SUSTAINABLE SANDHAI
A ‘CARBON NEUTRAL’ KOYAMBEDU MARKET

Sponsor

Partner

Chennai Metropolitan Development Authority

BASELINE REPORT

EXECUTIVE SUMMARY

The Tamil Nadu Government's Ministry of Environment, Climate Change, and Forest Department awarded a project to the Indian Institute of Technology Madras (IITM) on 15th July 2023. This project titled 'Sustainable Sandhai – A carbon-neutral Koyambedu market' is a collaboration with the Chennai Metropolitan Development Authority (CMDA), Tamil Nadu Pollution Control Board (TNPCB), and Greater Chennai Corporation (GCC). The project is supported by a grant of Rs. 1.357 Crores.

To effectively achieve the project objectives (See Annexure-I), IITM has outlined plans across several domains, encompassing Waste Management, Water Supply and Sanitation, Stormwater Management and Rainwater Harvesting, Building Structure & Engineering for Sustainability, Energy Utilization and Carbon Footprint, Traffic & Transportation, and Social Survey & Stakeholders Mapping. The teams have been formed for each domain, comprising IITM Faculty members, Consultants, Project Staff, and students. The project progress is structured in four stages: Inception Report, Status Quo Report, Concept Project Report, and Detailed Project Report. Here we bring the Baseline Report, based on extensive desk research and secondary data collection as well as a Preliminary Project Assessment involving the formulation of detailed methodological approach and primary data collection.

On 25th August 2023, TNPCB organized a meeting involving key stakeholders such as GCC, CMDA, Tamil Nadu Public Health Department, Tamil Nadu Animal Husbandry Department, and Tamil Nadu Energy Development Agency (TEDA) to delineate departmental responsibilities aligned with the project. Subsequently, IITM team and Consultants conducted the site visits to Koyambedu Market on 26th August 2023 and 2nd September 2023 to comprehend the current conditions of the Market Complex and lay a strong foundation for project implementation.

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1. INTRODUCTION

The Tamil Nadu Pollution Control Board (TNPCB) is keen to revitalize the Koyambedu Wholesale Market Complex (KWMC), aiming to transform it into a Carbon Neutral Zone. This initiative aligns with India's vision to attain a net-zero target by 2070, as outlined in COP26 held in October 2021. Recognizing the ambitious nature of this target and the state's determination to spearhead this endeavor, TNPCB is prepared to embrace the challenge.

This baseline report builds on the project's inception phase from initial payment date to till date. The work involved a range of activities including framing objectives for the verticals - Waste Management, Water Supply and Sanitation, Stormwater and Rainwater management, Building Structure & Engineering for Sustainability, Energy utilization and carbon footprint, Traffic & Transportation and Social survey & Stakeholders mapping.

2. SCOPE OF WORK

This Project is to prepare a detailed report for execution of proposed project 'Sustainable Sandhai – A Carbon Neutral Koyambedu Market'. It comprises a detailed examination to be done at KWMC along the following 7 verticals (See Fig 2.1):

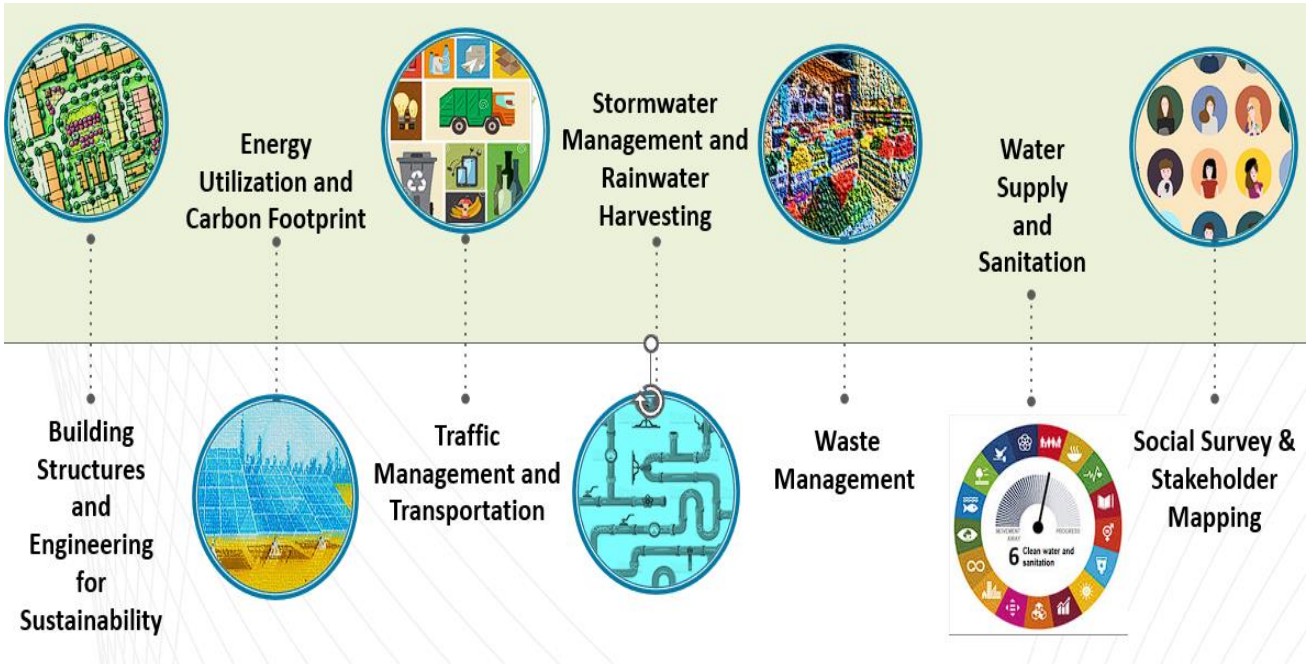

Fig 2.1 Verticals in 'Sustainable Sandhai – A Carbon Neutral Koyambedu Market' Project

3. EXPERT TEAM

IITM FACULTY MEMBERS

CONSULTANTS











ADVISORY MEMBERS

Dr.Dirk Weichgrebe
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4. LITERATURE REVIEW

The detailed review of the literature addresses the issue of urban organic waste (UOW) straining solid waste treatment (SWT) infrastructure in emerging economies. It investigates a potential of biochar derived from three significant UOW sources in India (banana peduncles, sewage sludge, and anaerobic digestate) to act as a long-term carbon sink in soils. The study assesses the chemical properties and thermal oxidative stability of these biochars using ATR-FTIR and TGA. Key findings from the literature show that biochar from sewage sludge (SS) and anaerobic digestate (AD) as well as their blends, contain higher levels of ash content, chlorine (Cl), and alkali and alkaline earth metals (AAEM) compared to biochar from banana peduncles (BP). To better evaluate the stability of these mineral- and ash-rich biochars, the study introduces a modified thermal oxidative recalcitrance index (TORi), as the conventional recalcitrance index (R50) is inadequate. Significantly, a specific blend of 50% SS, 30% BP, and 20% AD at the highest treatment temperature of 650°C exhibits the highest recalcitrance (TORi = 0.193), indicating its potential as an effective long-term carbon sink in soil. This underscores the importance of the synergy among the constituents SS, AD, and BP, which influences the structural properties and recalcitrance of the biochars. The study highlights that beyond aromaticity, elements like Si, Fe, and AAEM have a substantial impact on the biochar matrix and its ability to sequester carbon over extended periods [1].

Urban Waste Challenges

India's rapid urbanization has resulted in substantial municipal solid waste generation in urban centers. The study's main objective is to identify organic waste hotspots in Chennai and assess their potential for biogas production through anaerobic digestion. GIS Mapping: Geographical Information System (GIS) is used to create thematic maps that illustrate the identified hotspots and their biogas potential. Variability in Biogas Potential: The research uncovers significant variations in the biogas potential of individual waste streams, with values ranging from 240.2 to 514.2 mL per gram of organic dry matter. These variations are accompanied by organic dry matter reductions ranging from 36.4% to 61.5%.

Identification of Hotspots: Major waste generation hotspots are identified within urban bio-reserves, and the study estimates the biogas potential within a 5 km radius around these hotspots. Biogas Potential in Co-Digestion: The results demonstrate the biogas potential during anaerobic co-digestion, considering nearby bio-reserves in major hotspots, both with and without residential organic waste. The potential ranges from

4110.4 to 18,106.1 m^3 per day and from 253.2 to 5969.5 m^3 per day, originating from different quantities of waste.

Benefits of Co-Digestion: Co-digestion with nearby bio-reserves within major hotspots is found to enhance various factors, including the Carbon/Nitrogen ratio, oDM reduction, biogas production, and substrate availability. This approach helps address existing challenges in substrate management during anaerobic digestion of waste.

In summary, the literature review emphasizes the significance of leveraging urban waste for biogas production, particularly in the specific case of Chennai, India. The research highlights the substantial variability in biogas potential and the potential benefits of co-digestion in improving the efficiency of anaerobic digestion and waste management in urban areas [2]. The study investigates waste generated from a wholesale vegetable, fruit, and flower market as well as waste generated during cattle slaughter in Chennai, India.

Seasonal Variation: The research observes and studies variations in waste generation due to seasonal changes. The waste generation rates were found to be highest during the summer and winter seasons. December recorded the highest waste generation at 6683 tonnes, while May saw approximately 5754 tonnes of waste generated.

Sampling and Composition: The study conducted sampling during December to represent winter and May to represent summer. It evaluated the composition of waste samples, specifically the quantities of vegetable, fruit, and flower wastes present. Characterization of Wastes: The characterization of the wastes included the assessment of parameters such as total solids, moisture content, volatile solids, proteins, lipids, carbohydrates, and fiber content.

Treatment Suggestions: Based on the composition of the wastes, the literature suggests suitable treatment options to utilize the waste for various forms of bio-energy production [3]. Waste Composition in Bangalore: A detailed municipal solid waste (MSW) analysis was conducted for Bangalore. The study found that organic waste (OFMSW) constitutes a significant portion of urban household waste. It amounts to 59.0%, 63.3%, and 59.2% in low-density, medium-density, and high-density population areas, respectively. In contrast, urban litter spots and street sweeping waste had slightly lower OFMSW shares at 57.1% and 51.9%, while suburban litter spots had the lowest OFMSW shares at 47.5%.

Source of Waste Generation: Statistical analysis with a 95% confidence interval suggested that urban household waste and litter spot waste share the same source of generation.

Appropriate Screening Sizes: The study determined that screening sizes of 20, 60, and 80 mm are sufficient for managing urban MSW effectively.

Chemical Analysis and Heavy Metal Standards: Chemical analysis of the waste streams revealed that none of them complied with Indian heavy metal standards for compost.

Suburban OFMSW, in particular, was found to have the highest pollution levels post-rotting, with chromium (Cr) exceeding Indian standards by 100%, copper (Cu) by 395%, and lead (Pb) by 26% [4].

Increasing MSW Generation: Urbanization, industrialization, and social development in India have led to a surge in MSW generation, necessitating better waste management practices.

Organic Fraction: Approximately 50% of MSW in India comprises organic waste, which must be handled in an environmentally friendly way to prevent pollution. Anaerobic Digestion and Thermal Treatment: The text suggests using anaerobic digestion for wet and biodegradable organic waste and thermal treatment for dry and fibrous fractions to recover energy and value-added products.

Case Studies: The article references two collaborative research projects between India and Germany, funded by Indo German Science and Technology Centre (IGSTC), which focus on sustainable waste management at the pilot scale.

a. RESERVES Project: This project deals with organic waste from vegetable and flower markets and slaughterhouses in Chennai. It utilizes an innovative fermentation plant to recover material, energy, biogas, and produce hygienically safe digestate and fertilizer.

b. PYRASOL Project: This project addresses urban organic waste with high fiber content and digested municipal sewage sludge. It employs innovative solar drying and pyrolysis to obtain biochar, which sequesters CO2 and provides thermal energy [5]. This paper explores the concept of using sludge-drying greenhouses as an alternative to costly mechanical or thermal dewatering processes.

Key Points

Urban Waste Management Pressure: Rapid urbanization in emerging economy megacities results in a significant increase in wastewater and solid waste, creating pressure on disposal systems.

Organic Residues: Sewage sludge, which contains organic matter, is highlighted as a major challenge in waste management in these urban areas.

Local Management Approaches: The paper suggests that local management approaches, focusing on volume reduction of sewage sludge, can be an attractive option for these urban areas.

Sewage Sludge Drying: The text investigates the characteristics of sewage sludge drying and explores the theoretical principles behind designing sludge-drying greenhouses as a cost-effective alternative to mechanical or thermal pretreatment processes.

Vapor Balance Equations: The paper utilizes vapor balance equations to calculate the evaporation rate and employs a multiplicative model to predict humidity ratio differences in the drying process. Design Parameters: It discusses the estimation of design parameters for a sludge-drying greenhouse, with a case study example based on sub-tropical Indian climate conditions. Actual data from sewage sludge generation at Infosys IT-Complex campus in Bangalore city, along with local meteorological information, are used in this case study.

Sensitivity Analysis: The text presents a sensitivity analysis to understand how changes in one drying parameter can impact others and vice versa.

Adaptability: The design calculation model for sewage sludge drying greenhouses is designed to be adaptable to different locations by replacing specific sludge characteristics and meteorological data [6]. This text underscores the pressing issue of solid waste management (SWM) in India, with a specific focus on urban areas.

Increasing Solid Waste Generation: The text acknowledges the growing concern regarding SWM in India due to the rising population and the increased generation of municipal solid waste (MSW). This trend is attributed to changing lifestyles in urban areas. Inadequacy of Conventional Methods: It points out that the conventional methods of treating and disposing of mixed MSW are no longer sufficient to address the needs of the current generation of waste in urban areas.

Call for Innovative Solutions: Recognizing the limitations of traditional methods, there is a call for innovative treatment and disposal approaches to bridge the gap in SWM. Research and Expertise: The text mentions the research and expertise of CSIR-CLRI (Council of Scientific and Industrial Research - Central Leather Research Institute) in the management of tannery liquid and solid waste, including the use of various treatment methods such as aerobic, anaerobic, membrane, phyco-remediation, advanced, and thermal treatment methods.

Laboratory and Pilot Studies: The passage highlights that CSIR-CLRI has planned and conducted laboratory and pilot-scale studies to investigate different strategies for the treatment and disposal of municipal solid waste in urban areas, leveraging their expertise in waste management. Overall, this text emphasizes the growing challenges of SWM in India's urban areas and the need for innovative and empirical approaches to address this issue. It mentions CSIR-CLRI's involvement in research and development in this field, which could potentially lead to more effective and sustainable waste management solutions [7]. The presented text discusses the management of waste generated from vegetable, fruit, and flower wholesale markets (VFF) in India, focusing on the need for

sustainable waste treatment systems and the impact of fluctuating waste characteristics on biogas production and energy potential.

Waste Disposal Practices

In India, significant quantities of waste from VFF markets are typically disposed of without treatment at open dumpsites, highlighting the need for improved waste management practices. Importance of Detailed Information: To establish sustainable waste treatment systems, it is crucial to have detailed information about the temporal fluctuations in the mass and composition of VFF waste.

Study Objectives: The article aims to investigate the sources, extent, and influence of fluctuations in VFF waste characteristics and assess their impact on biogas production and energy potential.

Compositional Fluctuations: A comprehensive analysis of VFF waste in Chennai reveals significant fluctuations in the shares of individual waste components (vegetables, fruits, and flowers), ranging from 34.5% to 244.9% over the monitored year.

Independence of Waste Amounts: The study notes that waste amounts do not necessarily correspond to the amounts of fresh vegetables, fruits, and flowers entering the urban area, indicating complex waste dynamics.

Specific Biogas Yields (SBY): The text reports variations in specific biogas yields (SBY) of VFF waste, which ranged from 403.7 to 570.5 mL N/g organic dry matter during a 4-month analysis period.

Challenges in Measured SBY: A comparative analysis between calculated and measured SBY indicates that measured SBY are, on average, 9.7–22.4% lower, partially attributed to unfavorable C/N (carbon-to-nitrogen) ratios [8]. The text describes a project aimed at addressing the environmental and infrastructure challenges associated with the KWMC.

Poor Waste Management: The KWMC is currently poorly maintained, resulting in the generation of 200 tonnes of unmanaged waste daily. This situation highlights the need for improved waste management practices.

Stormwater Absorbing Measures: The project intends to protect the area with stormwater-absorbing measures. These measures will not only help manage stormwater but also enhance pedestrian access across the extensive site.

Solid Waste Recycling Program: The project includes the implementation of a solid waste recycling program, emphasizing the importance of waste reduction and recycling.

Enhancement of Sewage Treatment Plant: The Sewage Treatment Plant operated by metro water will be improved with post-treatment Natural-Based Solutions (NBS) treatment and

recharge. This will likely involve environmentally friendly techniques for treating sewage effluent and recharging it into the groundwater.

Cooperation with City of 1,000 Tanks: The project is a collaborative effort involving cooperation between Metro water and the "City of 1,000 Tanks." The recycling initiative is expected to increase the water assets of the city by leveraging existing infrastructure.

Stormwater Collection and Treatment: The project's main objective is to collect, treat, and recharge stormwater resulting from pluvial rains. This not only helps protect the area from floods but also ensures a sustainable water supply during droughts.

Constructed Wetlands: Post-treatment of sewage effluent will be carried out using constructed wetlands on a large scale, with a capacity of 150 MLD (Million Liters per Day). This system will generate clean effluent, which will be recharged across the site.

Greening and Groundwater Recharge: The clean effluent will be used to irrigate newly greened areas [9]. This contributes to cooling and creates additional groundwater assets, emphasizing the importance of environmental sustainability and water resource management.

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5. WASTE MANAGEMENT

PURPOSE

The primary objectives of our study at the KWMC encompass a thorough evaluation of waste generation across four distinct market types, viz. Vegetable, Fruit, Food grain, and Flower markets. The overarching aim is to establish the waste dynamics and drive sustainable waste management practices through active stakeholder engagement.

1. Quantitative Assessment of Waste Generation:

We intend to rigorously quantify the volumetric extent of waste generated within each market type. This quantitative assessment will provide a foundational understanding of the scale of waste generation, distinguishing between the different market types. Further to independent verification and validation, collaboratively involving market shops and waste collection agencies in data collection will enhance accuracy and inclusivity.

2. In-Depth Characterization of Waste Types and Composition:

Through meticulous data collection techniques and engagement with market associations, waste collection agencies, and market shops, we will conduct an in-depth characterization of waste types and their compositions. This will encompass organic wastes such as excess, damaged or rotten fruits and vegetables from the fruit & vegetable markets, floral waste from the flower market, and a sizable amount of packaging waste from the Food grain markets. Understanding these waste types is crucial for arriving at tailored waste management strategies.

3. Carbon neutrality prediction:

It is paramount to describe greenhouse gas (GHG) emission patterns and propose appropriate measures to mitigate GHG emissions from KWMC. Reduction in GHG emissions will be evaluated for all proposed alternative improved solutions, along with detailed economic assessments. Accomplishing net carbon neutrality in KWMC through segregation, recycling, bio-treatment, and incineration will be investigated.

