SUSTAINABLE SOLID WASTE MANAGEMENT STRATEGIES: A COMPARATIVE ANALYSIS OF URBAN CENTERS

Thesis submitted in partial fulfilment of the requirements for the award of the degree of

MASTERs in PLANNING

(2024-2025)

By **Anushka Yadav**

Roll No. 1230152007

Under the Supervision of

Prof. Dr. Mohit Agarwal

SCHOOL OF ARCHITECTURE AND PLANNING (SOA)

BABU BANARASI DAS UNIVERSITY, LUCKNOW

BABU BANARASI DAS UNIVERSITY, LUCKNOW

Report of M.Tech./M Pharma/M.Arch. Thesis/Dissertation Evaluation

Name of Student:_____Roll No._____

Department:_____

Thesis Title:_____

(in capital)_____

Thesis Supervisor(s):_____

Remarks: Satisfactory/Not Satisfactory (in case of not satisfactory give comments)

_____

_____

_____

_____ _____

Sign of Thesis Supervisor Sign of External Examiner

_____ _____

Sign of Head of Department Sign of Dean of School

_____

Convener

BABU BANARASI DAS UNIVERSITY, LUCKNOW

CERTIFICATE OF THESIS SUBMISSION FOR EVALUATION
(Submit in Duplicate)

1. Name : **Anushka Yadaav**

2. Roll No. : **1230152007**

3. Thesis title: **SUSTAINABLE SOLID WASTE MANAGEMENT STRATEGIES: COMPARATIVE ANALYSIS OF URBAN CENTRES**

4. Degree for which the thesis is submitted: **Masters in Urban & Regional Planning**

5. Faculty of the University to which the thesis is submitted
School of Architecture and Planning

6. Thesis Preparation Guide was referred to for preparing the thesis. ☐ YES ☐ NO

7. Specifications regarding thesis format have been closely followed. ☐ YES ☐ NO

8. The contents of the thesis have been organized based on the guidelines. ☐ YES ☐ NO

9. The thesis has been prepared without resorting to plagiarism. ☐ YES ☐ NO

10. All sources used have been cited appropriately. ☐ YES ☐ NO

11. The thesis has not been submitted elsewhere for a degree. ☐ YES ☐ NO

12. Submitted 2 spiral bound copies plus one CD. ☐ YES ☐ NO

(Signature of the Candidate) Name:
ANUSHKA YADAV
Roll No 1230152007

BABU BANARASI DAS UNIVERSITY, LUCKNOW

CERTIFICATE OF FINALTHESIS SUBMISSION

(To be submitted in duplicate)

1. Name : **Anushka Yadav**

2. **Roll No. : 1230152007**

3. Thesis title: **SUSTAINABLE SOLID WASTE MANAGEMENT STRATEGIES: COMPARATIVE ANALYSIS OF URBAN CENTRES**

4. Degree for which the thesis is submitted: **Masters in Urban & Regional Planning**

5. School (of the University to which the thesis is submitted)
School of Architecture and Planning

6. Thesis Preparation Guide was referred to for preparing the thesis. ☐ YES ☐ NO

7. Specifications regarding thesis format have been closely followed. ☐ YES ☐ NO

8. The contents of the thesis have been organized based on the guidelines. ☐ YES ☐ NO

9. The thesis has been prepared without resorting to plagiarism. ☐ YES ☐ NO

10. All sources used have been cited appropriately. ☐ YES ☐ NO

11. The thesis has not been submitted elsewhere for a degree. ☐ YES ☐ NO

12. All the corrections have been incorporated. ☐ YES ☐ NO

13. Submitted 4 hard bound copies plus one CD.

(Signature(s) of the Supervisor(s))
Name(s):……...……

(Signature of the Candidate)
Name:……...…….
Roll No …….
Enrollment No.:……

EXECUTIVE SUMMARY

One of the most common forms of physical activity is walking which is the mother of all the modes of transport which provides inexpensive and equal transportation options to improve residents' health and quality of life. Due to several associated advantages such as wellbeing of residents and improving health, reducing air pollution, traffic congestion and decreasing energy consumption, walking has become an interesting topic for researchers. To have modern cities with highly efficient transportation facilities which support walking, cities and neighbourhoods are trying to promote a pedestrian-friendly environment. As a result, walkability is a sustainable concept to improve the liveability of growing cities that describes the level of capability of the built environments to support walking for multiple purposes including transport, leisure and exercise purposes.

Although measurement of walkability includes several methods and approaches, this research has emphasized on the walkability index as well as neighbourhoods features that influence the willingness of people to walk. Since Lucknow is not considered a walkable city, it is valuable to investigate how this city has tackled this issue. Therefore, for better interpretation, one such neighbourhood in Lucknow was selected to examine the level of walkability and the factors affect that.

This study has several limitations and due to time and resource constraints, the sample size that was selected for the survey in each neighbourhood is limited. Therefore, the low response rate may influence the final results. The model outcomes were validated not only using the individual's perception determined from questionnaire survey but also utilizing mixed methods of GIS analysis in objective parameters of walkability. What makes this research unique is that all aspects of neighbourhoods such as physical, social and safety characteristics have been considered objectively and subjectively. The results of this study can assist policymakers and professionals to give more public space to walking and improve the quality of neighbourhoods' environments.

In conclusion, the overall result implies that due to defining indexes such as population density, mixed-use and connectivity for walkability, some aspects of neighbourhoods' features were recognized significant in this study. Among all of the physical aspects variables of neighbourhoods, accessibility is the most important factors influence walkability, however, the quality of built environment significantly affect people's perceptions as well and in social aspects of neighbourhoods, social interactions and liveliness of streets seem to be significant in walkability. Also, from safety aspects view, the most important factors were a sense of security and sense of safety that affect the walkability. The incredible outcome that was explored in this study is that the physical environment influence the social and safety aspects of neighbourhoods and social aspects influence the safety aspects of neighbourhoods. Therefore, there is an interrelationship between independent variables that can influence the willingness of people to walk.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to the individuals who have contributed to the completion of my Master's thesis Planning. Their unwavering support and encouragement have played a crucial role in my academic journey.First and foremost, I am immensely grateful to my thesis guide, Prof. Dr. MohitKumar Agarwal. His invaluable guidance, expertise, and unwavering support throughout this research endeavour have been instrumental in shaping the direction and quality of my work. His continuous encouragement, insightful feedback, and patience have truly been a source of inspiration for me.
I would also like to extend my heartfelt appreciation to my parents, Mr. Anand kr. Yadav and Mrs. Shakuntala Yadav. Their constant belief in my abilities, unwavering encouragement, and emotional support have been instrumental in this thesis's successful completion. Their profound wisdom and guidance have continuously motivated me to strive for excellence.

Lastly, I would like to extend my appreciation to all the individuals who have directly or indirectly contributed to my growth as a researcher and planner. Your collective efforts have played an integral role in shaping my academic and personal development. To everyone mentioned above and to those not mentioned individually but who have been a part of my journey, please accept my heartfelt gratitude for your unwavering support, guidance, and encouragement. This thesis would not have been possible without each and every one of you. Thank you for being a part of this significant milestone in my academic life.

(Ar. Anushka Yadav)

UNDERTAKING

I, Ms. Anushka Yadav, the author of the thesis titled "SUSTAINABLE SOLID WASTE MANAGEMENT: COMPARATIVE ANALYSIS BETWEEN URBAN CENTRES", hereby declare that this is an independent work of mine, carried out towards fulfilment of the requirements for the award of the Masters in Urban & Regional Planning at the Department of Architecture and Planning, BBDU, Lucknow. The work has not been submitted to any other Organization / institution for the award of any Degree/Diploma.

.....

Anushka Yadav
Roll No- 1230152007
Master's in Planning
2024-2025
School of Planning
Date-

TABLE OF CONTENT

LIST OF MAPS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The chapter commences by presenting an overview of the research topic, incorporating essential elements to grasp the background, challenges, gaps, and other pertinent factors. The introduction serves as a fundamental pillar for the entire research, drawing extensively from existing literature, scholarly investigations, and authoritative reports.

1.1. Background

Municipal Solid waste generated by India in urban areas is 62 million tons. Only 70% of the total Municipal waste is collected and 20% is processed and treated. Most of the solid waste is dumped in landfill sites. Solid waste in a simple way can be term as waste generated from any human activities which may include the domestic waste, waste from industries or may be generated from animals, etc. They are basically semi-solid or solids in nature. Solid wastes are the discarded or useless materials which people usually terminate by throwing or burning. Waste generated of industries or factories are known as industrial waste and waste that are generated from domestic households and any commercial sites are known as municipal solid waste. The maximum wastes are generated from residential area and they come under municipal solid waste. The domestic waste may include both bio-degradable and non-biodegradable materials The rapid growth of population has created serious deficiencies in the availability of infrastructure in the towns and cities of the countryThe country produces 36.5 million tons of waste every year out of which only 50-90 percent of waste generated is disposed in the urban areas.A large proportion of local body's budgets ie. about 20 to 50 percent is spent on the Municipal Solid Waste Management. It is estimated that ULBs spend about Rs. 500 to Rs. 1500 per ton on management of solid wastes for collection, transportation and disposal. About 60 to 70 percent of this amount is spent on collection 20 to 30 percent on transportation and less than 5 percent on waste disposal." In spite of the large expenditure on this activity, the service is deficient in quantity and quality and as a result it is not cost effective and is punctuated with numerous complaints.

1.2. Problem Statement

The annual waste generation increases in proportion to the rise of population and urbanization. Issues related to disposal of solid waste have become more challenging, as more area is required for the ultimate disposal of the solid waste. More than 90% of solid waste is directly disposed of in open land in an unsatisfactory manner and wastes that are not collected in proper time period from urban areas pose risks to the health of the community.
There is lack of proper provision for the primary collection of solid waste from every door step and their segregation, storage and efficient disposal. Lack of secondary waste storage depots and landfill areas are major challenge for public authorities. It is not only a technical challenge but it is also strongly influenced by political, legal, socio-cultural, environmental and economic factors as well as availability of resources. It is in the interest of humanity as a whole, that solid waste must be properly and systematically managed. The problem is mainly related to proper waste management, waste has to be managed efficiently and not only just disposed of. Solid waste management system must provide quality life and health security to all citizens. The management system used is unscientific, outdated and above all inefficient; along with low population coverage and marginalization of poor. Municipal laws governing the local urban bodies do not have adequate provisions to deal effectively with the ever growing problem of Solid Waste Generation.

1.3. Need for study

Proper solid waste management helps in maintaining the hygiene and cleanliness of environment, therefore it needs to be practiced both at household and city level because of environmental management and sustainable development. The present study is an attempt to study the present solid waste generation, its implications and challenges in city. Being the capital city, Faridabad is a fast urbanizing city of Uttar Pradesh having a large population that results in huge solid waste generation. To achieve sustainable development it is important to study the related issues and challenges so that they can be addressed before they become an irretrievable problem. Solid waste pollution is an emerging pollution in the city due to the gigantic volume of waste generation by different sources. There is rapid population growth and high standard of living in the city, which leads to increase in solid waste generation and its complexity. The present study evaluates the existing solid waste management practice in the Faridabad city. The basic purpose of the study is to assess the quantum of solid waste generation, the level of solid waste management and its environmental impact and subsequent health problems caused by mismanagement of solid waste and suggestions for the way out. The study will be helpful in bringing awareness regarding proper solid waste management practices among the community, urban planners and urban local bodies. The study has identified the challenges of solid waste management faced by the city, and need for proper planning and strategies to have sustainable solid waste management.

1.4. Research Gaps

When prediction is to be tested by scientific methods, it is termed as research hypothesis. It is a predictive statement that relates an independent variable to a dependent variable. Hypothesis taken for the present study are as follows –

1. Solid Waste generation has amplified due to population increase and rapid urbanization in the study area.
2. Solid Wastes are the significant contributor to environmental degradation in the study area.
3. The problem of solid waste generation has been augmented over the year in the study area due to inadequate, inefficient and improper disposal and management efforts of local bodies and city administration.
4. People's perception and public participation has a direct impact on the various aspects of solid waste generation and their efficient management.

In the present work both the primary as well as the secondary data has been used.

The primary data is collected through field survey by random sampling. The information of data related to solid waste generation in the city, their collection, transportation, composition on the basis of changing economic condition are collected through field survey. Initially a pilot study of the study area has been conducted and based on that a final questionnaire has been prepared to collect the data related to the basic information such as number of family members, their occupation, income,

literacy etc.

This chapter pertaining to the present practice of solid waste management, concludes

that:

The primary collection system of solid waste in Faridabad city is much unorganized.

The door-to-door collection is practiced only in 25-30% areas of the city, but it is only available in posh location of high income groups and in few medium income families.

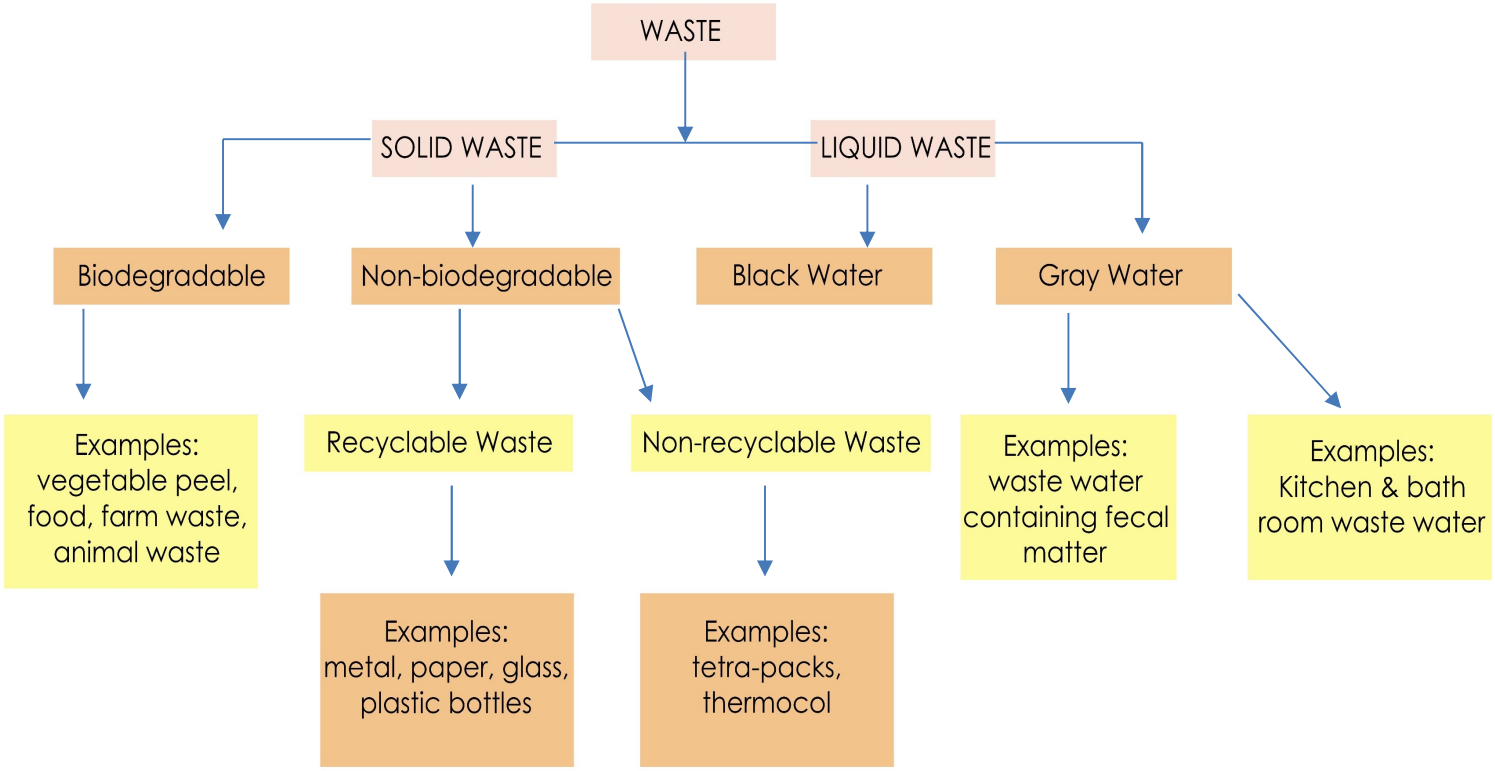
There is no significant initiative for primary waste collection system from commercial establishments, vegetable, fruits, meat and fish market by the urban authority.

