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CapaCITIES
LOW CARBON • CLIMATE RESILIENT • CITY DEVELOPMENT

Building Climate Resilience in Indian Cities

Compendium of Case Studies



Prepared by
ICLEI South Asia



About the Report:

This 'Compendium on Case Studies: Building Climate Resilience in Indian Cities' showcases best practices from the CapaCITIES Phase II Project, implemented across 8 cities in India with the support of the Swiss Agency for Development and Cooperation (SDC), India. The project has supported cities to prepare Net Zero Climate Resilient Action Plans, conduct sectoral technical assessments, and pilot innovative climate solutions that can be scaled up and replicated across urban contexts in India.

The case studies are organized around key themes of climate action, including renewable energy, clean mobility, urban biodiversity and greening, climate disaster preparedness and risk management, solid waste management, and green buildings. Collectively, these case studies illustrate climate-resilient and sustainable solutions and pathways of how Indian cities are integrating these best practices into their planning and implementation. These efforts contribute to India's Net-zero Vision by 2070 and support the global agenda for sustainable development.

Disclaimer:

While every effort has been made to ensure the correctness of data and information presented in this compendium, neither the authors nor ICLEI South Asia, project implementation partners, the project funder, nor participating cities do not assume any legal liability for the completeness, accuracy or inferences drawn from the material contained herein or for any consequences arising from the use. The views and interpretations expressed in this publication do not necessarily reflect those of the supporting organizations.

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FOREWORD



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It gives me great pleasure to present the *Compendium of Case Studies: Building Climate Resilience in Indian Cities*, which showcases pioneering initiatives on urban resilience under the Capacity Building for Low-Carbon and Climate Resilient Cities in India (CapaCITIES) Program. Implemented in close cooperation with the Embassy of Switzerland in India, the program represents a long-standing collaboration with partner cities and states to integrate climate action into urban planning, governance and development.

Since its inception in 2016, CapaCITIES has been at the forefront of cooperating with the Indian cities in addressing the multifaceted challenges of urbanization and climate change. By combining technical assistance, strengthening governance structures and facilitating peer-to-peer exchanges, the project has enabled cities to design and implement practical climate actions that strengthen urban resilience and reduce greenhouse gas emissions. Initiatives such as the formation of dedicated climate action cells, adoption of low-emission technologies and development of city-level Climate Resilient and Net Zero Action Plans are testimony to this effort.

Based on India's national goal of achieving Net Zero emissions by 2070, cities play a critical role as dynamic centers of economic growth, service delivery and innovation. Drawing from the experiences in mainstreaming renewable energy, sustainable mobility, water management and solid waste solutions, cities are building more livable, inclusive and climate-resilient urban futures.

The case studies presented here capture the journey of participating cities and also offer valuable lessons and replicable models for cities embarking on their own climate action pathways. These experiences have relevance beyond India and offer practical and adaptable solutions that can inform cities across Asia and Africa facing similar challenges. They present a broader vision of sustainable urban transformation where local leadership, institutional capacity and community participation come together to drive national and global climate goals.

I hope this compendium serves as an inspiration and a practical resource for policymakers, practitioners and development partners working to shape resilient and low-carbon cities for the future.

Yours Sincerely,

Philippe Sas
Head of International Cooperation

FOREWORD



We are pleased to present the “Compendium on Case Studies: Towards Climate Resilient and Sustainable Indian Cities,” which showcases pioneering efforts from the CapaCITIES Project cities. The initiatives have been supported by the Swiss Agency for Development and Cooperation (SDC) since 2016. We appreciate SDC for acknowledging the urgent need for climate resilience and sustainability in cities, which are vital growth centers benefiting millions of residents. As cities worldwide advance in climate action, it is encouraging to see Indian cities proactively making positive changes locally for global sustainable development. These efforts will significantly bolster India’s climate commitments and play a vital role in achieving Net Zero by 2070, paving the way for a thriving Viksit Bharat (Developed India) by 2047.

The case studies in this compendium are organized around key themes for climate action. These themes include harnessing renewable energy with rooftop and floating solar plants, enhancing urban biodiversity through Miyawaki forests, promoting low-carbon mobility zones, and effective solid waste management. They also focus on efforts for improving disaster preparedness through flood early warning systems and lake restoration, as well as climate-smart infrastructure, such as green-certified buildings. Together, these initiatives reflect the integrated approaches that Indian cities are adopting to foster resilience and sustainability, serving as models for broader implementation towards healthier and climate-ready urban future.

We extend our sincere gratitude to the SDC, participating cities and states, and all our partner agencies for their continued collaboration and commitment. Together, we aim to build momentum towards cities that are not only climate-ready but also inclusive, resilient, and sustainable for future generations.

Yours Sincerely,

Emani Kumar

Deputy Secretary General, ICLEI
Executive Director, ICLEI South Asia

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CASE STUDY 1

Implementation of 154 kWp Floating Solar PV Power Plant at Periyakulam Lake, Coimbatore



CASE STUDY 1

INTRODUCTION

Coimbatore, located along the banks of the Noyyal River, is the second largest city in Tamil Nadu. The Coimbatore City Municipal Corporation (CCMC) has embraced renewable energy (RE) initiatives, including the installation of over 6.3 MW (as of 2025) of solar power capacity, which has helped reduce dependence on fossil fuels while promoting clean energy transition and lowering of Green House Gas (GHG) emissions. With the growing demand for renewable energy and limited land availability, innovative solutions like floating solar power PV plants have gained traction globally.

Recognizing this potential, the CCMC explored the implementation of Floating Solar Photovoltaic (FSPV) plants in the lakes of Coimbatore through a feasibility study supported by CapaCITIES Phase II project, funded by the Swiss Agency for Development and Cooperation (SDC). Based on multiple factors, the CCMC then chose the Periyakulam lake, where eco-restoration efforts had been carried out under the Smart City Mission (SCM), to implement a pilot demonstration project of 154 kWp capacity with co-financing from the CapaCITIES Phase II project and the “Namakku Naame Thittam” Scheme of Government of Tamil Nadu.



**Floating Solar Photovoltaic
Installation at Periyakulam Lake,
Coimbatore**

PROJECT OVERVIEW

Location: Periyakulam Lake in Coimbatore, Tamil Nadu, India, spanning an area of 350 acres. The lake has a Full Tank Level (FTL) of 5.82 m and Maximum Water Level (MWL) of 6.51 m and Tank Bund Level (TBL) of 7.88 m.

Capacity and Area: 154 kWp (DC side) capacity FSPV plant installed over 0.2 hectares of Periyakulam lake area

Funding Partners: The total cost of the project was **INR 14.5 Million (US\$ 172,742)**, with 50% of the project cost funded by Government of Tamil Nadu under 'Namakku Naame Thittam' Scheme and the remaining 50% of the project cost was funded by the CapaCITIES Phase II project, supported by the Swiss Agency for Development Cooperation (SDC), India.

Exchange rate, 1 USD = INR 83.94, dated 01.09.2024

CASE STUDY 1

Purpose: To generate renewable energy for municipal consumption while utilizing water bodies effectively, reducing impacts from surface evaporation and land use.

Grid Connectivity: The electricity generated will be supplied to Tamil Nadu Power Distribution Company Limited (TNPDC), using a HT transformer installed on the lake bund.

Stakeholders: Directorate of Municipal Administration (DMA), Tamil Nadu Power Distribution Company Limited (TNPDC), Coimbatore City Municipal Corporation (CCMC), Tamil Nadu Electrical Inspectorate, and Government College of Technology, Coimbatore

TECHNICAL SPECIFICATIONS

Item	Descriptions
Solar Panels	FSPV plant consists of 280 solar modules, arranged as per specification on the floaters to optimize energy generation.
Type of Solar PV modules	Mono c-Si PERC, 550 Wp, 1000 V
Floating Platform	Thermoplastic, High Density Poly Ethylene (HDPE) based Floaters of 1410*560mm size with UV stabilizer
Anchoring and Mooring System	Helical / dead weight anchors and mooring cables made of galvanized steel
Power Converter	2 Grid-tied string inverters of 75 kW rating
Power Transformer	150 kVA, LV / 11 kV Oil Natural Air Natural (ONAN)
Grid Connectivity	Feed in at 11 kV (High Tension (HT) connection) to the local grid
Power Generation	Generates around 230,000 kWh (units) per annum
Safety	2 lightning arrestors, surveillance cameras and weather sensors

CASE STUDY 1



154 kWp FSPV Plant (Clockwise from top left: Site location map with HT evacuation point, aerial view of the floating solar array, inverter control room, and close-up of solar modules on floaters)

PROJECT OUTCOMES:

- **GHG Emission Reduction and Energy Savings:** The project has the potential to reduce greenhouse gas emissions by 118.63 tCO₂e annually through the generation of renewable energy. The installation of a 154 kWp floating solar system is expected to produce about 0.23 million kWh of renewable energy per year, which will help mitigate around 118.63 tCO₂e of GHG emissions.
- **Cost Savings and Financial Impact:** This initiative also delivers significant financial benefits, saving an estimated INR 16.61 million (US\$ 197,879) annually through generation of renewable energy.

LESSONS LEARNED:

- **Community Engagement and Transparency:** Engaging with local communities and stakeholders is vital to address environmental concerns and foster support for renewable energy projects, especially for floating solar PV plants in the lakes of the city.
- **Maintenance Complexity:** Regular inspections for biofouling, corrosion, and electrical safety are required.

CASE STUDY 1

ENVIRONMENTAL BENEFITS

- **Water Conservation:** Reduction in water evaporation from the lake and the solar panels act as a cover that reduces water evaporation.
- **Reduced Algae Growth:** Prevention of algae growth due to reduced sunlight penetration. The floating panels can reduce sunlight exposure to the water surface, potentially inhibiting algae growth. This can improve water quality by limiting the formation of harmful algal blooms, which can degrade water quality and harm aquatic life.
- **Carbon Footprint:** Reduction in carbon footprint by replacing fossil fuel-based energy generation
- **No Land Use or Habitat Disruption:** Unlike traditional ground-mounted solar installations, floating solar power plants do not require clearing land, which helps preserve natural habitats and biodiversity.

ECONOMIC BENEFITS

- **Higher energy efficiency** due to cooling effect of water
- **No land** acquisition costs
- **Reduced maintenance** compared to land-based solar plants
- **Boost tourism:** Installation also brings aesthetic benefits, as the floating solar panels enhance the scenic appeal of the lake. This is potentially boost tourism and recreational activities in the area, creating opportunities for local businesses and improving the region's overall economic sustainability.

SOCIAL BENEFITS

- **Environmental Education and Awareness:** The installation serves as a tangible example of innovative renewable energy solutions, potentially inspiring educational initiatives and increasing public awareness about sustainable practices.
- **Community Engagement:** Such projects can foster community pride and involvement, as residents witness local government efforts to adopt eco-friendly technologies, potentially leading to increased public support for future green initiatives.
- **Economic Opportunities:** The project may stimulate local economies by creating jobs in the manufacturing, installation, and maintenance sectors associated with floating solar technology.



Operational Infrastructure of the Floating Solar PV Plant – Monitoring Dashboard, Surveillance Camera & Weather Sensors, and HT Evacuation Site

CASE STUDY 1

MAINTENANCE OF THE PLANT:

The floating solar power plant at Periyakulam lake, requires regular maintenance to ensure optimal performance and long-life while minimizing environmental impacts. To ensure the efficient operation, the CCMC is planning to appoint a maintenance provider with appropriate technical skills responsible for its operation and maintenance (O&M). The key maintenance activities in the plant includes,

- Routine cleaning of 280 **solar panels** to remove dust, algae, and bird droppings, as well as inspecting for cracks or degradation that could reduce efficiency.
- The **floating structure and anchoring system** are checked for buoyancy, stability, and wear due to water level fluctuations.
- The **electrical components**, monitoring of performance and check for error codes of 2 inverters, cables, and grounding systems, are inspected to prevent corrosion and ensure seamless energy transmission.
- **Safety protocols**, such as secure access walkways and emergency preparedness measures are arranged for further enhance the reliability of the system.
- The effectiveness of **30 earthing points and 2 lightning protection systems** are regularly verified and monitored.
- To prevent theft of the solar power plant materials, **CCTV cameras** have been installed around the site, reflecting proactive security measures.

SCALE UP POTENTIAL:

The successful implementation of the project at Periyakulam Lake demonstrates its scale-up potential for replicating similar FSPV systems across other lakes in Coimbatore. The scale-up potential for Periyakulam lake is installation of a 10-megawatt (MW) floating solar photovoltaic (FSPV) plant over a 25-acre section of the lake. A scaled-up project of 10 MW capacity on the lake is expected to generate around 15 Million Units (MU) of electricity annually, contributing to a reduction of approximately 13,453 tCO₂e emissions per year.



Potential lakes for the scaleup of floating solar plant

CASE STUDY 1

Coimbatore Corporation to install floating solar panels at Ukkadam big tank

Coimbatore Corporation installs floating solar panels in Ukkadam Tank to generate 154 kW of electricity daily

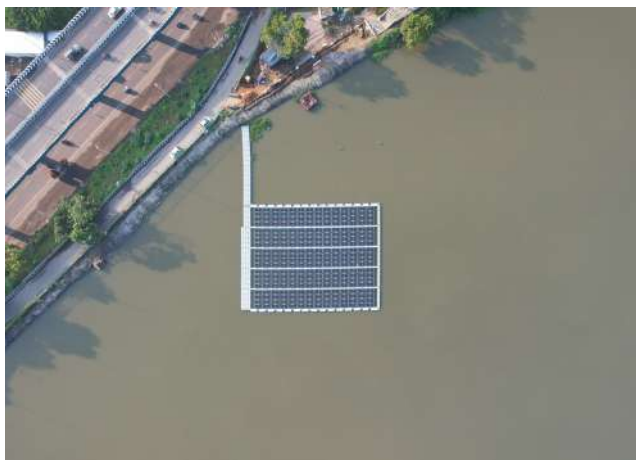
Updated - October 19, 2024 07:18 am IST - COIMBATORE

THE HINDU BUREAU

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A floating solar power plant at a cost of ₹1.45 crore being installed by the Coimbatore Corporation at Ukkadam Big Tank in Coimbatore on Wednesday. | Photo Credit: M. PERIASAMY



Project Implementation and Site Visit Activities during the Installation of the 154 kWp Floating Solar PV Plant at Periyakulam Lake

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CASE STUDY 2

Solar-Powered Opportunity Charging Buses in Ahmedabad



INTRODUCTION

Ahmedabad, a vibrant commercial and industrial hub with a rich cultural heritage, is located in the western state of Gujarat, India. As the largest city in Gujarat, it is home to over 7.1 million residents. The city is divided by the Sabarmati River, which flows through its centre, separating it into eastern and western regions. To promote sustainable, low-carbon urban development, the Ahmedabad Municipal Corporation (AMC) had launched the 'CapaCITIES II Project,' supported by the Swiss Agency for Development and Cooperation (SDC). The implementation of the project is being carried out in partnership with ICLEI - Local Governments for Sustainability, South Asia (ICLEI South Asia), South Pole, and econcept AG.