4. Recommendations for Waste Reduction and Recycling:

Collaborating closely with associations of different market types and the Market Management Committee (MMC), we will formulate precise recommendations to optimize waste reduction, enhance recycling initiatives, and implement sustainable waste generation reduction measures. Tailored recommendations will address the unique waste streams generated by each market type, ensuring practicality and efficiency.

5. Gap Assessment for Operational Efficiency:

In collaboration with the MMC and waste collection agencies, we will conduct a rigorous gap assessment within the current waste generation framework. This assessment aims to

identify areas where improvements can be made to foster an environmentally responsible and operationally efficient environment at the market. Recommendations will be derived to address specific gaps identified in waste management practices.

By integrating the various stakeholders, including market shops, associations of different markets, the MMC, and waste collection agencies, we aim to create a collaborative and inclusive approach towards sustainable waste management. Together, the project will drive positive change, promoting environmentally conscious practices and contributing to an efficient and responsible market ecosystem.

METHODOLOGY

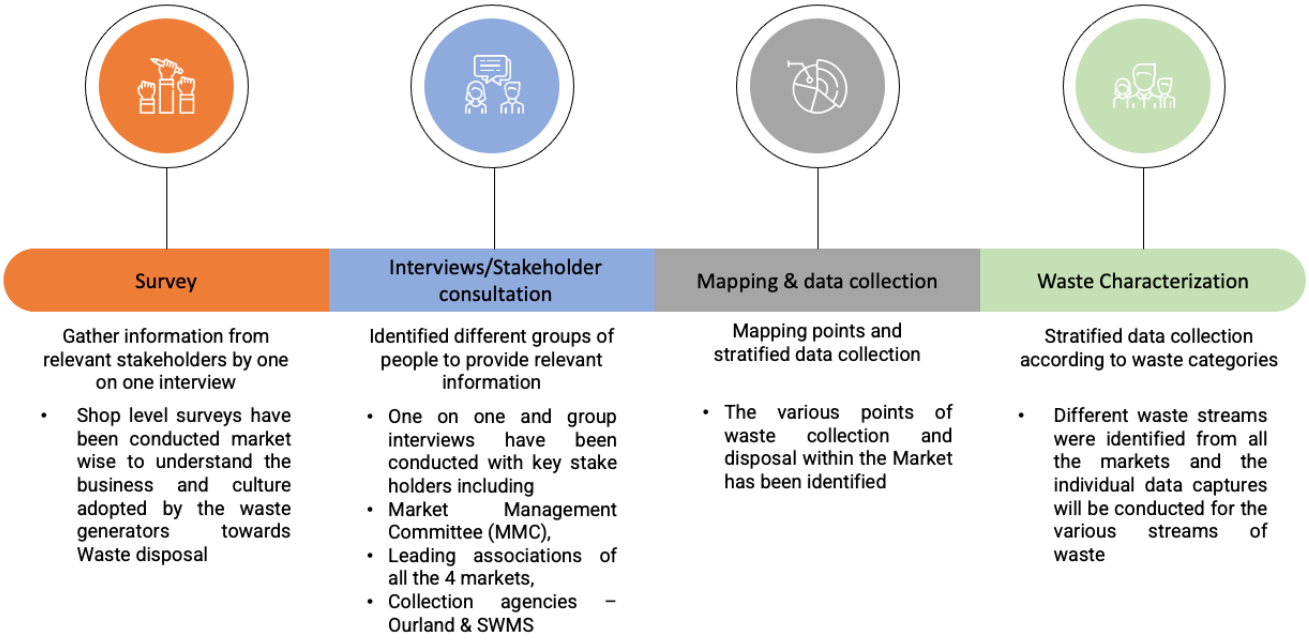


Fig 5.1: Methodological framework for Waste Management Vertical

In addition, current greenhouse gas (GHG) emission pattern of KWMC will be estimated. Alternative improved scenarios will be defined for a carbon neutral footprint. Business-as-usual scenario, with-policy scenario, no-landfill scenario, and scenario with recycling and/or waste to energy (through bio-treatment and/or incineration) will be investigated. A detailed economic assessment will be conducted for proposed alternative improved scenarios. The key outcomes from each part of the methodology is envisioned as follows:

Table 5.1: Detailed methodology and expected outcomes

Sl. No.	Methodology	Outcome
1	**Secondary Review** of existing data **Primary Data Collection** via Field visits including site visits & surveys at shop level, mapping of the different variety of products sold in the various categories of shops.	**Recommendations report** on basis of the observations and data analysis from the audit study
2	In depth Interviews with key stakeholders Review of site documentation with respect to waste collection and disposal	Documentation of the interviews with multiple stake holders within the Market complex
3	Waste audit and characterisation Study – On basis of material type – Stratified data collection market wise Types Identified 1) Vegetable Market – Banana Leaves & Peduncle 2) Fruit Market - Citrus, Non-citrus, inorganic waste including paper, plastic used for packaging 3) Food Grains – Packaging waste 4) Flower – floral waste, green waste, packaging waste (plastics)	Report on **existing situation, gap analysis** and development of **Waste management action plan** including recommendations for implementation
4	**Documentation of aggregation** of insights from Secondary Research and Primary Data sets during different timelines, BAU & Special Occasions	

KEY FINDINGS

1. Waste Generation Dynamics: Waste generation (WG) at KWMC is significantly influenced by various factors such as daily market rates of various commodities, key festivities, and seasonal variations. These fluctuations impact the volume and composition of waste generated.

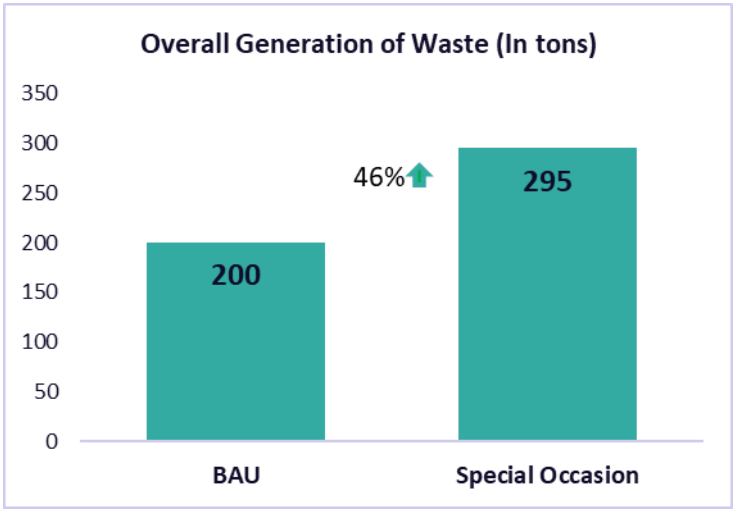


Fig 5.2: Overall Generation of water at the KWMC

The waste from all the four markets are collected to transported to a central dumping ground using various collection equipment/vehicles and then from the central dumping ground the waste is transported using large transport vehicles (Taurus) to Kodungaiyur dumping site. It has been observed that during none of the collection or disposal stages the waste is getting segregated. Further the assessments were conducted and found that during the Business As Usual (BAU), the generation of waste is fluctuating between 180MT to 220MT according to the data that has been recorded at the weighbridge before disposal.

From the baseline assessment done during one of the festivals (Ganesh Chathurthi) which fell during the audit period we were able to quantify and understand that there has been an increase in the generation of waste close to 46%. According to the discussions with MMC staff and the different associations, it was identified that there are three major festivals when the waste generation will be higher than usual which are Diwali, Navratri and Ganesh Chaturthi. The increase in the generation of waste during festivities is on an average 4 days, which multiplies to be 12 days per year where the generation is going to be higher than the daily average.

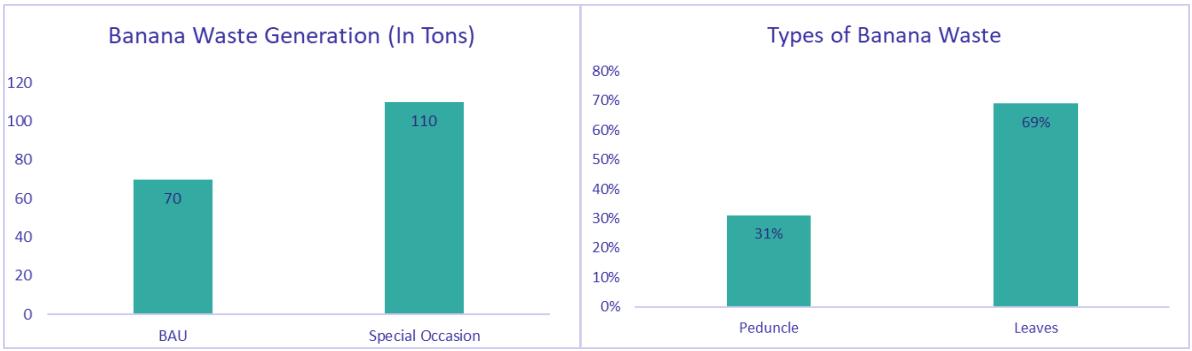


Fig 5.3: Quantity and type of Banana waste generated at KWMC.

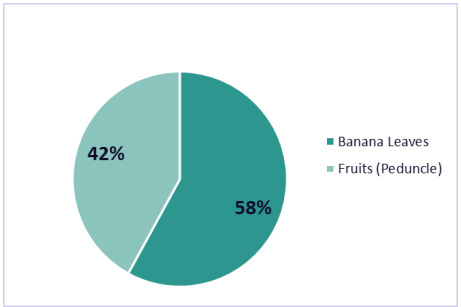


Fig 5.4: Types of fruit shops at the KWMC.

2. Market Dynamics and Waste Streams: The dynamics of the market parameters (such as prices and inflation) play a vital role in determining waste generation and types. Notably, banana waste stands out as a prominent waste stream. Additionally, fruit and food grain markets exhibit considerable levels of packaging waste.

3. Waste Segregation and Management Model: Waste segregation practices are currently inadequate, necessitating a shift from the prevailing tipping fee model to a more effective system focused on the collection of segregated waste into organic and inorganic categories. This shift is essential for efficient waste management. There are currently two major waste collection agencies

(i) Ourland Engineering Works Private Limited – This agency takes care of complete collection and disposal of the KWMC waste. They deploy manpower, different types of mechanical equipment and vehicles on a day-to-day basis in collection of waste. They engage an workforce of approximately 180 people for this works.

(ii) Srinivasa Waste Management Services Pvt Ltd (SWMS) – This agency deploys around 15 manpower along with a collection vehicle, they focus on collecting excess or spoilt fruits and vegetables to the Bio – CNG plant. They are collecting approximately 12 Tons of waste from the market. There is a lot more potential to increase the diversion of the organic waste to the Bio - CNG plant that can be explored.

Fig. 5.5: Waste aggregated from the fruit and vegetable market by SWMS

4. The fruit market, a bustling hub of fresh produce, has a significant environmental footprint due to the generation of both fruit and packaging waste. This waste can be categorized into two primary types: fruit waste, which can be further divided into citrus and non-citrus fruits, and packaging waste, including shredded paper, regular paper, straws, foam wire cushioning (commonly used for delicate fruits), and a fraction of plastic waste.
In an initial baseline assessment conducted across approximately 100 fruit shops, it was determined that these establishments collectively generated around 350 kilograms of packaging waste. This figure highlights the substantial amount of waste generated by the fruit market and underscores the need for effective waste management strategies.
Furthermore, in a parallel assessment focusing on fruit waste, approximately 430 kilograms of fruits were discarded by roughly 10 fruit shops. This fruit waste, while organic in nature, still represents a significant environmental concern, and efforts to minimize it could lead to valuable reductions in waste generation. All supporting photographs have been shared at the end of the report.

5. In contrast, the food grain market, another integral part of the local economy, also contributes to the waste stream, primarily in the form of packaging waste. This packaging waste includes items such as paper, cartons, raffia bags, multi-layered plastic (MLP) materials, and even garlic peels. The baseline assessment for this market revealed that approximately 160 kilograms of packaging waste are generated. Importantly, the food grain market produces a daily average of approximately 1000 kilograms of waste, emphasizing the need for proactive waste management solutions, including recycling initiatives, to address this significant volume of waste.
The fruits can be further classified into two categories namely the citrus and the non-citrus variety. This aspect of data helps us to identify the most suitable type of techonology available to manage the citrus type of fruit waste which cannot be handled using a biogas or biomethanization methods. In this study it was identified that there are two major varieties of citrus fruits available namely – Mosambi and oranges, there are around 52 and 24 shops selling Mozambi and oranges respectively.
There are seasonal variation in the generation of citrus fruit waste, during the audit day the Mosambi waste was 10.400 Tons, averaging out to be 137Kgs per shop, the major portion of this waste is Mosambi, the major factor attributing to this waste

generation is the way it is being packaged and transported. While the oranges are transported from various locations in crates leading less damage during transit, the mosambi's are transported loose in trucks with dry grass (hay) as a cushioning element. This leads to more damages during transport and loading, unloading with another category of waste, the dry grass used for packing and transportation. In a truck, on an average 250Kgs of dry grass is brought along with the fruits. While there are buyers for this dry grass for the cattle around the market, a large portion of it ends as a mixed waste in the dumpsite. If we can identify a better transport mechanism to this fruti both the waste during transport and the dry grass can be reduced. The other factor is the monsoons, during such seasons the citrus fruit waste will be the highest, reaching upto 25 Tons on an average.

One promising aspect of the food grain market's waste stream is its potential for recycling, as a substantial portion of it consists of recyclable packaging materials. By implementing recycling programs specific to this market, it is possible to divert a considerable amount of waste away from landfills and reduce its environmental impact.

In conclusion, the assessments conducted for both the fruit and food grain markets have shed light on the substantial waste generation within these sectors. These findings underscore the importance of adopting sustainable waste management practices and exploring recycling opportunities to minimize the environmental impact of these markets while promoting a more eco-conscious approach to their operations.

Fig 5.6: Mosambi Wholesale shop

Fig 5.7: Damaged fruits stored in crates within the shops to be discarded out

6. The flower market, while smaller in scale compared to other markets, is not exempt from contributing to the overall waste generated within the market. Typically, it accounts for approximately 3-5% of the total waste generated. However, it's important to note that this waste generation is influenced by various seasonal and market-specific factors.

The waste generated in the flower market is diverse and includes different categories. First and foremost, there is the waste produced from the flowers themselves. This can include discarded or unsold flowers, petals, stems, and leaves. Additionally, there is a variety of packaging and decorative waste used in the flower business, particularly in the creation of garlands and floral arrangements. This packaging waste can comprise materials like ribbons, paper, and plastic.

In conclusion, the flower market, although responsible for a relatively small portion of the market's waste, offers a promising opportunity for sustainable waste management and economic development. By harnessing the potential to recycle and upcycle flower waste and involving the local community, the market can reduce its environmental footprint while simultaneously creating valuable income-generating programs that benefit all stakeholders involved.

In response to inquiries about offering excess flower waste for value addition activities, the flower market expressed a willingness to participate, but with the condition of attaching a cost to it. This approach is driven by the need to recover costs associated with waste collection and transportation, as well as to incentivize and ensure the quality of participation in sustainability initiatives. Finding a fair and mutually beneficial arrangement through open dialogue and negotiation is essential for the success of such programs, while government or non-profit organizations may play a role in subsidizing or incentivizing business participation to strike a balance between economic interests and sustainability goals.

7. Understanding Cultural Factors: Understanding the cultural practices and behaviours of individuals/shopkeepers and various stakeholders within the market is crucial for formulating effective waste management recommendations. Cultural insights will inform strategies that align with the community's practices.

8. Infrastructure Needs: The revival of the biogas plant (defunct at the moment) and establishment of composting yards are imperative for KWMC. These facilities are vital to efficiently treat organic waste and reduce the disposal of organics in

Kodungaiyur dumpsite. The renewable energy and resources recovered will generate revenue through circular economy.

9.. Environmental and Health Challenges: The existing dumpsite is grappling with significant challenges including leachate issues, groundwater contamination, and fly infestations. These issues pose threats to both the environment and public health, necessitating urgent mitigation measures.

10. Sanitation Practices: The Waste Management (WM) agency is also involved in collecting and transporting sludge from drains within the market complex. The drains are often cleared and the sludge is left on the pavements to be later collected by the waste collection agency. A lot of eateries were observed along these locations as well, creating unhygienic conditions for the food served in such eateries. Improved sanitation practices are essential for maintaining a hygienic environment for all the stakeholders within the market complex.

Addressing these key findings will lay the foundation for strategic recommendations aimed at the best waste management practices at KWMC, promoting sustainability, and mitigating environmental and health concerns.

WAY FORWARD

Progress in Data Collection, Stakeholder Engagement, and Waste Characterization:

1. Data Collection: We have initiated data collection by implementing a comprehensive questionnaire drafted to gather insights into waste generation patterns and the culture of the waste generators at Koyambedu Wholesale Market Complex (KWMC). This ongoing process is providing valuable data on waste volumes and types within the market segments. An independent verification and validation will be carried out to ensure the accuracy and reliability of the data.
2. Stakeholder Engagement: Significant progress has been made in engaging various stakeholders crucial to our study. Comprehensive interviews have been conducted with market shops, associations, management committees, and waste collection agencies. These interactions provide essential insights into current waste management practices and challenges faced within KWMC.
3. Waste Characterization: We are actively implementing waste characterization using the methodology stated under section 3, systematically collecting waste samples from different markets. These samples will undergo detailed analysis to categorize waste types and determine compositions, providing a solid foundation for recommending effective waste management strategies. All analyses and testing will

be conducted using standard protocols in the state-of-the-art research facilities available at IIT Madras.

Upcoming Steps:

4. Recommendations and Best Practices: Building upon the ongoing data collection and waste characterization, we will synthesize the gathered information to formulate tailored recommendations and best practices. These recommendations will focus on waste reduction, recycling, and sustainable waste management strategies for each market segments and different categories of waste within KWMC. Notably, the biogas potential, waste-to-energy potential, recycling potential, and resulting waste diversion rate (from landfill) will be estimated for *Koyambedu Sustainable Sandhai*. Greenhouse gas reduction will be estimated at alternative improved scenarios for carbon neural footprint, with economic assessments.
5. Mass Balance: Subsequently, we will conduct a comprehensive material flow analysis and mass balance evaluation. This will involve tracking waste movement, quantifying waste inflow, categorizing waste streams, and analyzing disposal, recycling, and reduction efforts, contributing to a thorough understanding of waste management efficiency at KWMC.

   These ongoing and upcoming steps would result in a well-rounded waste assessment, essential for optimizing waste management practices at KWMC.

SUPPORTING PHOTOS

Waste generation and collection at Greens market

Banana waste (Peduncle & Leaves waste) generated at the Vegetable & Fruit Market

Waste collection at the Food grain market

The tricycles are hanged with multiple bags collecting recoverable dry waste from the market.

Waste collection at the fruit market: Assessment of packaging waste and fruit waste from different shops at the collected and measured using a tricycle from the fruit market

The floral waste comprising of multiple categories of flowers, the excess flowers were weighed from the shops and were transported to waste aggregation point just outside the flower market.