Majority of the households in the city practice open dumping of waste on vacant places, streets. The reason for the practice of open dumping in these wards is generally due to lack of dustbin availability near the households premise; thus, the households are compelled to dump the waste in nearby open place.

As there is no segregation of waste, all the mixed waste is dumped at the site without any processing and recycling.

The present numbers of vehicles are insufficient to manage the transportation of all these garbage collected. The collection efficiency of solid waste from different wards in the city by municipal vehicles is 67 per cent. Nearly 33 per Summary 17

cent of waste accounting for 82 tons of waste is left or uncollected by municipal vehicles. The uncollected waste littered on the road side, dumping site, drains and water bodies as a heap of garbage.



1.5. Aim and Objectives

AIM

To enhance MSWM through data adequacy and smart applications for a sustainable environment.

OBJECTIBVE

- To find out the main source of waste generation in the study area
- To estimate the volume of waste generated in the study area
- Bring about an improvement in the general quality of life in the area, by promoting cleanliness and hygiene.
- Encourage cost effective and appropriate technologies for ecologically safe and sustainable sanitation
- To find out the issues, if any, in the solid waste management process and suggest suitable and scientific mechanism in dealing with the solid waste. To identify the different zone generating the maximum amount of solid waste.
- Characterizations of that waste physically, and applying Reduce, Recycle and
- Reuse techniques wherever applicable.
- To propose an implementation strategy for Smart solid waste Management at local level through geo referencing and mobile application.

- To study the current behavioral pattern of waste generation and waste collection at ward level in Faridabad.
- To assess the new solid waste management system with integrated SWM system.
- To propose useful recommendations for development of a sustainable solid waste management system.
- Learning the role of rags picker and creating awareness to minimize the health effects toward the people handling the solid waste.
- To study the importance of public participation and scientific solid waste management.

1.6. Scope

1. Geographic Scope
Urban areas: Municipal corporations, smart cities, and peri-urban zones.
Rural settlements: Decentralized and low-cost approaches tailored to village settings.
Slums and informal settlements: Focus on inclusive waste services and informal sector integration.

---

2. Functional Scope
Waste Generation Analysis: Estimating quantity and types of waste (organic, plastic, e-waste, etc.).
Segregation at Source: Promoting and assessing household-level segregation practices.
Collection and Transportation: Evaluating efficiency, route optimization, and use of smart technologies.
Processing and Treatment:
Composting and biomethanation (organic waste)
Material Recovery Facilities (recyclables)
Waste-to-Energy (residuals)
Disposal: Scientific landfilling and legacy waste remediation.
Monitoring & Governance: Use of digital tools, policy enforcement, and institutional framework.

---

3. Technological Scope
Integration of IoT, GIS, and data analytics for smart waste tracking.
Use of decentralized treatment technologies such as home composters, community biogas plants.
Innovations in plastic recycling, e-waste processing, and construction waste reuse.

---

4. Environmental Scope
Reduction in environmental degradation caused by open dumping and burning.
Improved air, soil, and groundwater quality through sustainable practices.
Promotion of circular economy and zero-waste concepts.

---

5. Social Scope
Public participation and behavioral change in waste segregation and reduction.
Integration and upliftment of informal waste workers.
Creating awareness campaigns and school-based education initiatives.

6. Economic Scope
Job creation in collection, recycling, and treatment sectors.
Cost-effective models through Public-Private Partnerships (PPPs).
Revenue generation from recyclables, compost, and energy recovery.

7. Policy and Institutional Scope
Evaluation of SWM Rules 2016, Plastic Waste Management Rules, and EPR (Extended Producer Responsibility).
Institutional roles: ULBs, NGOs, private operators, and informal sector.
Policy recommendations for improved implementation and scalability.

1.7. Limitations

1. Institutional and Governance Limitations
Weak enforcement of policies: Despite comprehensive rules like SWM Rules 2016, enforcement is often poor at the local level.
Lack of coordination among multiple agencies (municipal bodies, pollution control boards, private contractors).
Inadequate monitoring and accountability mechanisms for waste management services.

2. Financial Limitations
Insufficient funding for infrastructure development (e.g., treatment plants, collection systems).
High capital and operational costs for advanced waste processing technologies.
Dependency on government subsidies, with limited scope for private sector investment in smaller cities.

3. Technological Limitations
Lack of access to modern technology in smaller municipalities or rural areas.
Inappropriate technology selection, leading to system failures (e.g., waste-to-energy plants without proper segregation).
Limited adoption of data-driven tools like GIS, IoT, or waste tracking systems.

4. Social and Behavioral Limitations
Low public awareness and participation in source segregation and composting.
Resistance to behavioral change due to habits, cultural practices, or lack of motivation.
Stigma around waste work, limiting the integration and formalization of the informal sector.

5. Operational Limitations
Inefficient waste collection and transportation, especially in dense or informal settlements.
Poor segregation at source, leading to contaminated recyclables and ineffective processing.
Lack of infrastructure like compost pits, biogas plants, and MRFs (Material Recovery Facilities).

6. Environmental Limitations

Space constraints for landfill development, especially in urban areas.
Emissions and leachate from poorly managed sites.
Limited success in plastic and hazardous waste management.

7. Data and Knowledge Limitations
Inaccurate or outdated data on waste generation, composition, and flow.
Limited research and local case studies to guide policy and innovation.
Lack of baseline assessments and performance evaluation tools.

1.8. Methodology

Research methodology helps in achieving the objectives of any study and restrains the researcher from deviating from the desired line of work. The proposed research work is the study of solid waste generation its implications and management in FARIDABAD city for which relevant and adequate data is needed for a
systematic spatial study. Therefore in the present study, field observation has been considered as the basic method of data collection. The following methods were used
in this study;

1. **Sampling Procedure**

For the purpose of selecting the sample, stratified random sampling design was adopted.

 The first stage consisted of selection of wards as a unit of study from 110 wards of FARIDABAD City. In all 78 wards were selected on the basis of their location and population, selecting 10 wards from each zone except Zone D which has only 8 wards.

 At the second stage, households were selected as micro-unit of study, which were selected on the basis of different income groups from 78 wards. About 23 households were sampled from each ward, accounting to 1840 in total households from 110 wards.

2. **Interview Schedule**

The data was collected by interviewing the respondents from the sampled households by using the interview schedule. The questions were developed with the help of pilot survey of local residents. Keeping the objectives at center a draft schedule was then prepared in the form of questionnaire asking general questions, information about the household profile and their condition, waste generated, problems associated with waste and health conditions.

3.Collection of Data

In first phase Data were collected through personal interviews with the help of the questionnaire (Appendix I). Where primary data is collected through questionnaire made after a pilot survey of the FARIDABAD City and interviews of the concerned stakeholders at three levels namely household level, ward level, and city level. The researcher interviewed the selected respondents from the sampled household personally. Data collection has been done in three phases - first during March-June, 2018 (second quarter of first half of 2018), second during July- September, 2019 (third quarter of second half of 2019) and thirdly just after the Covid-19 pandemic during October-November, 2021 (fourth quarter of 2021). The survey has helped in

identifying the genesis and types of solid waste generation and in assessing the amount of solid waste generation in the study area, per capita in particular and at city level, in general. The average percentage of each component i.e. biodegradable and non-biodegradable has been calculated from each zone separately for performing a comparative analysis of solid waste generation among all zones and at the city level.

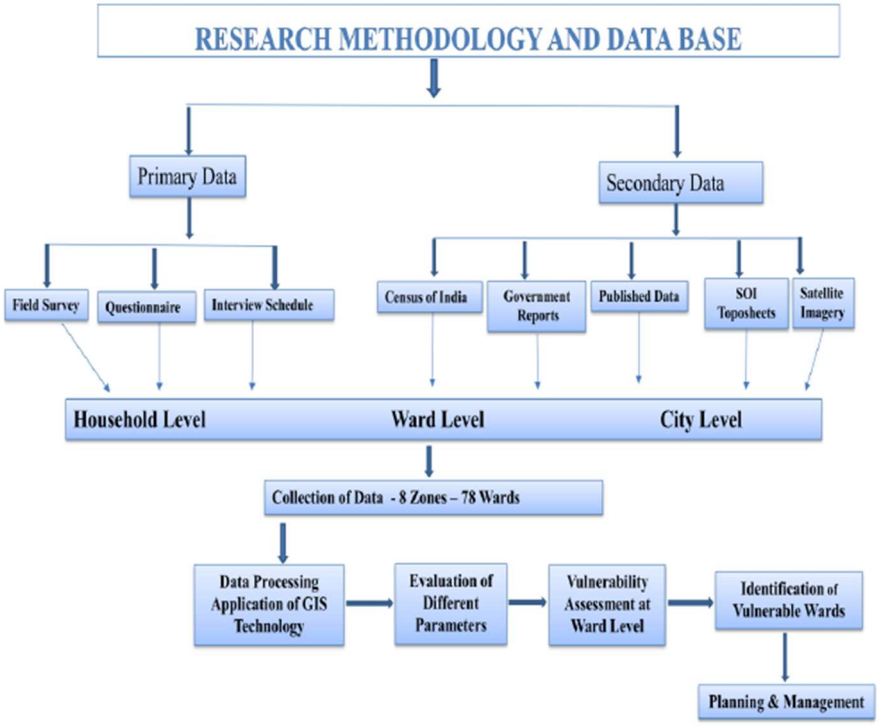
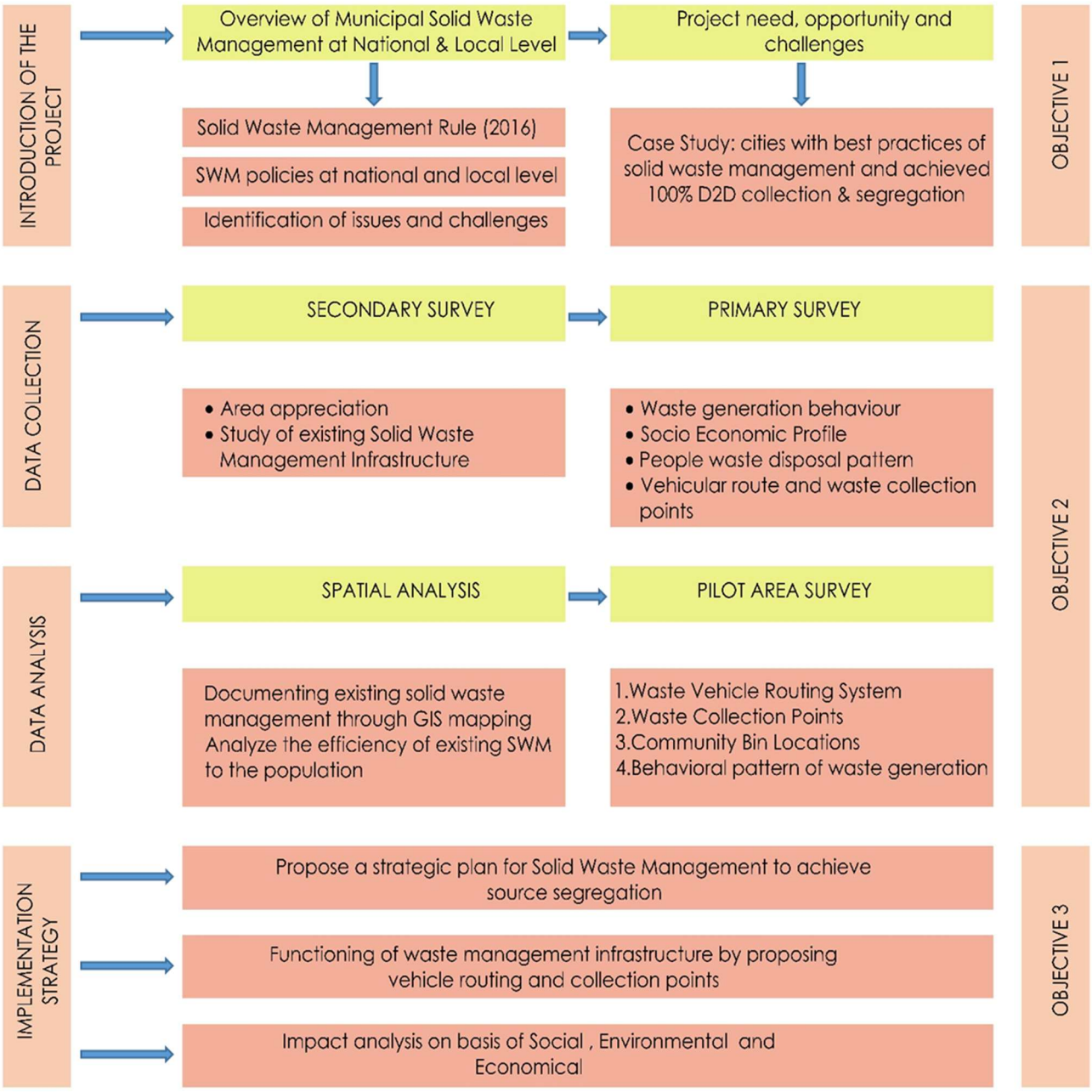


Figure (i): Research Methodology

The problem of Solid Waste Management is acquiring huge proportions especially in class I Indian cities. The problems related to MSW range from insufficient manpower, poor transportation facilities and primitive tools and techniques of handling, collecting and disposing solid waste.