AMC developed the 'Climate Resilient City Action Plan – Towards a Net Zero Future (Net-zero CRCAP),' which focuses on reducing the city's carbon footprint and enhancing resilience to climate change, with technical support under the CapaCITIES II project. The project also supported implementation of the pilot project 'Solar-Powered Opportunity Charging Station for BRTS Electric Buses,' aiming to enhance the operational efficiency of the city's existing electric buses in the public transport system while promoting renewable energy use.

EXISTING SCENARIO

The AMC operates a fleet of 200 electric buses as part of its Bus Rapid Transit System (BRTS), which consumes over 18 Million Units (MU) of conventional electricity annually. These buses are charged overnight using slow-charging infrastructure at two depots, Vastral and Naranpura. According to the gross cost operational contract between AMC and the contractor, each bus is required to cover a minimum of 200 km/day, at a fixed rate of INR 55 per km.

In Ahmedabad, the average mileage of electric buses varies from 80 to 140 km per full charge, depending on the route. Since it is efficient to recharge the bus when the battery drops to 20%, these buses return to the depot for fast charging during the day to complete the required 200 km daily run, as mandated by the gross cost operational contract. However, this mid-day charging disrupts operations and reduces efficiency.

This conventional operating model generates approximately 4,000 kilometres of non-revenue or "dead" travel distance daily (about 20 kilometres per bus), as buses travel to and from depots for recharging. Additionally, it leads to a total of 600 hours of non-productive operating time each day (2.5 to 3 hours per bus for intermediate charging, including travel time) for the entire fleet of 200 electric buses.

As a result, AMC loses about 1.4 MU of energy annually due to these dead operating distances, alongside substantial revenue losses from non-productive operating time. Furthermore, AMC incurs a cost of INR 55 per km for dead operating distances, resulting in an annual loss of approximately INR 80 million.

CASE STUDY 2

KEY PROJECT FEATURES

Name of the project	Solar-Powered Opportunity Charging Station for Electric Buses
Location	AMC's plot near RTO Junction (Plot size: ~3500 m)
Type of project	Co-finance project supported by AMC and CapaCITIES Phase II Project
Project Finance (Subsidies and Financial Incentives)	Project Cost supported under CapaCITIES II: INR 15.72 Million (US\$ 187,253) Installation of a 240kW opportunity electric charger (Mindra CCS II type charger with dual guns), a 120kWp grid-connected Solar PV system (217 numbers of solar panels – Solex make, 550 Wp of capacity each), and a robotic solar panel cleaning mechanism. Project Cost Co-financed by AMC: Approx. INR 20 Million (US\$ 238,266) • Provision of a 500-600kW HT connection and panel room. • Installation of a 180kW opportunity electric charger (CCS II type with dual guns). • Civil works including pavements, RCC, wall boundaries, gate, streetlights, and other necessary amenities

PROJECT BENEFITS & IMPACTS

Operational Efficiency and Revenue Enhancement: By enabling on-route charging for approximately 40-45 electric buses, the project has eliminated around 120 hours of non-productive operating time each day. This improvement not only maximizes bus utilization but also contributes to increased revenue generation.

Significant GHG Emission Reduction and Energy Savings: The project has the potential to reduce greenhouse gas emissions by 470 tCO₂e annually, through both energy savings and the generation of renewable energy.

- The installation of a 120 kWp solar PV system is expected to produce about 0.17 MU of renewable energy per year, which will help mitigate around 140 tCO₂e of GHG emissions.
- Additionally, by reducing the need for buses to return to depots for charging, the project saves approximately 0.4 MU of electricity annually, further reducing GHG emissions by 330 tCO₂e.

Cost Savings and Financial Impact: This initiative also delivers significant financial benefits, saving an estimated INR 15 million annually by eliminating payments to contractors for non-revenue-generating travel distances (dead kilometres).

POTENTIAL FOR SCALE-UP

The successful implementation of this project has encouraged the city government to pursue similar initiatives aimed at improving energy efficiency. AMC has already identified 4-5 additional locations for the development of on-route charging stations to further enhance the operational efficiency of electric buses on the BRTS route.

Since most Indian cities operate buses under a gross cost model, the introduction of on-route chargers offers a valuable opportunity to boost the effectiveness of urban transport systems, while achieving substantial energy and cost savings.

LESSONS LEARNED

Addressing concerns from bus operators on shifting perceptions and to build confidence:

One of the major challenges was overcoming the initial hesitations and perceived barriers from electric bus operators regarding the use of on-route/opportunity chargers. Operators were concerned about potential impacts on battery life and wear on charging ports, which could increase maintenance costs under the gross cost model. This challenge was successfully addressed by demonstrating the positive outcomes of a pilot project, which helped shift perceptions and build operator confidence.

Effective stakeholder collaboration and coordination ensured timely implementation:

The success of the project hinged on strong collaboration and clear coordination among all stakeholders, including contractors, bus operators, AMC, and the CapaCITIES project team. A shared understanding and the creation of synergies were crucial, as was the clear delineation of roles and responsibilities. This collaborative governance approach ensured the project was completed within the set timeline.

Tapping into the energy-saving and renewable energy potential of the e-mobility sector:

Each electric bus consumes approximately 250 kWh of electricity daily, a significant amount. To align with net-zero emissions targets, there is a clear opportunity for government departments to promote the integration of renewable energy solutions, particularly for charging electric buses and public charging infrastructure.

Reevaluating contractual agreements for sustainable investments:

The current gross cost model, in which bus operators manage the fleet and contractors cover electricity costs, requires reassessment. Under this structure, government investments in renewable energy (RE) infrastructure for charging electric buses may not yield direct financial benefits, as the energy savings are passed on to the contractors. Revisiting these agreements could help ensure that renewable energy investments provide more sustainable financial returns.

CASE STUDY 2



Solar Powered Opportunity Charging Depot and Electric Bus Fleet, Ahmedabad

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CASE STUDY 3

Pilot Implementation of Rooftop Solar PV plant for Public Buildings in Siliguri



CASE STUDY 3

INTRODUCTION

Siliguri is strategically located in the area known as Chicken Neck Corridor, an important link connecting the states in Northeast India and the neighbouring countries with rest of India. Hence the region is also referred as the 'Doors to Northeast India'. Owing to this strategic location Siliguri has emerged as a commercial nerve centre of the region. It is a rapidly growing urban centre providing key services in the sectors of hospitality, administration, transport, freight, perishable and non-perishable consumables among others.

Siliguri faces mounting energy needs linked to public services and infrastructure due to an ever increasing population and service demand. Siliguri Municipal Corporation (SMC) has implemented the CapaCITIES Project in partnership with Swiss Agency for Development and Cooperation in two phases, namely from 2016 to 2019 and 2019 to 2024. The Project, aligned with India's climate goals and net-zero commitments, addressed the water supply, solid waste management, wastewater, energy, transport, health and stormwater sectors of the city. Throughout the course of the Project, SMC conducted technical assessments and implemented various pilot demonstration projects, including a 25 kWp distributed rooftop solar PV installation for one of its office buildings.

EXISTING SCENARIO

Siliguri's GHG emissions have doubled in a decade from 0.83 million in 2011 to 1.65 million in 2021. Electricity consumption contributed to 27% of the emissions. Historically, the city has solely relied on grid supplied electricity resulting in emissions, higher costs and operational vulnerability in the face of climate shocks. Municipal assessments indicated a substantial rooftop solar potential in the city. SMC decided to implement a pilot demonstration project on solar PV installations to reduce GHG emissions from municipal operations and encourage citizens to do the same.

The SMC Main Administrative Building with a truss mounted rooftop spanning 148.18 was selected as the site for implementation of the pilot 25 kWp rooftop solar PV project. The installation also included battery backup and grid integration to maximize renewable power usage.



**25 kWp Rooftop Solar PV System
Installed at Siliguri Municipal
Corporation Office**

CASE STUDY 3

TECHNICAL SPECIFICATIONS

Item	Description
PV module	Mono PERC C-Si Modules
Inverter	1000 V DC, 3-ph, 50 Hz, 25 kW, hybrid solar string inverter with battery and grid integration facility.
Battery	Lithium Iron Phosphate (LiFePO4) type with Battery Management System as per standards.
Earthing cable	Module to module - Cu cable, Inverter earthing and other BoS components as per standards
Lightning Protection	Early Streamer Emission (ESE) air terminal type lightning arrester with 100 m radial coverage.
Miscellaneous	Fire extinguisher, lighting system, auxiliary supply system, signages, lugs, cable ties, cable trays, thimbles, sleeves, cable identification tags, wall anchors, conduits, connectors, cable

IMPLEMENTATION

The pilot project was implemented as a co-financed project between SMC and the CapaCITIES project in 2024. The CapaCITIES project funded a total cost of INR 3.28 Million (US\$ 39,028) for implementation of the hybrid Solar PV system while SMC funded the construction of the physical infrastructure for housing the hybrid solar PV system for a total cost of INR 0.37 Million (US\$ 4420)

The implementation of the project hinged upon strong interdepartmental collaboration, steered by the Climate Core Team, established as part of CapaCITIES’ governance framework. The Climate Core team, led by the Mayor, clearly outlined the roles and responsibilities of the key stakeholders. Scheduled monitoring meetings ensured project delivery was timely and post project operational outcomes were achieved.



25 kWp Rooftop Solar PV System
Installed at Siliguri Municipal
Corporation Office

CASE STUDY 3

PROJECT BENEFITS

The rooftop solar demonstration is engineered as a hybrid, i.e, grid connected yet capable of battery storage, system. This ensures uninterrupted power supply even during grid outages. The power generated offsets peak load, supplying municipal operations while reducing power bills and GHG emissions. The project resulted in **annual savings of INR 100,033 in 2024-25** while **reducing GHG emissions by approx. 10 tCO₂e** during the same period. The project built technical capacity among the municipal staff and promoted buy-in across government offices thereby addressing operational hesitancy related to adoption of new technologies.

SCALE-UP POTENTIAL

Encouraged by the success of the pilot demonstration, SMC has prepared a detailed project report and submitted it to Urban Development and Municipal Affairs (UDMA) Department, Government of West Bengal, for financing the installation of distributed rooftop solar PV modules in all municipal buildings and facilities. As of June 2025, UDMA had accorded administrative sanction to the project, and were exploring the financial modalities of implementation. This initiative will contribute to India's NDC goal of '50% cumulative electric power installed capacity from non fossil sources by 2030'. The replication and scaling initiatives, already underway, position Siliguri as a regional frontrunner in climate resilience.

LESSONS LEARNED

- Integration with aged building infrastructure required site specific adaptations for module mounting and electrical safety
- Municipal staff required training and awareness sessions to foster acceptance of hybrid systems, particularly for battery operation and fire safety
- Pilot demonstrations help address skepticism and encourage wider replications

The distributed rooftop solar PV pilot in Siliguri's municipal headquarters demonstrates practical climate action at city scale, delivering measurable GHG reductions, budgetary savings and energy resilience. The implementation model, grounded in co-financing and proactive stakeholder engagement, can serve as a best practice for other cities aiming to transition to net-zero emissions.

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CASE STUDY 4

Increasing Penetration of Electric Autorickshaws under Green Mobility Zone (GMZ) Program of Rajkot



CASE STUDY 4

INTRODUCTION

Rajkot, Gujarat's fourth-largest city with a population exceeding 2 million, was ranked 22nd among the world's fastest-growing cities between 2006 and 2020. The city has taken proactive steps towards climate-resilient and sustainable development, focusing on comprehensive planning, implementation, and continuous monitoring. In 2019, with the support of the CapaCITIES Phase I project, funded by the Swiss Agency for Development and Cooperation (SDC), Rajkot developed its second-generation Climate Resilient City Action Plan (CRCAP). This plan has now evolved into the 'Rajkot Net-zero CRCAP,' aligning with India's Net Zero Vision by 2070, as part of the CapaCITIES Phase II project, also supported by the SDC. Additionally, the project has supported a pilot initiative offering subsidies for 100 electric autorickshaws (e-autos) under the Green Mobility Zone (GMZ) Program, promoting sustainable urban transport.

EXISTING SCENARIO

The number of registered vehicles in Rajkot has surged from 0.45 million in 2011-12 to 1.8 million in 2023-24, marking nearly a fourfold increase in a decade. The transportation sector now accounts for 41% of the city's overall energy consumption and contributes 24% of its total greenhouse gas (GHG) emissions.

Public transport in Rajkot is provided by Rajkot Mass Transport Services (RMTS) and the Bus Rapid Transport Services (BRTS). RMTS operates 107 buses across 54 routes, serving over 25,000 passengers daily. The BRTS runs on a dedicated 10.7 km corridor with 22 buses, transporting more than 24,000 passengers each day. The Rajkot Municipal Corporation (RMC) has transitioned from diesel buses to electric, with a total of 250 electric buses proposed of which are 125 operational, while the remaining 125 are in the procurement process.

Autorickshaws are the preferred mode of intermediate transportation in Rajkot. A report titled "Last Mile Connectivity and Electrification of BRTS Corridor," prepared under the CapaCITIES Phase I project, identified key routes where electric autorickshaws (e-autos) could significantly improve first- and last-mile connectivity to the BRTS system. This initiative aims to enhance the efficiency of the existing public transport system while also reducing GHG emissions and air pollution.

Despite financial incentives and subsidies of INR 48,000 from the Government of Gujarat and additional incentives from the national government, several barriers have hindered the adoption of e-autos:

- **Lack of trust in technology:** Auto drivers were skeptical about the reliability and performance of e-autos compared to traditional internal combustion engine (ICE) vehicles.

CASE STUDY 4

- **Limited availability of public charging stations:** Concerns were raised about the practicality and convenience of charging e-rickshaws, due to the insufficient number of EV charging stations.
- **Range anxiety:** Drivers were worried that the range of e-autos on a full charge would be insufficient for their daily operations.
- **High upfront costs:** Beneficiaries are required to pay the full cost upfront, with subsidies disbursed later, which creates a financial burden. Loans typically cover 80% of the cost (depending on eligibility), requiring buyers to arrange the remaining 20% as margin money.

To address these challenges, RMC launched a pilot project under the SDC-supported CapaCITIES Phase II initiative. This included additional financial incentives for the first 100 beneficiaries, awareness campaigns, stakeholder engagement, and an easier loan process to encourage the wider adoption of e-autos.