6. WATER SUPPLY AND SANITATION

PURPOSE

The objective of this survey is to understand the Koyambedu market's water and sanitation management plan, and document associated site conditions. It is our understanding that the outcome of this survey will be used to design a comprehensive water management system with site-specific toilet facilities.

METHODOLOGY

To achieve the objective, Stratus visited each toilet in the market with the pre-prepared questionnaire and collected information from adjacent store operators/owners and toilet operators. Our priority was to understand the locations of the borewells in use and how the well water was being used (non-potable: Toilets, showering cloth washing, and potable: hand wash, restaurants, and tea shop). The condition of the toilets was also documented for future recommendations. The following steps were followed:

1. Site Visit - Collection of data from the local maintenance person at each toilet facility.
2. 2. Preliminary Data - Stratus used the site map provided by IITM via KMMD to locate the toilets and the bore wells.
3. Upon visiting the toilet, the following information was documented on the questionnaire:
    a. Condition of the toilet (Indian/western),
    b. Size of the overhead tank on the toilet,
    c. Bore well being used for each toilet
4. In addition, the following information was also collected:
    a. Where possible, verified the existing stormwater network identified on the site map and its condition
    b. Where possible verified sewage network map and its site condition

KEY FINDINGS

Stratus conducted a field survey between September 12 and 15, 2023. The questionnaire was used to collect information requesting water usage and toilet users and its maintenance. Stratus visited 37 toilets in the vegetable market, 19 toilets in the fruit market, 12 in the flower market, and 14 toilets in the food and grain department. Overall, Stratus visited 82 toilets and collected information related to

water use and sanitation. Documented information related to groundwater pumping and usage from approximately 28 active borewells. Inactive bore wells were approximately 37. Stratus verified location, and size of water storage tanks at each toilet and the size of the common water storage tank in the market.

A mobile phone was used to take field photographs of toilets and borewells (please see attached). Stratus interviewed many individual shops in the vicinity of the toilets to develop an understanding of toilet use. Upon developing an understanding of how the toilets are being used, only toilet maintenance staff were interviewed. All observations were documented on the questionnaire (please see attached).

Observations

1) Out of these 82 toilets, 21 toilets are closed and not in use due to water shortage and no maintenance.
2) Toilets are being used by the market staff, laborers, and public who visit the market.
3) Each toilet has an attached overhead tank with individual borewell/inter-connected borewells sharing water to other toilets.
4) The bore wells are approximately 200 to 250 feet deep, 6-inch diameter with a 2-hp submersible pump installed. One or two wells use jet pumps.
5) Water from the well is pumped to two 2000-liter sintex tanks located on top of each toilet.
6) All 28 bore wells in the market are in use.
7) Wells attached to toilet Nos. T2, T4, T6, T8, T13, T16, T17, T18, T19, T30, T35, T37, T42, T44, T50, T51, T52, T55, T56, T59, T60, T68 are not in use. These toilets are using water from the adjacent bore wells (see attached table).
8) Pumps in the wells are operating between 18 and 20 hours per day since toilets are being used continuously to take showers and for flushing.
9) Water usage is high when the crowd is high in the market, particularly on the weekends and festival days.
10) Water yield is low in many wells due to the continuous pumping of water.
11) A newly installed borewell (not surveyed) was identified in the parking lot and measured water level (depth to water at 59ft).
12) The shop owners observed (complained) that the maintenance of the toilets was not being done as expected.
13) Approximately 50 to 200 users have been using the toilets daily for showers, and flushing Purposes.

14) All the toilets require payment to be used. There are separate toilet rooms for women but that is also used by men since most of the users are men.
15) We observed that people were washing their clothes in the toilets as well.

A few of the toilets were blocked from use and closed due to blockage in the sewage line or lack of water in the borewells. In general, toilets will be closed if there is no water, particularly during summer months. Apart from the borewells attached to toilet, there are a few shops (shops in the truck unloading bay, restaurants, and tea shops) that have individual borewells. They are also using the wells every day, for cleaning etc.

Three water storage structures were identified in and around the market. One in the southern side of vegetable market, one in the food and grain market, and one in the northeastern side. The water storage tank (overhead tank with a storage capacity of 2 lakhs liters) in the vegetable market is not in use. The shop owners use water cans delivered to the shops.

The water storage tank in the food and grain area (overhead tank with storage capacity of 2 lakhs liters) is in use. In addition, there is an underground storage tanks with four divisions of 2.5 lakhs liter capacity each (total of 10 lakhs liters). Water from this underground storage tank is pumped to toilets in the food and grain area via the overhead tank. The source of water is from borewell and metro water. Metro water is used as back up when the yield from the bore well is low.

The tank in the northeast direction is old and not in use. It has a capacity of 2 lakh liters. An underground tank exists at this location also, and its capacity is 25 lakh liters. Four RO (Reverse Osmosis) plants are located (the source water for each RO plant is a separate bore well) in the market (See table attached). The treated water is stored in a 5 KL concrete above ground tank. Treated water is used for all purposes, including drinking. It is informed that wastewater is directed to urinals installed inside the market.

Wastewater generated from the shop area and toilets were collected in 5 wells at Pumping Station. From the wells, 25 lakh liters of wastewater is pumped daily to Sewage Treatment Plant (STP) which is operated by Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB).

SUPPORTING PHOTOS

Separate Toilet zone for each gender

Storage tank provision for each toilet

Interior view of toilet complex

Unhygienic Urinals basins

Overhead Water Supply Tank

RO Plant pumping station

RO unit

7. STORMWATER MANAGEMENT AND RAINWATER HARVESTING

PURPOSE

The work aims to develop a comprehensive and integrated approach to sustainable water through efficient and proper stormwater management, rainwater harvesting, and improving groundwater storage and quality in the Koyambedu market region. Integrating rainfall and runoff data, feasible rainwater harvesting methods by stormwater management modelling and ensuring appropriate design changes, if necessary, will ensure a sustainable and environmentally responsible approach to water management in the market area. The market area is located on a ridge between the Coovum River and the Virugumbakkam - Arumbakkam canal, with some parcels of open lands. The systematic approach planned as a part of this study will ensure augmenting water availability by suitable rainwater harvesting techniques, reducing the runoff and prevention of groundwater contamination.

METHODOLOGY

The steps involved in achieving sustainable water management are briefly presented in this section.

Stormwater Management:

1. Site Assessment:
   Conduct a field survey to assess existing conditions and identify problem areas.
2. **Data Collection and Analysis:**
   a. Digital Elevation Maps (DEM) for the study area.
   b. Land Use Land Cover data to understand the urban landscape.
   c. Soil maps to assess soil characteristics.
   d. Stormwater drainage network maps and data.
   e. Intensity-Duration-Frequency (IDF) curves of the region and understanding the rainfall patterns.
   f. Review previous Detailed Project Reports (DPR) for stormwater drainage networks in the region (if available)
3. **Stormwater Management System Design:**
   a. Utilization of the Storm Water Management Model (SWMM) to create a hydraulic model of the drainage network.
   b. Design a stormwater management system that includes detention

basins, stormwater ponds, permeable pavements, and green infrastructure.

c. Determination of the required capacity to mitigate flooding.
d. Incorporate strategies for improving drainage efficiency and reducing excess runoff.

4. **Inundation Mapping:**
    a. Use SWMM to model inundation for various synthetic storms and design storms.
    b. Create inundation maps to visualize flood-prone areas.
5. **Model Validation and Field Data Integration:**
    a. Validate model results using field data, such as rainfall data and water level measurements.
    b. Address issues like drain unclogging and incorporate these findings into the model.

Rainwater Harvesting:

1. **Data Collection:**
    a. Gather relevant data, including soil information, geological data, infiltration test results, and pumping/recharge tests.
2. **Feasibility Assessment:**
    a. Analysis of the collected data to assess the feasibility of rainwater harvesting methods for the region.
    b. Consideration of factors like soil permeability, geology, and groundwater availability.
3. **Sustainable Urban Drainage Design:**
    a. Design of rainwater harvesting infrastructure, which may include infiltration galleries, detention ponds, artificial recharge wells, and contour swales.
    b. Incorporate rain gardens, green roofs, and other landscape and architectural elements to enhance aesthetics and functionality.
4. **Assessment of the impact of rainwater harvesting methods:**
    a. Validates SWMM model will be used to assess the impact of the planned interventions.
    b. Modification of locations and methods if need be and testing their efficacy with the model.

5. **Monitoring and Maintenance:**
    a. Recommend monitoring protocols to ensure the continued effectiveness of the system.

Groundwater Quality:

1. **Data Collection:**
    a. Data on groundwater levels and quality, including historical data if available.
    b. Identification of potential contamination sources and their characteristics.
2. **Modelling and Assessment:**
    a. Using screening-level natural attenuation modelling to delineate existing plumes and assess contamination extent.
    b. Evaluation of potential contamination pathways and migration risks.
3. **Remediation Strategies:**
    a. Develop remediation strategies tailored to the specific contamination sources and hydrogeological conditions.
    b. Consider techniques such as in-situ remediation, extraction and treatment, and monitored natural attenuation.
4. **Scenario Analysis:**
    a. Create scenarios to assess the effectiveness of different remediation strategies.
5. **Report and Recommendations:**
    a. Compile all findings and design elements into a comprehensive stormwater management plan.
    b. Provide recommendations for implementation and long-term maintenance.
    c. Present findings, modelling results, and remediation strategies in a comprehensive report.
    d. Provide recommendations for immediate actions and long-term management to mitigate groundwater contamination.

KEY FINDINGS

A field survey was conducted to assess the current conditions and problems in the Koyambedu market regarding stormwater management and rainwater harvesting.

1. Clogged drains prevent the natural flow of stormwater and lead to inundation during monsoon. As the entire market is paved/concreted, most of the rainwater goes out as runoff, causing inundation. Pictures taken during the field visits are shown below.

Fig. 7.1: Clogged drain at Fruit market

Fig. 7.2: Exterior of drain connection

Fig. 7.3: Clogged drain in Food & Grain Market

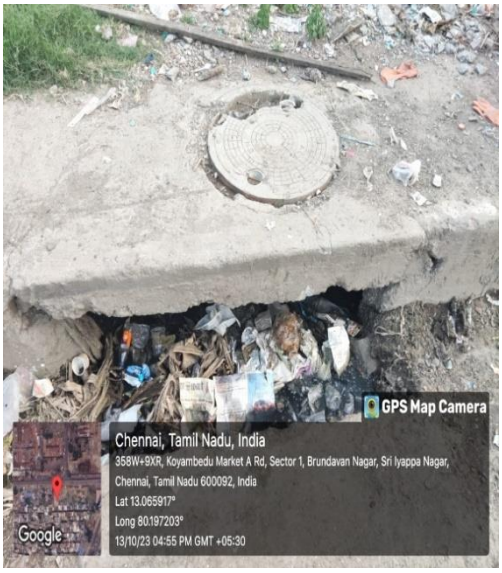


Fig. 7.4: Clogged drain outside Vegetable Market

2. The waste dumpsite is situated in an open area in the market, and during the monsoon season, it can lead to the generation of leachate, potentially infiltrating the groundwater table and causing groundwater contamination. To assess the leachate's ingress into the groundwater table, a systematic approach was undertaken. Ten sample points, comprising open wells and boreholes, were strategically located at radial distances of 500 ms and 2000 m with dumpsite as centre.

Water samples were meticulously collected from identified locations, and a comprehensive analysis was conducted to evaluate water quality parameters, including Total Dissolved Solids (TDS), Salinity, Conductivity, Dissolved Oxygen (DO), Bio-Chemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), Total Nitrogen (TN), and Colony Forming Units (CFU).

Fig. 7.5: Locations of groundwater sampling wells

Table 7.1: Water quality parameter for each sample

Sample No	Sample Type	TDS (mg/l)	Salinity (ppt)	Conductivity (µS/cm)	DO (mg/l)
1	Borewell	592	0.59	1196	4.96
2	Borewell	1462	1.48	2850	7
3	Borewell	3580	3.67	6710	4.31
4	Coovam	668	0.67	1343	4.33
5	Openwell	550	0.55	1114	4.94
6	Openwell	426	0.43	867	2.86
7	Borewell	449	0.45	914	3.12
8	Openwell	418	0.42	854	3.63
9	Virugambakkam	585	0.59	1182	0.15
10	Openwell	716	0.72	1437	5.16
11	Openwell	222	0.22	458	4.86
12	Openwell	555	0.36	1124	4.8

Table 7.1 (continued): Water quality parameter for each sample

Sample No	Sample type	BOD((mg/l)	COD (mg/l)	TOC (mg/l)	TN (mg/l)
1	Borewell	21.16	78.43	0.69	2.50
2	Borewell	80.22	292.82	2.89	0.80
3	Borewell	60.31	177.47	4.46	0.90
4	Coovam	160.38	286.44	9.45	9.01
5	Openwell	29.12	56.13	1.50	1.20
6	Openwell	72.2	190.46	0.20	7.14
7	Borewell	232.2	516.82	5.38	2.52
8	Openwell	33.74	91.21	0.43	2.74
9	Virugambakkam	-	3696.25	52.50	24.21
10	Openwell	40.59	94.44	2.47	3.04
11	Openwell	160.72	392.13	2.04	0.64
12	Openwell	95.76	273.66	1.37	2.45

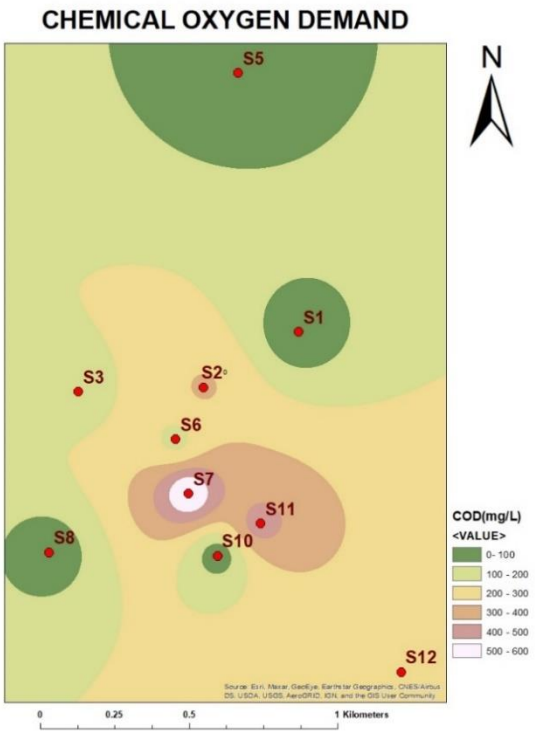


Fig. 7.6: COD mapping of sample locations

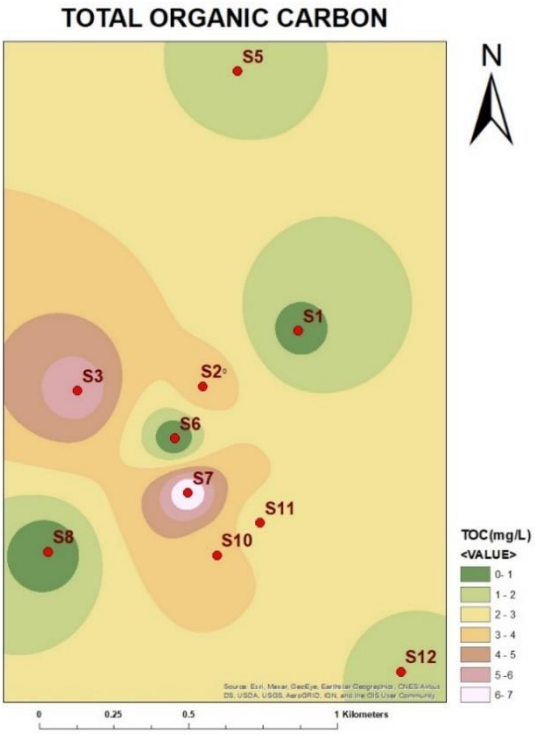


Fig. 7.7: TOC mapping of sample locations

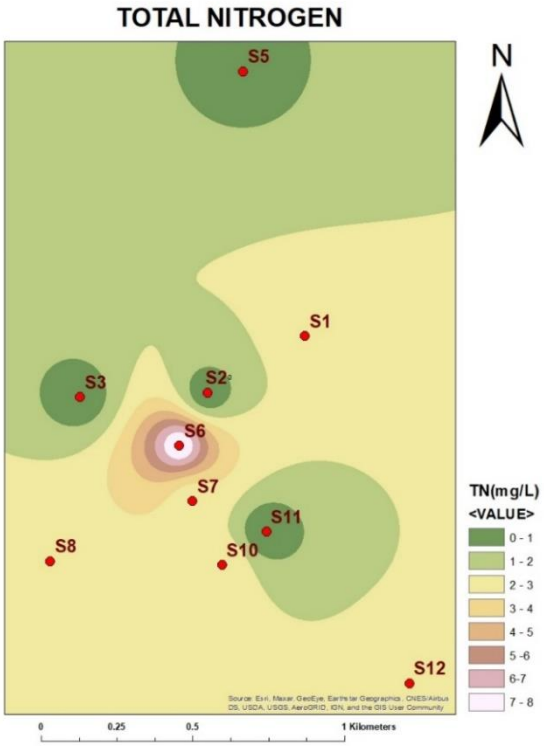


Fig. 7.8: TN mapping of sample locations

Table 7.2: Water Quality – Colony Forming Units

S.no	Sample No	Sample type	Volume (ml)	Dilutions	TBX (Blue colonies)	TBX (White colonies)
1	**Sample 1**	Borewell	0.1 ml	1	0	TNTC
			0.1 ml	10	0	444
			0.1 ml	100	0	3
			0.1 ml	1000	0	0
2	**Sample 2**	Borewell	0.1 ml	1	0	TNTC
			0.1 ml	10	0	660
			0.1 ml	100	0	460
			0.1 ml	1000	0	102
3	**Sample 3**	Borewell	0.1 ml	1	0	TNTC
			0.1 ml	10	0	160
			0.1 ml	100	0	28
			0.1 ml	1000	0	0
4	**Sample 4**	Coovam river	0.1 ml	1	2	TNTC
			0.1 ml	1000	0	4
			0.1 ml	10000	0	1
			0.1 ml	100000	0	0
5	**Sample 5**	Openwell	0.1 ml	1	0	20
			0.1 ml	10	0	1
			0.1 ml	100	0	0
			0.1 ml	1000	0	0
6	**Sample 6**	Openwell	0.1 ml	1	5	TNTC
			0.1 ml	10	1	166
			0.1 ml	100	0	11
			0.1 ml	1000	0	0
7	**Sample 7**	Borewell	0.1 ml	1	0	420
			0.1 ml	10	0	146
			0.1 ml	100	0	34
			0.1 ml	1000	0	4
8	**Sample 8**	Openwell	0.1 ml	1	TNTC	TNTC
			0.1 ml	10	1	79
			0.1 ml	100	0	37
			0.1 ml	1000	0	3
9	**Sample 9**	Virugambakam canal	0.1 ml	1	TNTC	TNTC
			0.1 ml	10	112	TNTC
			0.1 ml	100	36	148
			0.1 ml	1000	3	26
10	**Sample 10**	Openwell	0.1 ml	1	0	512
			0.1 ml	10	0	67
			0.1 ml	100	0	2

			0.1 ml	1000	0	0
11	**Sample 11**	Openwell	0.1 ml	1	1	398
			0.1 ml	10	0	56
			0.1 ml	100	0	32
			0.1 ml	1000	0	3
12	**Sample 12**	Openwell	0.1 ml	1	0	29
			0.1 ml	10	0	0
			0.1 ml	100	0	0
			0.1 ml	1000	0	0

From the above data, we can infer that S2, S7, S11, S12, Coovam River(S4) and Virugambakkam canal(S9) has higher COD values which cannot be use for domestic purpose since it is contaminated.