INTRODUCTION OF THE PROJECT
Overview of Municipal Solid Waste Management at National & Local Level
Project need, opportunity and challenges
Solid Waste Management Rule (2016)
SWM policies at national and local level
Identification of issues and challenges
Case Study: cities with best practices of solid waste management and achieved 100% D2D collection & segregation
OBJECTIVE 1
DATA COLLECTION
SECONDARY SURVEY
PRIMARY SURVEY
• Area appreciation
• Study of existing Solid Waste Management Infrastructure
• Waste generation behaviour
• Socio Economic Profile
• People waste disposal pattern
• Vehicular route and waste collection points
DATA ANALYSIS
SPATIAL ANALYSIS
PILOT AREA SURVEY
Documenting existing solid waste management through GIS mapping
Analyze the efficiency of existing SWM to the population
1.Waste Vehicle Routing System
2.Waste Collection Points
3.Community Bin Locations
4.Behavioral pattern of waste generation
OBJECTIVE 2
IMPLEMENTATION STRATEGY
Propose a strategic plan for Solid Waste Management to achieve source segregation
Functioning of waste management infrastructure by proposing vehicle routing and collection points
Impact analysis on basis of Social , Environmental and Economical
OBJECTIVE 3

1.9. Expected Outcomes

1. Environmental Outcomes

Reduction in land pollution: Decreased reliance on landfills due to waste diversion through recycling, composting, and reuse.

Lower greenhouse gas emissions: Reduced methane from landfills and lower carbon footprint from waste processing.

Improved air and water quality: Prevention of leachate contamination and reduction of open burning of waste.

Enhanced resource recovery: Increased recycling and reuse of materials, conserving natural resources.

Biodiversity protection: Less land encroachment for dumping; healthier ecosystems in and around urban areas.

---

2. Economic Outcomes

Cost savings in waste handling: Efficient collection, segregation, and processing reduce overall management costs.

Job creation: New employment opportunities in recycling, composting, waste-to-energy, and logistics.

Revenue generation: Sale of compost, recyclables, and energy from waste-to-energy plants.

Support for circular economy: Industries benefit from secondary raw materials and reduced input costs.

---

3. Social Outcomes

Improved public health: Reduction in disease vectors due to better waste disposal and reduced open dumping.

Empowered informal sector: Formal inclusion of ragpickers and waste workers with better income and working conditions.

Increased community participation: Better awareness and involvement of citizens in segregation and recycling.

Enhanced urban aesthetics: Cleaner streets, reduced litter, and improved city image.

---

4. Institutional Outcomes

Improved governance and monitoring: Implementation of data-driven tools for waste tracking and policy enforcement.

Policy compliance: Adherence to SWM Rules 2016, plastic bans, and EPR regulations.

Scalable and replicable models: Successful pilot projects can be scaled or replicated in other regions.

---

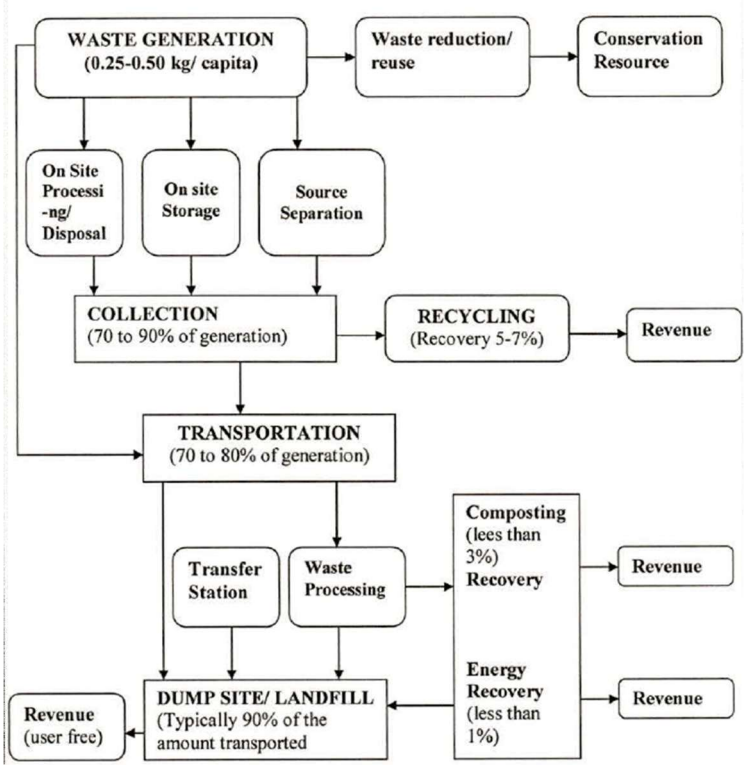
5. Sustainability Outcomes

Long-term waste reduction: Shift in consumption patterns toward sustainable and minimal-waste lifestyles.

Adoption of circular economy principles: Systematic reduction in waste generation through design and behavior changes.

2. LITERATURE REVIEW

2.1. Concepts



It is observed that there is conflicting data about the actual quantum of waste generation in urban India because there is no system of periodically collecting data on waste generation.
Collection efficiency of Municipal Solid Waste in cities and town is low due to non-uniformity in the collection syste

1. Conceptual Framework
Define key terms: *solid waste*, *sustainable management*, *waste hierarchy*, *circular economy*, etc.
2. Global Perspectives
Overview of waste generation and management practices in developed and developing countries.
Case studies of successful SWM models (e.g., Sweden, Japan, Germany).
Technologies used: composting, waste-to-energy, recycling systems.
3. Indian Context
Key sources: CPCB reports, SWM Rules 2016, MoHUA guidelines.
Major cities' performance: Indore, Pune, Mysuru.
Challenges in segregation, informal sector inclusion, and landfill dependency.
4. Technological Interventions
Role of IoT, GIS mapping, smart bins, digital tracking.
Advances in bioreactors, decentralised composting units, recycling facilities.
5. Social and Institutional Perspectives
Public participation and behavioral change.
Role of NGOs and community-based organizations.
Informal sector integration and socio-economic impacts.

6. Policy and Legal Framework
Solid Waste Management Rules (2016), EPR Guidelines.
National policies and local municipal acts.
Evaluation of implementation challenges.

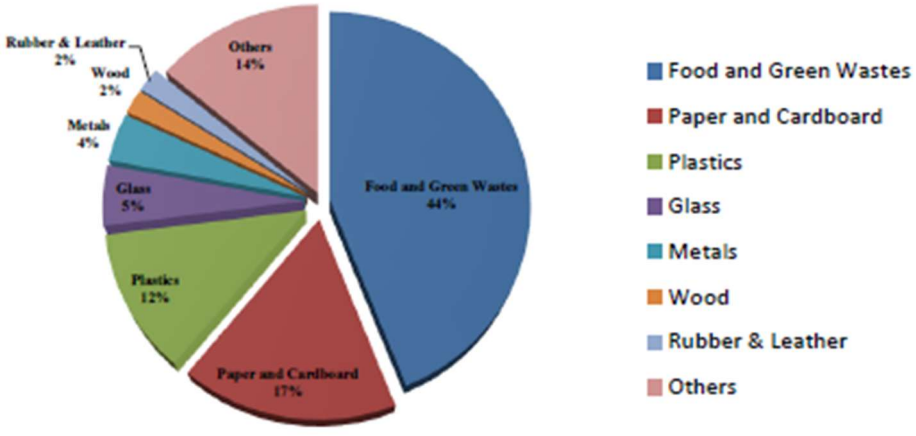
2.2. Solid waste management and its impacts

Solid Waste Management (SWM) refers to the collection, transportation, treatment, recycling, and disposal of solid materials that are discarded as waste. It plays a crucial role in maintaining environmental quality, public health, and sustainable urban development. The nature and composition of solid waste vary significantly across regions depending on urbanization levels, economic activity, consumption patterns, and public awareness.

An inefficient or unsustainable SWM system leads to various **negative impacts** on the environment, human health, and the economy. These impacts are often more severe in developing countries where waste is frequently dumped in open sites or water bodies, and waste segregation is largely absent.

2.1Global Scenario

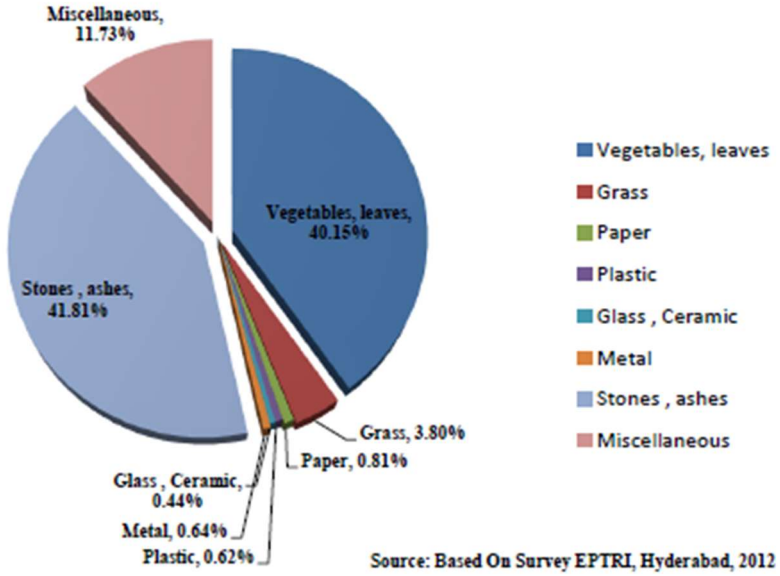
At global level the waste composition differs as per the income levels having different consumption pattern. As per World Bank Report, at global level food and green wastes has the maximum contribution in waste composition which accounts for about 44% , paper and cardboard 17%, plastics 12%, glass 5%, metals 4%, wood 2%, rubber & leather 2% and others 14% (Figure 2.3).
The composition of solid waste in India indicates lower organic matter and high ash or dust contents. It has been estimated that recyclable content in solid wastes varies from 13- 20 % and combustible material is about 80-85%. As per the survey of Environment Protection Training Research Institute, the composition of Municipal Solid Waste consists of more than 50% of organic wastes.



Source: World Bank Report, 2016

2.2Indian Scenario

Several Geographical factors such as temperature, moisture and changing climatic condition affect the physical and chemical composition. Every urban areas produces similar wastes only their density, volume and quantity changes from place to place and region to region. FARIDABAD city is located in sub humid climate and its waste generation is also high due to urbanization and several economic activities both the factor adversely affect the management of solid waste because its early decomposition spoils the whole system. It creates heavy pollution and health problems in city areas due to lack of spatial factor. The disposal sites are also located in open spaces and create adverse condition after every rainy season.



2.3 Prevalent Practices and Key Issues in Management of Municipal Solid Waste

One depressing feature ofIndian urban scene is that heaps of solid wastes dotting all over the places. This, in spite of the considerable efforts made by the municipal authorities to collect and dispose-off all the wastes. Since the quantity and quality of solid waste generation is closely linked to the population size, industrial process, standard of living and consumer behaviour, the problem of Municipal Solid Waste Management (MSWM) is becoming more intricate with the relentless urban growth. Our cities are growing not only in terms of number of people but also experiencing physical expansion. As a result, the existing disposal sites, are getting filled-up soon, and are also being surrounded by residential colonies whose population is exposed to
hazards.

Dimensions of Urban Solid Waste Problem

Every individual is a waste generator in one form or the other. In addition to natural organic wastes, human beings contribute to inorganic wastes e.g. metal products, glass wares and electronic gadgets etc. Plastic based packing material is one of the major forms of Solid Waste which is difficult to dispose-off. This means that if increase in per capita solid waste is assumed to be directly proportional to the increase
in per capita gross domestic product ofIndia which is around 2.25 percent1 at present
the volume of solid waste to be handled will become an astronomical figure in near future. Interestingly, in a recent study for Greater Mumbai, higher rate of increase in waste generation per capita **i.e.** 4.49 percent is observed and the volume of waste estimated accordingly for the year 2011 is 5011 tones per day which is frightening.

Comparison of Municipal Solid Waste composition by Weight

Component	Greater Mumbai	Tokyo
Paper	10.00	42.00
Glass	0.20	1.20
Metal	0.20	1.20
Plastic	2.00	8.50
Textile	20.00	3.80
Wood/ Grass	20.00	4.70
Food waste	20.00	32.90
Ash/ Soil	38.00	0.10
Other	6.00	5.60
Total	**100.00**	**100.00**

Source: UNCRD, City profile, 2001.

Types of Solid Wastes

Broadly speaking solid wastes can be div ided into the following three types:-

1. Municipal and farm
2. Hospital
3. Industrial and Mine

Municipal and farm Waste3

: Municipal and farm wastes can further be classified
into organic and the inorganic wastes. Table-2.2 (next page) dep icts the list of major ingredients of organic and inorganic wastes.

Industrial and Mine Wastes4

: Industrial and mine wastes may include the
fo llowing-

- Fly ash from coal using industries.
- Red mud from aluminum industries.
- Slag from steel plants.
- Spent pot lining from aluminum industry.
- Cement kiln dust.
- Gypsum.

Sludge from paper mill and other sources.

■ Press mud from sugar factory waste.

• Mine washing.

Major Ingredients of Municipal Solid Waste (organic and inorganic)

Organic (Mostly Biodegradable)	Inorganic (Mostly Non-Biodegradable)
▪ Vegetable waste ▪ Food waste ▪ Coconut shell ▪ Pith ▪ Dry twig, leaf, wood ▪ Straw, husk and agricultural residues ▪ Dairy and poultry waste ▪ Cattle dung ▪ Leather ▪ Cloth ▪ Paper ▪ Sewage sludge ▪ Rags ▪ Plastic, nylon, polythene	▪ Broken glass ▪ Empty glass bottles ▪ Spoiled electric bulbs ▪ Tin and other metals ▪ Stones ▪ Bricks ▪ Ceramic ▪ Earth (Soil)

Components of Hospital Waste

▪ Empty bottles ▪ Injections bottles ▪ Used syringes ▪ Tin ▪ Plastic ▪ Rag	▪ Colton ▪ Blood ▪ Operated human organs ▪ Clinical wastes ▪ Radioactive wastes

Sources of Urban Wastes and their Composition[8]

	Urban Source	Waste	Composition
1	Domestic household	Garbage	Wastes from preparation, cooking and serving of food; market wastes from handling, storage and sale of food.
		Rubbish, trash	Paper, cottons, boxes, wood, barrels, tree branches metals, tin cans, dirt, glass, crockery , minerals.
		Ashes	Residue from fuel and combustion of solid wastes.
		Bulky wastes	Wood furniture, bedding, metal furniture, refrigerators, rubber types.
2.	Commercial, institutional, hospital , hotel restaurant, stores, offices, markets	Garbage	Same as domestic.
		Rubbish, trash	Same as domestic.
		Ashes	Same as domestic.
		Demolition wastes	Lumber, pipe, brick, asphaltic material and other construction material.
		Construction wastes	Scrap lumber, pipe, concrete, other construction materials.
		Special Wastes	Hazardous solid and semi liquids explosives, pathological wastes, radioactive wastes,
3.	Municipal, streets sidewalks, power plants, sewage treatment plants, septic tanks.	Street refuse	Sweeping, dirt leaves, Catch basin dirt, content of litter receptacles etc.
		Dead animals	Cats, dogs, horses, cows, marine animals etc.
		Abandoned vehicles	Unwanted cars and trucks left on the public property.
		Fly ash, incinerator, residue, boiler slag	Boiler house cinders, metal scraps, shavings, minerals, organic materials, charcoal, plastic residues.
		Sewage treatment	Solids from coarse screening and grit chambers and sludge from setting tanks.