KEY PROJECT FEATURES

Name of the project	Increasing Penetration of Electric Autos under Green Mobility Zone (GMZ) Program of Rajkot
Type of project	Co-finance project supported by RMC and CapaCITIES Phase II Project
Project Finance (Subsidies and Financial Incentives)	• INR 48,000 subsidy/ financial incentives from the Government of Gujarat • INR 30,000 additional subsidy under CapaCITIES Phase II project through RMC • Easy loan process to the beneficiary through effective coordination between banks and Original Equipment Manufacturers (OEMs)/ dealers under the GOI's Mudra Loan Scheme as applicable • Scheme outreach activities under National Urban Learning Mission (NULM) • Government of Gujarat's Vajpayee Bankable Yojana through District Industries Centre (DIC): Additional subsidies varying from 10% to 20% of total approved loan amount, depending on categories and applicability



Electric Auto-Rickshaw Deployed under the Green Mobility Initiative in Rajkot

CASE STUDY 4

IMPLEMENTATION PROCESS

Stakeholder Consultation for Effective Implementation: With support from the Rajkot Municipal Corporation (RMC), a joint consultation was organized involving Original Equipment Manufacturers (OEMs), e-auto dealers, and first-time e-auto buyers. The aim was to ensure smooth project implementation and raise awareness about the advantages of e-autos over conventional internal combustion engine (ICE) autorickshaws.

Empanelment of E-Auto Dealers: RMC held discussions with e-auto dealers to standardize vehicle specifications and establish procurement guidelines, simplifying the process for beneficiaries and standardizing the subsidy disbursement process under the CapaCITIES project. After a series of consultations, Atul Auto and Mahindra agreed to be empaneled with RMC. The pre-defined specifications for e-autos include:

- L5 type e-auto with D+3 seating capacity
- Lithium-Ion battery with a range of 100 km per full charge
- Automotive Research Association of India (ARAI) approval along with other necessary certifications

Bank Discussions for Easier Loan Processes: In discussions with over 15 banks, it was agreed to provide more favourable loan terms for beneficiaries under the Green Mobility Zone (GMZ) program. While traditional loans typically cover 80% of the capital cost, participating banks agreed to offer loans covering up to 90% for this initiative.

Outreach Activities: Empaneled dealers conducted live demonstrations of e-autos and outreach efforts were made under the National Urban Livelihoods Mission (NULM) to inform potential beneficiaries about additional subsidies from the state government, the loan process, and benefits available through programs like the Vajpayee Bankable Yojana. These live demonstrations played a crucial role in overcoming barriers such as trust in technology, concerns about charging infrastructure, and range anxiety, encouraging wider adoption of e-autos.



Distribution of Financial Incentives for Electric Auto-Rickshaw Beneficiaries under the Green Mobility Initiative, Rajkot

CASE STUDY 4

BENEFITS & IMPACTS

GHG Mitigation: The project has the potential to reduce greenhouse gas emissions by 168 tCO₂e annually.

Economic Empowerment: The initiative has created livelihoods for individuals from economically disadvantaged backgrounds, contributing to both social and economic development.

Improved Connectivity: By enhancing first and last-mile connectivity, the project has improved transportation efficiency and accessibility for commuters across the city.

Increased Adoption: Awareness campaigns, along with the pilot project, have led to a significant rise in interest and adoption of e-autos among auto drivers.

Boosting Buyer Confidence: The Green Mobility Zone (GMZ) Program successfully demonstrated the operational efficiency of e-autos, helping to build confidence among potential buyers and encouraging broader adoption.

SCALE-UP POTENTIAL

This project has high replication potential in other cities of Gujarat, particularly through Gujarat Corporate Social Responsibilities Authority (Gujarat CSR Authority). Gujarat CSR Authority has prepared a scheme to provide financial support of INR 30,000 for selected cities submitting proposal in provided format by Gujarat CSR Authority, upon further approval. Similarly, such project can be replicated in other cities by providing additional financial incentives under various national/ state/ city schemes, ease of loan process and creating single window approval system.



Drivers opting for e-Autos under the program due to subsidy and other incentives

CASE STUDY 4

LESSONS LEARNED

A Comprehensive Approach: Addressing both financial and non-financial barriers is critical to promoting the adoption of new technologies, ensuring broader and sustained acceptance.

Effective Stakeholder Coordination: Successful initiatives require strong coordination between stakeholders, including dealers, banks, and beneficiaries, to build trust and drive engagement.

Strategic Partnerships: Collaborating with banks to offer loans covering 90% of the vehicle cost was vital in making e-autos financially accessible, significantly lowering the entry barrier for potential buyers.

Co-Financing Models: Implementing co-financing models, where dealers provided discounts of INR 30,000 (covering 10% of down payments) reimbursed by the CapaCITIES project, effectively reduced the upfront financial burden on buyers, encouraging higher adoption.

Leveraging Government Schemes: Tying up with the District Industries Centre (DIC) and utilizing benefits from schemes like the Vajpayee Bankable Yojana provided an additional layer of financial support, making e-autos more appealing to potential buyers.

Stimulating Market Competition: The successful adoption of e-autos attracted new manufacturers and led to the opening of additional dealerships (e.g., Kinetic, Piaggio), increasing options for buyers and further driving adoption.

Streamlined Loan Processes: Simplifying loan applications and providing support for necessary documentation helped attract more beneficiaries and accelerated the adoption process.

Inclusivity: The ease of driving e-autos made them an attractive option for older individuals, broadening the range of interested buyers.

Advocacy from Early Adopters: Beneficiaries who experienced significant cost savings after the pilot project became advocates for e-autos, creating a ripple effect that encouraged more drivers to make the switch.



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CASE STUDY 5

Design and Implementation of Pilot Miyawaki Urban Forests in Siliguri, Udaipur, Vadodara



CASE STUDY 5

INTRODUCTION

Miyawaki technique of growing forests is a unique methodology which comprises of pre-determined steps and procedures for planting of trees. The technique was developed by Dr. Akira Miyawaki, a Japanese Vegetation Ecologist, and is regarded widely as the most effective plantation method to quickly regenerate degraded forest lands by closely planting a variety of native tree species that are best suited for the specific location. The benefits of the Miyawaki technique have made it a popular choice for cities across the globe to develop urban forests, and several Indian cities have successfully developed Miyawaki technique based urban forests in their cities to increase their percentage of green cover and native biodiversity.

Three Indian cities Siliguri, Udaipur and Vadodara have designed and developed Miyawaki urban forests as pilot projects with technical and financial support under the CapaCITIES Phase II project. Udaipur developed Mohta park as a Miyawaki urban forest, while Siliguri and Vadodara developed urban forests in Lower Bhanu Nagar and Chhani lake area in the respective cities. These pilot project have also been scaled-up leading to development of similar urban forests across multiple locations in these cities. The key features of a Miyawaki technique based urban forest are given below:

Miyawaki Urban Forest – Key Features	
Planting Density	3 to 7 trees per sq. m
Green Surface Area	30 times more than a meadow
Survival Rate (Natural Selection)	15% – 90%
Growth Rate	1.5 m/year (rainforest), 1 m/year (temperate forest), and 0.3 m/year (Mediterranean forest)
Growth Stabilization	From 15-20 years (temperate zone), 30-40 years (tropical zone)
Final Average Size	20 m (upper layer or emergent/canopy layer of a forest), 4m (lower layer or understory)
Density after Stabilization	0.5 to 2.5 trees per sq. m
Biodiversity (Fauna)	18 times more (mean of different species)

CASE STUDY 5

MIYAWAKI PROCESS FOR CITIES

The over-arching steps that city governments need to follow in order to develop urban forests in their cities using the Miyawaki technique is explained below:



The Miyawaki forest development process begins with **soil analysis and preparation**, as it is essential for ensuring that the soil has the required nutrition to provide a strong foundation for plant growth in the early period after plantation. This involves studying soil texture and assessing parameters such as organic carbon, nitrogen, pH, potassium, and phosphorus, along with visible signs of soil fauna. Based on the findings, natural soil treatments are applied using perforation materials like rice husk or groundnut shells, water retainers such as coco peat, and organic fertilizers like cow manure and vermicompost. Beneficial microbes such as Rhizobium and Arbuscular Mycorrhizal Fungi (AMF) may also be added to enhance nutrient availability. Loamy soil is preferred for its balanced texture, and finally, a mulch layer—comprising of dried grass, straw, or leaves—is added to retain moisture and regulate temperature.

The next step is **determination of native species** through a quadrat survey in a native forest within the same agro-climatic zone. This helps identify dominant native trees, shrubs, and herbs, ensuring that 50% of the species composition includes the five most dominant species, followed by the next abundant ones (25–40%), and a smaller proportion of less common natives. This mix promotes ecological balance and biodiversity.

Once the list of native species is finalized, **saplings are procured** from certified nurseries—ideally those managed by the respective State Forest Departments—ensuring a height of 60–80 cm and good genetic quality. Before plantation, the site must be prepared with proper access for vehicles, water supply arrangements, storage for saplings and equipment, and a resting area for workers.

During plantation, the soil is excavated up to 3–4 feet, enriched with organic additives, and returned loosely to allow aeration. Pits of 12"×12" are dug at 1.5–2 feet intervals in a triangular pattern, and saplings are planted with care to avoid clustering of the same species. Bamboo supports are provided to prevent bending, and each plant is mulched with 0.5 kg of material to retain moisture. Watering is done thoroughly after planting, and an ideal density of three trees per square meter should be maintained.

Finally, **maintenance and monitoring** of Miyawaki urban forest plantation should continue for two years to ensure healthy growth, with regular watering, weeding, and observation of soil and plant health to help the urban forest achieve self-sustainability. The saplings that die within the 2-year period should also be replaced with the same species to maintain the species mix intended for the location.

CASE STUDY 5

CASES FROM INDIAN CITIES

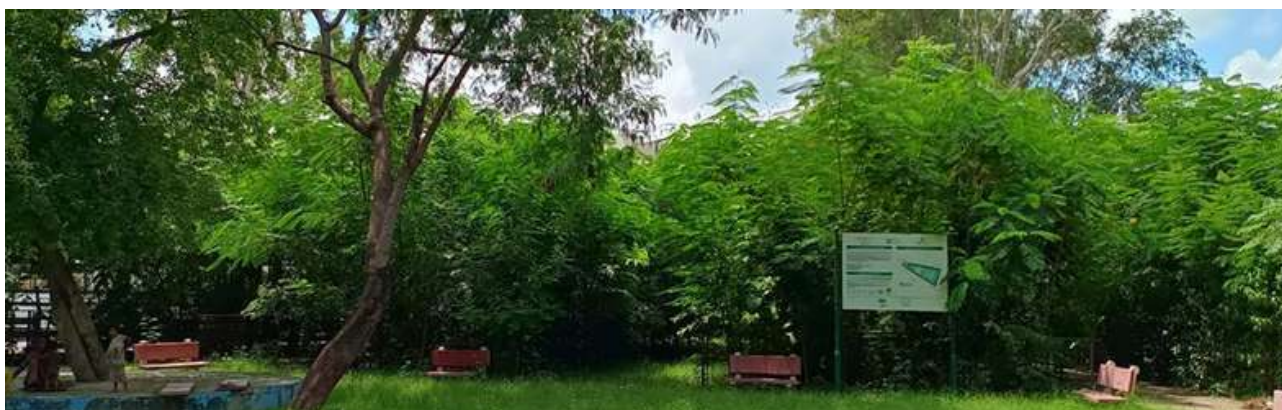
Mohta Park, Udaipur

The Miyawaki method of urban forest development was implemented at Mohta Park, Udaipur, to create a dense and native urban forest ecosystem within the premises of a small urban park. The park area has been thoughtfully redeveloped to balance green space development with improved usability, attracting more visitors from the surrounding neighborhood. This pilot project was scaled-up, leading to development of similar Miyawaki urban forests in 3 other locations in the city.

The Miyawaki urban forest development was implemented at Mohta park under a co-financing agreement between the Udaipur Municipal Corporation (UMC) and the CapaCITIES project. The project supported site preparation, plantation, tree tagging, hoardings, two-year maintenance, and training of officials & gardeners were supported through a funding of INR 2,536,242 (US\$ 30,215) while the UMC undertook leveling and cleaning of the site, fencing of plantation pockets, and restoration of park infrastructure.

Urban Forest Details:

- **Total Park Area:** 4,709 sq.m
- **Miyawaki Plantation Area:** 2,400 sq.m
- **Total Number of Trees Planted:** 9,500
- **Number of Tree Species:** 37



CASE STUDY 5

Chhani Lake Area, Vadodara

The green cover in the park area adjacent to Chhani Lake in Vadodara was improved by implementing Miyawaki technique based planting of dense and fast-growing trees native to the region. This was undertaken as a pilot project under the CapaCITIES project that supported the design and implementation of the Miyawaki based urban forest. The project funded INR 1,853,780 (US\$ 22,085) for implementation of the pilot project while the biodiversity experts from the project team helped design the urban forest and provided technical assistance as needed.

Miyawaki urban forest development in Chhani lake area has led VMC to develop similar green spaces using Miyawaki technique in 75 pre-determined locations covering approximately 33 acres across the city. VMC is also mulling for more such projects in Vadodara by financing initiatives using the tree fund concept and carbon credits.

Chhani lake park area Urban Forest Details:

- **Total Park Area:** 20,000 sq.m
- **Miyawaki Plantation Area:** 9,000 sq.m
- **Total Number of Trees Planted:** 3,000
- **Number of Tree Species:** 38



CASE STUDY 5

Lower Bhanu Nagar, Siliguri

An urban forest was developed in Lower Bhanu Nagar, Siliguri, using the Miyawaki technique to establish a dense plantation of native species. Implemented under the CapaCITIES project, the initiative aimed to create a functional carbon sink to capture atmospheric greenhouse gases (GHGs) and to enhance the city's ecosystem services, while supporting local biodiversity and ecological balance. The CapaCITIES project funded the plantation works at a cost of INR 1.9 Million (US\$ 22,635), while the Siliguri Municipal Corporation (SMC) contributed towards civil and electrical works on site amounting to a cost of approximately INR 1.1 Million (~US\$ 13,000) 282.74). Together, these efforts have transformed the site into a thriving green space that supports urban resilience and climate action.