3. The mapping of the storm drain and sewage network connections was accomplished by utilizing the topographical data of the Koyambedu market area in conjunction with the stormwater drain information provided by the Market Management Committee.

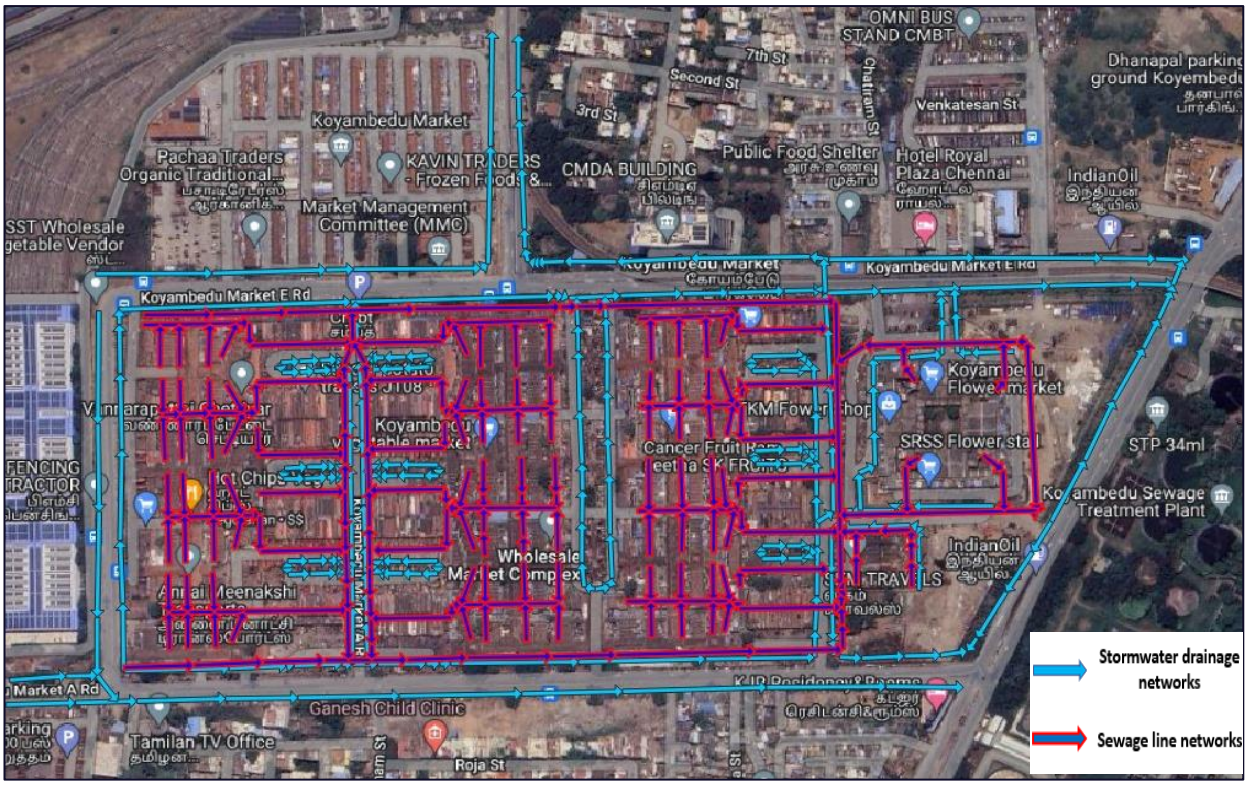


Fig. 7.9: Stormwater and sewage drain mapping

4. A series of soil samples were systematically obtained at varying depths, extending upto 92.5 feet, as part of the recent borehole logging activities conducted within the

confines of the vegetable market in Koyambedu. The primary objective of this endeavour was to gain a comprehensive understanding of the subsurface soil characteristics within the Koyambedu market region.

Fig. 7.10: Borewell preparation work

Fig. 7.11: Collection of soil sample

Fig. 7.12: Soil samples (5ft to 60ft)

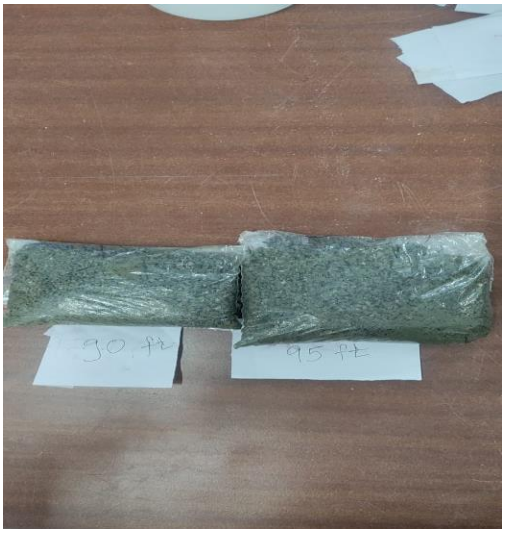


Fig. 7.13: Soil samples (90ft and 95ft)

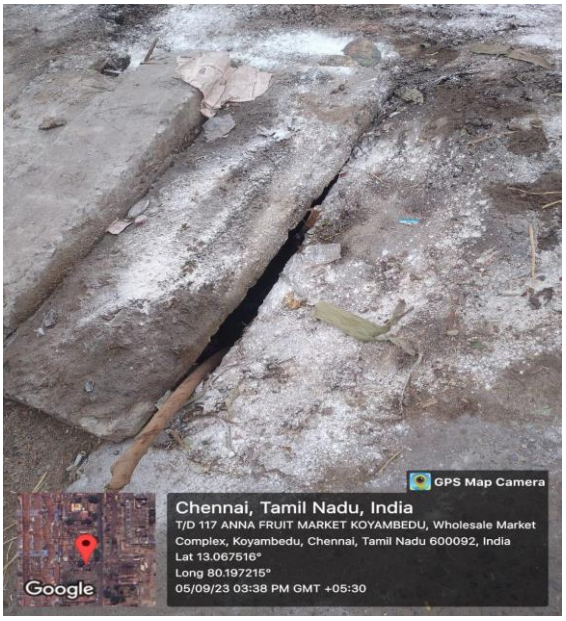
Table 7.3: Soil information

S.no	Depth(feet)	Sample type
1	Upto 15	Sand
2	17.5	Mixture of Sand and Black clay
3	30	Black clay
4	50	Thick sticky clay
5	65	Mixture of black clay and limestone
6	85	Slate
7	92.5	Reached rockbed

WAY FORWARD

1. Ten locations within and outside the market area have been earmarked for tubewell drilling up to a depth of 30 feet. These tubewells will serve as long-term monitoring points to assess groundwater levels and observe groundwater recharge dynamics before and after rainwater harvesting infrastructure implementation.
2. The drilling is scheduled during the last week of October, and equipment for water level monitoring and infiltration test equipment will be procured by early November.
3. The utilization of the Storm Water Management Model (SWMM) to developa hydraulic model of the drainage network, as well as the assessment of inundation patterns for various synthetic and design storm scenarios, is currently underway. The findings will be included in the subsequent phase report.
4. An architectural competition for both B. Arch and M. Arch students is being planned to design the landscape to incorporate blue-green methods withinthe market premises to enhance institutional outreach.

SUPPORTING PHOTOS



Damaged Drainage slabs

Drainage space occupied by shopkeepers

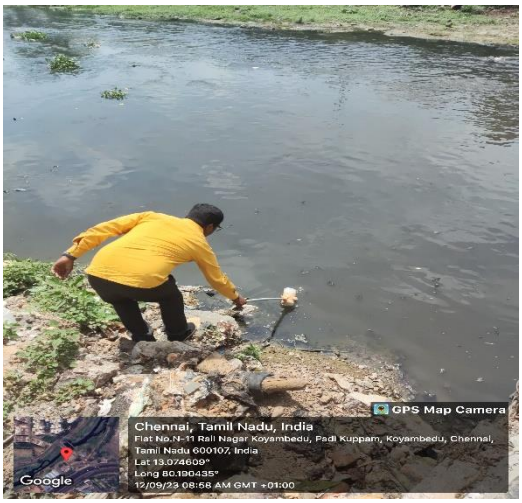
Drainage blocked by solid waste

Damaged drainage junctions

Strom Water Drainage

Drainage blocked by plastic waste

Unmaintained Borewells



Water collected from Covvam river

8. BUILDING STRUCTURES AND ENGINEERING FOR SUSTAINABILITY

PURPOSE

MMC, an autonomous body which oversees the functioning of KWMC, has approached IITM for providing Technical Consultancy for Making Koyambedu Market Complex as plastic free and carbon neutral. As a part of the process, IITM has planned to conduct Structural Health Assessment of the structure located in the Koyambedu Market Complex through the Centre for Urbanization, Building and Environment (CUBE).

In this context, a multi-disciplinary team of experienced civil engineering professionals are carrying out a detailed site inspection and planned to conduct appropriate Non-Destructive and Partial Destructive tests to assess the physical condition of the structures. The purpose has been to carry out an overall condition assessment of the existing structures and buildings in respect of its soundness of structural & non-structural members as well as the functional effectiveness of services. The findings of the inspection are mentioned in this report.

Fig. 8.1: Satellite image of KWMC.

METHODOLOGY

Koyambedu Market Complex and associated buildings were constructed before 1996 and some of the basic key information regarding the structures such as Grade of concrete and Reinforcement details are not available to review the existing structural design. Hence, conduct of ND/PD tests in selective locations are imperative to assess the structural health. Accordingly, the scope of structural assessment is deliberated in 3 stages as mentioned below:

STAGE 1 - Detailed Visual Inspection for checking

(i) Structural Distress and Deformation
(ii) External settlements, defects, and cracks
(iii) Signs of deterioration of structures and corrosion
(iv) Dampness and leakages

STAGE 2 - Conducting Non-Destructive/Partial-Destructive tests in all buildings to assess the structural health condition of existing RCC elements and reinforcements through visual inspections

(a) Ultrasonic Pulse Velocity Test
(b) Half Cell Potential Test
(c) Core sampling and testing
(d) Carbonation Depth Test
(e) Evaluation of chlorides and pH
(f) Concrete cover test.

STAGE 3 - Report Preparation

Analyse the findings and prepare the distress mapping of the structure, thereby providing conditional assessment as well as structural stability recommendations.

KEY FINDINGS

The visual inspection has been carried out around the perimeter of the structures and the buildings in the market. Some of the observations made during the inspection are as below:

1. Structural Elements

(a) Spalling of Concrete & Loss of Reinforcement

Extensive corrosion of reinforcement bars and concrete spalling were observed at multiple locations. The severe corrosion of these reinforcement bars significantly compromises the structural integrity and overall quality of the concrete.

Fig. 8.2: Spalling of Concrete & Loss of Reinforcement

Lack of adequate cover has resulted in spalling of concrete at the beam joints.

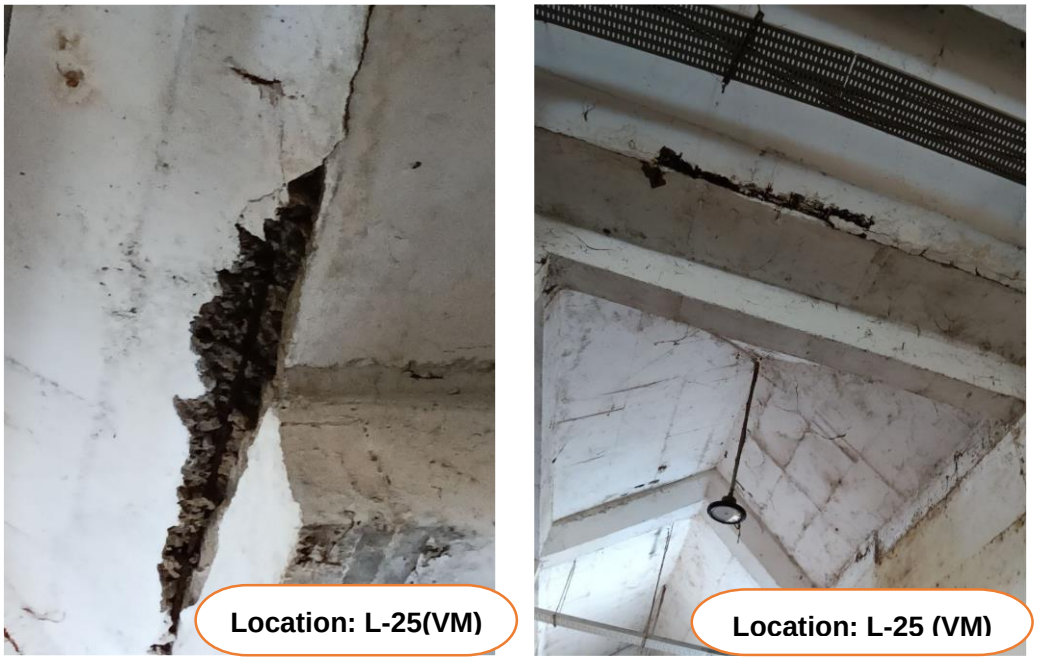


Fig. 8.3: Spalling of Concrete & Loss of Reinforcement

(b) Dampness and Seepage

Heavy dampness and seepage have been detected in many critical areas, including columns, masonry walls, slab-column junctions and beams.

Fig. 8.4: Dampness and Seepage in Vegetable Market.

2. Non-Structural Elements

a) Unwanted Vegetation

Unwanted vegetation growth observed on the terrace and notably a substantial banyan tree which causing structural damages.

Fig. 8.5: Unwanted vegetation

b) Deterioration of Roof Structure

The Madras terrace roof is deteriorating due to various factors, such as weathering, moisture infiltration, and drainage block is also noticed.

Fig. 8.6: Deterioration of the roof structure

WAY FORWARD

From the visual investigation and analysis undertaken towards the condition assessment, the major defects identified are depicted in the chart below:

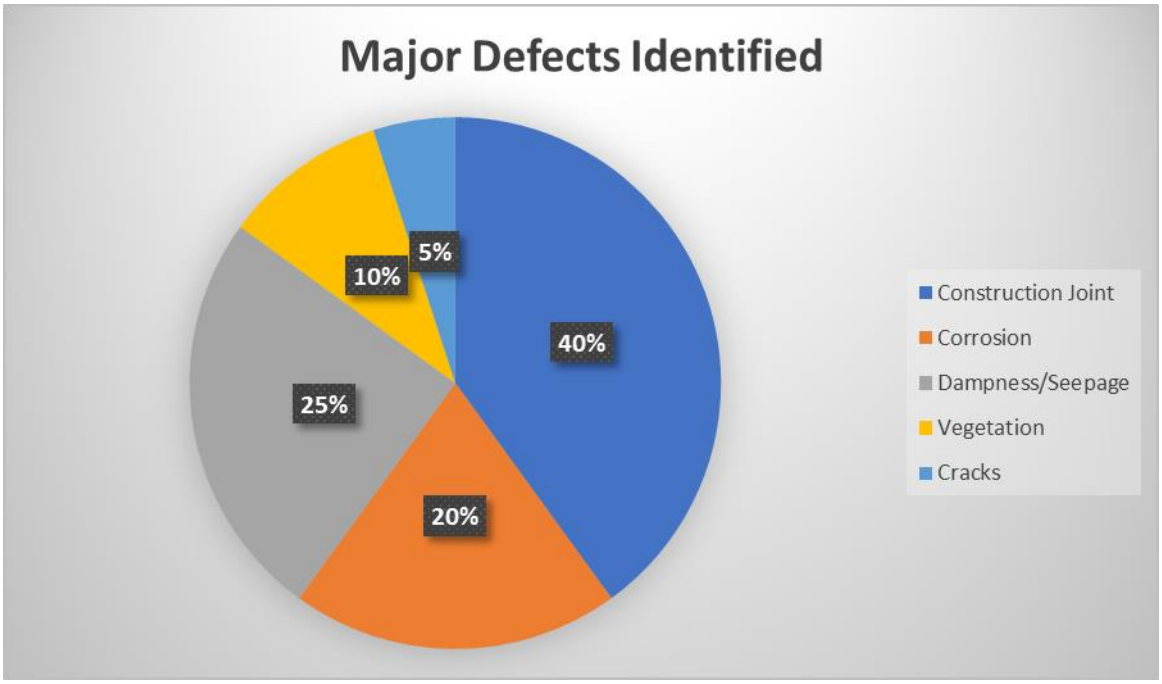


Fig. 8.7: Major defects identified. Note: This is tentative data which may vary after detailed investigation/Testing.

Based on the observed conditions, a comprehensive report will be provided, addressing the structural integrity, non-structural elements, and the functional capacity of the structure.

SUPPORTING PHOTOS

Shop ceiling- spalled / corroded rebar

External staircase cracks / damages

Terrace areas debris blocking rainwater

Lintel damage at the shop entrance

De-structure in the outer walls

Damaged toilet complex roofs

Seepage of water from roof

Damage in roof of flower market

9. ENERGY UTILIZATION AND CARBON FOOTPRINT

PURPOSE

The overarching objective of this study is to improve the overall energy efficiency of the KWMC by reducing its specific energy consumption (kW/Sq.ft), which will eventually result in the reduction of its overall carbon footprint, enabling it to evolve as a "Sustainable Sandhai" on the energy front. The study includes overall demand management study, power quality study, and detailed energy assessment, including performance analysis of the common utilities, particularly Lighting, Fans, Air Conditioners, Motors & Pumps used in the Vegetable, Fruit, Food grain and Flower markets.

Pre-assessment Data Collection:

The study fundamentally begins with this phase of pre-assessment data collection, where the energy assessment team will conduct an in person meeting with the energy team/maintenance team officials at Market Management Complex (MMC) office to get to know the details of the available service connections, its contracted/sanctioned demand, its connected load details, energy bills for each service connections, overall electricity distribution schemes, use points and purpose of the common utilities, specifications of the utilities that comes under their direct control for which they pay the energy bills. Fetching all the details either in hard or soft format is essential for the assessment team to do a preliminary study to plan the walk-through assessment.

Walk-through Assessment:

A complete walk-through of the market complex will be done with the entire energy assessment team, where the data/information gathered in the pre-assessment phase will be physically validated by the team. This involves physical examination of the existing service connections, name plate details, models, and other specifications and operating conditions of the respective utilities considered for assessment. This phase will enable the assessment team to identify the most energy intensive areas/utilities which has the real potential for energy conservation, and the detailed energy assessment study will be planned and performed accordingly.