Municipal Solid Waste Management in selected class –I cites of India

City	Waste generation per person (gram/day)	Waste collection per person (grams/day)	Collection efficiency (%)	Ranking
Surat	458	435	98.00	1
Chennai	591	478	80.87	2
Bangalore	554	444	80.14	3
Ahemedabad	518	409	78.95	4
Mumbai	596	469	78.69	5
Pune	580	353	73.54	6
Borada	463	259	55.93	7

Source: Guruprasad Mohapatra,, A new approach in Solid Waste Management: Surat Municipal Corporation,. 2001

Deficiencies in Prevalent Practices

1. Storage of Waste at Source

Storage at the source of waste generation in the first essential step towards appropriate
waste management. This is substantially lacking in most of the urban areas.

Domestic / Trade waste etc.:- Except in posh residential and commercial areas, most of the households, shops, establishment etc, do not keep domestic trade waste bins, and instead throw the waste on the street as andwhen-gerreratecf. It 1s seen that only a limited number of people go to the dust bin provided by the local body to dispose-offthe waste and that too, if the bin is nearby.w hose who keep domestic or trade waste bins, rarely bother to see whether the waste discharged into the municipal bin or disposed-off on the street by their maid
ervant. Most of the waste thus comes on the roads, streets and lanes treating the public street as receptacle of waste.

Construction waste:- The storage and disposal of construction waste is totally neglected in the country. Builders and contractors and the people at large, deposit the
construction waste just outside their houses/shops/ streets along major roads, thus obstructing the traffic. There is no system of storage of construction waste in a container.13

Infectious and hospital waste: - Clinical waste has an adverse impact on human health, if the waste comes into contract with individuals. This area of waste management is grossly neglected. A large number of hospitals, nursing homes, pathology labs and health care centers are situated in urban areas but they do not discharge their duties for the safe disposal of hospital waste. The infectious wastes gets mixed up with the domestic solid waste and gets deposited at the common disposal sites.

Thus, it can be concluded that the existing facilities for storage of waste are highly inadequate and unsatisfactory.

2. Segregation at Source

In all parts of the country, people by and large do salvage re-usable or saleable materials from waste and sell it for price such as newspaper, glass bottles, empty tins, old clothes etc. and to that extant reusable material is not thrown out for disposal.

However, a lot of recyclable dry waste such as waste paper, plastic, broken glass, metal etc. is not segregated and is thrown on the streets. Such waste is picked up in the larger urban areas by the poor waste pickers for their livelihood. By throwing recyclable waste on the streets or into common dustbins, the quality of recyclable material deteriorates as it gets mixed by wet waste which often contains even contaminated and hazardous waste. Segregation of recyclable material at source is thus not seriously practiced by households and establishments, who throw mixed waste on the streets or in the municipal bins.

3. Primary and Secondary Collection of Waste

This is most important component of Solid Waste Management ser,vices. This system is primitive and inefficient.Except for a few posh residential areas where private arrangement exits, there is no arrangement for house to house collection of waste. Dust bins at short distances are provided only at a few places for the households/ establishments to deposit their domestic/ trade/ industrial waste. At most of the places where some dust bins have been provided for disposing the waste, the distances between the bins are large and bin sizes are also inadequate

Faulty design of the collection dustbins: - Besides inadequate dustbins, the dust bin design is found to be inappropriate. Either bottomless pre-cast round concrete bins are provided or masonry bins are constructed on the road side. These bins necessitate double handling of waste. The sites where the bins are provided are not properly paved, giving rise to unhygienic conditions around the bin 1

Street sweeping:- sweeping is the most common method of collection of all types of municipal waste as most of the waste is disposed of on the streets. In spite of this situation and the need to clean all streets daily, it is observed that all the roads and streets are not being swept on a daily basis. Further, the road length to be swept by the sweeper is not standardized, nor is any planning done to direct which streets would be swept daily or on alternate days or tw~ weak etc. depending upon concentration of population / activity of roads/ streets. Adhocism prevails in this regard as there is no prescribed yardstick.

The main drawbacks of the current street sweeping practices are: -

(i) Though waste is produced and thrown on the street every day, the street sweeping is not carried out on-8undays and public holidays in many cities and (iii) There are large variations in street sweeping norms. They vary from I 00 meters/ sweeper/ day to 5 km/ sweeper/ day.

(iv) Tools given to the sweepers are inadequate and inefficient.

(v) Neglect of slum areas leads to major flooding caused by garbage thrown into water drains.

(vi) In spite of street sweeping, th~ ads do not look clean as heaps made by one sweeper are not picked by another set of staff on time and quite often heaps are not removed for long, leaving a backlog of waste on the lanes/roads/ streets.

4. Transportation of waste

Transportation of waste in the cities and towns is being done in various ways. In smaller towns bullock carts, trolleys, trailers, power-tillers, tricycles etc. are mainly used for transportation of waste. These vehicles are used for the primary collection of waste from dust bins. They are also used to transport the waste either to a transfer

station or to an ope2.,_ dumping site, incorrectly called " landfill site". *V*
In large cities hydraulic tipper trucks, trucks, dumper placers, roll-on - roll-offmachines, refuse collection machines and/ or compactors are used. Front end loader machines that can load 3 to 4 tones are also used for transportation of waste.
Major drawbacks in the prevailing system of transportation are listed as under:

- The fleet of vehicles is not optimally utilized;
- Waste handling is done manually and loading and unloading is time
- consuming. This reduces the productivity of manpower.
- Transportation fleet does not synchronize with the type of dustbins provided.
- The system is a potential health hazard for the workers as all types of waste
- including hospitaVinfectious waste, human excreta etc. are disposed off in the
- common dust bin or on the streets.
- Dustbins are not cleared on a daily basis. Many dust bins are cleared once or
- twice a week or even latter.
- The number of vehicles is inadequate.
- The hydraulic vehicles need proper maintenance and well trained staff in the
- work shops.
- The workshop facilities are not adequate.
- No monitoring of vehicle movements is done.
- Debris and garbage are often collected in the same trip.

Disposal of Waste

The solid waste from different collection points are dumped by different method like open dumping sites, sanitary land fills and composting. Most of the smaller municipalities adopt dumping of waste due to non availability of mechanized means of transport. This method is highly risky to health as such areas become breeding grounds for the flies and mosquitoes. Besides expenditures on waste treatment and disposal is abysmally low and is usually less then 5 percent of the total expenditure on municipal solid waste management. About 94 percent of cities resort to indiscriminate dump in of domesticcl commercial, industrial and medical w~ in low lying areas. Consequently this leads to contamination of ground and surface water

Sanitary land filling: Sanitary land filling is the most appropriate method and is commonly used in the larger c ities like Delhi, Mumbai etc. Most of the waste is disposed off by sanitary land filling method. According to the report most of the wastes in Asian Cities is disposed off in landfills, which are generally open dumps rather than proper sanitary landfills. The report identified two main determinants of environmental degradation in developing countries, namely economic factors and institutional inadequacies. In many cities, wastes are dump directly into lakes and rivers,often -contaminating drinking water and spreadin.gas., es. The committee constituted by the Supreme Court ofIndia has suggested that land filling should be used only at the last step in the waste processing chainz not for Only rejects should be land filled in a scientific manner. The life span of landfill s ites varies from one to ten years. Finding suitable landfill sites is a major problem for the urban local bodies, owing to stiff resistance from the public in locating dumping sites in their neighborhoods.

Composing: Most of the local bodies do composing of wastes by both manual and mechanized methods. G<:(mposting by manual method is more prevalent because it involves low cost and less skilled manpower. Mechanization in composting has only been introduced in a few big cities with the objective of speeding up the process of aeration and bacterial breakdown of material and production of quality compost. Researche indicates that less t-han 3 percent of the total cost for Municipal is being spent on disposal. This now widely accepted that disposal costs would need to be over 7 percent to provide adequate environmental protection. The Government of India has taken initiatives to provide adequate financial support to the urban local bodies for installing the composting plants.

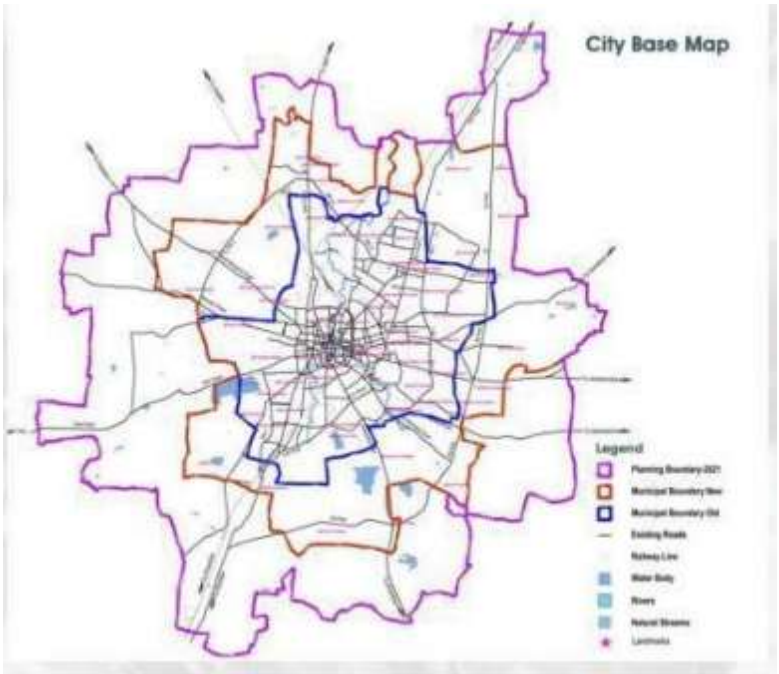
1.1. Case Examples

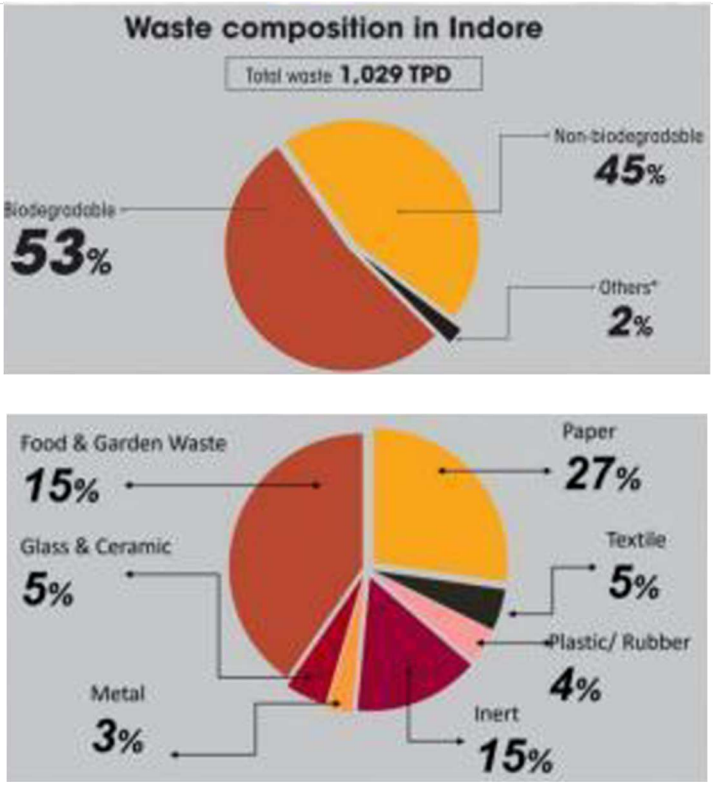
Case studies have long been used as a qualitative research tool in the social sciences. They provide in-depth insights into real-life situations and serve as a foundation for implementing ideas and methods. Case studies allow researchers to explore complex phenomena, understand practical implications, and bridge the gap between theory and practice. They inform decision-making, drive positive change, and contribute to knowledge advancement.

1.1.1. INDORE

Indore, an education hub and the commercial capital of Madhya Pradesh, is situated on the Malwa Plateau. It generates about 1,029 tonne of waste daily (392.4 g per person per day). Indore has been ranked the cleanest city of India in Swacch Survekshan surveys since 2017

`





THE PROBLEM

Before 2016, the Indore's had over a thousand garbage- vulnerable points in the city. Segregation of waste at source was almost nil.

Mixed waste was dumped in the Devguradiya trenching ground and even in open areas and public land.

The river Kahn, which flows through Indore, had become a sewer.

THE SOLUTION

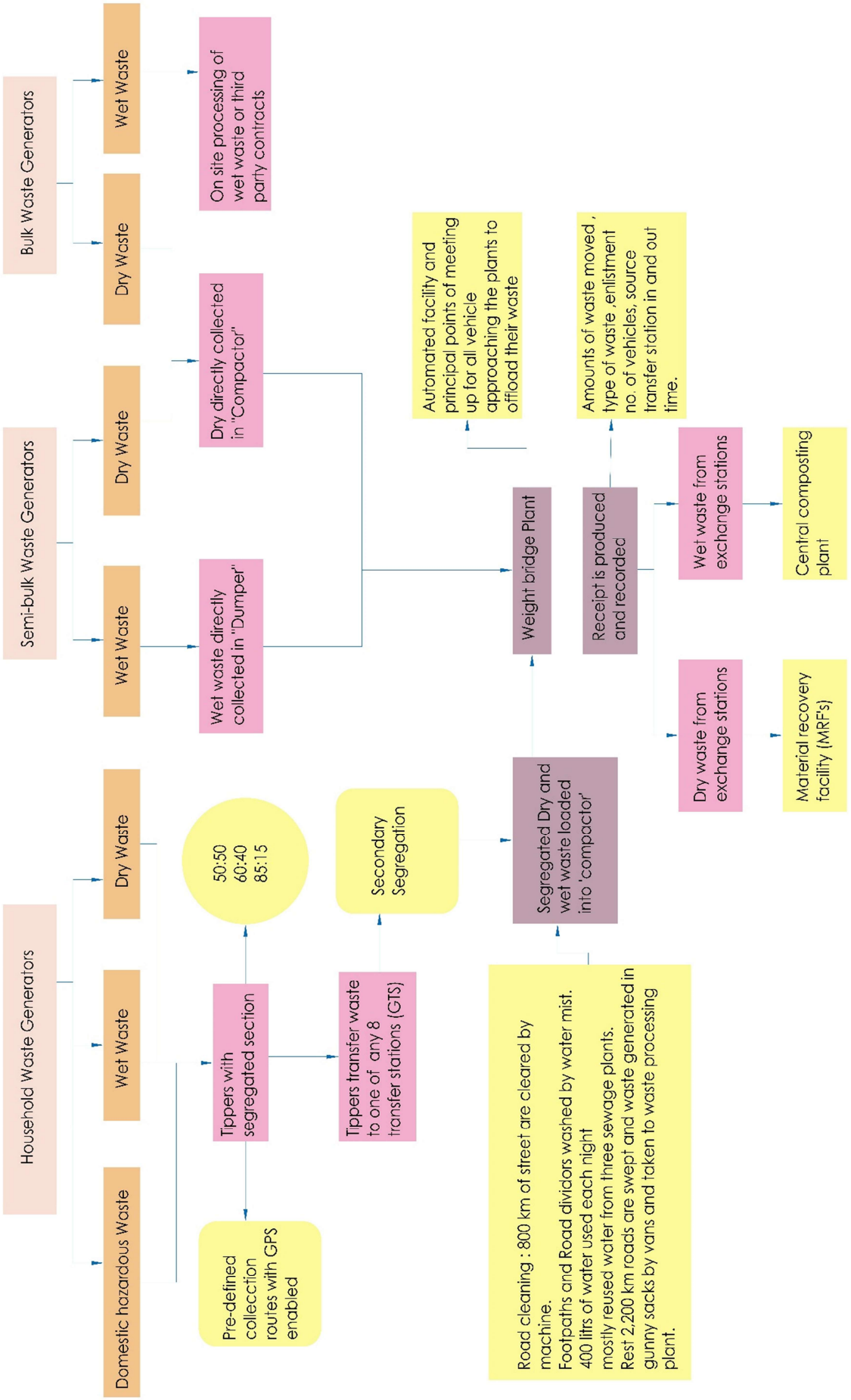
Finally, in 2015, the mayor expressed concern about the lack of cleanliness. IMC started door-to-door collection as a pilot project in Wards 42 and 71

IMC also undertook awareness programmes in these wards to motivate residents to segregate their waste into biodegradable and non- biodegradable fractions.