Urban forest details:

Total Park Area: 2,500 sq. m

Area under Miyawaki Plantation: 2,000 sq. m

Total Trees Planted: 6,000

Number of Tree Species Used: 24



BENEFITS OF URBAN FORESTS

- **Increase in Green cover:** Miyawaki urban forests create thick, self-sustaining forests in compact areas that grow approximately 10× faster than conventional plantations
- **Enrichment of Soil:** Enriches soil by increasing organic content, water retention capacity, and reduces soil erosion. and soil enrichment
- **Enhanced Biodiversity:** Enhances local biodiversity by providing habitat for birds, insects, and arthropods
- **Groundwater Recharge:** Improves groundwater recharge by enhancing percolation of stormwater, mitigating runoff and urban flooding
- **Climate benefits:** Improves micro-climatic conditions by mitigating impacts of heat island effect and the dense green cover absorbs CO₂, acting as carbon sink.
- **Air & Noise Pollution Reduction:** Acts as a natural sound and pollution barrier, can absorb dust and harmful pollutants in the air.
- **Aesthetics:** Increased total and per capita green cover enhances the aesthetics of the urban spaces and built environment

CASE STUDY 6

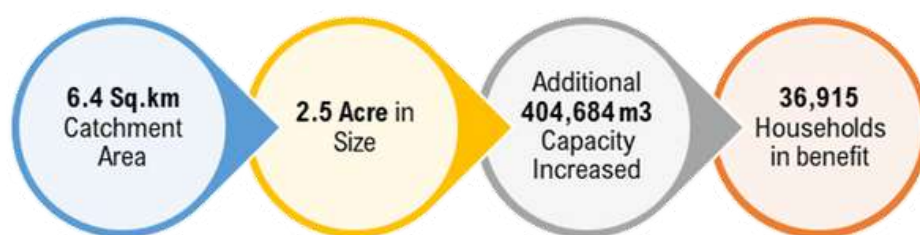
Enhancing Flood Resilience by restoration of Chettikulam Lake in Tiruchirappalli



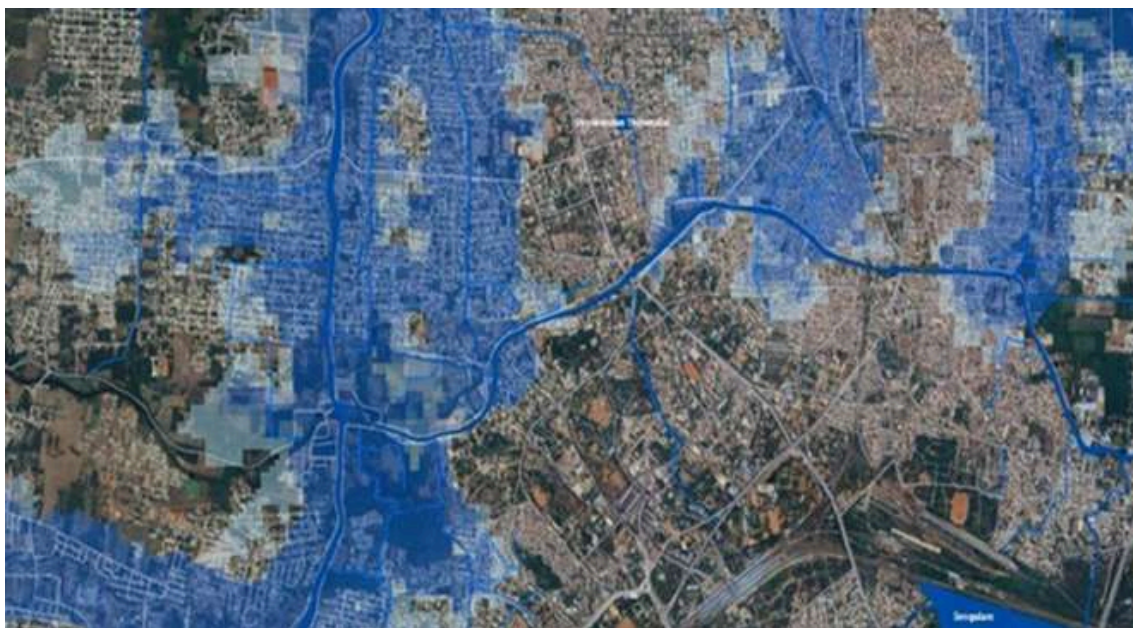
CASE STUDY 6

INTRODUCTION

The restoration of Chettikulam Lake, a vital water body for Tiruchirappalli's ecological balance and urban resilience, presents several opportunities for enhancement. Managing disruptions to the natural water flow—caused by interlinkages with urban areas through streams and channels—requires focused attention. Optimizing the lake's maintenance, particularly addressing siltation and pollution, is crucial for successful restoration. Securing adequate and consistent funding for regular monitoring, maintenance, and long-term sustainability will also be essential. Finally, fostering strong collaboration among key government departments—including the Public Works Department, Tamil Nadu Water and Drainage (TWAD) Board, Department of Irrigation, and the Tiruchirappalli City Corporation (TCC) — will ensure effective project implementation and long-term management.



In this context, the TCC, in collaboration with ICLEI South Asia, commissioned a watershed and flood management study to investigate the root causes of flooding within the city and identify potential remedial measures. This report outlines the initial findings from the field visits conducted at the inception of this study. These field studies primarily focused on visiting flood-affected and flood-prone areas identified by the TCC, ICLEI SA, District Disaster Management Cell, with the aim of understanding the underlying reasons for the recurring flooding incidents. Effort is made to figure out possible measures to mitigate the impacts of flooding.



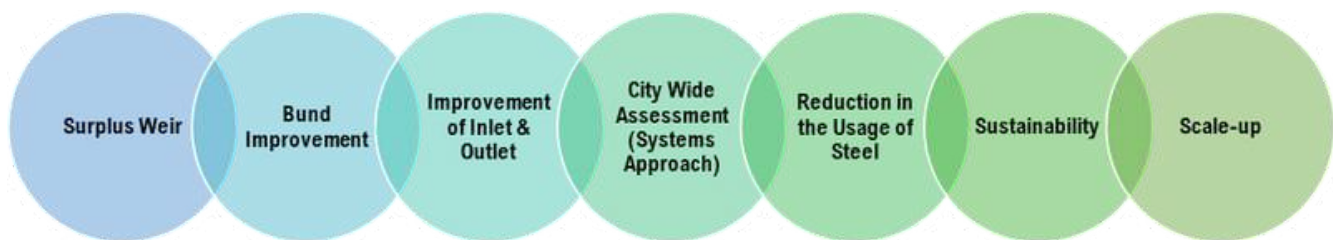
Koraiyar River Urban Flood Reaches based on intensity during the Heavy Rain

INNOVATIVE APPROACH FOR LAKE RESTORATION:

Conventional lake restoration efforts in Tiruchirappalli have largely focused on desilting and superficial beautification, often neglecting ecological and hydrological considerations. Typically, ward offices manage lakes in isolation, preventing a comprehensive understanding of hydrological connectivity across the watershed. This fragmented approach overlooks the lake's role in regulating water flow dynamics, as well as its upstream and downstream impacts. Moreover, coordination among key stakeholders—such as the Public Works Department, TWAD Board, Irrigation Department, Agricultural Department, and State Highway authorities—has often been limited.

As a result, critical ecosystem services provided by urban lakes, including flood attenuation, groundwater recharge, and biodiversity conservation, are frequently undervalued, leading to suboptimal outcomes.

This project introduces a comprehensive, systems-based approach² to lake rejuvenation, linking the functional hydrology of Chettikulam Lake with flood mitigation across the larger Koraiyar basin. Chettikulam not only plays a pivotal role in reducing flooding in Kalinga Nagar and Ayyappan Nagar but also helps lower inflow into the Koraiyar River. The interventions aim to preserve the lake's hydrological function while demonstrating the value of a basin-level approach.



Importantly, this initiative highlights that resilience interventions yield benefits beyond the immediate project site. By adopting a systems approach, both upstream and downstream communities can benefit from flood mitigation and reduced inflows to the Koraiyar River. This underscores the need for investments in water resilience that account for ecosystem services and populations across the entire watershed.

CASE STUDY 6

KORAIYAR BASIN AND CHETTIKULAM LAKE



Chettikulam lake Catchment Area

The Koraiyar River basin, located on the western periphery of Tiruchirappalli city, encompasses both urban and rural areas. Flowing from south to north, it eventually joins the Cauvery River. During heavy rainfall, the Koraiyar's water volume rises sharply, causing flooding in several colonies, including Shanmuganagar, Fathima Nagar, and Ayyappa Nagar. When Cauvery River levels are high, backwater effects further worsen flood conditions.

Chettikulam Lake, situated on the southwestern flank of the Koraiyar basin, primarily collects rainwater runoff from surrounding residential areas such as KK Nagar and Ayyappa Nagar. Once full, surplus water is discharged through a 1.5 km surplus channel into the Koraiyar River. However, over time the lake became heavily silted, losing storage capacity. Consequently, stormwater began flooding nearby settlements, while sewage inflows from KK Nagar and Ayyappa Nagar further contaminated surface and groundwater.

The renovation project will restore the lake's original storage capacity of 150,234 cubic meters, increasing it to 404,684 cubic meters. TCC will also divert and lift sewage inflows, eliminating contamination risks. Bund lining and strengthening will prevent breaches, ensuring safe storage. Together, these interventions will significantly enhance flood resilience in surrounding communities.

Additionally, a defunct irrigation channel upstream between KK Nagar/Ayyappa Nagar and the lake will be improved to link with the Koraiyar River, ensuring excess water is diverted directly into the river. While this major engineering work will be financed primarily by the city, ICLEI South Asia will provide partial co-funding to catalyze action.

CASE STUDY 6

PROJECT INTERVENTIONS

Surplus Weir: Upgrading the surplus weir will significantly enhance the ~2.5-acre waterbody's storage capacity by raising water levels by an additional 2.3 meters. This improvement, along with a revised discharge level of 4.5 meters (up from 2.2 meters), will optimize downstream flow management and mitigate urban flood risks within the 6.4 sq. km (1,581 acres) catchment area.

Bund Improvement: The approach for bund strengthening will lead to creating an established practice for bund strengthening across all water bodies in various locations in the city limit. This will also reduce the flood devastation caused due to breaking of bunds as in previous years in Tiruchirappalli.

Improvement of Inlet & Outlet: Currently water body restorations are looked at in isolation without improvement of inflow and outflow and lack of an integrated strategy. This leads to repeated siltation and also contamination of the water body and groundwater. The proposed Chettikulam intervention has been identified after a robust city-wide integrated study and will also demonstrate the benefits of improving the inlet and outlet.



Joint Inspection with Tiruchirappalli Corporation Officials, ICLEI South Asia Representatives, and the Project Team.

CASE STUDY 6

STRATEGIC OUTLOOK

1. City Wide Assessment (Systems Approach): The flood risk assessment conducted by the CapaCITIES II project represents the first city-wide assessment of its kind for flood water management in Tiruchirappalli. Unlike conventional ward-level interventions, which can often be counterproductive in urban contexts, the CapaCITIES II intervention adopted a city-wide perspective. The significance of this comprehensive approach is further emphasized in the recommendations of the city-wide report.

2. Reduction in the Usage of Steel: Traditionally, reinforced concrete is employed for both lower and upper toe walls in water body restoration projects. However, a structural analysis of lateral loads and superimposed loads revealed that stone pitching is a suitable alternative for the upper toe wall. This design optimization not only minimizes the use of steel and cement, both of which have significant embodied carbon emissions, but also reduces overall construction costs. These cost savings can be strategically reallocated towards other sustainable urban infrastructure projects within the jurisdiction of the Urban Local Body (ULB), contributing to a more environmentally and economically sound approach to urban development.



Field Visit and Technical Discussion at Chettikulam Lake Restoration Site, Tiruchirappalli

CASE STUDY 6

3. **Sustainability:** The Commissioner of Tiruchirappalli City Corporation has already agreed in multiple meetings that the O&M cost of the pilot project will be taken over as part of the routine TCC work from their municipal budget in subsequent years.

4. **Scale-up:** This project presents a valuable opportunity to scale up this holistic approach to lake restoration across the city, moving beyond simplistic desilting and cosmetic interventions towards a more ecologically-sensitive and sustainable model. By prioritizing ecological integrity and considering the broader watershed context, this approach can serve as a valuable blueprint for future urban water body restoration efforts.

5. **Raising public awareness:** About urban flooding is crucial for building community resilience. By educating residents about the causes and consequences of flooding, such as heavy rainfall, inadequate drainage systems, and climate change, we can empower them to take proactive measures. This includes understanding personal flood risks, preparing emergency kits, and implementing flood-proofing measures in their localities.

WAY FORWARD

The Chettikulam Lake restoration demonstrates that ecologically sensitive, systems-based interventions can deliver multiple co-benefits:

- Reduced flood risks.
- Improved water storage and quality.
- Long-term sustainability through municipal ownership.
- Blueprint for city-wide and regional scale-up.

This project highlights how urban resilience investments must be designed not only for immediate site-level improvements but also for watershed-scale impacts—ensuring benefits for both upstream and downstream communities.



Representation of Development work at the Chettikulam lake

CASE STUDY 6



Desilting and Bund Strengthening



Channel and Surplus weir restored

CASE STUDY 6



Bund Improvement work



Improved surplus gate, channel, and bund with stone pitching, native tree plantation, solar-powered street lighting at Chettikulam Lake

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CASE STUDY 7

Flood Early Warning and Monitoring System in Thamirabarani River for Tirunelveli City



CASE STUDY 7

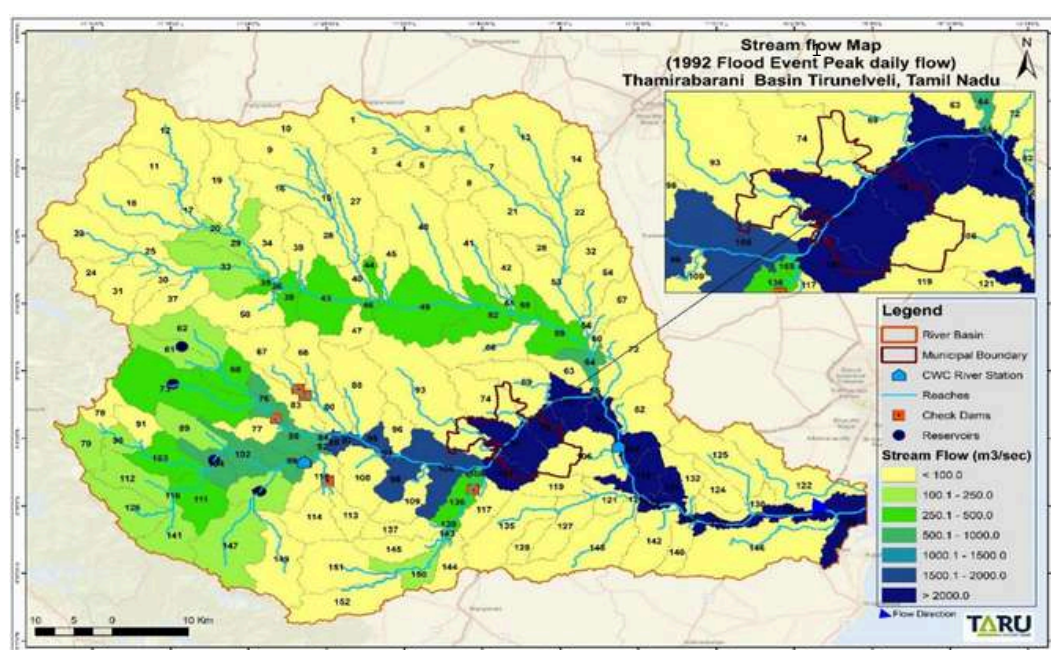
INTRODUCTION

Tirunelveli is the 6th largest city in Tamil Nadu with more 0.55 million population. Tamil Nadu's only perennial river, Thamirabarani, flows through the city bifurcating it into eastern and western parts. In recent past, the river often flows at full capacity during heavy rainfall, as witnessed in 2015, 2018, and 2021 endangering the population living in low lying areas along the banks of the river. Also, the city faces challenges with urban flooding at times of heavy rainfall during north-east monsoon season between October and January.