Detailed Energy Assessment:

The detailed assessment will be performed by the assessment team in support/coordination with the respective officials at MMC/TNEB/KWMC as and when required. The assessment will be performed with the respective energy assessment instruments such as Power Quality Analyzer, Lux Meter, Ultrasonic Water Flow Meter, Tachometer, Power Clamp Meter, etc and as per the actual requirements. The live energy

consumption & performance measurements will be taken for all the required utilities and it will be verified/validated with the concerned officials before taking it for analysis. The complete analysis will furnish the existing performance of the utilities, based on which the assessment team will make their observations and respective recommendations in the form of energy conservation measures to project the possible energy savings.

Detailed Assessment Report:

A detailed energy assessment report will be generated based on the assessment and its analysis, where the complete details of the study will be furnished with all relevant data/information on energy savings in respective areas/utilities. The team will also provide investment cost details for all the energy conservation measures along with the Return on investment figures. In case of any special requirements, the assessment team shall also connect the MMC/KWMC officials with the respective vendors to get more information about the energy efficiency products/services suggested for future implementation planning.

METHODOLOGY

The work started with the pre-assessment data collection by meeting various officials at MMC & TNEB on two phases, on 7th of September & 13th of October respectively to get the required details. The assessment team met the following officials to gather relevant information –

1. Mr. Vignesh (Electrical Maintenance) at MMC office
2. Mr. Muthu (R.O Plant Maintenance) at MMC office
3. Mr. John (In-charge Common Cold Storage Facility) at Common Cold Storage Plant
4. Mrs. Chitra (Superintend Engineer) at TNEB Thirumangalam H.O
5. Asst. Engineer at Nerkundram, Arumbakkam Substation TNEB Office
6. Mr. Chokalingam at MMC office
7. Mr. Karunamoorthi (Asst. Engineer) Koyambedu Sub Station TNEB Office

The assessment team has also made a complete walk-through of the KWMC once after getting the details from the respective officials to verify and validate the same on numbers and capacities. So as per plan, the assessment team has completed the initial two phases of the study – the pre-assessment data collection and walk-through

assessment of the complete market facility. This has the following key findings and observations.

KEY FINDINGS

There are 77 common LT connections under the direct control of MMC which supplies to all the common lightings, air conditioners, fans, bore well pumps and STP pumps. Each service connection has different sanctioned demand and respective connected load in it.

a. Tube Light Fittings – 414 Nos (120W capacity each)
b. High Mast Lights Fittings – 35 Nos (6*300W capacity each)
c. Split Air Conditioners – 4 Nos (1.5 Tonnes capacity each)
d. STP Pumps – 2 Nos (20 HP capacity each)
e. RO plant – 4 Nos (5KLD capacity each) running under 40% recovery, delivering 2KLD

A proposal for 216 kW Roof Top Solar is under execution.

The specifications of the Common Cold Storage Facility under the control of MMC are as follows:

Storage Capacity – 2500 MT
Established – 1993 (30 yrs old facility)
HT connection with sanctioned demand of 95 kVA
Max. Reached demand till date – not more than 70 kVA
Ammonia chiller of 50 TR capacity
Temperature requirement – 3 to 9 Deg C
No. of AHUs – 20 nos
Ammonia Circulation pump – 3.7 kW
Cooling Tower circulation pump – 5.5 kW
All the motors are subjected to rewinding and are of IE2 efficiency type
Average capacity utilization – 40%
Average energy consumption – 20,000 units/month

There are about 3995 shops all put together from vegetable, fruit, food grain & flower markets, which has individual service connections and its connected loads for them which is under the control of the individual shop owners, and this does not come under the common control of MMC. The major utilities in the shops are lighting and fans. There

are cold storage facilities available in some of the shops, for which the capacities and other details must be requested directly from the shop owners.

The following are the details of the service connection of all the 77 common LT connections under MMC (also tabulated below) and the observations from the assessment team –

Area	SL.No	SC.No	Contracted Demand (kVA)	Reached Demand (kVA)	Demand Utilization %	Power Factor	Unit Consumed (kWh)	Fixed Charges (INR)	Total Amount Payable (INR)	Demand Penalty (INR)
Food Grain Market	1	176061121	2	1.46	73%	0	924	408	10309	
	2	176061122	2	0.82	41%	0	418	408	4888	
	3	176061123	2	1.16	58%	0	771	408	8673	
	4	176061124	2	1.12	56%	0	997	408	11090	
	5	176061125	5	0	0%	0.99	2180	1020	24333	
	6	176061126	5	1.23	25%	0.99	3543	1020	38930	
	7	176061525	2	1.42	71%	0	772	408	8684	
	8	176061526	2	0.68	34%	0	924	408	10299	
	9	176061527	2	0.98	49%	0	1104	408	12224	
	10	176061528	2	1.1	55%	0	760	408	8556	
	11	176061529	2	1.4	70%	0	1466	408	16106	
	12	176061530	2	1.42	71%	0	917	408	10235	
	13	176061531	2	0.88	44%	0	829	408	9283	
	14	176061532	2	2.12	106%	0	1087	408	12178	
	15	176061533	10	2.56	26%	0	855	2040	11214	
	16	176061534	5	0.36	7%	1	160	1000	2685	
	17	176061535	5	0.22	4%	0.97	170	1020	2848	
	18	176061536	5	0.4	8%	0.98	146	1020	2591	
	19	176061537	5	0	0%	0	72	1020	1508	
	20	176061538	100	7.44	7%	0.64	1884	30700	57317	
	21	176061539	5	0.26	5%	0	42	1020	1314	
	22	176061540	4	2.19	55%	1	1329	816	15059	
	23	176061541	5	1.18	24%	0.99	784	1020	9424	
Vegetable Market	24	1760498	9	32.02	356%	0.98	7094	1836	95818	17781
	25	1760495	15	7.05	47%	0.99	6156	3060	68975	
	26	17604914	23	5.53	24%	0.99	3536	4692	42568	
	27	17604915	10	6.34	63%	0.99	4445	2040	49647	
	28	1760491541	30	21.28	71%	0	16220	6120	179805	
	29	1760491543	8	4.91	61%	0.99	4512	1632	49935	
	30	1760491545	32	10.03	31%	0.98	4521	6528	54988	
	31	1760491546	5	3.22	64%	0.94	3305	1020	36405	
	32	1760491547	11	10.38	94%	0	7970	2244	87589	
	33	1760491548	10	6.6	66%	0.99	4751	2040	52919	
	34	1760491551	10	7.89	79%	0	5782	2040	64062	
	35	1760491552	8	2.12	27%	0.99	1303	1632	15597	
	36	1760491555	27	24.84	92%	1	19654	5508	215947	
	37	1760491557	14	13.06	93%	0.99	8020	2856	88767	
	38	1760491559	10	2.92	29%	0.94	1462	2040	17706	
	39	1760491560	10	2.26	23%	0.99	2060	2040	24100	
	40	1760491561	10	2.25	23%	0.99	1892	2040	22304	
	41	1760491562	10	2.35	24%	0.98	1562	2040	18775	
	42	1760491563	10	1.82	18%	0.99	1387	2040	16893	
	43	1760491564	10	3.76	38%	0.99	2781	2040	31821	
	44	1760491565	10	2.18	22%	0.98	1143	2040	14294	
	45	1760491566	6	2.6	43%	1	4850	1224	53121	
	46	1760491567	10	2.36	24%	1	2461	2040	28389	
	47	1760491569	10	4.89	49%	0.95	3867	2040	43445	
	48	1760491571	5	4	80%	1.01	3211	1020	35400	
	49	1760491573	5	0	0%	0	0	1020	1020	
	50	1760491574	9	2.76	31%	0.96	1784	1863	20945	
	51	1760491575	10	6.59	66%	0.98	5843	2040	64597	
	52	1760491643	6	190.3	3172%	0.98	42	1224	6813	3356
	53	1760491644	26	1.53	6%	1	13987	5304	154904	
	54	1760491645	9	5.48	61%	0.99	4865	1836	53924	
	55	1760491654	3	0.12	4%	0	71	612	1103	
	56	1760491704	10	3.98	40%	1	276	2040	31340	
	57	1760491885	17	2.36	14%	0.54	4125	3468	47612	
	58	1760492035	19	9.25	49%	0.87	1323	3876	18126	
	59	1760492173	8	3.59	45%	0.92	423	1632	6196	
Flower & Fruit Market	60	17651460	20	4.35	22%	0.99	3681	4080	43496	
	61	17651492	10	1.63	16%	1	1186	2040	14743	
	62	17651493	10	3.85	39%	0	4448	2040	49648	
	63	17651494	44	5.24	12%	0.94	4120	8976	53097	
	64	17651497	8	4.05	51%	0.97	5196	1632	57250	
	65	17651498	8	2.38	30%	0.95	2015	1632	23211	
	66	17651499	9	2.48	28%	0.93	1796	1836	21073	
	67	17651500	11	2.52	23%	0.96	2184	2244	25630	
	68	17651873	6	1.62	27%	0.86	2127	1224	23991	
	69	17651874	42	35.03	83%	1	20310	8568	226135	
	70	17651876	6	4.32	72%	0.99	3589	1224	39656	
	71	17651878	6	2.04	34%	0.95	2324	1224	26108	
	72	17651934	10	1.7	17%	0.95	2562	2040	29459	
	73	17651935	25	22.28	89%	0.85	8471	5100	95925	
	74	17651974	19	5.43	29%	0.84	1320	3876	18194	134
	75	17652520	13	9.46	73%	0.99	5623	2652	62887	
	76	17652521	23	16	70%	0.99	10506	10506	117208	
	77	17652555	19	13.06	69%	0.89	3522	3876	41683	

1) Among the 77 LT connections, 38 connections have 10 kVA & above sanctioned demand and the remaining 39 connections have sanctioned demand of below 10 kVA
2) 23 connections are underutilized, where the demand utilization percentage is below 25%, in which 10 connections are under 10% utilization
3) 2 connections are overloaded, and are under penalty
4) The remaining 52 connections are effectively utilized, among which about 15 connections are with 70% and above utilization.
5) All put together, the monthly average energy bills for these 77 LT connections comes around INR 30,75,000

WAY FORWARD

The detailed energy assessment will be performed by the assessment team, which comprises the following, based on which a detailed assessment report will be submitted;

1. Demand management study will be conducted for the 23 common LT connections which are under 25% utilization and 2 LT connections which are under penalty in order to evaluate the reason behind in-effective demand utilization. There are lot of potential in saving fixed charges.
2. All the utilities connected to these 77 common LT connections will be assessed in detail on their performance and energy consumption. This study will be conducted in 4 phases, which will include the assessments of 20 LT connections in each phase. Energy efficient utilities with less energy consumption will be suggested.
3. Overall power quality study and the complete distribution pattern within the KWMC will be studied in detail. This needs approval from the MMC and TNEB officials at the time of study. This will result in cutting down unwanted fixed charges and penalty for power quality issues.
4. Detailed energy assessment for the common cold storage facility
    - Transformer study
    - Power quality study
    - Chiller performance
    - Pumps & motors study
    - Cooling Tower study
    - AHU study
5. Lighting study is done for suggesting energy efficiency lights based on LUX level study using LUX meter.

6. Water flow and power consumption will be measured for the pumps to assess their overall performance.

Based on the concurrence from the individual shop owners, the energy assessment for all the 3995 shops will be conducted to assess their lighting, fans & cold storage systems, and respective solutions will be provided for energy savings.

SUPPORTING PHOTOS

Damaged power line connections

Unmaintained power control boxes

Power transmission

Cold storage complex

Cold storage room

Non-functional Bio methanation plant

Unused lab space
in bio-methanation plant

10. TRAFFIC MANAGEMENT AND TRANSPORTATION

PURPOSE

The objective of this survey is to understand the Koyambedu market's Traffic movement to understand the carbon footprint, and document associated site conditions. It is our understanding that the outcome of this survey will be used to estimate carbon emission due to traffic movements and design a comprehensive management system with site-conditions.

METHODOLOGY

To achieve the objective Stratus visited the market with the pre-prepared questionnaire and collected information from the drivers and market management. Our priority was to understand the vehicle movement and being used (shipment of vegetables, fruits & flowers, Grains). The following steps were followed:

1. Site visit – Collection of data from the local Market management team and drivers of vehicles.
2. Preliminary Data - Stratus discussed vehicle movement schedule with RTO (Mr.Madhavan-9444792579) of Koyambedu Market Management Committee (KMMC) to plan survey schedules.
3. Upon visiting the site, the following information was documented on the questionnaire
    a. Vehicle registration number
    b. Vehicle load and product details
    c. Place of origin and payment details
    d. Time of arrival and type of vehicle

KEY FINDINGS

Stratus visited the site on 29th and 30th September to collect information regarding the market schedules and vehicle movements (Physically verified in the market - 10PM to 6AM). It is observed that market vehicle movements are mostly in the midnight to early morning. So, we have conducted all the data collection work in the specific time. Vegetable Market was assessed on 3rd October night and Fruits and Flower Marker was assessed on 4th October night. The collected data were documented below:

1. Overall, 450 vehicles were recorded which includes large vehicles (12 wheels) to small vehicles (4 wheels) to deliver vegetables at Koyambedu market. Most of them are coming from Andhra, Karnataka, Maharashtra, Madhya Pradesh and

different parts of Tamil Nadu). A minimum of 4 ton to maximum 15 tons of product has been unloaded using this vehicle at Koyambedu market.

a. Approximately 100 vehicles (large to small) observed carrying vegetables from Karnataka.
b. Approximately 100 vehicles (large to small) observed carrying vegetables from Andhra Pradhesh.
c. Approximately 10 vehicles (large to small) observed carrying vegetables from Maharashtra.
d. Approximately 250 vehicles (large to small) observed carrying vegetables from different parts of Tamil Nadu (Places – Thiruvallure, Gummidipoondi, Trichy, Ooty, Villupuram, Thindivanam, Vellore, Thiruvannamalai, Kanchipuram, Dharmapuri, and Coimbatore).

2. Overall, 114 vehicles were recorded which includes large vehicles (containers - 18 wheels) to small vehicles (4 wheels). Most of them are coming from Andhra, Karnataka, and different parts of Tamil Nadu). Imported fruits were also delivered using these vehicles from the airport.

a. Approximately 23 number of 4 wheel and 22 number of 6 wheel loading vehicle delivered banana and papaya from Andhra Pradesh.
b. Approximately 2 number of 4 wheels, 11 number of 6 wheels and 1 number of 8-wheels loading vehicle delivered fruits (largely pomegranate) from Karnataka.
c. Approximately 18 number of 4 wheel, 20 number of 6 wheel and 4 number of 8 wheels loading vehicle delivered fruits from different parts of Tamil Nadu (Places – Aathur, Chengalpattu, Villupuram, Cuddalore, Vellore, Arcot, Madurai, Thiruppatur and Coimbatore).
d. Approximately 15 vehicles observed carrying imported fruits from Chennai Airport.

3. Market shops were paying the transport charges to the vehicles.
4. Due to urgency few drivers were not sharing full information. Since the drivers need to deliver the product on time.
5. All the vehicles have to unload their product and leave the market in the given time. There is an agent to manage the vehicle unloading area linked with each shop.
6. Labors with cycle rickshaw will be used to unload the product and the sold product is again loaded in a vehicles to move into the city for the local vendors.
7. Local vehicles were used to distribute the product to the city. Approximately 50 numbers of 4-wheel vehicles were used daily.

8. We observed that local vendors/buyers were moving the product using two wheelers approximately 100 numbers daily. Apart from that market individuals are using two wheelers and keeping vehicles inside the market.
9. Local Police is using their vehicles to monitor the market activities.
10. On site we observed that, A private contractor (Sri Mangalam) is taken the parking contract of KMMC area and providing tokens for each vehicle during the entry. KMMC person is also collecting the details of vehicles in the night time (Data - Vehicle Number, To which shop vehicle goes, In and out time, Token number and signature of shop person)
11. KMMC owned cleaning vehicles like JCB, bobcat is being used daily for the market maintenance.
12. Three-wheel (auto) vehicles are used for travel by the daily buyers/shop keepers in the day time. Few shop owners are using their own car for travel.
13. Only one entry gate and four exit gates for the vehicles movement in the vegetable market. Field data sheets were attached in the annexure.

WAY FORWARD

The future work will involve:

1. Survey at food and grains area,
2. KMMC maintenance vehicle details, Dump site area vehicle details
3. Detailed report of all the survey

SUPPORTING PHOTOS

Truck bay at vegetable market

Truck bay at fruit market

Tariff for vehicle parking

Trucks from other states

Buffer zone for parking

Loaded Trucks

Traffic Survey

Entry of the parking area

Six Wheel vehicles

Four Wheel vehicles

Ten Wheels Vehicles

12 wheel vehicles

Loading and Unloding

Loading - City movement vendors

Market Cleaning Vehicles

11. SOCIAL SURVEY AND STAKEHOLDER MAPPING

PURPOSE

IIT Madras and Centre for Urbanization, Buildings and Environment have been asked to prepare a Detailed Project Report for (re)developing/reinvigorating the Koyambedu Wholesale Market as a Carbon Neutral Zone by the Tamil Nadu Pollution Control Board. This is being envisaged in line with India's vision to achieve net zero target by 2070 as committed in the COP 26 held in October 2021.

While the focus is on carbon neutrality through multiple verticals of water, waste, energy, building structure, etc., **we recognize that carbon neutrality must go hand-in-hand with a more holistic mission to make the market-place green and sustainable**. Further-more, for technological solutions to successfully make the marketplace carbon neutral and more sustainable, the social context including the policy and governance structure, the stakeholders' perceptions, preferences, and practices matter immensely (e.g. consider waste management – unless shopkeepers are on board, it is impossible to implement proper source segregation practices which can be a threat to efficiency of any waste management solution). Therefore, as part of the baseline study we plan to examine the social context of the Koyambedu marketplace with the primary intention of ensuring that we have a good understanding of:

a) the various stakeholder groups who use, manage/govern, and therefore are affected by and also affect the Koyambedu marketplace and its sustainability;
b) the perceptions of the key user groups (for instance the shop owners) about current challenges, how they would like to see the space evolve towards becoming more socially and environmentally sustainable;
c) the social and policy context shaping the marketplace and its affairs.

Ultimately, the **aim is to co-create a vision of a sustainable/carbon neutral market place in conjunction with the various stakeholder groups** such that Koyambedu becomes a model for other such markets across Tamil Nadu and beyond.

METHODOLOGY

For the baseline study the team planned to undertake the following activities:

a) Developing an understanding of the policy and governance framework regulating the Koyambedu Market through secondary review of existing policies and interviews with relevant stakeholders (e.g. representatives from CMDA/the Koyambedu Market Management Committee, the Traders' Associations) – review of The Tamil Nadu Specified Commodities Markets

(Regulation of Location) Act 1996 (Act 24 of 1996) - done; some informal interactions have been carried out while additional interviews with MMC representative and Traders' Associations will be conducted in the following months.

b) **Conducting a survey with the shopkeepers of all 4 types of market (Vegetables, Fruits, Flowers and Grain) - 216 shops have been surveyed (access survey:** https://forms.gle/w9yBWi4i8Exrt6NW6**) ;** Out of these 197 are vegetable shops, 98 are fruit shops; 43 are flower shops; 47 are food grain shops – as such the survey sample maintains the proportional break down of the 4 types of shops.

c) **Conducting semi-structured interviews with representatives of different user groups to understand the current social and environmental status and needs of these groups and the market** – laborers, truck drivers, security guards, street vendors in and outside the market, and some customers and conservancy workers have already been interviewed.

d) **Documenting and mapping of marketplace and vicinity through a photo diary method (focus on types of activities and user groups) -**Yet to be finalized.

e) **Developing a stakeholder map and identifying dependencies, tensions and cooperations/social networks so we know who may need more attention during implementation phase, how to build ownership to ensure long term sustainability of green/carbon neutral solutions in the market etc –** will be done in the following months.