IMC ran another pilot- to check whether tricycles or auto-tippers are better for door-to-door collection.

In February 2016, Indore started pilot programme in ten wards.

WORKING OF MUNICIPAL SOLID WASTE MANAGEMENT OF INDORE



INDORE INTELLIGENT CITY MANAGEMENT SYSTEM

Traffic Management
Automated Traffic control
Pedestrain crossing

Lane Management

Lane control signs
Lane management in emergency

Online monitoring of waste processing
Gio fencing
Allow the tracking of manpwer and vehicle fleet present in service area

Compartmentalised vehicle for collection of bid-degadable, non- biodegaradable, domestic hazardous, electronic and sanitary waste.

Segregated Dry and wet waste loaded into comapactor

1.1.2 PUNE

Solid waste comprises unwanted and discarded materials from houses, street sweeping, and commercial and industrial operations. Increase in urban population and changing life styles lead to the generation of solid waste. Generally, solid waste is heterogeneous in nature such as mixture of vegetables, food items, paper, plastics, rags, glass etc. If solid waste is disposed off on land in open areas, then it causes a negative impact on the environment, ground water and on health. The most common problems associated with improper management of solid waste include diseases, odor nuisance, fire hazards, atmospheric and water pollution, aesthetic nuisance and economic losses (Jilani, 2002). There has been a significant increase in solid waste generation in India over the years from 100 gm per person per day in small towns to 500 grams per persons per day in large towns. Currently most of the municipal waste in India is being disposed unscientifically (Akolkar, 2005). Generally municipal solid waste is collected and deposited in landfill such unscientific disposal attract birds, rodents and fleas to the waste site and create unhygienic conditions (Suchitra, et al. 2007). The degradation of the solid waste results in the emission of carbon dioxide (CO2), methane (CH4) and other trace gases.

STUDY AREA

Pune is the second largest fast developing urban agglomerations in Maharashtra and ranks eight at national level. It is now rapidly changing its character from an education-administrative center to an important industrial hub and the IT center. Pune is a plateau city situated near the western margin of the Deccan Plateau. It is situated at an altitude of 560 m above the mean sea level. PMC lies between latitudes 18° 25'N and 18° 37'N and longitudes between73° 44'E and 73° 57'E and the geographical area is around 243.84 Sq.Km with a population of 3.1 million composed of 76 general electoral wards(according to 2011, Census of India). These wards were converted in 14 administrative wards by Pune Municipal Corporation (Figure 1). The density of the city was 12,777 persons/ Sq.Km. The area in the central part of the PMC is densely populated than the marginal regions.

Table 1: Primary and secondary data details

Segment : Pune City	Sources
Toposheets No. 47F/14/1 to 47F/14/6, F/15/NE, F/15/NW and 47F/15/SE	Survey of India, scale 1:25000
Google Image	Internet
Geological Map	Geological Survey of India, Pune
Satellite Imagery – Landsat 5 TM (February, 2011)	Global Land Cover Facility (GLCF) earthexplorer.usgs.gov web site
Demographic details from Primary Census abstracts for, 2001 and 2011	Directorate of census operations, Census of India
All Secondary data related Solid Waste Management, Land use/ Land cover etc.	Pune Municipal Corporation (PMC)
Ward maps and Administrative Boundary	Pune Municipal Corporation (PMC)

MSW GENERATION

Generation of MSW has an obvious relation to the population of the city, caused by bigger cities generate more waste. Kolkata metropolitan area generates the largest amount of MSW (11,520 TPD or 4.2 million TPY) among Indian cities. Municipal Waste is generated as Dry Waste and Wet Waste. It is observed that the previous literature tropical countries show the higher percentage of wet waste than dry. Pune city generates dry and wet waste approximately in equal proportion (i.e. 50%-50%). The garbage generated is dependent on the activity prevalent in the area where as wet waste generation is more in residential and commercial area such as hotels or food industry. About 40 per cent of the waste is generated from households (domestic waste), followed by hotels, restaurants and other commercial establishments which together account for over 50 per cent of the waste generated (Figure 3).

Table 2: Source of MSW Generated in PMC

Sr. No.	Source	Quantity of Waste Generated per day- tons	Composition in %
1	Domestic (Households)	400	40
2	Commercials	250	25
3	Market Areas	50	5
4	Hotels and Restaurants	250	25
5	Vegetable waste (19 Markets)	50	5
	Total	**1000**	**100**

Source: Revised City Development Plan for Pune - 2041, Maharashtra. Under JNNURM

The total waste generated is in the range of 1300 to 1400 metric tonnes (MT) per day (per capita of 500 grams per day). The waste generated was collected, transported and disposed at land fill site which is about 20 km away from Pune at Uruli Devachi from the 1st of June 2010. PMC has stopped open dumping and total waste generated is processed scientifically.

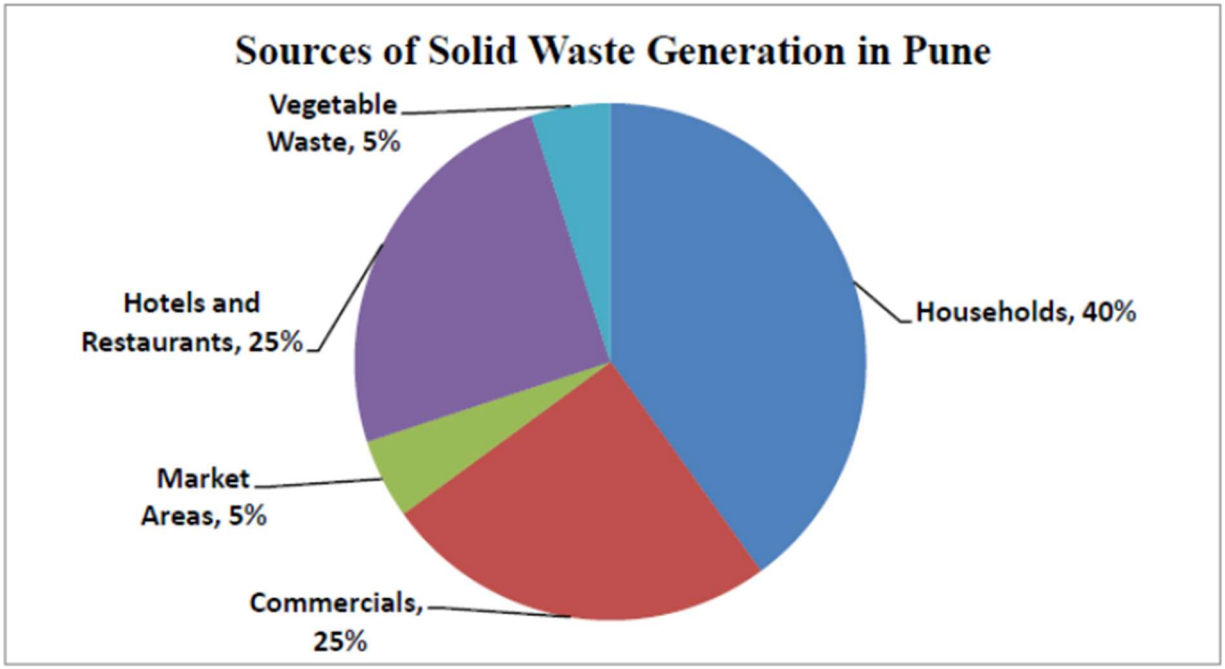


Figure 3: Sources of MSW Generation in PMC

RESULTS AND DISCUSSION

The main components of waste management are collection, segregation, storage, transportation, treatment and disposal. Currently, most of the cities MSWM system

includes above mention all components of waste management.

Waste Segregation

Segregation at source is the most important step in waste management and is done in two major categories: wet waste and dry waste. Wet waste is the bio degradable solid waste includes residential waste of all kinds and waste from markets and slaughterhouse. Dry waste is the recyclable solid waste that includes paper and plastic of all kinds excluding hazardous waste material. Waste segregation was made mandatory by Hon. Supreme court and Govt. of India Gazette dated 3rd October 2001 and Municipal solid waste management and handling rules 2000. PMC has implemented solid waste segregation system for dry and wet waste in the city. 1st July 2005 was the last date for the residents for the non segregation waste collection. The corporation has started collection of only segregated waste from households which have forced the residents to segregate the waste. PMC has adopted decentralized pattern of solid waste segregation and disposal at its source through vermicomposting.

Table 3: Segregation of MSW at source

Total Waste Segregated	**48 % to 50 %**
Wards	20 % to 65 %
Properties	42%
Societies	30%
Bungalows	47%
Slums & Chawls	32%
Hotels & Restaurants	85%

Source: Pune City Sanitation Plan, 2011

Waste Collection

Waste collection is the removal of waste from houses and all commercial places to collection site from where it will go for further treatment or disposal. The Corporation organizes the collection and transportation through a team of its own conservancy workers and a fleet of vehicles and dumperplacers. The waste is also collected with the help of rag pickers by carrying out door-to-door collection in certain areas; these rag-pickers are not the employees of PMC, but they make their livelihood by salvaging recyclable waste from collection points and dump yards and they are also paid Rs. 10 per month by each household.

Table 4: Ward-wise solid waste collection vehicles

Sr. No.	Name of Ward office	Ghanta truck	Containers	Compactor Buckets
1	Aundh	6	66	31
2	Ghole Road	11	120	21
3	Nagar Road	10	25	0
4	Dholepatil Road	8	62	18
5	Warje Karvenagar	14	115	46
6	Kothrud	13	42	12
7	Sangamwadi	12	33	0
8	Sahakar Nagar	5	39	18
9	Dhankawadi	4	74	20
10	Bibwewadi	5	81	135
11	Tilak Road	9	55	6
12	Bhavani Peth	6	59	37
13	Kasba Vishram	6	104	33
14	Hadapsar	4	61	35
	Total	**113**	**936**	**412**

Source: Pune City Sanitation Plan, 2011

Table 6: Use of Vehicles for Waste Transportation

Sr. No.	Type of Vehicle	Nos.
1	Ghanta Truck	113
2	Compactor	17
3	Mini Compactor	10
4	Hotel Truck	23
5	Dumper Placer	83
6	Bulk Refuse Carrier(B.R.C.)	60
7	Tractor	5
8	JCB	22
9	Loaders	2
10	Bulldozers	2

Source: Pune City Sanitation Plan, 2011

Best Practice Models for SWM in Pune City PMC has undertaken some innovative projects on pilot basis to manage solid waste generated in the city. Two such successful projects are: 1. 'Garbage Free Katraj' Model 2. 'Electricity Generation' through wet waste generated in hotels in Kothrud area. Successful implementation of these projects at ward level has proved it to be a replicable model, which can be initiated phase wise in other wards of the city. These models are cost effective and demonstrate that people's participation in such programs help in implementing it successfully.

COMPARITIVE ANALYSIS OF CASE-STUDIES

CITY NAME	KEY STRATEGIES IMPLEMENTED	CHANGES OBSERVED	SOCIAL, ENVIRONMENTAL, ECONOMICAL IMPACT	LESSON LEARNT	REPLICABILITY
INDORE	• 100% door to door collection and segregation at source • Participation of stakeholders and good governance • Robust monitoring system and enforcement through a series of by-laws.	• Behavioral change in people by awareness programme • "Do Bin Har Din" campaign through vehicle promoted segregation • Including top officials made people believe and understand the importance • Self Help Groups in nooks and canneries • Zero Waste Tag to market and colonies	• **Social Impact:** Illegal collection and dumping activities reduced • **Economical Impact:** Prevented 630 tons of waste from reaching dumpsites and generates Rs52 lakhs per annum • **Environmental Impact:** Efficient segregation and subsequent processing resulted no waste ends up in landfill	**Participation of all, development of all:** Indore shows us when we all come together with a single goal, then it can achieve wonders. **Segregate, segregate, segregate:** achieving 100% segregation at source before jumping to any other aspect	Indore shows us that Door-to-door collection of segregated waste is possible in every city, town and village of India through good governance and earning the trust of people to make them understand the issue.
PUNE	• Sanitary waste management to eradicate only 1% of waste generation • Red Dot Campaign encouraged people to segregate sanitary waste	• 50 per cent of the citizens covered by the Corporation separated sanitary waste from other waste. Around 1.5 TPD of sanitary waste is collected and transported. • People segregate sanitary waste wrapped up paper with red on it	• **Social Impact:** Citizens have developed a sense of responsibility towards handling sanitary waste. • **Economical Impact:** Out of 248 tons of sanitary waste generated, Pune generate 238 tons of recycled sanitary pads.	• The Red Dot Campaign is one of the best way for making people responsible in handle sanitary waste. • Integration of informal workers gave them confidence	The IEC programme of sanitary waste separation is easily replicable. PMC's reaching 2.14 million people (50 per cent population of Pune) is an example for urban local bodies in other cities to follow.

3.STUDY AREA

Faridabad city located in the **south-eastern part of Haryana** is the headquarter of a district by the same name.

• It is the largest city in the state and its **economy** is mainly based on **industrial activities.**

• Faridabad alone generates about **60 percent of the revenue of Haryana** with its large number of industrial units i.e. tractors, motorcycles, switch gears and refrigerators etc.