In order to improve stormwater management in the city Tirunelveli City Municipal Corporation (TCMC) with technical and financial support from the CapaCITIES project undertook watershed assessment of the city to identify flood vulnerable areas for structural and nature-based solutions that can mitigate urban flooding challenges. The TCMC also checked the feasibility of deploying a Flood Early Warning and Monitoring System (FEWMS) in Thamirabarani river basin for Tirunelveli city.

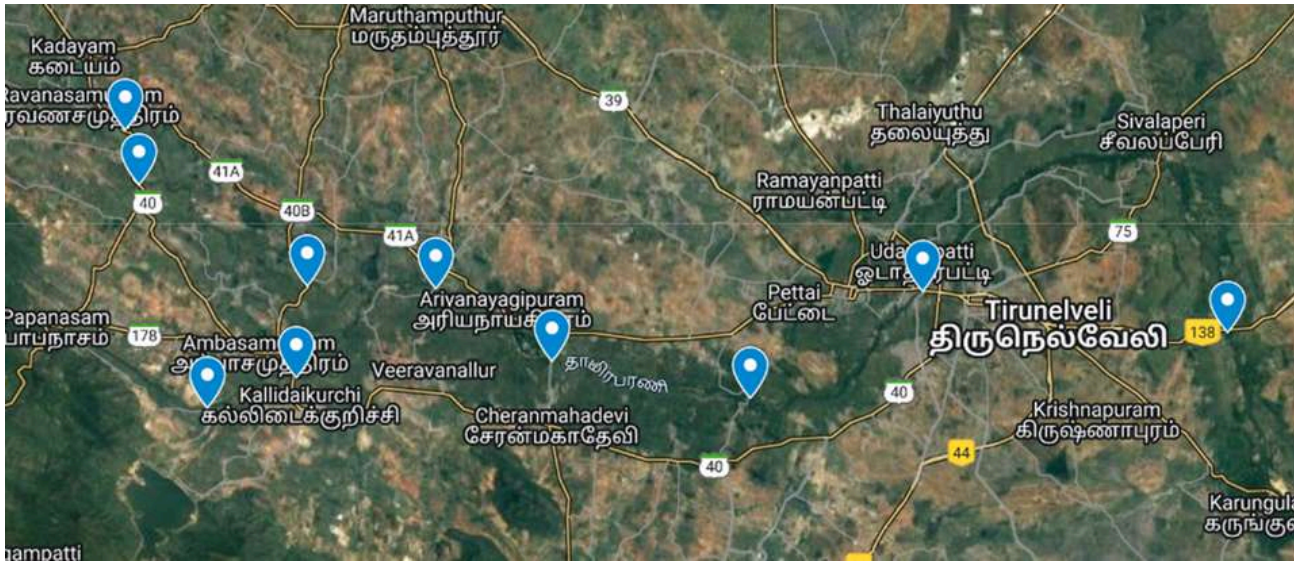
FEASIBILITY OF DEPLOYING FEWMS

Feasibility assessment of Thamirabarani river was undertaken by a team of hydrologists who estimated Thamirabarani river stream flow during heavy rainfall using existing flow data from dams in upper Thamirabarani basin. Based on the stream flow simulation and consultations with water resource department of Tamil Nadu Public Works Department 10 feasible locations were identified along Thamirabarani river basin for deploying radar based water level recorders for the flood early warning and monitoring system. Figure below shows the location of sensors in the basin.



Streamflow Estimation based on 1992 Flood Event in Thamirabarani River Basin, Tirunelveli

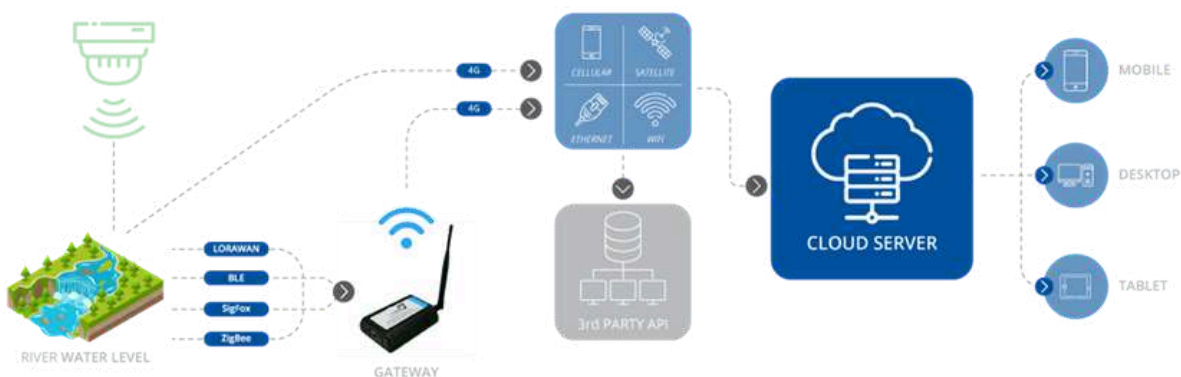
CASE STUDY 7



Locations of Flood Monitoring Sensors in Thamirabarani River basin, Tirunelveli

WORKING OF FEWMS

RADAR based Automatic Water Level Recorder (AWLR) Sensors send radio waves towards the river and measures the distance between them. Gateways collect the data from sensors and send it to a cloud layer where all the readings are stored, which are then made accessible from end-to-end IoT dashboard from anyplace in real-time. The auto calibration algorithms of the FEWMS process the readings from the sensors to accurately ascertain the water level and flow rate of the river. If the water level reading exceeds the threshold flood stage at each monitoring station of the river, the IoT dashboard will give alerts and promptly sending of SMS notifications to alert the decision-making authorities using SMS gateway of mobile providers.



Data Flow Architecture of the Flood Early Warning System, Tirunelveli

CASE STUDY 7

TECHNICAL DETAILS OF FEWMS

Item	Details of deployment
10 Radar-based Automatic Water Level Recorders	Automatic Water Level Recorders (AWLR) deployed in the 10 identified locations across Thamirabarani river basin to monitor water flow levels
4 Weather Sensors	• 1 Automatic Weather Station (AWS) installed at Pettai 50 MLD Water Treatment Plant (records Temperature, Rainfall, Humidity, and Wind data) • 3 Automatic Rainfall Gauging Stations (ARGS) in the other 3 zones of city: ◦ Thatchanallur Zonal Office – Near Tirunelveli Junction ◦ Indoor Stadium – Darling Nagar ◦ Health Service Centre – Thirumal Nagar
50 Cameras	• 36 cameras deployed in Flood Vulnerable Areas in Tirunelveli city • 14 cameras deployed along with weather and water level sensors for safety of equipment • Camera view access through the OEM's desktop and mobile application
FEWMS Dashboard	• Displays flood advisory in the 10 sensor locations based on water flow • Flood warning status for Tirunelveli city based on Mukkudal flow (to include upstream sensor based on further calibrations) • Local weather conditions based on live data feed from the sensors • Provides access to historical record of data from the sensors

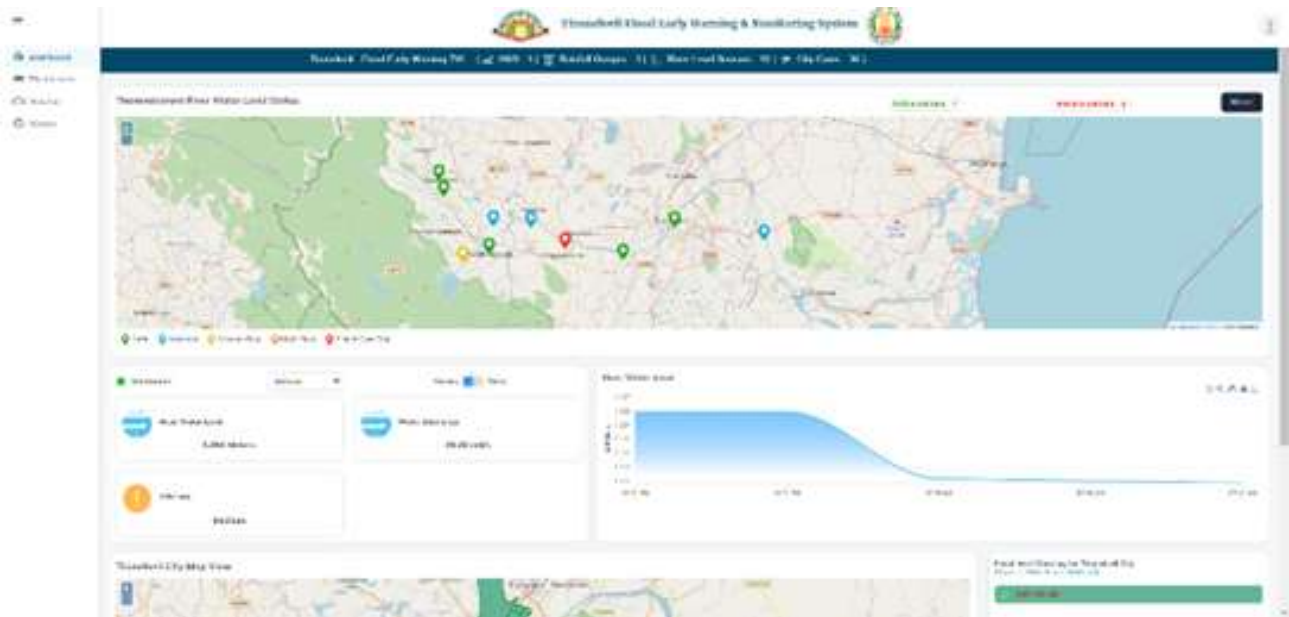
The FEWMS project primarily consists of 10 Radar-based Automatic Water Level Recorder (AWLR) sensors deployed in strategic locations across Thamirabarani river basin, and integrated to a web-based dashboard, which provides advanced warning to the city by continuously monitoring the water flow in the river. In addition, weather sensors in 4 zones of the city and 36 cameras in flood vulnerable locations within the city were installed to monitor riverine and urban flooding that impacts the daily livelihoods in the city during extreme rainfall events, especially in the North-east monsoon season.

Outcomes: 1) FEWMS dashboard integrated into the existing digital infrastructure of Government such as Integrated Command and Control Centre (ICCC) of Tirunelveli City Municipal Corporation and the Control Room of Disaster Management Cell of Tirunelveli District Collectorate, 2) Cameras ensuring safety of sensors, provide live feed of flood levels in sensor locations and flood vulnerable areas in the city

CASE STUDY 7



Installation of Bridge-Mounted Automatic Water Level Recorders as Flood Monitoring Sensors



Real-Time Monitoring Dashboard of the FEWMS Platform, Tirunelveli

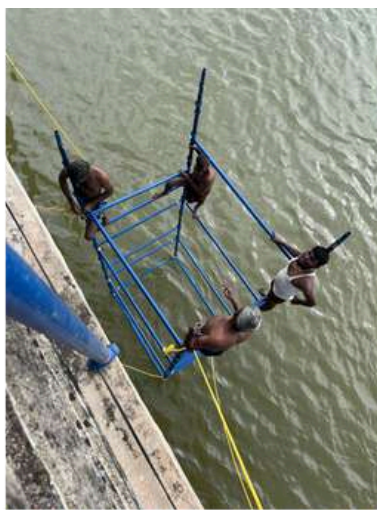
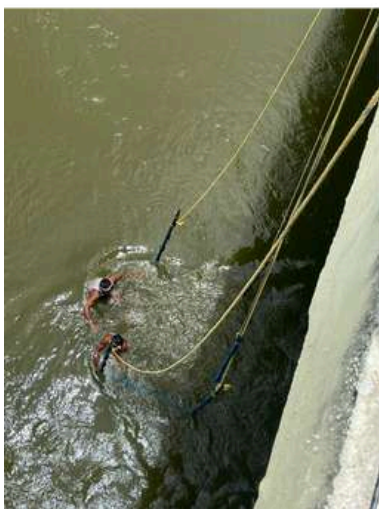
CASE STUDY 7

SCALE-UP POTENTIAL

The project has scale-up potential to include monitoring of the basin of Chittar river, a tributary of Thamirabarani that confluences with Thamirabarani river downstream of Tirunelveli city, which determines the volume of water flowing in the river when it empties into the Bay of Bengal near Tuticorin city which often gets impacted by flooding in Thamirabarani river during heavy rainfall. The FEWMS project is one of the few unique projects in India that undertakes basin level monitoring of river flow and is replicable in other river basin systems in Tamil Nadu and other parts of the country.

CHALLENGES IN IMPLEMENTATION

- Securing No-Objection Certificates from different authorities for mounting sensors on bridges was challenging due to procedural efforts and time taken
- Installation of sensors on deck of bridges were challenging as the workers had to swim to sensor point to install the scaffolding that can then be used by welders and technicians for installing the sensors



Challenging Installation of Bridge-Mounted Flood Monitoring Sensors

CASE STUDY 8

Processing Organic Municipal Solid Waste through Biomethanation in Udaipur



INTRODUCTION

Udaipur, known as the "City of Lakes" is situated in southern Rajasthan, covers 64 sq. km area with a population of 554,148. Celebrated for its rich culture and heritage, Udaipur attracted around 2 million tourists in 2023. It was also one of the first 20 cities selected under the Smart City Mission in 2015.

With rapid urbanization, the city faces increased demand for services like Municipal Solid Waste Management (MSWM). Udaipur generates approximately 220 tonnes of waste per day (as of 2021), including construction debris, with 68% of the waste being organic. The city's waste management infrastructure consists of a 2 TPD biomethanation plant, a 20 TPD biomethanation (waste-to-CBG) plant, a 60 TPD composting facility, a 90 TPD Material Recovery Facility, and a 50 TPD C&D waste processing plant. Untreated waste is transported to a landfill at Balicha village, 20 km from the city.

This case study highlights Udaipur Municipal Corporation's first waste treatment facility, a 2 TPD biomethanation plant, constructed and operationalized under the CapaCITIES Phase I in 2019. The success of this pilot project paved the way for a larger 20 TPD biomethanation plant under the Smart City Mission (SCM).