KEY FINDINGS

Introduction: The KWMC was established by The Chennai Metropolitan Development Authority (CMDA) in order to decongest the central business district at George Town. Given its location adjacent to The Chennai Mofussil Bus Terminus, connection to the Central and Egmore Railway Stations and the Chennai International Airport via highways and metro, the market remains strategic in terms of easily accessibility[1].

The wholesale market for perishable goods was established across an area of about 70 acres and it started to function in December of 1996[2]. A food grain market was added much later, in 2011. According to data shared by Koyambedu Wholesale Market

[1] Market Management Committee 2019 (file:///C:/Users/proy/OneDrive/Green%20Koyambedu%20Project/Koyambedu(Market%20Management%20Committee).pdf.pdf

[2] ibid

Committee (KWMC), currently, the market spreads across 72 acres and includes a total of 3941 shops (1985 vegetable shops, 992 fruit shops, 472 flower shops, and 492 grain shops) accounting for one of the largest such market in Asia.

The market is regulated by The Tamil Nadu Specified Commodities Markets (Regulation of Location) Act 1996 (Act 24 of 1996). As per this Act, the Koyambedu Wholesale Market Committee or Market Management Committee (MMC) is responsible for the daily management including overseeing service delivery (water, sanitation, electricity, traffic management etc) and should have representation from the Traders Associations. Currently, MMC interacts with representatives of the Traders' Associations for critical decision-making issues. The governance of the market and the role of the traders' associations there-in will be further explored in the next phase of work.

In the following section, we present the key findings based on the baseline study and data we have collected so far.

Key stakeholders identified

i. The Chennai Metropolitan Development Authority (CMDA)
ii. the Market Management Committee (MMC)
iii. Shopowners (the shops belong to these people, who may be renting the space)
iv. Traders' Associations (there are multiple associations across market types)
v. Laborers
    a. Loadmen / Gangmen (some are part of formal associations - ~1,00,000 loadmen)
    b. Employees (temporary or permanent) working in the shops (loading, billing, packing, selling)
vi. Customers
    a. Retailers buying in wholesale
    b. Middle-men between retailers and wholesalers
    c. Individual citizens buying for consumption
vi. Truck/Tempo Drivers
vii. Conservancy Workers (Srinivasa and Our Land Pvt. Ltd)
viii. Security Guards
ix. Informal/unauthorized vendors (inside and around the perimeter of the market)
x. Unexpected stakeholders: Cattle and their Owners

Fig. 11.1: Some of the Key Stakeholders in the Market

Primary Stakeholders - Shopkeepers and Labors

In order to get feedback from the shopkeepers and the laborers working in the shops who spend the maximum time in the market 216 shops were surveyed. The learnings from this survey are presented below.

Ownership status

- Nearly equal number of responders owned (51%) and rented (49%) shops. This ratio was similar irrespective of the size of shop. However, there were variances across market type: In the grains market there were significantly more renters (92%) to owners (8%) whereas the flower (67%) and fruits (70%) markets had predominantly more owners. The vegetable market had marginally greater number of renters (55%) to owners (45%).
- While those who were renting were mostly doing so from other individuals, there were some instances, where shopkeepers were renting directly from CMDA, especially in the grains market which is one of the more recent additions (2015). In another instance, one shopkeeper reported paying 40% of the income generated from the shop in the flower market area as commission to the owner. These

conditions suggest the need to distinguish between space owners and shop owners (from here on, shopkeepers) who need not be the same people.

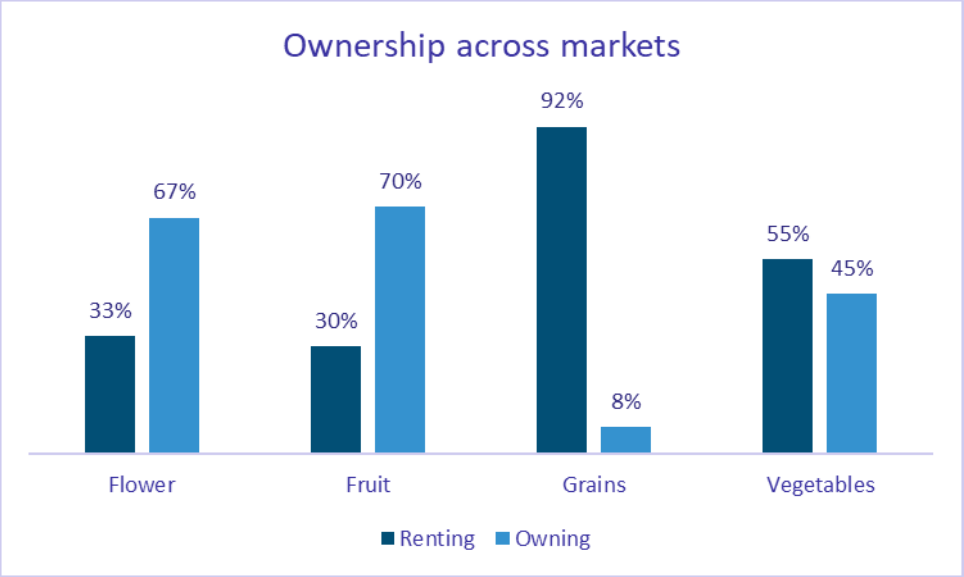


Fig. 11.2: Shop owners

- Ownership information is relevant because any physical transformation in the shop spaces will require buy-in from the owners. There is a likelihood that space owners who do not use the space and only rent it out may not be interested in taking any responsibility associated with upgradation. However, it should be noted that nearly 60% of the respondents/shopkeepers, irrespective of whether they were owners or renters, have been running their shops since the beginning of the market (including grains market) and are likely to be invested and willing to support sustainable redevelopment efforts.

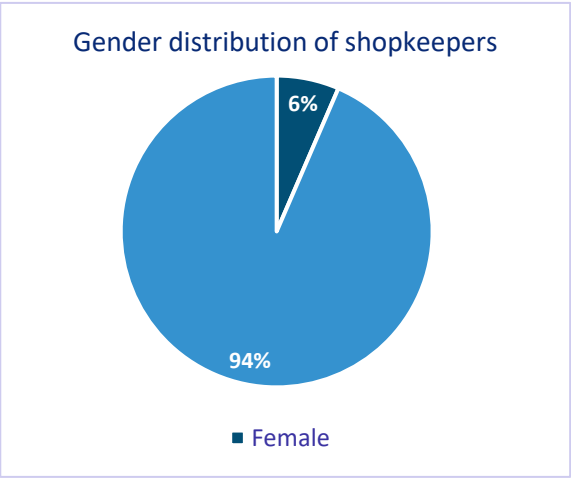


Fig. 11.3: Gender distribution of shopkeepers

Women entrepreneurs

- Of the total shops surveyed only 6% were owned or rented by women and these shops were across vegetables, fruits and grains markets. Most of the women in the market were engaged in jobs such as billing and sales. Interestingly we did not come across women officially renting or owning shops in the flower market. However, there were several informal shops (without shop numbers) run by women on the stairs and just outside the market (within the compound) (see section on other stakeholders for more details).

Origin of Employers and Employees

- Of the 216 respondents, 62% respondents are from Chennai while the remaining are all from other parts of Tamil Nadu. Most of the shopkeepers employ labour at their shops and more than 77% of them employ up to 5 peaple. These labourers are mostly from other areas in Tamil Nadu outside Chennai such as Ariyalur, Trichi, Vizhupuram and Perumbalur.
- More than 95% of the shopkeepers live outside the market. However, nearly all the shopkeepers had some or all their labourers living inside the shop without their families. While the larger shops (above 300 sq.ft.) are built to have space above the shops to use as a living space, in most cases the labourers live in the shop/same floor.

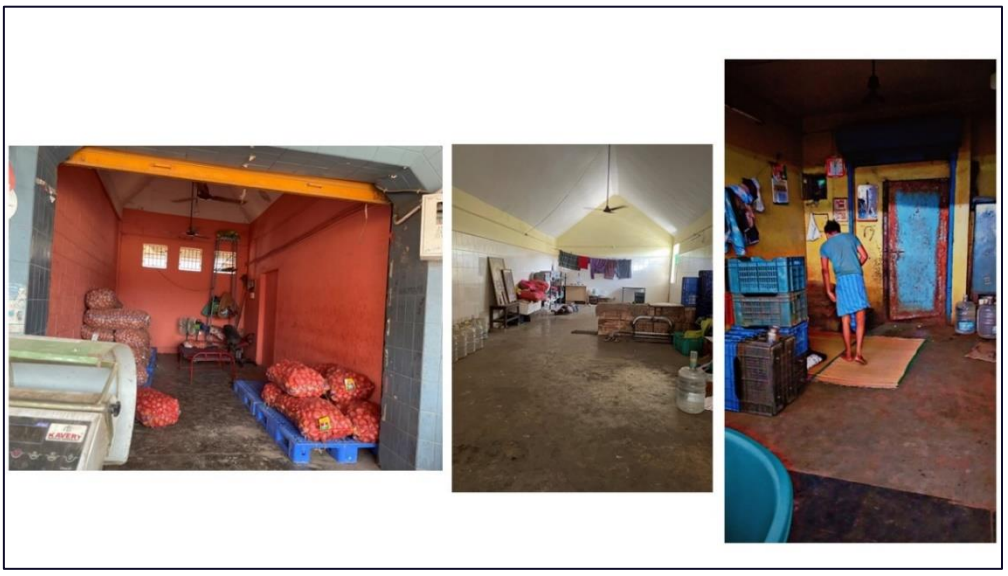


Fig. 11.4: Living space of labourers

Traders' Associations and their function

- More than 60% of shopkeepers are part of some trade association irrespective of market type (i.e., flower/ fruit/ vegetable/ grains). There are several such trade associations of different types and these are categorized by market such as the Koyambedu Vegetable Sellers Association, Chennai Wholesale Flower Agents Association, Chennai Fruits Commission Agents Association and the Koyambedu Foodgrains Association[3]. According to the secretary of one association in the fruit market, there are five such associations in the fruit market alone. Associations also exist by fruit / vegetable type. For instance, Koyambedu Chikoo Sellers Association or the Koyambedu Tomato Sellers Association.
- The function of these associations was not clear from conversations with respondents. Some respondents said that they have not got any benefits from being members while others stated that the association helps to solve their issues. Conversations with a secretary of one of the Fruit Associations said that they charge a membership fee of Rs 300 per month and use the money to conduct medical camps and/or pay Diwali bonuses for employees. He also stated that the association represents members' concerns to the MMC but that there needs to be more frequent communication with the MMC who "do not get out of their AC rooms!"
- Another stakeholder and active member of a Koyambedu Vegetable Sellers Association said that they conduct meetings every month with members where they can raise their concerns. The primary role of the association is to represent views of members regarding any issues (such as traffic flow) as and when they arise to the MCC. The same person also said that they meet MMC frequently to discuss issues and that the MMC does not take any market management decision without meeting with the heads of all associations. However, both association representatives questioned the payment of maintenance fees when basic cleanliness and hygiene are not being maintained in the market.

Key Challenges in the Market:

i. Access to basic services (water, sanitation, health care and electricity)

[3] These names were given to us from memory and the actual names are likely to vary slightly.

- Overall, across all market types, more than 60% of respondents stated that they faced issues in accessing either one or all these basic services. However, across the services, variations were reported.

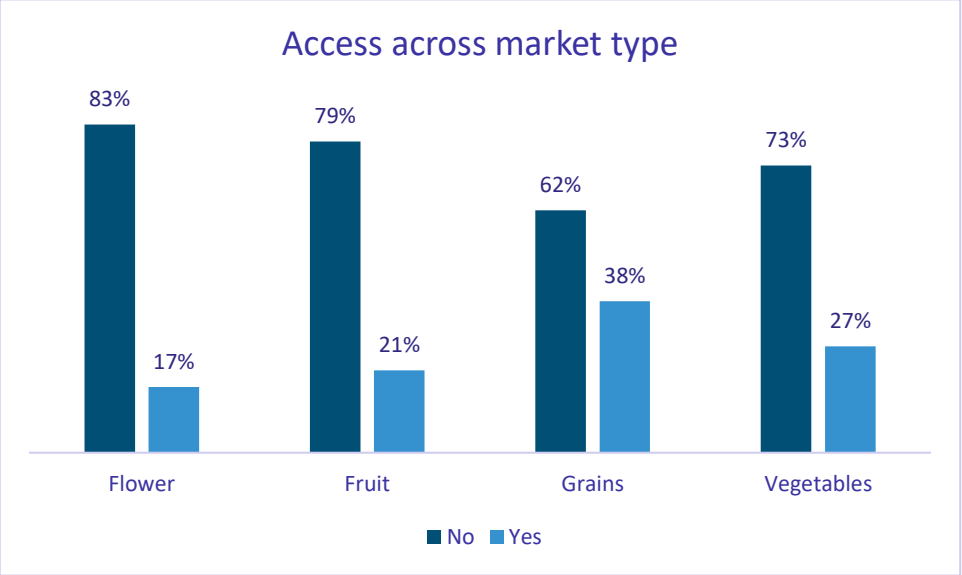


Fig. 11.5: Access to basic services

Water

- With respect to water, 67% of respondents said they had access to water for drinking and domestic purposes. However, of this 67%, half the respondents explicitly mentioned buying water can and it is highly likely that the other half also buy can water but did not say so.
- Conversations with respondents and other stakeholders and field observations revealed other forms of informal and formal means of accessing water – water cans and pots of water are being sold, a drinking water dispensing station near the flower market (set up by MMC), some respondents (7%) also reported having their own borewells in the shop. These shops were in the vegetable and fruit markets. Private water tankers were also noticed supplying water to the shops.
- Several respondents elaborated on their problems in accessing water and spoke of poor water quality and mentioned not having access to any water facility for drinking or washing their face, despite paying water tax. This quote from a shopkeeper highlights the issue: **"previously we had metro water connection but for past 5 years there is no water supply from metro water but we are paying the water tax."**

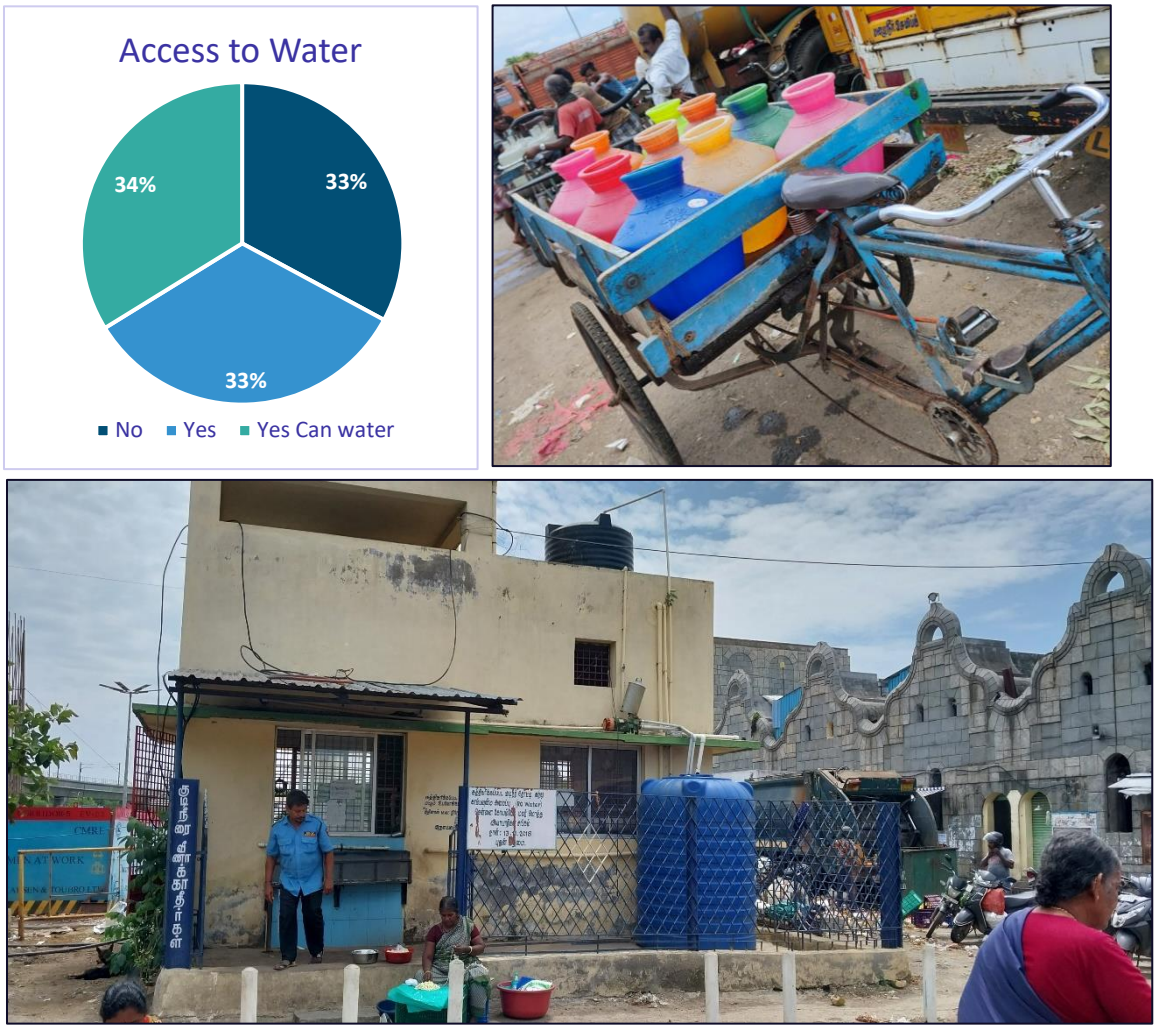


Fig. 11.6: Clockwise from top left: Pie chart showing access to water, pots of drinking water filled from a private tanker ready for sales, a free drinking water dispensing station set up by MMC near the flower market.

Sanitation

- More than 50% of respondents stated that they either do not have access to sanitation facilities or had to pay to use the public toilets across all four markets. The charges for using these public toilets varied between Rs 5 and Rs 20 per use depending on whether the use was for the toilet or for bathing or washing etc. However, several respondents reported their unhappiness with the maintenance of the toilets saying that it was unclean and unhygienic and not usable.