Figure: Location Map Faridabad
Source: Map of India

- The city is situated on the **Delhi Mathura National Highway No-2** at a distance of 32km from Delhi.
- The city is connected by **railway** on the Delhi-Mathura double track broad-gauge line of **the Central Railways.**
- Hence **accessibility** of the city is very **high.**
- The district is bounded on the north by Delhi, on **the south by Palwal district,** on the **east by Uttar Pradesh** on the **west by Gurgaon district.**

The Yamuna flows on the northern side of the city.

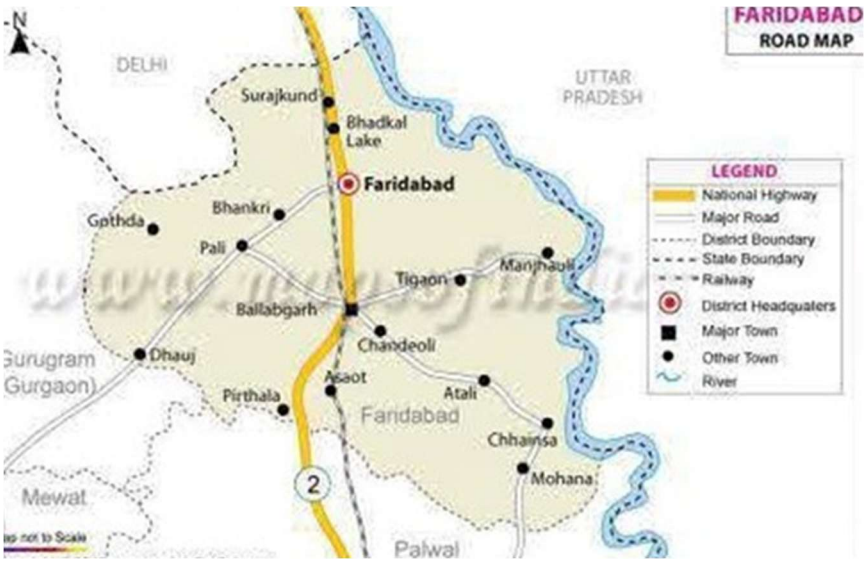


Fig: Location Map Faridabad

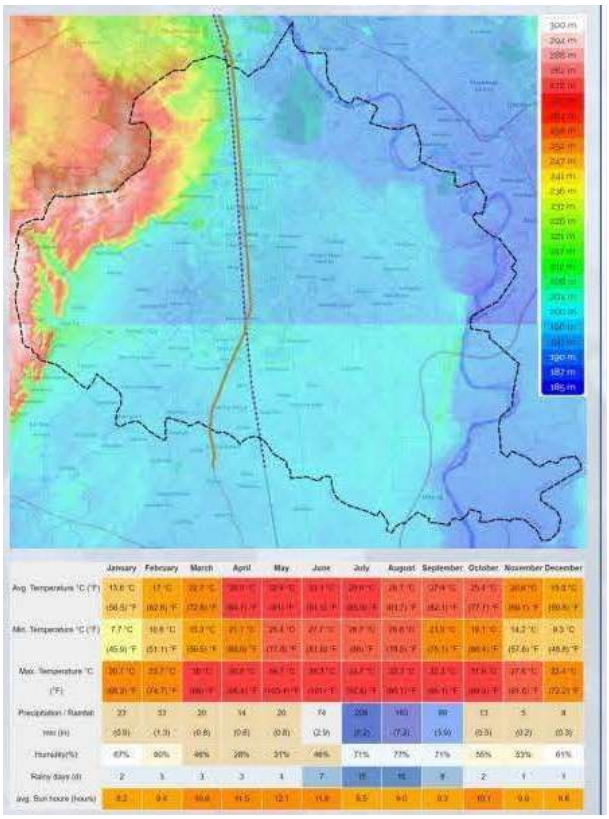
3.1City Introduction

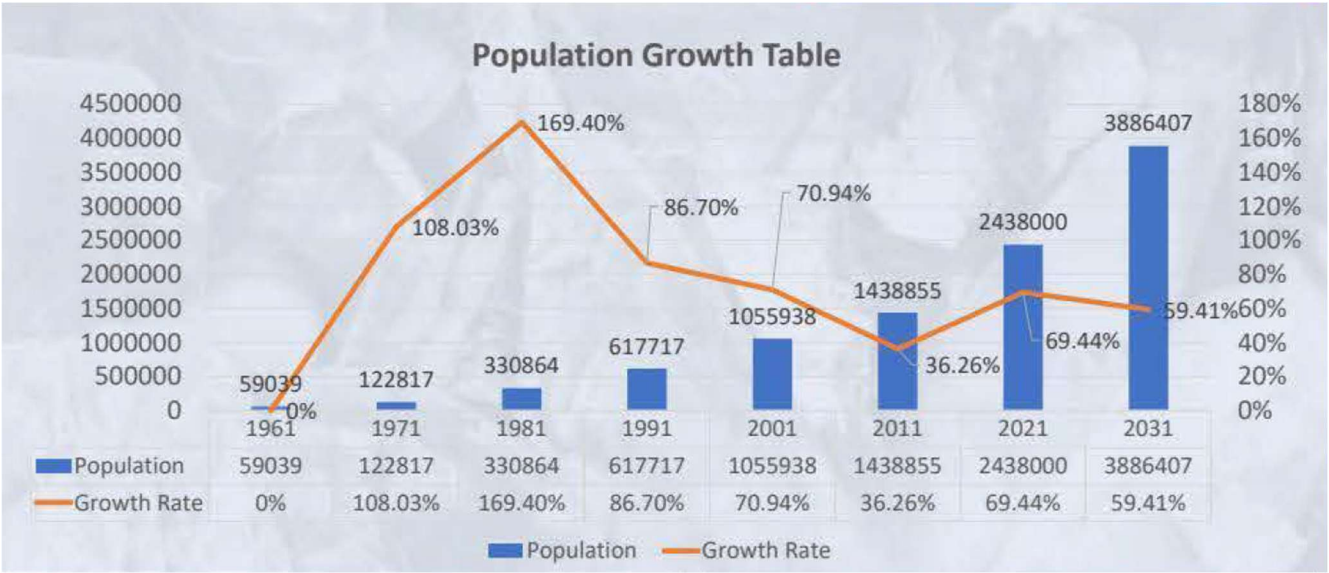
The **Municipal Corporation** was constituted in **1994** under the Haryana Municipal Corporation Act 1994. It became the only million plus city in the state of Haryana as per the 2001 Census. At present there are **two tehsils** in the Faridabad dist rict viz. **Faridabad** itself and **Ballabgarh.** Recently Palwal, a new district has been carved out of Faridabad district. Faridabad is **emerging hub** of real estate, education, health, sports and tourism. It is a drive from **mono-functional to multifunctional**

Source: Author

• PHYSICAL AND CULTURAL SETTING

Faridabad town experiences a **semi-arid climate** which is characterized by wide temperature variations and scanty and **irregular rainfall.** During summer, the **maximum temperature** may reach upto **45°C** in the month of June while in winter the **minimum temperature** drops upto **1.9°C** in February. The relative humidity remains maximum during August reaching above **85%** and minimum during May below **15%.** The normal **annual rainfall** in Faridabad district is about **542 mm.**





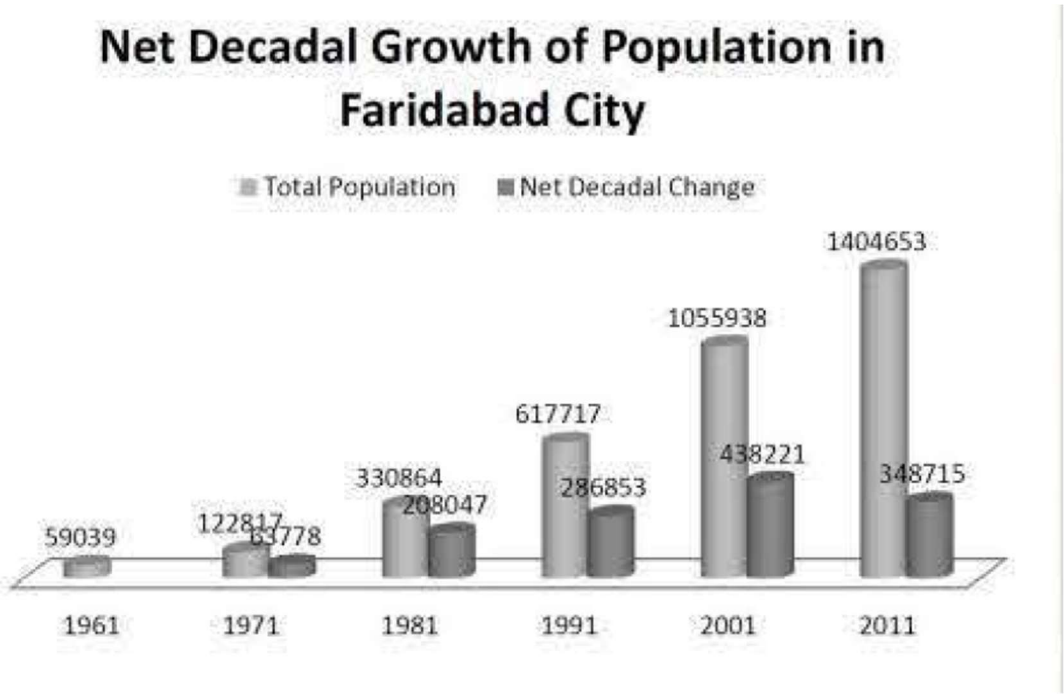


Figure: Decadal Population growth of Faridabad
Source: Census of INDIA

- Faridabad is th e most populated city of Haryana state. The total popu lation of the cit y in **2001** was 1,055,938 peop le.
- Out of the tot al popu lat ion **581,069** are **male** and **474,869** are **female**
- which comprises **55** % and **45** % of the tot al population respect ively.
- Total population under th e age of 18 years was 158,60 3 with 85,805 boys and 72,798 girls. Thus the **deficit of girls emerged to 13,007.**
- Of th e total child ren in th e age group of 0-6 yearsboys account for 54.1 per centage while girls account fo r 44.9 percentage.

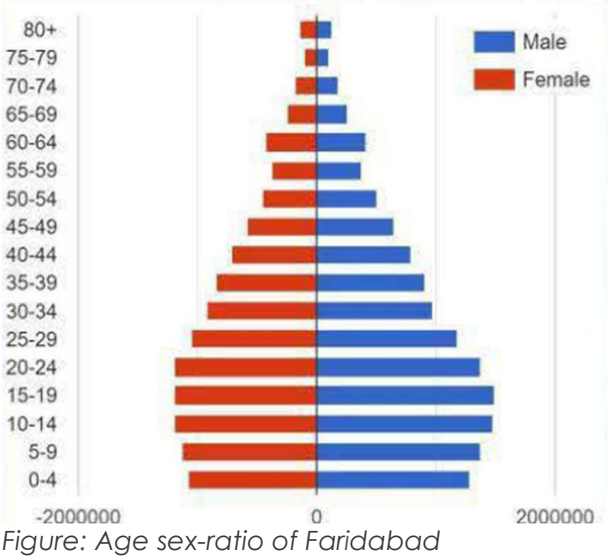


Figure: Age sex-ratio of Faridabad

Source: Census of INDIA

3.2 ECONOMIC CHARACTERISTICS

Year	Cultivators	Agriculture laborer	Worker in household industries	Other workers
2001	20.09	8.63	3.18	68.1
2011	4.78	5.06	5.57	84.59
2021	2.12	2.42	13.75	81.71

Figure: Decadal Employment distribution of Faridabad
Source: Comprehensive Mobility Plan, Faridabad

Faridabad, a constituent part of NCR is home to one of the major industrial estates of Asia which houses a **large number of manufacturing industries.** Economy of Faridabad is mainly dependent on Industry.

• There are 16 multinational companies (MNC), 809 ISO-based industries, **205 medium and large-scale industries** and **399 small-scale units** as per the records of the District Industrial Centre, Faridabad.

Year	Projected Population of Faridabad	Projected Population under MCF	Projected Employment of Faridabad	Projected employment under MCF
2001	1055938	157567	406474	423573
2008	1524180	177814	510470	550752
2011	1792279	251813	600246	883072
2021	2818569	472692	1097828	1646010
2026	3412108	653850	1369474	2138380

Figure: Projected Population and Employment
Source: Comprehensive Mobility Plan, Faridabad

Assumption for Employment Projections

• 15 % of SEZs area will be allocated for residential and for residential area assuiming a density of 200 persons per hectors.
• 50 percent of employees will be residing at FBC and working at outside SEZs
• Workforce participation ratio is assumed around 39 during 2011 to 21 and it will maintain the same pace during 2021 to 2026.

3.3 Demographic profile

The **work force participation rate (WFPR)** of Faridabad city as per Census **2001** is **38 percent** that is about 4 lakhs. A decline in WFPR over the decades is observed, due to the **change in the economic character** of Faridabad from being predominantly primary/secondary it is now **tertiary/service oriented.**

Year	Population Growth	Workforce participation ratio
2001	68%	33
2021	61%	39
2026	69%	40

Figure: Population growth and workforce Participation ra tio within FMUC
Source: Comprehensive Mobility Plan, Faridobad

4.SITE ANALYSIS

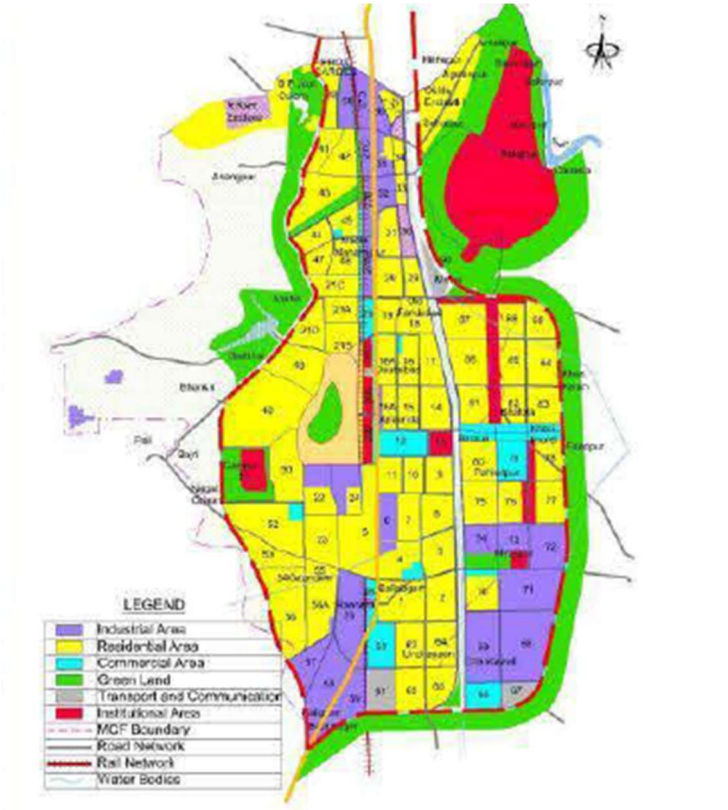


Figure: Faridabad Development Plan
Source: Comprehensive Mobility Plan for Faridabad