2 TPD PILOT BIOMETHANATION PLANT

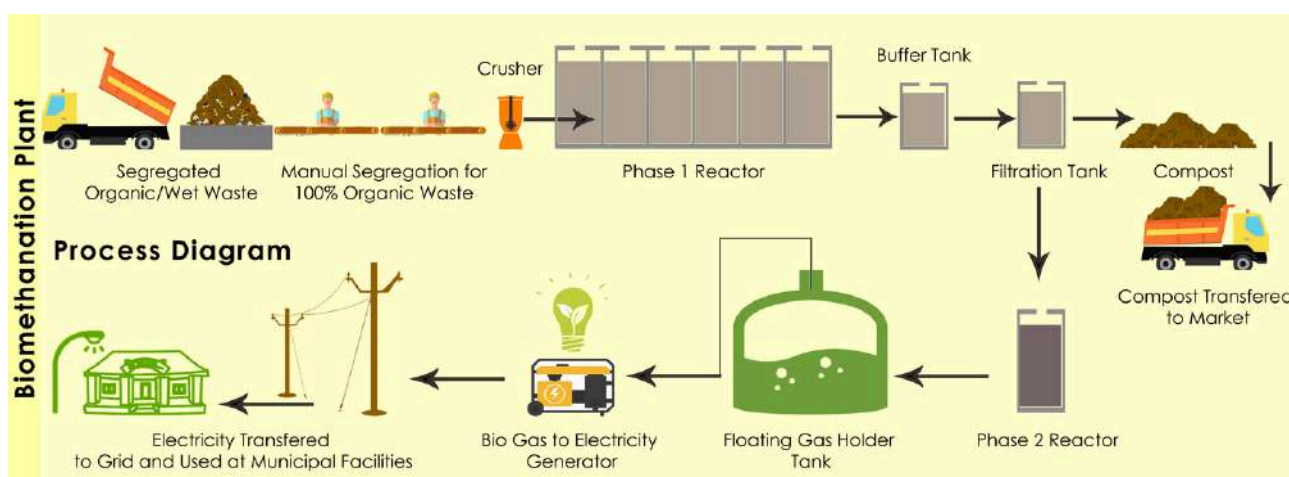
Udaipur faced significant challenges in managing municipal solid waste (MSW) sustainably. Until 2019, all collected waste was dumped at the Balicha landfill, 20 km from the city, contributing to high transportation costs, pollution, and increased greenhouse gas (GHG) emissions. To address this, ICLEI South Asia conducted a waste quantification and characterization study in 2017 under the CapaCITIES Phase 1 project, revealing that 68% of Udaipur's waste was biodegradable with 82% moisture content. A feasibility study evaluated windrow composting, vermicomposting, and biomethanation technologies. Based on land availability, workforce, end-product use, and budget, a decentralized biomethanation plant of 2 TPD capacity was chosen to be implemented at Madri Fire Station.

The Energy and Resources Institute (TERI) got selected for the implementation of the pilot 2 TPD plant on a Design, Build, Operate, and Transfer (DBOT) model using its Bi-phasic Anaerobic Digestion Technology based on TERI's Enhanced Acidification and Methanation (TEAM) Process. In this biphasic biomethanation technology, anaerobic digestion takes place in two phases that enhances methane yield. At the end of phase I, solids separated from acidified liquid are directly transferred to the gas holder tank, which improves the overall production of biogas and electricity generation. This also reduces the bad odour and helps to maintain the hygiene of the surroundings. While usual biomethanation technologies take around 42 days to produce biogas, this is significantly reduced to 7 days by the TEAM process.

CASE STUDY 8



2 TPD Biomethanation Plant (Waste to Electricity) at Madri Fire Station and its Inauguration (From Left)



Process Diagram of the Biomethanation Plant

The Operational Mechanism of 2 TPD Biomethanation Plant:

1. Segregated MSW is unloaded onto a raised platform.
2. MSW is further sorted on a 7 m conveyor belt to remove inert and non-biodegradable waste, which is sent to the MRF.
3. The biodegradable waste is ground (2-3 cm) with water using a vertical wet grinder.
4. In the first phase (hydrolysis and acidification), the slurry is fermented in reactor tanks for six days.
5. After six days, the slurry is pumped to a filtration tank where solids are separated, dried, and turned into compost.
6. The filtrate is mixed in a buffer tank and tested for pH, which is adjusted with caustic soda if necessary to ensure proper anaerobic bacteria growth.
7. The liquid is transferred to the Up Flow Anaerobic Sludge Blanket (UASB) reactor, where biogas is produced and stored in a floating gas holder.
8. The stored biogas powers a 30 kVA gas genset, converting biogas into electricity.

CASE STUDY 8

BENEFITS OF THE PILOT PROJECT

The 2 TPD biomethanation plant has led to significant improvements in waste management and environmental sustainability. In 2020-21, the plant scientifically processed 293 tons of wet waste, reducing the amount of waste transported and dumped at the landfill, leading to lower fuel requirements for waste transportation. This also improved cleanliness and hygiene in nearby wards.

The plant produced 8,838 m³ of biogas which was then used to generate 13,313 kWh of electricity, reducing the conventional power needs of the Fire Station, UMC. Despite only being operational for nine months due to COVID-19, the plant reduced GHG emissions by 349 tons of CO₂e in 2020, with **potential to reduce 1,437 tCO₂e at full capacity**. The scientific disposal of waste mitigated air, water, and soil pollution, while also reducing health risks associated with waste during the rainy and summer seasons. Additionally, it proved to be cost-effective by lowering waste management costs and providing employment to informal workers.

The success of this pilot also enhanced environmental awareness and built confidence among city officials, contributing to the construction of a 20 TPD biomethanation plant under the Smart City Mission. This further increased waste processing capacity and reduced emissions in Udaipur's MSW sector.

LEARNINGS FROM THE 2 TPD PILOT PLANT

- The conveyor belt should have side walls to prevent waste from falling off during operation.
- A single motorized pump limits simultaneous operation of slurry transfer (crusher to acidification reactor) and acidified liquid to MS filtration.
- An MRF facility at the same location is recommended to improve system efficiency and reduce transportation costs for unsegregated dry waste.
- Frequent UASB leakages are hard to repair due to its RCC construction.
- High freshwater consumption at the plant can be reduced by reusing effluent from the gas holder and UASB, making the process more efficient.
- The MS conveyor for separating solids from acidified liquid is inefficient, as the solid is moist and viscous, leading to unhygienic conditions.
- Installing a biogas purification unit for CO₂, H₂S, H₂, and N₂ would improve gas engine performance and output.
- Limited land availability in urban areas increases transport costs, making site selection critical for optimizing costs.
- Lack of state policy on power purchase from waste-to-energy plants hinders the financial viability and scalability of the waste-to-electricity model.
- Finding a contracting agency for O&M of smaller plants is a challenge.

CASE STUDY 8

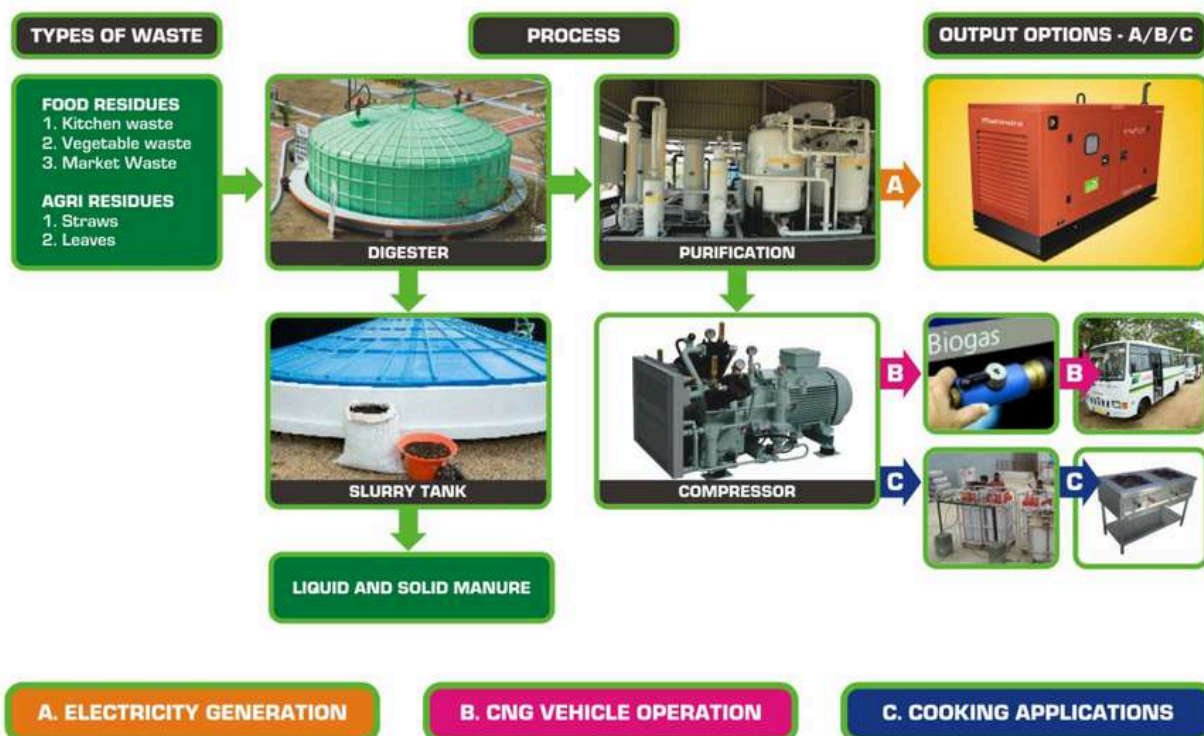
SCALE-UP TO 20 TPD WASTE TO ENERGY PLANT

Based on the success of the 2 TPD biomethanation plant pilot, UMC decided to build a 20 TPD city-scale biomethanation plant as part of the Smart City Project, on the bioremediated site of the previous Balicha dumping yard. A 60 TPD MRF facility was also constructed on the same site to process dry waste. Insights from the 2 TPD plant informed the technology choice for the larger plant.

Without a state-level power-purchase policy for waste-to-energy, UMC opted to produce Compressed Bio Gas (CBG) for sale in the open market. The plant, built by Mahindra Waste to Energy Solutions Ltd (MWTESL) on a DBOT model, has been operational since February 2021, with MWTESL handling its operation and maintenance for 15 years.



20 TPD
Biomethanation
Plant in Udaipur



CASE STUDY 8

TECHNICAL FEATURES OF THE PLANT

Particular	Description
Plant Capacity & Location	20 TPD, Dumping Yard, Balicha
Plant Type & Category	Biomethanation Plant, Waste to Energy (CBG)
Base Technology	Basic Khadi & Village Industries Commission (KVIC) model biogas digester with water sealing technology along with agitation mechanism
Output	CBG, Compost (by-product), Electricity (for internal use in the plant as a power backup)
Methane Purity level	93-96%
Average Raw Bio Gas and CBG Production Capacity	1600 m ³ /day → 600 kg/day
Bio Fertilizer	8 tons/day
Usage	Cooking fuel in Hotel Industry
Electricity Source & consumption	Power Grid, 50 Units per ton of organic waste
Nos. of personnel working at the plant	26
Envisaged Plant Life	20
Financial Model	VGF (Viability Gap Funding)
Project Cost	Total Project Cost with 15 Years AMC: INR19.9 Cr VGF amount quoted by MWTESL: INR.9.95 Cr.

UNIQUENESS OF THE PLANT

- Completely mechanical plant with computerized monitoring of gas purification and CBG production units.
- Green initiative constructed on reclaimed land part of the Balicha dumping yard and there is no discharge or residue generated from the plant as effluent or sludge.
- There is zero freshwater demand in the processing of organic waste, as the water demand is met by recycling the effluent from the digester.
- Gravitational feeding minimizes electricity consumption.
- The CBG produced by the plant is compatible with vehicles; hence, it can also be sold to the local CNG dealers.

CASE STUDY 8

OVERALL BENEFITS

The plant supports renewable energy use by providing clean fuel for cooking, electricity generation, and transportation. It promotes a circular economy by converting organic waste into Compressed Bio Gas (CBG) and compost, enhancing resource efficiency and generating revenue. CBG also helps reduce operational costs by being used for electricity generation and as vehicle fuel. Dry waste is transferred to an on-site Material Recovery Facility (MRF), reducing transportation costs and improving plant efficiency.

By processing 12 TPD of biodegradable waste, the plant addresses nearly 19% of the city's total waste, supporting UMC's zero landfill goal. It significantly lowers city-level GHG emissions and supplies clean fuel to local hotels, with the potential to reduce around 4000 tonnes of CO₂e annually when operated at full capacity. Additionally, the plant's scientific approach to waste disposal minimizes air, water, and ground pollution. The centralized nature of the plant makes it easier for UMC to monitor and maintain.

ISSUES AND CHALLENGES

- Like other intermittent energy sources (solar, wind), the weather also affects biogas production. Biogas generation is less in the winter and rainy seasons.
- Need to ensure continuous supply of source segregated wet waste.
- In the absence of any segregation unit in the plant, there is a need to ensure that the waste received is 100% segregated. The presence of dry waste in large quantity creates unnecessary hassle in handling the waste along with decreasing the overall efficiency of the plant.
- It is more capital-intensive than the decentralized facility. Also, considering the quantum of segregated organic waste a feedstock, such technologies should not be preferred, for smaller towns or municipalities.
- In order to create a market demand for CBG, the operator is presently selling the CBG at a lower price than the market rate to hoteliers. This has impacted the financial sustainability of the plant. There is a need to formulate a state level policy promoting usage and cost of CBG from waste.
- There is a need to create awareness among key actors and stakeholders to ensure successful operation of the plant in the long run.

LEARNINGS FROM THE PROJECT

UMC had a good learning opportunity while implementing both i.e. decentralised and centralised plants. Learning from the implementation and operation of both the plants should be used for developing more efficient waste management systems in towns like Udaipur. Some of the significant learnings include:

- For the successful and efficient operation of a biomethanation plant, 100% source-segregated waste is required as feedstock.
- Pilot-scale plants help cities understand the intricacies of designing and operating such technology, including manpower requirements, skill development, capacity building, and financial considerations. These pilots allow testing of technology under local conditions and identifying necessary adaptations, enabling informed decision-making before investing in larger centralized plants.
- Contracting a private agency for the O&M of decentralized plants can be challenging. Cities should explore capacity-building initiatives for the informal sector and consider employing personnel through national or provincial livelihood support programs, such as the National Urban Livelihood Mission (NULM) in India. This approach is crucial for ensuring the financial sustainability of the plant.
- Conducting a market analysis is essential to assess the demand and viability of the plant's final output (e.g., biogas, power, CBG).

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CASE STUDY 9

Support to LEED Certification for Urban Administrative Building in Chennai, Tamil Nadu



INTRODUCTION

The Sustainable Urban Administrative Building (UAB) project aimed at upgrading the Commissionerate of Municipal Administration's existing office facility to achieve LEED Gold certification. This initiative demonstrates the Government's commitment to creating energy-efficient and environmentally responsible buildings through sustainable design and operational practices. The successful completion of this project resulted in the building receiving LEED Gold certification, setting a benchmark for future green building projects in the state.