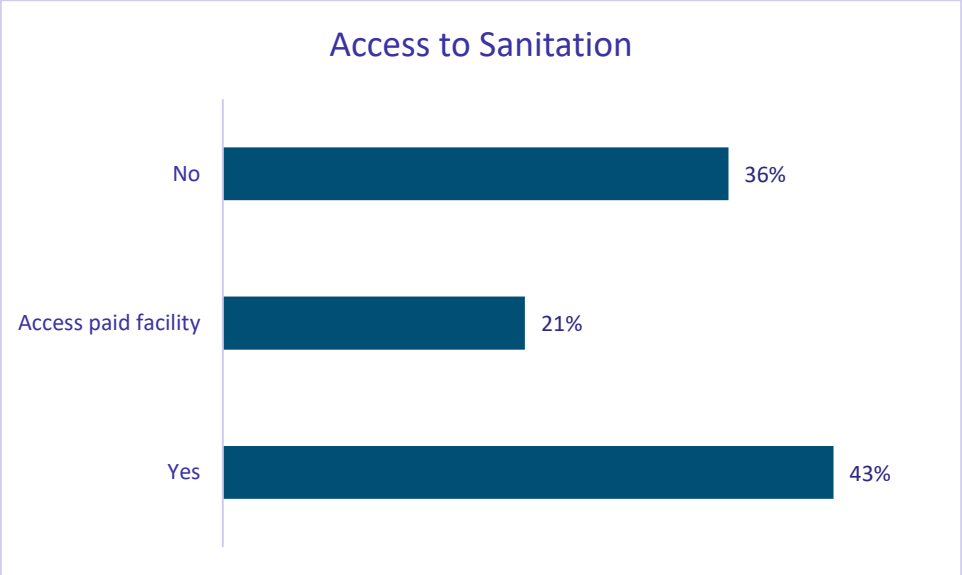


Fig. 11.7: Access to sanitation

- It was also recorded by the women respondents that there were only common toilets for men and women and no separate toilet for women. This quote from a respondent explains the situation, **"there is no safety for women, especially in the evening as men drink and due to that, using common toilets are difficult and each time we pay for the toilet that is not cleaned."** Charging for the toilets has also resulted in people defecating in the open around the toilets making the entire space unhygienic, unusable, difficult to clean for the sanitation workers (predominantly women, some of who live close to the toilet) and posing a significant health risk to all users and those in and around these toilets.

Fig. 11.8: Toilets in the flower market

- Public urinals – During the field visits, the team came across free public urinals in the middle of the vegetable market. While installing these were a good attempt to provide free sanitation services, it does not take into account the cultural / social aspects of access i.e., the lack of privacy for the user. The signage to these structures is also problematic – they are clearly inaccessible to women, yet the signage indicates the opposite.


Fig. 11.9: Free public urinals

- According to a staff at the MMC, as per the Koyambedu market design, shops over 300 sq. ft were designed and built with toilets within the shops. Yet these toilets are predominantly dysfunctional. Of 215 respondents, 81% stated that they did not have toilets inside their shops. According to the respondents the primary reason for this is the lack of water in the toilets. Some shopkeepers have chosen to use the allocated toilet space for storage etc. Some have also invested their own money to put up overhead tanks to ensure water access in the toilets.

Health care

- With respect to health care, it was found that 74% of respondents had access to some kind of health care service although these were all **private services outside the market**. Field observations and discussions with MMC staff revealed that there is currently no facility inside the market complex. In fact, the existing clinic was locked. The team learnt that Apollo Hospitals will be taking over the existing clinic after renovation but until then there is no makeshift facility that can offer first aid to the lakhs of people working in the market. Some reported that occasionally Trade Associations organize health camps.

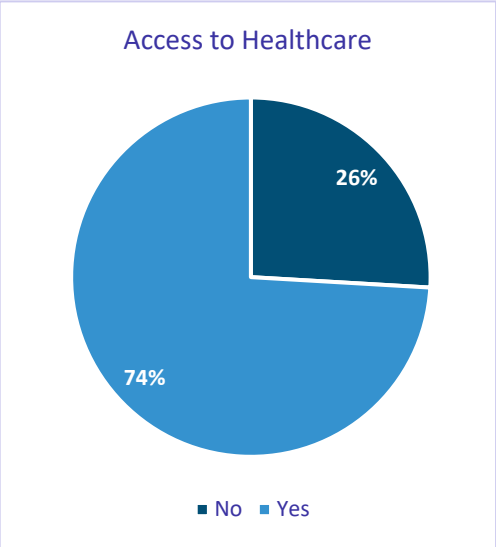


Fig. 11.10: Access to healthcare (private) and the closed healthcare centre (right)

Electricity

- Among the services, respondents report relatively good access to electricity with 94% stating they do not face any issues. Majority of those that did report an issue (65%) were in the vegetable market where they spoke about frequent power cuts.

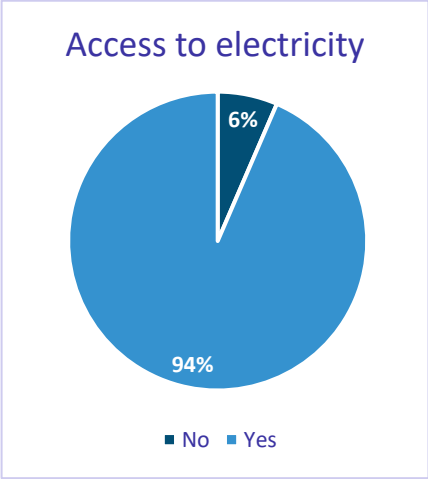


Fig. 11.11: Access to electricity

ii. Socio-environmental Challenges

- Respondents were asked to describe socio-environmental threats i.e., water logging, water seepage, waste management, lack of safety and others that they faced, if any. More than 50% of respondents stated that they faced one or more of

these threats. Variations in threats faced were reported across the four markets: In the fruit and vegetable markets, 65% of respondents stated that they face one of the above threats. In comparison, more respondents said that they did not face any threats (more than 55%) in the flower and grains market than those that did so.

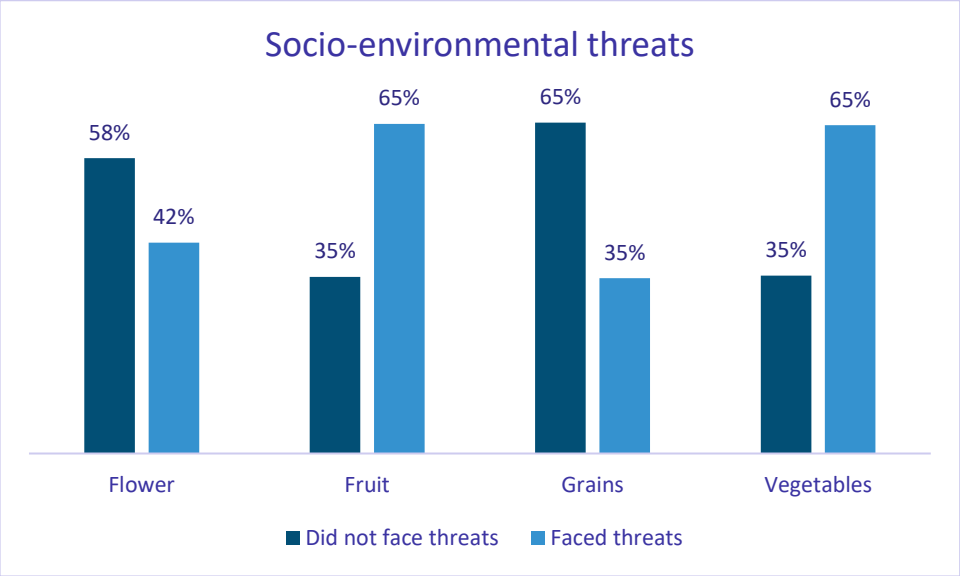


Fig. 11.12: Socio-environmental threats experienced by market type

- In terms of the type of threat, again more than 50% reported facing issues of water logging, 16% stated that they face safety related issues while less than 10% highlighted issues like dust and pollution, waste management and water seepage.

Fig. 11.13: Types of threats faced

- In terms of the breakdown of these threats by market, there were no significant differences. **Water logging and poor drainage** was the most commonly reported threat across all four markets during bouts of rain. Respondents also spoke about it being difficult to walk through the alleyways in the market due to slush mixed with dumped vegetable waste – specifically cauliflower shells and a resultant **mosquito menace** in the vegetable market. Indeed, field observations from walking through the vegetable market also highlighted these issues.
- Interestingly while **poor waste management practices** were visible throughout the Koyambedu market complex, very few respondents (7%) highlighted it in the survey and those that did were in the vegetable, flower and fruit markets which suggests that the shopkeepers do not mind the mess. This is probably due to a

combination of issues such as polluters not taking responsibility for what and how they dispose waste, a lack of awareness on the right waste management practices, no penalties for violators etc. As such, waste is being collected every day from all four markets and after 2pm and there is scope for improving the entire system.

- Around 16% of respondents highlighted issues of **safety and security** across all four market types. These respondents spoke about the market being unsafe for women, fruits and vegetables sometimes being sold in the bathrooms and in unhygienic conditions, instances of drug and alcohol abuse, theft, especially in the fruit market and the inability to access the police. Our field visits also showed the presence of a couple of TASMAC shops in the periphery of the market. One shop is opposite the grains section where shopkeepers complained of drunk people coming into the empty living spaces above their shops with women and disposing off alcohol bottles at night (hardly anyone lives in the food grain market complex, even none of the labourers). Respondents spoke about the need for security for the shopkeepers and the workers.

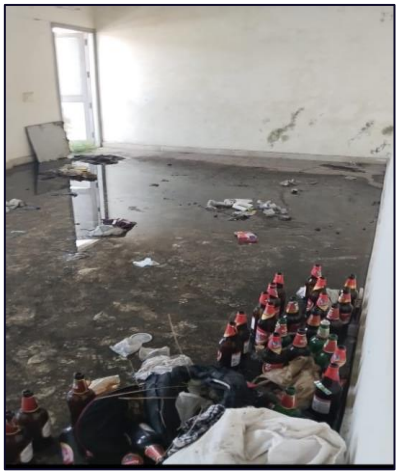


Fig. 11.14: The slushy mess of vegetable waste along the pathways of the vegetable market

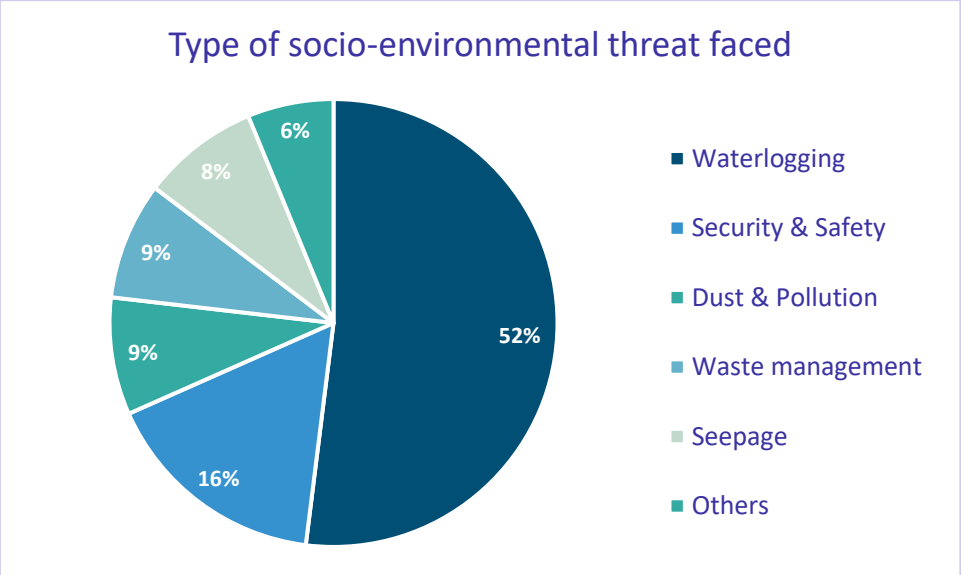


Fig. 11.15: alcohol bottles disposed in the rooms above the grain shops

Fig. 11.16: Clock wise from top left: Water seepage issues in grain and flower markets, exposed electricity infrastructure in the veg and flower market

- **Water seepage** due to poor building quality was also reported from all four markets by 7% of respondents. This was also apparent from visual observations during the field visits. The team noticed water seepage through ventilators in the grains market, through the walls and ceiling and into open electricity boxes in other markets.
- **Dust and pollution** were reported from the vegetable market alone where respondents linked it to heavy traffic and dust from sacks used to transport supplies. While other respondents discussed the threat from cows. Before the market development, cattle owners used this area for grazing. Many of them continue to let their cattle graze in the market, especially in fruits and vegetables market where ample food is available for them. There have been occasions when market users, specifically labourers, have been injured due to these animals. Some shopkeepers complained that the cattle owners bribe the security guards who then let the animals in to the market. **The cattle and their owners may need to be acknowledged as an unexpected stakeholder/user group and brought into discussions.**

Fig. 11.17: Cow menace

Secondary Stakeholders

In addition to the shopkeepers and labourers who may be described as the primary users of the market, several other stakeholders also spend substantial time in the market. In the following section, the focus is on these secondary stakeholder groups – their working and living conditions, which resonates with the sentiments, priorities, and concerns expressed by the shopkeepers.

Fig. 11.18: Clockwise from top left: A load-man who is member of Dr. Ambedkar Loaders' Association; an independent load-man unloading sacks; some load-men being interviewed in the vegetable market (bottom pics)

Load-Men/Gang-Men

- Loading and unloading material is a major job in the market. As such a substantial population of young and middle-aged men remain involved in this work and are collectively called Load-men or Gang-men.
- Dr. Ambedkar Loaders' Association is an association of such laborers that have strong presence specifically in the vegetable market. While they also work in the other three markets, the presence of independent laborers is more common in fruits, flowers, and grains sections.

- According to our discussion with a group of load-men, in the vegetable market alone there are 5 load-men's associations, about 5000 laborers, while there is likely to be about 1,00,000 such laborers in the whole market.
- These men mostly live outside, but near, the market.
- During the working ours they use the toilets at the shops that they are working for since the common market toilets are in poor shape and they have to pay to use them. During the interview, one load-man suggested that they have to pay a fee of Rs 20 for bathing.
- Health issues and injuries remained a concern as no good government medical facilities are available in the market; even for first aid they need to access private facilities outside the market.
- The load-men also spoke of the challenges of collecting and delivering to and from each shop, especially, in the ones along the narrow alleys, where cars/trucks/tempos cannot enter.
- Those who are independent laborers and not part of any association are likely to be more exploited. Those interviewed reported working from 11pm in the night to noon next day at Rs 15 per sack loaded/unloaded (weight carried per sack can vary between 20kgs to 110kgs).

Truck Drivers

- The truck drivers bringing items to the market comprise of an important user group in the market area. These truck drivers usually make a number of trips each month and stay for 2 to 4 days in the area before getting back.
- Several of these truck drivers park their trucks in one of the main truck parking areas to the SW part of the market. This parking area also allows private buses. Earlier CMDA made a night shelter/hotel available for these drivers at a cost close to the parking area, but now this is being used as a restaurant because there were no takers for these paid rooms. Now the truck drivers mostly live inside their trucks.
- The truck drivers spoke of sanitation and garbage as the two major problems in this space. One end of the parking space is being used as a dumping place and many of the storm water drains, especially those close to the dumping site was filled with garbage.
- Bathroom facility was available within the parking area and drivers could also buy drinking water cans from here. However, echoing sentiment of others, one of the

truck drivers complained **"even to wash my face, I need to pay. I pay Rs 5 per use, and Rs 20 for a bath."**

- There seemed to be mostly Tamil drivers coming from other parts of the state, but there were also a significant number of out-of-state truck drivers.
- Interestingly a cultural divide was apparent between these groups – the Tamil drivers rested and chatted under the limited trees available towards the entrance of the parking area, while most drivers from northern states stuck to themselves on the other side. The out-of-state drivers also preferred to cook and eat inside

their trucks/buses as compared to the Tamil drivers who generally ate at nearby hotels.

- They also pointed out the lack of medical facilities and mentioned that they go to any nearby medical shop if required.

Fig. 11.19: Clockwise from top left: North Indian truck driver showing-off gas cylinder that he uses for cooking inside the truck; group of Tamil truck drivers sitting under tree-shade; one private bus driver sleeping inside the bus baggage area; garbage clogging

Security Guards

- The security service is contracted out to MV Security Agency.

- The security guards are all men approximately in the age group of 25-45 years.
- Most of them are from North India, specifically Bihar, and have been working there since 2004.
- One of them said that he has farm land in Bihar which is enough to feed his family back home and for all other expenses like children's education, they rely on his salary from working here as a security guard.
- These men live in an informal space behind the CMDA/MMC security office. Temporary living arrangement has been put up using tarpaulin sheets, tin sheets and asbestos roofs.
- They cook in the open using clay cook stoves. They get access to drinking water by buying canned water and use the toilet inside the MMC building.
- Also seem to have access to electricity – most likely drawing it from MMC building to run wall fans and bulbs.

Fig. 11.20: Living spaces for the security guards

- During rains they all move to the first floor / 2nd floor of the MMC office building for shelter
- The security guards mentioned that the tendering system ensures that the lowest bidder wins the contract and this has a negative impact on their salaries. Earlier contractors have offered health insurance, but not anymore.
- While the security guards themselves did not mention, from the shopkeepers, it was apparent that sometimes there are tensions between the North Indian security people and the local shopkeepers.

The conservancy/sanitation workers

- Primarily two groups of sanitation workers work in the market under two private contracted companies – the first work for Srinivasa Waste Management Services Pvt. Ltd. and the second work for Our Land Pvt. Ltd.
- Majority of the workers were women- especially those cleaning the toilets. Also, within the waste collection process usually the women do the collection, and men handle Bobcats, tricycles.
- The workers of Srinivasa Waste Management are engaged in waste collection from different parts of the market – they work for 8-10 hours (9am - 5.30pm) and get a salary of ~ Rs.12,000.
- Usually, the waste collectors report at MMC building and sign in after which they are assigned their work site (usually 3 people per block);
- They are equipped with tricycle, broom, rake, containers - after collection fruits and vegetable waste from the market is brought to a common place from where a Bobcat takes it to the truck bay or is directly taken to the truck bay from where garbage trucks take it to the biogas plant in Chetpet; flower waste was reported to be taken to a nearby parking area from where big garbage trucks take them away.
- Most conservancy workers reported having access to sanitation facility but mentioned that only common washroom for both men and women were available.
- They also reported accessing drinking water from the shops while some carried water from home. They also reported living outside the market and brought food from home.
- They spoke about having access to all basic amenities, but at a cost.

- Those working for Our Land Pvt. Ltd. are involved in sanitation work – cleaning toilets (usually twice a day).
- Many of the sanitation workers are elderly women, migrants from northern states, and live inside the market, in the alleys close to the toilets, under poor hygienic condition.
- One such sanitation worker mentioned having to clean human faeces by hand without any protective gloves and requested that alternatives should be available to do this sort of work.

Fig. 11.21: Waste workers in the market

Street vendors/unauthorized vendors

- There are hundreds of street-side vendors all around the periphery of the market as well as inside the market. Field observation around the market periphery suggest that maximum concentration of the street vendors is along the E-Road close to the main entrance.
- From the outset there seems to be a majority of women vendors, but there are also men, many of whom have been around as long as the market itself.