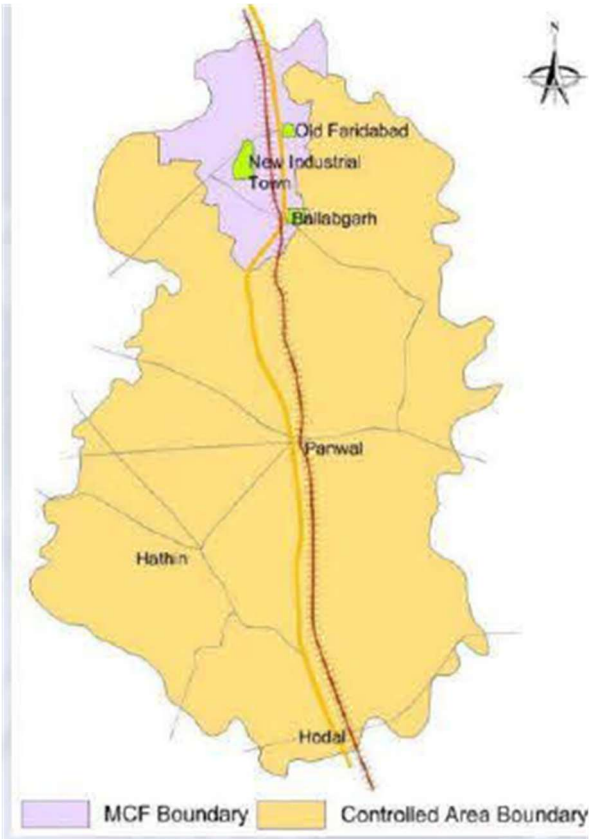
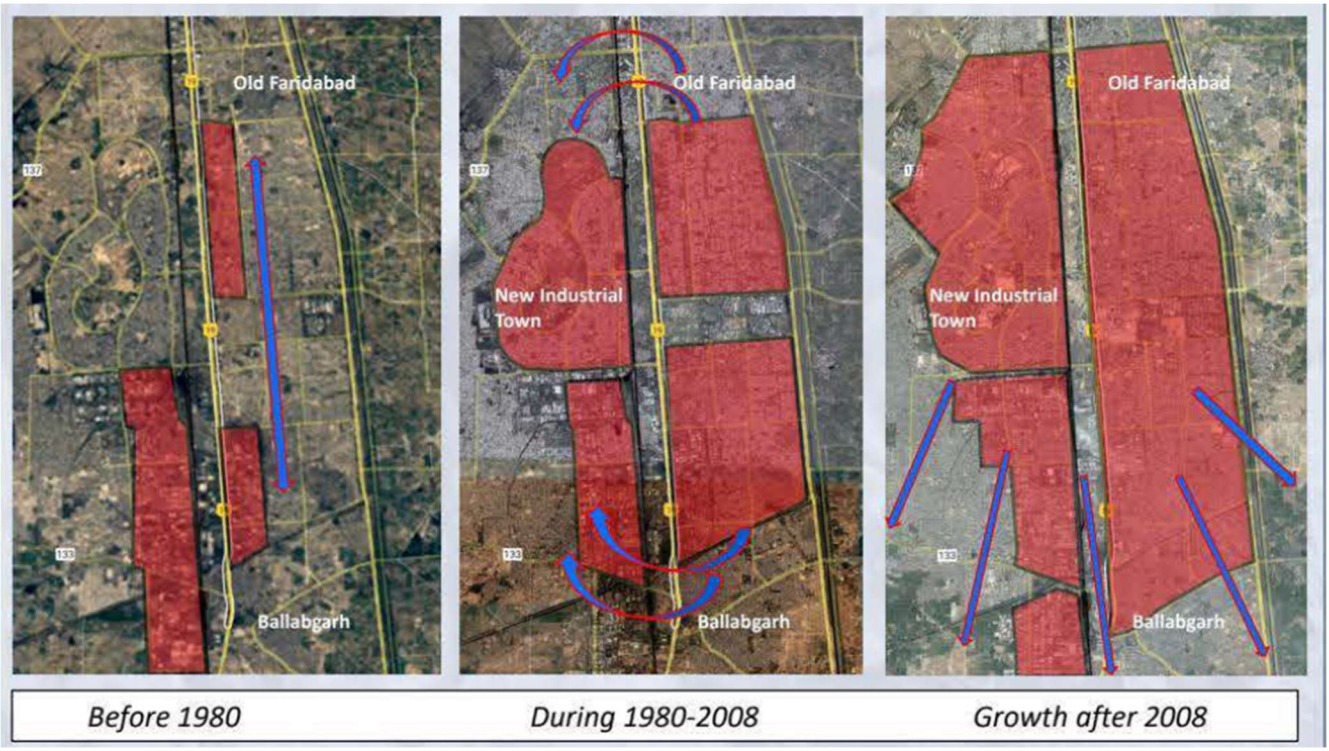


Figure: MCF Boundary Marking
Source: Map of India

The study is focused on the Faridabad and Ballabgarh urban areas.
The present municipal area of Municipal Corporation of Faridabad (MCF) is approx.208 sq.km.
About 75% of the MCF area is already developed.



It is observed that the areas to wards Faridabad have been **on high demand for fast paced growth** where real estate activity has pick ed up considerabl y during the past five years.

Major commercial **developments observed along NH2** and either side of th e national highway.

The following can be note from the study area growth

- Pull factor was observed between **Delhi-Faridabad-Ballabgarh** before 1980
- Development moved towards **New Industrial Town** during 1980 to 2008
- Growth Expected towards **East Faridabad and South West** of Faridabad after 2008

DEVELOPMENT PLAN

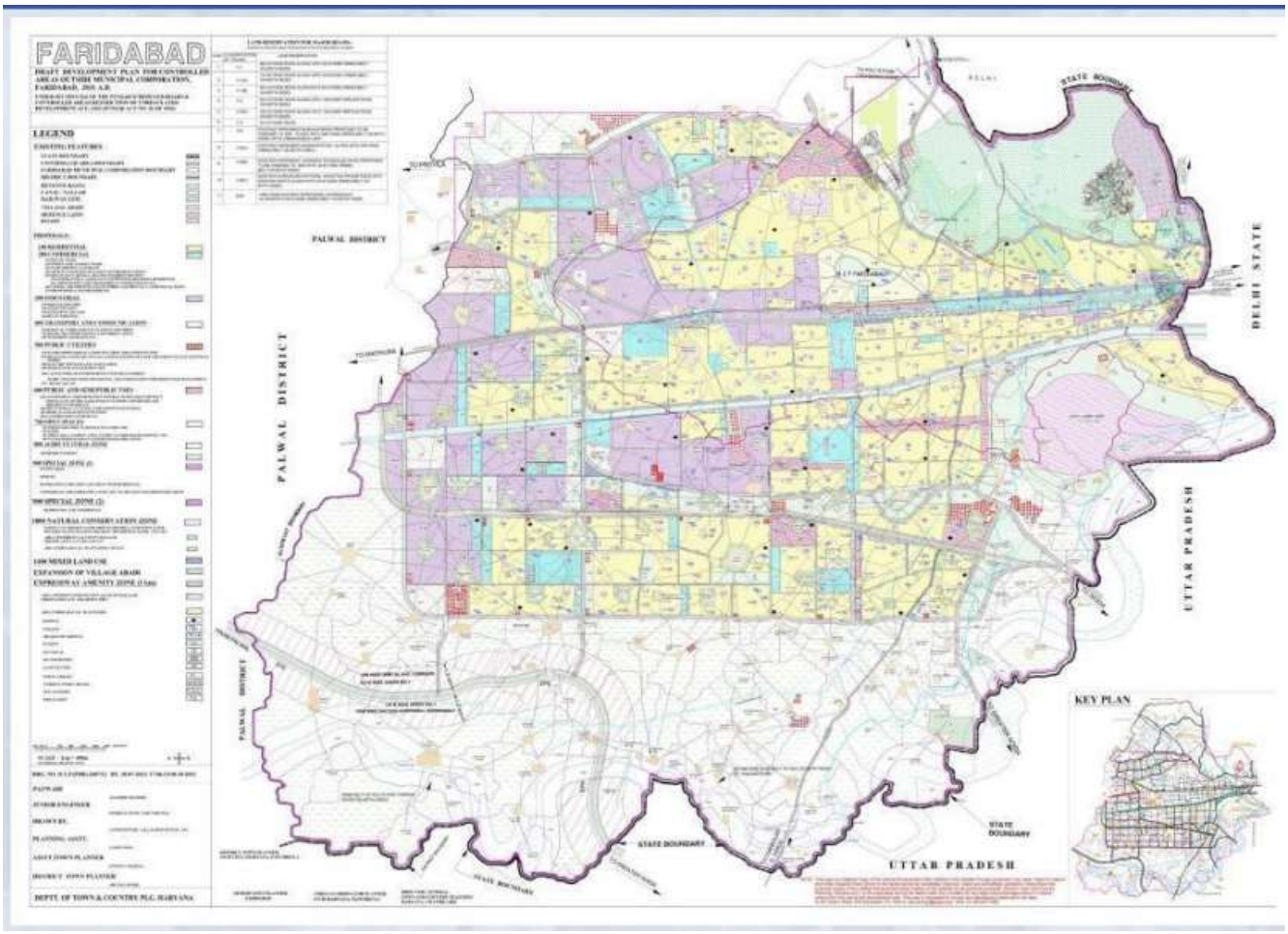
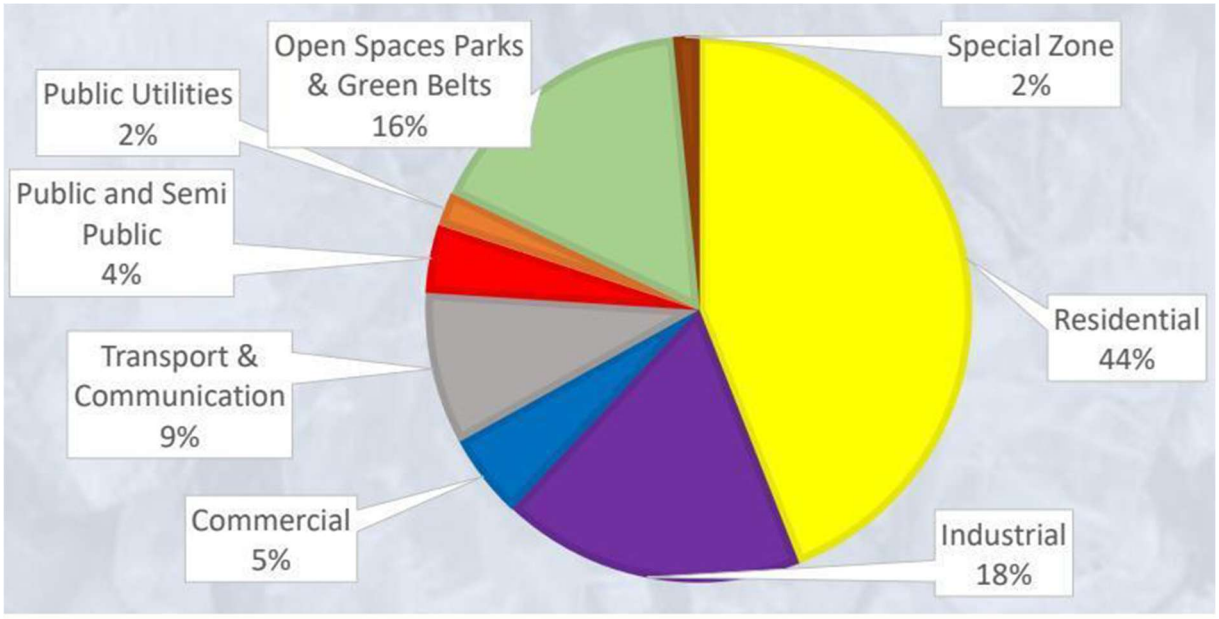


Figure: Draft Development Plan, 2031
Source: Faridabad Master Plan, 2031

Landuse	Existing Land-Use		Proposed Land-Use 2031	
	Area in Ha	Percentage	Area in Ha	Percentage
Residential	7795	49.7	14328	44
Industrial	3136	20	5861	18
Commercial	773	4.9	1628	5
Transport & Communication	1554	9.9	2931	9
Public and Semi Public	530	3.4	1303	4
Public Utilities	155	1	651	2
Open Spaces Parks & Green Belts	1295	8.3	5373	16.5
Special Zone	442	2.8	488	1.5

Figure: Land-Use Distribution, 2031



If we compare existin g and proposed, then in order to accommodate 17.5 Lakh persons by 2011,15,679 Ha of land has been proposed for acquisiti on, while in 2014, 34,368 Ha of land has been proposed to accommod ate 38.86 Lakh persons. It shows **the demand of land is increasin g day by day. Agricult ural land is m oving ou t of Faridabad city outskirts.** Agricultural land converted to residential and comm . use in attempt to de-clog Delhi

BASE MAP OF MUNICIPAL CORPORATION FARIDABAD

The rapid urbanization, **increasing commercial and industrial** activities and changing life styles in Faridabad are leading to a steady **increase in the generation of solid waste.**

MCF is responsible for the **collection, transportation and disposal** of all solid waste generated in the city, except the untreated bio-medical waste and hazardous industrial waste, which is taken care of by the respective generators.

