedabad 2000: Crises and Response. Economic and Political Weekly, 1627-1638.

Stahre, P. (2005). 15 Years Experiences of Sustainable Urban Storm Drainage in the City of Malmo, Sweden. World Water and Environmental Resources Congress 2005. Anchorage.

Thakker, H. (2020, August 14). Planning and Implementation of Large Infrastructure Projects: Lake Interlinking Project - Ahmedabad Experience. (M. Iyer, Interviewer)

UNDESA. (2018). World Urbanization Prospects: The 2018 Revision, Online Edition.

UNDP; NITI AAYOG. (2015). Social Sector Service Delivery: Good Practices Resource Book. New Delhi: United Nations Development Programme.

Urban Flooding, India - Urban Climate Change Factsheets In India - Urban Climate Change Fact Sheets. New Delhi, India: National Institute of Urban Affairs, 2016

# Notes

CUPP CENTER FOR URBAN PLANNING AND POLICY CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION CEPT UNIVERSITY

**CENTER FOR URBAN PLANNING AND POLICY**

Near AES Boys Hostel Campus, University Ground, Navrangpura,

Ahmedabad - 380 009