Project Overview:

- **Site Area:** 44,000 sq. ft.
- **Location:** Santhome High Road, MRC Nagar, Raja Annamalai Puram, Chennai
- **Target:** LEED Gold Certification
- **Technical Partners:** ICLEI South Asia (through CapaCITIES Phase II project)

KEY SUSTAINABLE FEATURES

- **Energy Efficiency:** Installation of state-of-the-art LED lighting and high-efficiency HVAC systems significantly reduced energy consumption.
- **Water Conservation:** Water-efficient fixtures, atmospheric water generation systems, and rainwater harvesting were implemented, resulting in a 30% reduction in water usage.
- **Sustainable Materials:** Over 20% of materials were sourced locally, minimizing transportation emissions. More than 50% of construction waste was recycled or repurposed.
- **Indoor Environmental Quality:** Use of low-emitting materials and abundant natural light ensures a healthier and more comfortable environment for the building's occupants.
- **Waste Management:** A comprehensive waste management system with segregated bins for recyclable and non-recyclable waste.
- **High-Performance Glazed Glass:** Installation of energy-efficient glazing improves thermal insulation, reducing the need for artificial cooling and enhancing energy efficiency.

CASE STUDY 9

IMPLEMENTATION PROCESS

A systematic process for the implementation of this project to ensure that all aspects of the building's design and operation were aligned with LEED Gold standards. The sequence of the steps involved were:

1. **Stakeholder Consultation:** Early engagement with stakeholders, including government officials, environmental experts, and building occupants, was key to defining rating goals and long-term functional requirements.
2. **Sustainability Assessment:** A detailed sustainability assessment was conducted to identify opportunities for energy optimization, water conservation, and the use of sustainable materials.
3. **Certification Process:** Upon completion of the assessment, the project team submitted documentation to the U.S. Green Building Council (USGBC) and successfully achieved LEED Gold certification for the building.

GREEN BUILDING AUDIT DETAILS

A comprehensive technical audit was carried out on the building's performance, addressing energy use, material sourcing, water consumption, and indoor environmental quality. These audits were aligned with LEED Gold certification criteria, which evaluate buildings on a 110-point scale across various categories.

The LEED (Leadership in Energy and Environmental Design) rating system is a globally recognized framework for evaluating the sustainability of buildings. It awards points across various categories, with a total of 110 points available. These categories include:

1. **Location and Transportation (16 points):** Encourages sustainable site selection and access to public transportation.
2. **Sustainable Sites (10 points):** Focuses on minimizing the impact of the building on ecosystems and water resources.
3. **Water Efficiency (11 points):** Aims to reduce water consumption and improve management.
4. **Energy and Atmosphere (33 points):** Focuses on energy performance, renewable energy, and reducing greenhouse gas emissions.
5. **Materials and Resources (14 points):** Encourages the use of sustainable materials and waste reduction practices.
6. **Indoor Environmental Quality (16 points):** Ensures good indoor air quality, natural lighting, and thermal comfort.
7. **Innovation (6 points):** Recognizes innovative practices or strategies that go beyond the standard criteria.
8. **Regional Priority (4 points):** Awards points for addressing geographically specific environmental priorities.

Buildings can achieve different certification levels based on the total points earned: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points), and Platinum (80-110 points).

CASE STUDY 9

KEY HIGHLIGHTS OF THE UAB

- **Energy Efficiency:** The building scored high marks in the Energy and Atmosphere category due to the installation of energy-efficient systems and a reduction in energy consumption by approximately 25%.
- **Water Efficiency:** Achieved significant reductions in water use, scoring well in the Water Efficiency category. The rainwater harvesting system and water-saving fixtures contributed to a 30% decrease in overall water use.
- **Materials and Resources:** Over 50% of construction waste was recycled or repurposed, and more than 20% of materials were sourced locally. This was recognized under the Materials and Resources category. Since the building was built after demolition of a smaller building that existed on the site, demolition waste was incorporated into construction. This information was gathered from the assessment conducted by the site engineers.
- **Indoor Environmental Quality:** The building scored high in maximizing natural light and using low-emitting materials, ensuring a healthy indoor environment for its occupants.

The building achieved a total of **75 points**, earning it the prestigious **LEED Gold certification**.

HIGHLIGHTS

- **LEED Gold Certification:** UAB received LEED Gold certification, a testament to its sustainability.
- **Operational Efficiency:** The building's retrofit is expected to provide long-term energy savings, reducing operational costs over the building's lifetime.
- **Community Impact:** The project serves as a model for sustainable urban development and engages the public in the importance of green building practices.

CHALLENGES

- **Procurement Process:** The public procurement process often led to delays, especially when sourcing green-certified materials and technologies, which must be accounted for in future projects.
- **Process Challenges:** Most of the administrative buildings are very actively used, so doing retrofitting by stopping active use or creating alternative working accommodation for officials is a huge logistics challenge that requires detailed planning.
- **Integration of Technologies:** Ensuring that all systems, from HVAC to water treatment, were seamlessly integrated posed challenges, requiring continuous monitoring and adjustments to optimize performance.

CASE STUDY 9

ENABLERS FOR SCALE-UP

Given the success of the Sustainable UAB project, scaling up green building interventions for public buildings across Tamil Nadu has been identified as a key priority in the state's sustainability roadmap. The lessons learned from this building's retrofit can be applied to other municipal buildings across the state.

Replicability: The UAB retrofitting approach can be replicated across other government buildings in Tamil Nadu by following similar design principles, energy-efficient technologies, and sustainable material use. A standardized process supported by cost-benefit analysis and performance benchmarks can guide future retrofits, ensuring scalability, efficiency, and reduced implementation time and costs.

Technology and Tools: The use of building performance monitoring tools and energy audits will be essential in ensuring that similar projects achieve comparable or higher sustainability ratings.

Training and Capacity Building: Scaling up requires the training of municipal employees, contractors, private builders and practicing architects on green building standards, LEED certification processes, and sustainable construction practices.

Financial and Policy Support: A potential scale-up initiative would need the backing of the Tamil Nadu government to ensure financial support and policy alignment to incentivize energy-efficient construction.

By replicating this model, the state could reduce its overall emissions footprint, contribute to national sustainability targets, and set a precedent for other regions in India.

The state of Tamil Nadu has shown active interest in scaling this action by adopting this model to bring 1 million+ sq. ft of municipal building space under green building certification.

CASE STUDY 9

FUTURE PLANS

Following the success of UAB, the Tamil Nadu government plans to retrofit additional public buildings in addition to mandating these standards for all new municipal buildings, aligning with the state's broader climate goals. This will include scaling up similar energy-saving initiatives, such as adopting solar panels, further optimizing HVAC systems, and retrofitting more municipal buildings for LEED certification.



**LEED Gold Rating Certified
Urban Administrative Building**



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CASE STUDY 10

Design Evaluation and Certification Support for Green Public Buildings in Tiruchirappalli



CASE STUDY 10

INTRODUCTION

The Tiruchirappalli City Corporation (TCC) embarked on a pioneering initiative to construct two Library-Cum-Knowledge Centres at Palakkarai and Cantonment (Kuduppapallam) as sustainable green buildings. This project was undertaken with technical support from the CapaCITIES Phase II project and reflects the Tamil Nadu Government's commitment to mainstreaming green building practices in public infrastructure. The centres are envisioned as model facilities that demonstrate how educational infrastructure can be both environmentally responsible and socially beneficial across Tamil Nadu. The 2 building sites that were selected for implementation are:

- **Building 1:** Palakkarai (**Built-up Area: 649 sq. m**)
- **Building 2:** Cantonment (**Built-up Area: 729 sq. m**)

Tiruchirappalli experiences a warm and humid climate, with average temperatures exceeding the range of 22°C to 24°C. With average humidity ranging between 40-60%, excluding monsoon periods, it can contribute to thermal discomfort, underscoring the need for climate-responsive design and natural effective ventilation strategies. The prevailing winds from the South-West and North-East, with an average velocity of 5 m/s, offer a significant potential to improve thermal comfort by improving natural cooling, by:

- Improving Building orientation and fenestration design to harness winds effectively.
- Strategically positioning operable windows to capture the prevailing breeze, the design can optimize natural ventilation, enhance the indoor air quality and occupant comfort while simultaneously reduce reliance on energy-intensive mechanical cooling systems.

As part of the CapaCITIES Phase II project, a comprehensive technical design evaluation was proposed for the 2 buildings to ensure alignment of the building design and specifications with green building certification standards and the sustainability goals of the TCC. The initial building design and specifications were based on a prototype model recommended by the Directorate of Municipal Administration (DMA), which is a standardized municipal building design intended to ensure uniformity, cost efficiency, and easy replication across the cities in the state.



Using these initial building design and specifications as the baseline, a comprehensive review of the building design, technical specifications, cost estimates, and other relevant tender documentation was undertaken by green building experts under the CapaCITIES Phase II project and provided recommendations to incorporate green building principles into the design of buildings as required to meet the Indian Green Building Council (IGBC) Green Building Standards and Criteria.

CASE STUDY 10

OBJECTIVES OF DESIGN EVALUATION

The key objectives of the technical design evaluation and certification support provided under the CapaCITIES project for developing the 2 public buildings as green buildings in Tiruchirappalli city are:

- Integrating climate-responsive and resource-efficiency into the building design and specifications to meet IGBC certification criteria.
- Align the design with IGBC Platinum rating criteria, while also referencing Excellence in Design for Greater Efficiencies (EDGE) Green Building Standards for cross-verifying projected energy and water savings.
- Provide technical recommendations and guide TCC in implementing green building measures through the final design and tender documentation.
- Provide technical support to TCC in submission of documentary evidence as per the criteria for green building certification under IGBC.

DESIGN RECOMMENDATIONS

Based on the comprehensive evaluation of the design of buildings, a set of green building interventions for integration into the initial building design and specifications were recommended. The TCC endorsed the recommendations aimed at enhancing energy and water efficiency, thermal comfort, and overall environmental performance of the Library-cum-Knowledge Centers, and the green building features were incorporated into the revised design and tender documentation:

- **Climate-Responsive Design:** The building orientation was optimized to capture southwest and northeast winds (average 5 m/s), with operable windows strategically positioned to promote natural cross-ventilation. This enhances indoor air quality and occupant comfort while reducing reliance on mechanical cooling systems.
- **Energy Efficiency Systems:** Recommendations included high-performance windows and doors, efficient HVAC systems, building automation, and LED lighting with daylight controls, leading to optimized energy management and reduced operational energy demand.
- **Water Conservation Measures:** Use of low-flow fixtures (toilets, faucets) and rainwater harvesting systems was proposed to minimize potable water use and improve stormwater management.
- **Sustainable Materials:** Locally sourced and low-embodied energy materials were recommended, including the use of AAC blocks and recycled content, alongside strategies for on-site waste minimization and reuse of construction materials.
- **Indoor Environmental Quality:** Low-VOC paints and finishes, combined with enhanced ventilation and daylighting, were suggested to create a healthier and more comfortable indoor environment for students, youth, and community users.

IMPLEMENTATION PROCESS

The design evaluation process and green building certification support was carried out systematically to ensure that all proposed interventions were technically feasible and aligned with IGBC Platinum and EDGE benchmarks. The process emphasized stakeholder engagement, technical analysis, and integration into final tender documentation to facilitate on-ground implementation. The **key steps in the implementation process are:**

- **Stakeholder Consultation:** Early consultations were held with officials from the (TCC) including the Engineering, Town Planning, Estate, and Education Departments along with representatives from the Directorate of Municipal Administration (DMA). These discussions helped define green building goals, certification targets, and operational requirements for the proposed Library-cum-Knowledge Centers.
- **Baseline Review and Gap Identification:** The base Type III prototype design was reviewed against IGBC Platinum and EDGE criteria to identify performance gaps related to energy efficiency, water management, material use, and indoor environmental quality.
- **Feasibility Assessment:** The ICLEI South Asia technical team conducted a comprehensive review to evaluate the feasibility of the proposed Library-cum-Knowledge Centers for achieving green building certification. The assessment analyzed the floor plans, building orientation, Mechanical, Electrical, and Plumbing (MEP) layouts, daylighting, thermal comfort, solar rooftop potential, building materials, and landscape elements such as tree cover and shading.
- **Technical Consultations and Validation:** Multiple rounds of consultations with TCC engineers, DMA, and design consultants were undertaken to validate the feasibility of each proposed measure, ensuring they could be integrated within the existing design and budget framework.
- **Integration of Green Building Criteria:** The review proposed targeted improvements in architectural design, material selection, and technical specifications to strengthen the project's compliance with green building principles.
- **Tender Documentation Alignment:** The finalized recommendations were incorporated into the tender and construction specifications, ensuring that contractors could effectively implement the proposed green features during project execution.
- **Implementation of Proposed Measures:** Recommended features such as energy-efficient lighting, low-flow fixtures, and rooftop solar systems were implemented during construction, translating design recommendations into on-ground action.
- **Certification Support:** Supported validation and submission of documentation to IGBC, which then reviewed the documentation and recommended a few minor installations and documentation updates for awarding of certification.
- **Monitoring and Performance Tracking:** TCC, with support from ICLEI South Asia, began post-construction monitoring of energy and water use to verify actual performance and document the benefits of implemented measures.

PROJECT OUTCOMES AND BENEFITS

- **Reduced Energy Consumption:** Compared to the base case (conventional Type III design), the proposed green design achieved a 72.05% reduction in energy use at Palakkarai and 68.24% at Cantonment, driven by optimized building orientation, efficient material use, and integration of rooftop solar systems.
- **Lower Operating Costs:** Enhanced energy and water efficiency measures contribute to reduced electricity bills, lower maintenance needs, and overall life-cycle cost savings, improving the financial performance of both centres.
- **Improved Indoor Environment:** The inclusion of natural ventilation, daylighting, and low-emission materials supports better indoor air quality, thermal comfort, and user well-being, particularly for students and community visitors.
- **Reduced Environmental Impact:** The 30 kW rooftop solar system on each building offsets approximately 45 MWh (0.045 MU) annually, reducing reliance on grid electricity and avoiding around 16.4 metric tons of CO₂ emissions per building, totaling nearly 32.9 metric tons of CO₂ emissions per year.
- **Demonstrational Value:** These centres serve as model public buildings, demonstrating how municipal projects can integrate green design principles to achieve significant energy savings and carbon reductions, paving the way for wider replication across Tamil Nadu.

Potential Energy and CO ₂ emissions reduction		
Parameter	Palakkarai Site	Cantonment Site
Design case energy consumption	0.076 MU/annum	0.085 MU/annum
Base case energy consumption	0.111 MU/annum	0.125 MU/annum
Estimated PV generation	0.045 MU/annum	0.045 MU/annum
Built up Area (sq.m)	649 sq.m	729 sq.m
Design Case EPI (Incl. PV offset)	47.92 kWh/sq.m/year	55.41 kWh/sq.m/year
Base case EPI	171.43 kWh/sq.m/year	171.33 kWh/sq.m/year
Energy Savings	72.05%	68.24%



Knowledge and Study Centre Building, Tiruchirappalli, Tamil Nadu

POTENTIAL FOR SCALE-UP

Given the success of the design and implementation process, this initiative demonstrates the feasibility of integrating green building principles in public infrastructure. The project serves as a replicable model for other municipal and institutional buildings across Tamil Nadu, aligning with the state's broader sustainability and low-carbon development goals.