- Most of these vendors live in the surroundings of the market and have been doing business here since the beginning of the market.
- Other than fruits, vegetables, greens and flowers, which the vendors are buying from the market and selling outside, some street vendors are also selling juices, and prepared food items. Many women were noticed to be collecting rejected fruits, vegetables, and greens from the roadsides for selling purposes – but understandably none of the street vendors interviewed agreed to selling collected/rejected material.
- Several of the street vendors, especially, along the front-side of the market had official street vendor's card issued by the Greater Chennai Corporation (GCC) which grants them permission to carry on their business – as such these vendors are not frightened of eviction by the police; they chose to sell outside on the street because rent is unaffordable for them inside the market.
- These street vendors are using temporary set ups – carts, umbrellas, tarpaulin sheets, crates to set up their shops and leave this material behind at night. Some street vendors interviewed pointed out that safety was not an issue as the community of street vendors look out for each other.
- Heat and rain pose obvious threat to these people working in the open – one woman selling flowers (garlands) outside the market complained that there were **"too many mosquitoes during the rainy season and skin allergies bothered her during the heat of summer."** Another man selling fruits on a cart, suggested that **during rains, he has to raise his shop to avoid the stagnated water and also suffers due to lots of mosquitoes.**
- Most of these street vendors bought water cans and said that they hardly use the public toilets in the area which are extremely dirty and require a fee for use. This is also indicative of the degree of open defecation that most likely results because of poor sanitation facilities.
- One fruit juice seller informed that **CMDA has given them dustbins with instructions that they collect waste in it and dump in the street bins, a few yards away** – this is suggestive of a system in place to manage the waste in the peripheries of the market as well by CMDA.
- Parking in the peripheries blocking these businesses seems to be a problem as many customers try to avoid parking inside the market because of the cost.
- A substantial number of vendors also are selling fruits, vegetables, and flowers inside the fruit, vegetable and flower market respectively, but do not have any

shop number. These are unauthorized vendors who have been using the space for earning a livelihood almost since the beginning of the market. They face similar insecurities and lack of access to basic services like clean toilets as the street vendors.

- One such woman selling bananas and drumsticks in the vegetable market premises suggested that: **`I have been here my whole life and do not know any other place where I can sell my things."**
- CMDA/MMC once in a while raids the market to remove encroachments and confiscates the products of those selling illegally within the market – the collected items are usually sent to orphanages. The unauthorized vendors usually tend to come back the next day.
- Only in the food grain market such unauthorized vendors were not common, nor was much street vending happening along the peripheries of the foodgrain market.

Fig. 11.22: Street vendors and unauthorised vendors inside and outside the market

WAY FORWARD

Survey and interview data gathered from the different stakeholder groups and the above analysis highlights **that interventions to make the Koyambedu wholesale market a more sustainable place should be sensitive to the need of those (e.g. labourers and women) who are most affected by the current situation of the market – especially of poor services.**

- As discussed earlier, nearly all the labour employed by the shops live inside the market, specifically inside the shops they work in. For water, these labourers rely on the goodwill of their employees to make provisions for can water in the shops which they use. But they are obligated to depend on public facilities especially for sanitation and hygiene and health care and for these services they are required to pay per use irrespective of whether the use is for washing one's face, the toilet, bathing or washing clothes. These charges are likely to be ~ ₹100 per day considering multiple uses and are unaffordable for the labourers. This situation compromises their ability to maintain good health and hygiene and encourage open defecation.
- Like labourers, women in the market, whether they are formal or informal vendors, or sanitation workers or conservancy workers or even customers, are also severely affected by the lack of adequate, affordable, safe and hygienic sanitation facilities. Some women shopkeepers spoke about using private toilets inside neighboring shops from social relationships they have built up, but most of them are predominantly unable to use the facilities during their working hours causing sever implications for their health, especially menstrual health.
- The complete lack of a U-PHC or any other public health facility which offers affordable and good health services in the market is concerning especially considering the market is open 24x7 with thousands of people working and living inside. As such, there is no facility where people can get basic first aid, which is a critical need especially for the thousands of load-men working in the market, who are prone to injuries from carrying heavy stuff. While most respondents access private health care services outside the market, these involve fees which over a period of time are unaffordable for the labourers, the load-men, and result in them avoiding to going to the doctors, affecting their health.
- As such, it is important to note that access to water and sanitation and indeed any other basic services has multiple dimensions such as a) availability in adequate numbers, b) safety and hygienic condition for use, c) cultural appropriateness/acceptability, and d) affordability. **It is therefore important to consider all these dimensions of access to basic amenities when (re)developing these infrastructures and putting together a proper management/maintenance plan.**

As such, the learnings from this social and stakeholder vertical will inform this project in the following ways:

- First, the learnings will influence prioritization of areas of intervention – sanitation and access to water definitely stands out as major concerns followed by waste management wherein there is ample scope for improvement.
- Second, the study highlights how the needs are different in different sections of the market – therefore interventions may need to be customized for specific market types/sections (e.g., while waste management needs special attention in the vegetable market, heat mitigation in the largely concretized space might need to be the focus in the food grain market).
- Third, certain stakeholder groups may need to be brought on board for long term sustainability of specific interventions to be successful (e.g., in order for any waste management solution to be successful, bringing the shopkeepers on-board and raising awareness among them might be necessary).
- Fourth, the proposed facilities and solutions offered should keep the most marginalized groups in mind, e.g., the women, the sanitation workers. This point is already elaborated above.

In the next phase of work, our goal is to engage in the following activities to develop the plan for a more sustainable Koyambedu Market.

a) Identify and fill the gaps in understanding governance and stakeholder relations– specific stakeholder groups who have been left out in baseline study will be consulted through interviews and any other gaps in our understanding will be identified and relevant steps will be taken. A stakeholder map that presents the relationships and linkages between the various user groups will be prepared to help identify a management strategy to work with these groups in the visioning (and possibly implementation) phase of this project.
b) Leverage the learnings to prioritize interventions – the learnings will inform all the other verticals of work so that proposed interventions are sensitive to stakeholder needs, practical concerns, and feasibility.
c) Co-create a Vision for a Sustainable Sandhai - during the next phase of work on vision development, we intend to interact more closely with the key stakeholder groups to ensure that the process is participatory and takes into account the needs and priorities of the key stakeholders. This will ensure greater support and ownership from these stakeholders.
d) Design management frameworks - to ensure long term management and sustenance of the project interventions (be it biogas plants or greening strategies), well-thought-out frameworks involving different stakeholders will be proposed.

12. SITE VISIT PHOTOS


Life
Time


ஆவடி காவல்

13. CONCLUDING REMARKS

Work in the different verticals till date highlights some of the key areas where deeper research and interventions would be required to make the market space more sustainable and Carbon Neutral. Some of the key challenges identified for each vertical are –

Waste Management: The team comprehensively evaluated waste generation across the Vegetable, Fruit, Food grain, and Flower markets within the KWMC and identified avenues for driving sustainable waste management practices through stakeholder engagement. The study involved a quantitative assessment of waste generation, in-depth characterization of waste types and composition, prediction of carbon neutrality, recommendations for waste reduction and recycling, and a gap assessment for operational efficiency. The key findings emphasized the dynamic nature of waste generation influenced by market parameters and festivities, significant waste streams in fruit and food grain markets, and the potential for recycling in the food grain market. Understanding cultural factors and addressing environmental and health challenges were deemed crucial. The way forward involves further data collection, stakeholder engagement, waste characterization, and culminating in recommendations and best practices for optimized waste management at the KWMC.

Water Supply and Sanitation: The methodology involved site visits to each toilet within the market, collecting data through a prepared questionnaire, prioritizing understanding borewell locations and water usage. The study encompassed assessing the condition and specifications of toilets as well as documenting groundwater usage from active and inactive borewells. The key findings shed light on the widespread use of toilets by market staff, laborers, and the public, interconnected borewells supporting multiple toilets, water management challenges, and specific observations on water usage patterns. Notably, the team identified underused or closed toilets due to water scarcity and lack of maintenance, emphasizing the need for an enhanced sustainable water management system in the market.

Stormwater Management and Rainwater Harvesting: The market is spread over 120 hectares and most of the space is impervious, which has serious implications for poor stormwater drainage – the situation further aggravated by waste disposal challenges –, waterlogging, related issues of mosquito infestation, to name a few. This also underlines

the need for rainwater harvesting and recharging the groundwater supply with relevant interventions.

Building structures and Engineering for Sustainability: Some of the building structures had deteriorated over time due to inadequate maintenance. Especially in the flower market, rainwater retention in the roof and seepage issues are severe. In the food grain market also, rainwater tends to come through the windows of the first floor and flood the corridors making these spaces unusable. Over a period of time, these shops have also begun to face seepage issues.

Energy Utilization and Carbon Footprint: The team aims at enhancing the energy efficiency of the Koyambedu market by reducing specific energy consumption (kW/Sq.ft), thereby reducing its overall carbon footprint and advancing towards sustainability. The methodology involved initiating a baseline energy study, a thorough facility walk-through, and gathering baseline data on energy consumption to identify areas for detailed energy assessment. Subsequently, a detailed energy assessment is conducted, focusing on utilities with high energy consumption. The key findings show various connected loads and major energy-consuming components including lighting, STP pumps, and bore-well submersible pumps. Among the crucial recommendations are the proposals for a 216-kW rooftop solar project and further scrutiny of the existing cold storage facility. The way forward includes detailed assessments of the common cold storage facility, lighting, overall load patterns, and power quality management, with the goal of recommending energy-efficient solutions and strategies for the market's energy sustainability.

Traffic Management and Transportation: The audit methodology encompasses traffic flow analysis, evaluation of entry and exit points, parking facilities assessment, safety measures, pedestrian and vendor traffic management, and public transport integration assessment. The key findings from site surveys include detailed data on vehicle movements and produce transportation from various regions. The proposed way forward emphasizes a comprehensive traffic audit to analyze patterns, congestion points, vehicle movement, and integration with surrounding roads for improved traffic management within the market premises.

Social Survey and Stakeholder Mapping: Shopkeepers are the primary stakeholders in the Koyambedu Market. According to survey results, almost similar percentage of the shopkeepers are renting the shop space (51%) as are owning them (49%). Only 6% of

shopkeepers surveyed in the market were women. However, many of the street vendors, unauthorized sellers in the market, conservancy and sanitation workers are women. The social survey underpins the need to ensure that interventions to improve access to basic services such as water and sanitation must keep the marginalized stakeholder groups in mind.

In the next phase, the team will build on these initial learnings and develop a vision for a sustainable, inclusive and carbon neutral Koyambedu market.

ANNEXURE: PROJECT PROPOSAL

SUSTAINABLE SANDHAI
A 'CARBON NEUTRAL' Koyambedu Market

1.0 Background of the Project

Tamil Nadu Pollution Control Board is keen to reinvigorate the Koyambedu Wholesale Market as a Carbon Neutral Zone. This is being envisaged in line with India's vision to achieve net zero target by 2070 as committed in the COP 26 held in October 2021. While this is an ambitious target, keeping in mind the State's commitment to pioneer this effort and move towards achieving it, the State's apex body for Pollution Control – TNPCB ispoised to take up this challenge and reinvent the Koyambedu Wholesale Market as a Carbon Neutral Zone as a model benchmarking project for others to emulate.

For this purpose, TNPCB has approached IIT Madras to prepare the Detailed Project Report for this challenging assignment. IITMadras plans to associate their faculty from different departments who have expertise in Water, Waste, Sanitation, Energy, Traffic, structural engineering, Sustainability to guide and work with consultants with domain knowledge in the respective areas. This proposal is submitted by IIT Madras in association with Centre for Urbanization, Buildings and Environment. Centre for Urbanization, Buildingsand Environment, an outfit of IIT Madras supported by Government of Tamil Nadu

2.0 Scope of the Work

Phase 1: Establishing the Status Quo

This phase comprises of detailed studies required to establish the Status Quo of theMarket in terms of various parameters, namely,

a) Social Context and Stakeholder Mapping
b) Structural Audit
c) Energy Audit
d) Waste Audit
e) Water Mass Balance
f) Existing Carbon Footprint
g) Traffic Audit

The outcome of this exercise will be a complete understanding of the existing situationand identification of challenges that need to be addressed.

Phase 2: Vision for Carbon Neutral Koyambedu Wholesale Market

In this phase a vision for carbon neutral and sustainable Koyambedu WholesaleMarket will be developed. The vision will encompass a holistic view of the asset's lifecycle interms of development and operations stage both. This vision will comprise of various identified project components that will be required to reach the identified targets in the vision.The vision will assist in finalizing the project components that will be developed further in to detailed designs.

Phase 3: Towards Carbon Neutrality

This phase will comprise of the following four components

a) Detailed project Report.
b) Operations and Maintenance Framework and Documentation.
c) Monitoring & Evaluation – Key Performance Indicators.
d) Awareness Program.

Phase 4: Project Implementation

a) Bid Assistance – Tender Documents.
b) Bid Evaluation Assistance.
c) Project Management Consultancy during Execution.

3.0 Detailed Methodology

The project will be carried out in three phases and detailed tasks and activities arementioned as below.

3.1 Phase 1: Establishing the Status Quo

3.1.1 Task P1.1: Desk Research& Study

a) Study of Concepts and Documentation of Best Practices – Carbon Neutrality,Circularity in waste and water management, Efficient Traffic Management etc.
b) Analysis of National and International Best Practices – Carbon NeutralCommercial Areas / Market Areas.
c) Use of Integrated Technologies and Advanced Solutions for likely projectcomponents.
d) Integrating resilience concepts in the project.

3.1.2 Task P1.2: Secondary Data Collection

a) Existing Proposals, Relevant Documents and Past Studies.
b) Master Plan of Existing Market Complex.
c) Location and Connectivity.
d) Relevant Legal and Policy Framework.
e) Meteorological and Soil Data.
f) Existing Information on Natural Drainage Pattern.
g) Existing Institutional Framework.

3.1.3 Task P1.3: Surveys and Studies

a) Urban Level Studies

- Photographical Documentation of Site Surrounds.
- Land Use Pattern.
- Access and Connectivity.
- Traffic Movement.
- Urban Infrastructure around the Site.
- Water Resources.

b) Environmental Context

- Baseline Environmental Data
- Identification of Challenges.

c) Social Context

- Baseline Social Data
- Study of Social Context around the Site
- Dependent and Relevant Activity Mapping in Close Vicinity of Site
- Street Vending Survey in Close Vicinity of Site

d) Stakeholders Mapping& Consultations.

- Activity and User Group Mapping
- Structured Interviews

e) Site Traffic and Transportation Systems .

- Traffic Management
- Amenities – Parking, , Recreational zones, etc.
- Existing Area available for Project components development

f) Structural Assessment

- Rapid Distress Assessment through visual inspection.
- NDTs / Tests if required.
- Identification of Issues and Possible Rectification Measures.

g) Energy Audit

- Inventory of the energy consumption of the market
- Scope and design of Renewable Energy Usage

- Cold Storage facilities
- Identification of Issues and Possible Rectification Measures

h) Solid Waste Audit

- Types and quantity of waste generated.
- Segregation of Waste.
- User-Group producing Wastes.
- Location of Functional/ Non-Functional Waste Management facilities.
- Existing type of Treatment and Disposal methods of generated Wastes [Solid Waste, Plastic and Paper Waste, Banana leaf and Stem Waste, Flower Waste and other identified categories].
- Location of Existing Disposal/Landfill Site and potential future site

i) Water Mass Balance

- Water Consumption, Demand and Supply
- Sanitation Facilities
- Wastewater– Generation and Recycling / Disposal
- Water Stagnation during rainfall event
- Surface Water runoff, Ground Water – Rainwater Harvesting

j) Existing Carbon Footprint

- Carbon Accounting due to energy usage
- Types of GHG gasses: Methane and Nitrous Oxide emitted from wastedisposal and treatment.
- Identifying Areas of Improvement

3.1.4 Task P1.4: Identification of Challenges

a) Identify the Challenges
b) Identify the areas of improvement
c) Identify Likely Project Components

Phase 2: Vision Towards Carbon Neutral and Sustainable Sandhai

Finalizing Project Components in the six domains of Water, Waste, Energy, Traffic, Sanitation, Buildings for achieving the Vision based on principals of Self Sustainability and Circular Economy. This will be donein coordination with the CMDA and TNPCB engineers and administrators.

Phase 3: Detailed Project Report

Detailed Project Report with detailed designs of finalized components along withestimates, specifications and BoQ (Bill of Quantities).

Phase 4: Implementation Assistance& Support

a) Assistance in preparation of tender documents.
b) Assistance in preparation of responses to technical queries during bidding process.
c) Project Management Consultancy
d) Recommendations for the institutional framework towards effective operating and maintaining the Market complex.
e) Awareness program and documentation for the associated team of community members, technical staff administrative staff on operations and maintenance and

technologies deployed.

4.0 Proposed Deliverables& Timelines

S No	Milestone / Deliverable	Description	Duration	Cumulative Duration
1	Report	Tasks Covered 1. Desk Research 2. Secondary Data Collection Includes Preliminary Assessment of the Project with Detailed Approach and Methodology.	1 Month	1 Month
2.	Status Quo Report	3.Primary Surveys and Studies – Establishing the Status Quo	2months	3 months
3	Concept Project Report	4. Vision Towards a Carbon Neutral State Includes detailed assessment of the site and outlines the vision towards achieving carbon neutral status	2 Months	5Months
4	Detailed Project Report	Tasks Covered 5. Detailed Project report Includes detailed design and engineering for finalised components along with estimates, specifications and BoQ.	4 Months	9 Months
5	Bid Assistance		As Required	As Required
6	Institutional Framework & Capacity Building Plan	Recommendations for the institutional framework towards effective operating and maintaining the Market complex Awareness program and documentation for associated team of community members, technical staff administrative staff on operations and maintenance and technologies deployed.	1 Months	10 Months

5.0 Proposed Personnel Deployment

Expert Members

Prof. Indumathi Manivannan Nambi
Prof. Rajnish Kumar
Prof. Vinu R
Prof. Mohanakrishnan Logan
Prof. Ligy Philip
Prof. Mathava Kumar S
Prof. Tanushree Parsai
Prof. Balaji Narasimhan
Prof. Elango Lakshmanan
Prof. Venkataraman Srinivasan
Prof. Piyush Chaunsali
Prof. Alagappan P
Prof. Ashwin Mahalingam
Prof. Venkatarathnam G
Prof. Satyanarayanan Seshadri
Prof. Aravind Kumar Chandiran
Prof. Gitakrishnan Ramadurai
Prof. Parama Roy
Dr. Charuta Kulkarni

Advisory Members

Dr. Dirk Weichgrebe
Leibniz University, Hannover
Germany.

Dr. Amory Lovins
Co-Founder, Rocky Mountain Institute, USA.

Project Staff

Dr. Ranjith Kumar R
Mr. Hebron D

Student

Mr. Navin
Mr. Varun

Key Personnel

Architect - Urban Planner
Environmental EngineerWaste Management consultant
Carbon Accounting Specialist
Hydrologist and hydrogeologist
Civil and Structural Engineer
Green Building / Sustainability
Energy and Safety Auditor

Key Partners:

1. Centre for Urbanization, Buildings and Environment
2. Samudhyoga Waste Chakra

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