The key Enablers for scale-up of green building adoption for public buildings are:

- **Capacity Building and Awareness:** Developing a strong Strengthening institutional capacity is essential for scaling up similar green building initiatives. Training programs are to be conducted for municipal engineers, contractors, architects, and private developers focusing on green building design, certification processes, and sustainable construction practices to ensure effective adoption.
- **Conduct Building Energy Audits and Benchmarking:** Energy audits, benchmarking, and use of digital modelling and monitoring tools should be regularly adopted across new and existing public buildings to identify efficiency gaps and to track performance, and guide data-driven design and retrofit improvements.
- **Financial and Policy Support:** Scaling up green building projects across Tamil Nadu will require financial incentives, policy backing, and integration with existing government schemes, enabling wider replication within public infrastructure.

By replicating this model, the state could reduce its overall emissions footprint, contribute to national sustainability targets, and set a precedent for other regions in India.

CASE STUDY 10

CHALLENGES

- **Limited Awareness and Adoption:** Despite increasing interest in green building practices, awareness and adoption of green building concepts among developers and public administrators remain limited, often resulting in delays in the approval process.
- **Professional Skill and Capacity Gaps:** Limited technical expertise among architects, engineers, and contractors in applying sustainability principles and technologies is a key barrier for widespread green building adoption. Targeted capacity-building programs, hands on experience in adopting sustainability into design and construction, certification courses, and continuous professional training are required to enable adoption of climate-responsive and resource-efficient buildings.
- **Lenient Policy Enforcement:** Despite the presence of mandatory regulations and green building rating systems such as the Energy Conservation Building Code (ECBC) and IGBC, inconsistent implementation and enforcement continue to hinder the growth of the green building sector.
- **Lack of procurement policy reforms:** Lack of continuous integration of energy-efficient or green building certified building materials and equipment, and nature-based materials into the Schedule of Rates (SOR) prepared by Tamil Nadu Water Supply and Drainage Board (TWAD), and Public Works Department (PWD). This, in turn, hinders the adoption of green building by local governments, as SOR rates do not reflect the higher costs of energy-efficient materials and systems.

WAY FORWARD

It is critical to include a dedicated budget for green-certified materials within contractual frameworks. This would help overcome challenges linked to contracting practices and SOR limitations. Integrating pre-approved green specifications into standard tender documents can streamline procurement and reduce ambiguity during execution. Capacity-building workshops for contractors and municipal engineers on certification pathways and material compliance will further support smoother adoption. Establishing a centralized repository of certified vendors and products can accelerate decision-making and ensure consistency across projects.



Launch of the Knowledge and Study Centre Initiative by the Hon'ble Chief Minister of Tamil Nadu

To scale impact, more demonstration projects can be undertaken across diverse public building typologies such as schools, offices, and healthcare facilities to showcase replicable models. Further, establishing a holistic policy framework and dedicated financing mechanisms will be critical to mainstream green building adoption.

CASE STUDY 11

Development and implementation of Tamil Nadu Urban Livability Framework



CASE STUDY 11

INTRODUCTION

The Tamil Nadu Urban Livability Framework (TNULF) was developed to assess and enhance the quality of life in urban areas across the state. It establishes a ranking methodology for 21 Corporations, 138 Municipalities, and 490 Town Panchayats, covering settlements from large metropolitan areas to small towns. The Directorate of Municipal Administration (DMA), under the Municipal Administration and Water Supply (MAWS) Department of Government of Tamil Nadu, oversees and manages the delivery urban services across all ULBs in the state.

The framework is built on 13 thematic areas and 108 parameters, adapted from ICLEI's Basket of Solutions (BoS) tool, developed in collaboration with eConcept under the CapaCITIES project. The BoS provides urban sustainability strategies addressing governance, environmental management, and social equity. Its integration into TNULF enables Tamil Nadu to adopt solutions tailored to the state's urbanization challenges, particularly around climate resilience and sustainability.

Recognizing climate action as central to urban livability, TNULF embeds climate-related parameters under the thematic area Climate Action & Resilience. These guide Urban Local Bodies (ULBs) in mitigating environmental risks and strengthening adaptive capacity. The TNULF was designed in collaboration with ICLEI South Asia and eConcept AG, drawing from international best practices (European Energy Efficiency Index, OECD Smart City Measuring Framework, CSCAF, Municipal Performance Index, and Urban Outcomes Framework) and finalized through expert consultations. The framework also accounts for variation in ULB capacity by classifying them as follows:

- **By ULB Type:** Corporation, Municipality, Town Panchayat
- **By Population:** >1 million, 0.5–1 million, 0.1–0.5 million, <0.1 million

Tamil Nadu is one of India's most urbanized states, with 48.45% of its population living in urban areas (Census 2011), significantly above the national average of 31.16%. This high level of urbanization underscores the relevance of TNULF in addressing the challenges and opportunities of urban development.

OBJECTIVE

The vision of Tamil Nadu is to create sustainable, resilient, and inclusive urban spaces that accommodate rapid urbanization while addressing environmental and socio-economic challenges. This aligns with the state's broader commitment to climate resilience and sustainability, ensuring that urban growth enhances citizen well-being, supports economic development, and preserves natural resources. TNULF provides a structured, data-driven approach to achieve this vision. Its key objectives are to:

- Identify strengths and areas for improvement in ULBs.
- Facilitate targeted interventions and resource allocation.
- Promote healthy competition to drive sustainable development.
- Enable knowledge exchange and best practice sharing.
- Establish a baseline for future assessments.

CASE STUDY 11

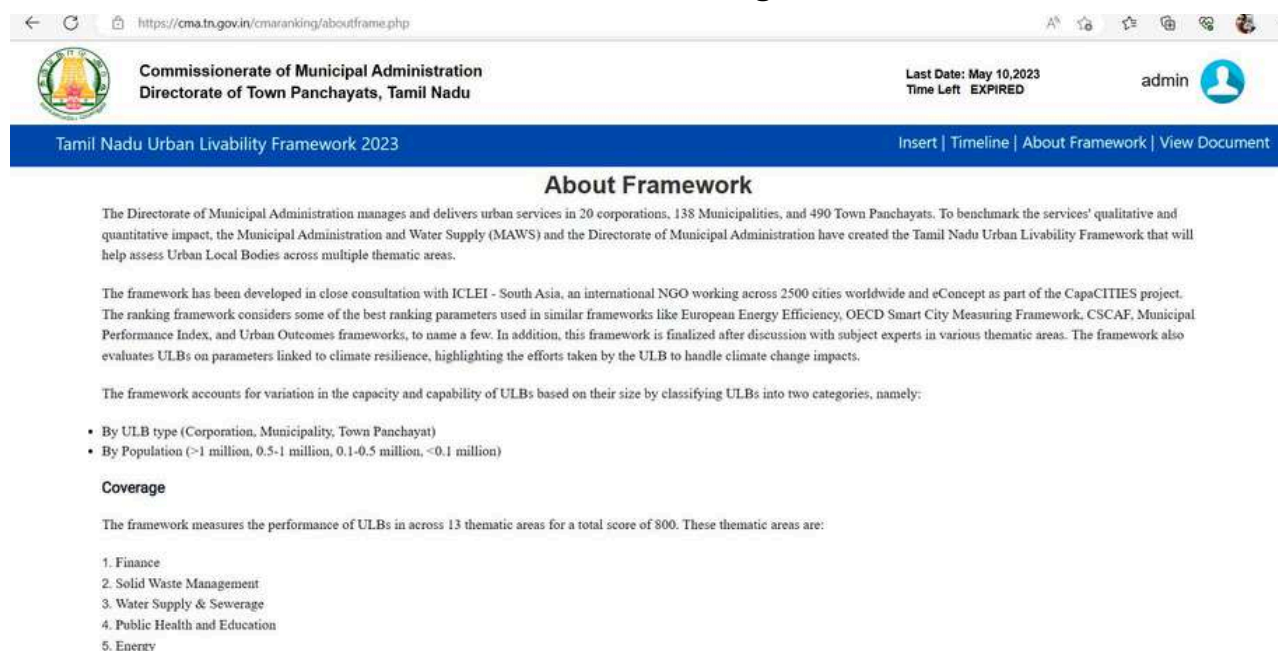
METHODOLOGY

TNULF adopts a multi-faceted approach, incorporating both qualitative and quantitative data, and the methodology is structured across the following key components:

- **Thematic Areas:** The framework was structured around 13 thematic areas, including:
 - Finance
 - Solid Waste Management
 - Water Supply & Sewerage
 - Public Health and Education
 - Energy
 - Transport & Mobility Infrastructure
 - Planning
 - Green Cover, Biodiversity, and Pollution
 - Climate Action & Resilience
 - E-Governance Initiatives
 - Capacity Building
 - Citizen Engagement & Transparency in Governance
 - Innovation & Recognition
- **Parameters and Indicators:** A total of 108 parameters were selected from ICLEI's BoS tool, supplemented by consultations with experts to establish a holistic set of criteria to assess performance across the thematic areas.
- **Data Collection:** Data is gathered using a web-based application where ULBs submit data along with evidence in the form of reports and information submitted for other government schemes and validated by the head of the ULB.
- **Scoring and Ranking:** The scoring and ranking methodology of TNULF is designed to provide a transparent and comparable assessment of ULBs. Each ULB is evaluated on 108 parameters, with the process structured as follows:
 - **Point Scale (0–4):** Every parameter is scored on a five-point scale, ranging from 0 to 4.
 - **Percentile Method:** For each parameter, the best-performing ULB is considered the 100th percentile. Accordingly, ULBs scoring up to the 90th percentile is awarded four points for that parameter. For negatively oriented parameters, the lowest value represented the 100th percentile.
 - **Relative Weightage:** Parameters considered more critical for livability and resilience are assigned higher weightage. Each parameter score is multiplied by its respective weightage factor to ensure that priority areas had greater influence on the final results.
 - **Computation of Scores:** The weighted scores are aggregated to calculate thematic scores across the 13 thematic areas, which are then combined to generate a composite livability score for each ULB.

CASE STUDY 11

- Ranking:** ULBs are ranked within their peer groups (Corporations, Municipalities, and Town Panchayats) and population categories (>1 million, 0.5–1 million, 0.1–0.5 million, <0.1 million) to ensure fair and equitable comparison.
- Validation and Review:** Draft scores and rankings of ULBs undergo validation by a State Evaluation Committee. Final rankings are published only after rigorous validation using data from the state's Common IT Application software, official submissions from ULBs, and cross-checked against state and national datasets.



Tamil Nadu Urban Livability Framework 2023 – Webpage Overview

IMPLEMENTATION AND IMPACTS

The TNULF was implemented in multiple iterative rounds, integrating feedback from pilot testing and stakeholders, to refine its methodology and address challenges in effective implementation of the assessment framework:

- Pilot Phase:** A pilot phase was conducted in select urban areas to test the framework's effectiveness and refine the methodology.
- Statewide Implementation:** Following the pilot phase, the framework was fully rolled out across all urban bodies in Tamil Nadu in 2023.
- Review and Validation:** Continuous data validation by a state-level Evaluation Committee ensured the framework's robustness and fairness.
- Feedback Incorporation:** Stakeholder feedback from ULB officials and community representatives played a critical role in improving the framework's accuracy.

CASE STUDY 11

The Department of MAWS currently uses the TNULF assessment as a reference baseline to monitor the progress of ULBs at periodic intervals annually and reward them. As of now, 2 rounds of state-wide TNULF assessments have been undertaken with support from the CapaCITIES project, demonstrating the framework's effectiveness as a tool for data-driven urban governance.

All data collected through the TNULF is securely stored in a centralized database, and will be continuously monitored and updated during consecutive rounds of the TNULF implementation. Advanced analytical tools are applied to generate actionable insights, which inform and guide state-level decisions related to urban planning, policy formulation, resource allocation, infrastructure improvement and locally targeted interventions at the ULB level.

Examples of analysis driving state-level decision making:

- **Best Practices Sharing:** For instance, a top-performing ULB shared a successful initiative in solid waste management, which involved a zero-waste program that reduced landfill dependence by 30%. This practice was prioritized in their SBM 2.0 action by several other corporations.
- **Policy Formulation:** Data highlighting water supply shortages in certain municipalities led to the allocation of additional resources for water infrastructure upgrades in the World Bank-funded TNCRUPD program.

The screenshot displays the 'Tamil Nadu Urban Livability Framework 2023' dashboard. The header includes the logo of the Commissionerate of Municipal Administration, Directorate of Town Panchayats, Tamil Nadu, and a user profile icon labeled 'admin'. The dashboard features a navigation bar with links: Dashboard, Insert, Timeline, About Framework, and View Document. Below the navigation bar, there are several categories represented by colored squares: 1. FINANCE (orange), 2. SOLID WASTE MANAGEMENT (green), 3. WATER SUPPLY & SEWERAGE (blue), 4. HEALTH & EDUCATION (red), 5. ENERGY (purple), 6. TRANSPORT, MOBILITY & INFRASTRUCTURE (teal), 7. CITY PLANNING (light blue), 8. GREEN COVER & BIODIVERSITY (dark green), 9. CLIMATE ACTION & RESILIENCE (light green), 10. E-GOVERNANCE INITIATIVES & INNOVATION (dark blue), 11. CAPACITY BUILDING (light green), and 12. CITIZEN ENGAGEMENT & TRANSPARENCY IN GOVERNANCE (dark blue). The '1 FINANCE' category is selected and highlighted in orange. Below this, there are five sub-sections for data entry: 1.1 Per capita revenue, 1.2 Own source income to total revenue, 1.3 Loan repayment factor, 1.4 Per capita capital expenditure, and 1.5 Budget Variance. Each sub-section contains a table with input fields for various metrics, including revenue, population, and ratios. The bottom right corner of the interface mentions 'StrataGIS by Infomaps'.

Tamil Nadu Urban Livability Framework 2023 – Finance Data Entry Interface

CASE STUDY 11

CHALLENGES

The implementation of the framework faced several challenges, including:

- **Data Availability:** Ensuring the availability and accuracy of data across all parameters, especially in smaller Town Panchayats, was a challenge.
- **Resource Constraints:** Limited financial and human resources in some urban bodies hindered the effective implementation of the framework.
- **Stakeholder Coordination:** Coordinating among various stakeholders, including government departments, local bodies, and communities, required extensive effort and collaboration.

SCALE-UP POTENTIAL

Given TNULF's success, there is potential for scale-up. Other departments of the Government of Tamil Nadu are exploring using TNULF as a model, which could have the potential to be replicated by other states. The framework's methodology and insights can be replicated in other regions, allowing for a broader impact on urban sustainability across India.

NEXT STEPS

The TNULF represents a significant step forward in improving the quality of life in urban areas across the state. By providing a robust, data-driven approach to assessing and improving urban liveability, the framework has set a benchmark for other regions to follow. Despite the challenges, the positive outcomes and lessons learned from this initiative highlight its potential to drive sustainable urban development and improve the well-being of residents in Tamil Nadu's urban areas.