MCF organizes the collection and transportation of the waste through a team of its **own conservancy workers** and a **fleet of vehicles** and **dumper placers.**

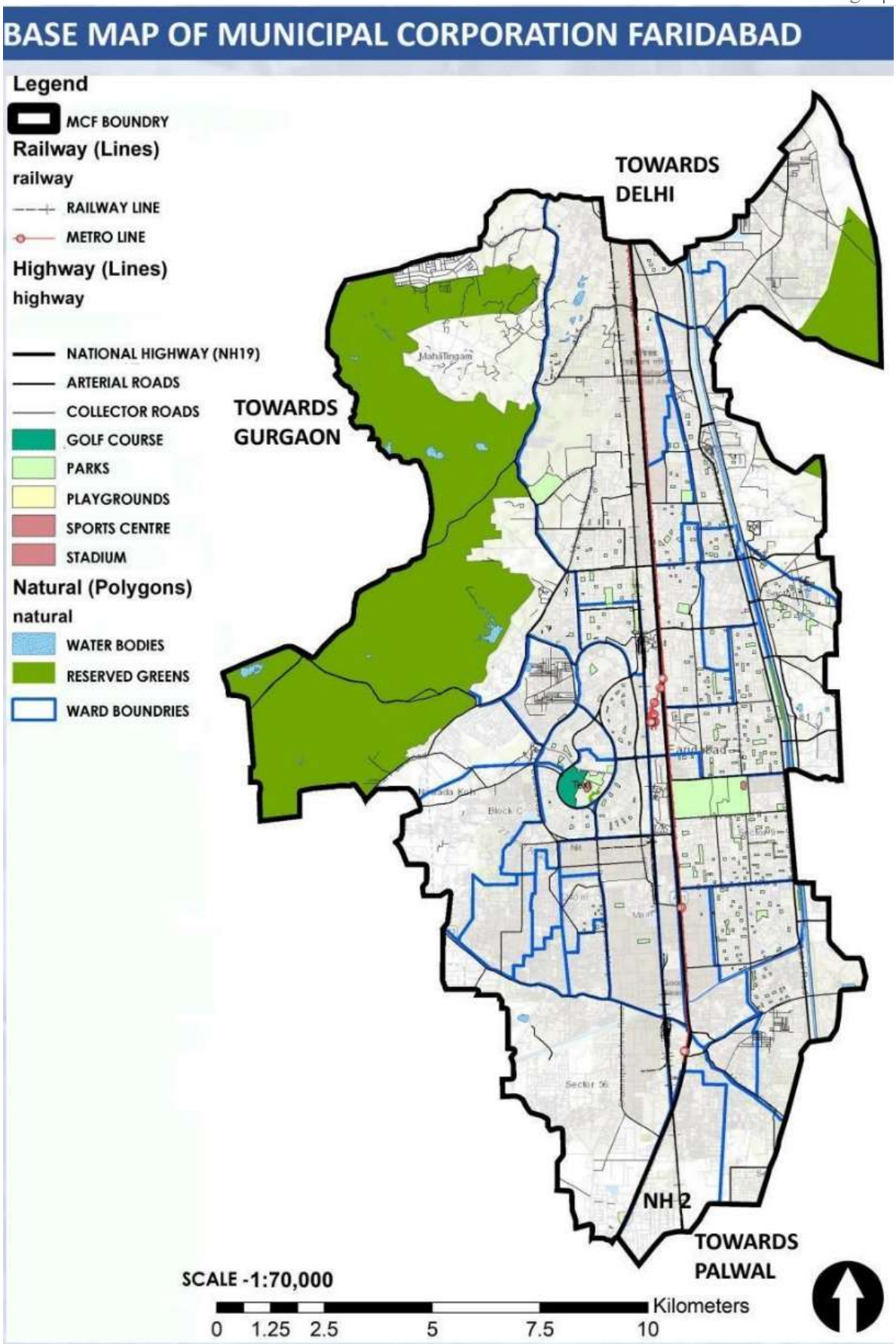
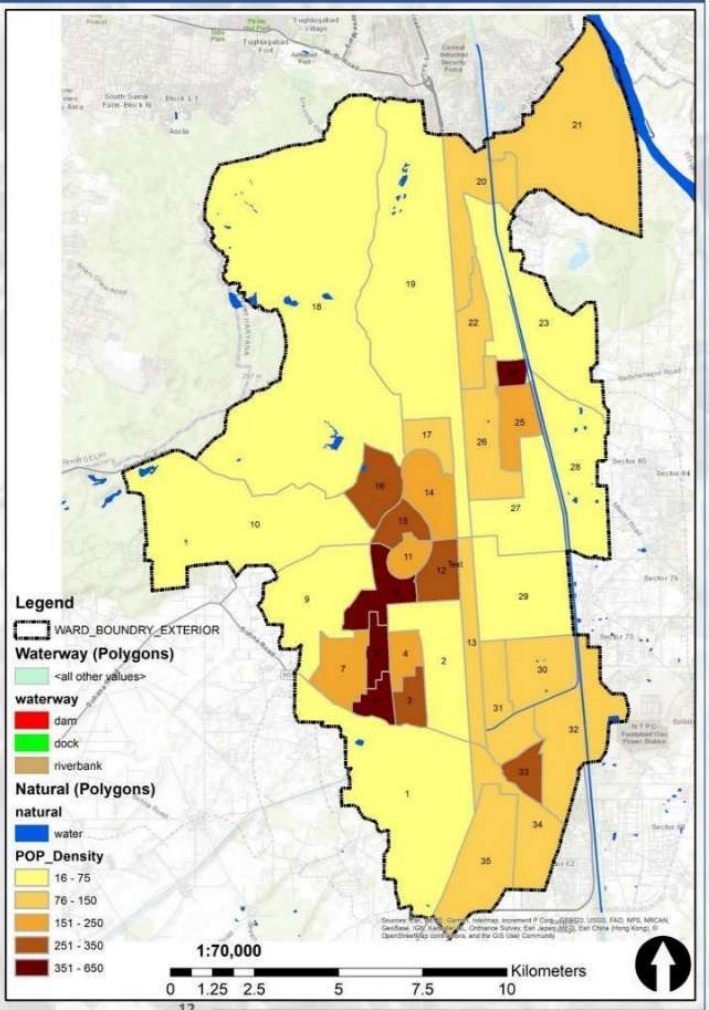
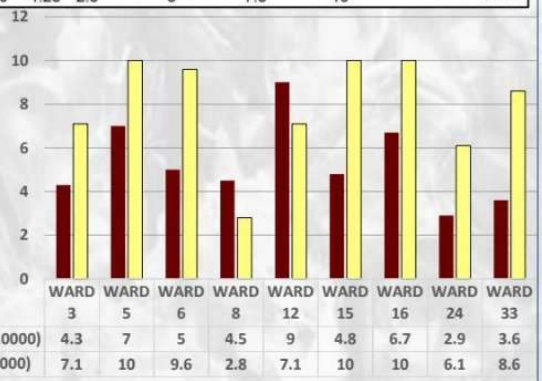


Figure: Base Map, MCF boundary Faridabad
Source: Self-generated

POPULATION DENSITY

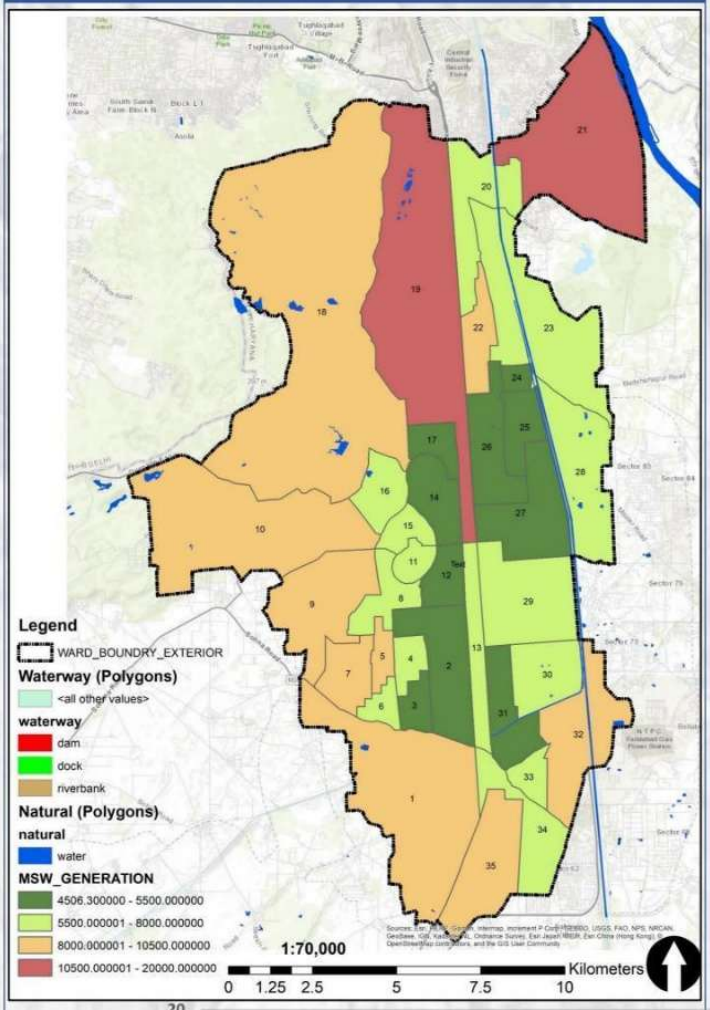




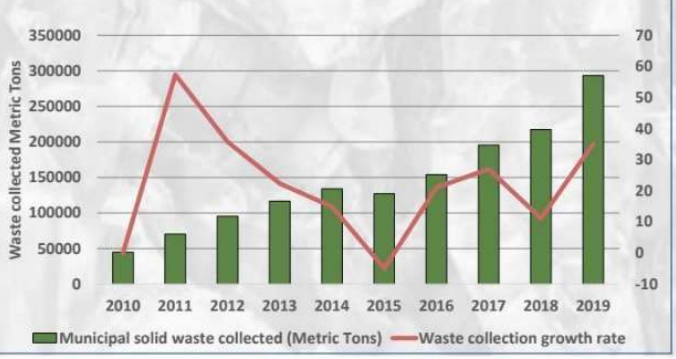
	WARD 3	WARD 5	WARD 6	WARD 8	WARD 12	WARD 15	WARD 16	WARD 24	WARD 33
Population (in 10000)	4.3	7	5	4.5	9	4.8	6.7	2.9	3.6
Household (in 1000)	7.1	10	9.6	2.8	7.1	10	10	6.1	8.6

- Faridabad is divided into **35 zones**, out of which **9 wards have high population density.**
- Higher population density are seen in New Industrial Town (NIT) comprises of **Wards 8,11,12,14,15 and Old Faridabad areas.**
- NIT was the first residential area developed to allocated the people migrating for work opportunities due to industrial setup in Faridabad.

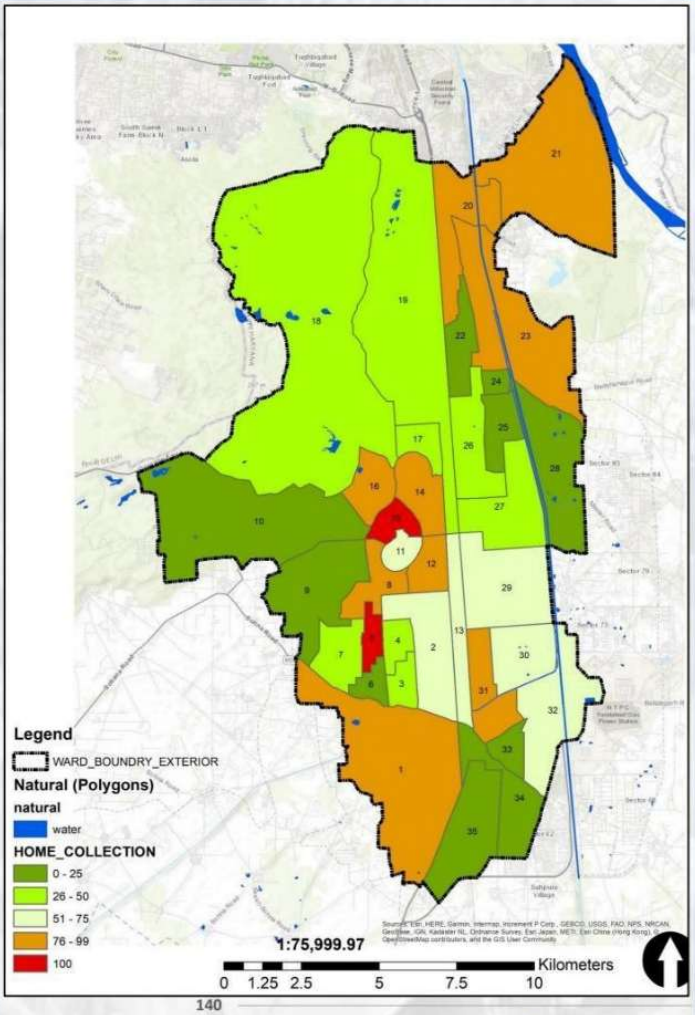
MUNICIPAL SOLID WASTE GENERATION

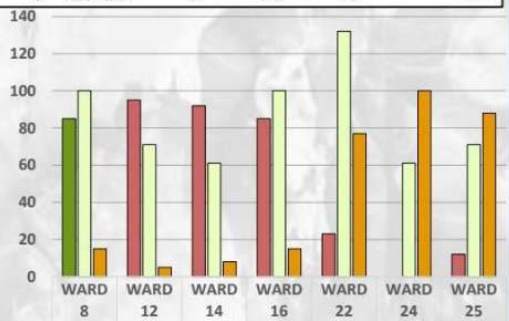


	WARD 8	WARD 12	WARD 14	WARD 15	WARD 10	WARD 18	WARD 19	WARD 21	WARD 27
MSW Generation TPD	6.7	5	4.2	7.2	9.2	9.2	14.2	18	3.6
Household (in 1000)	7.1	10	9.6	2.8	7.1	10	10	6.1	8.6



DOOR TO DOOR COLLECTION

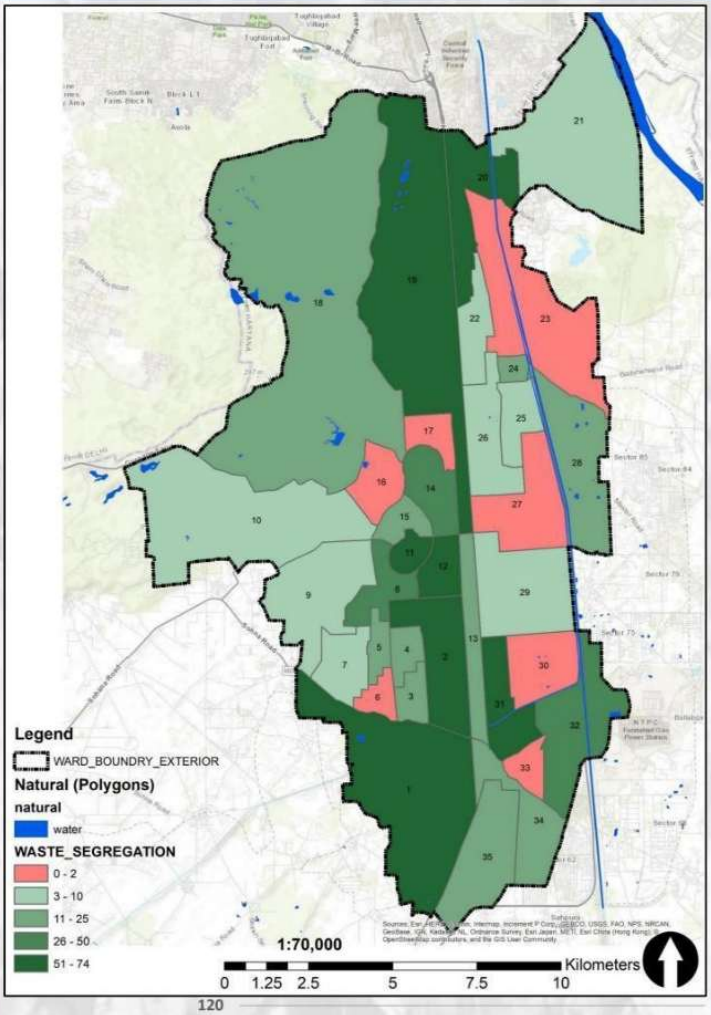


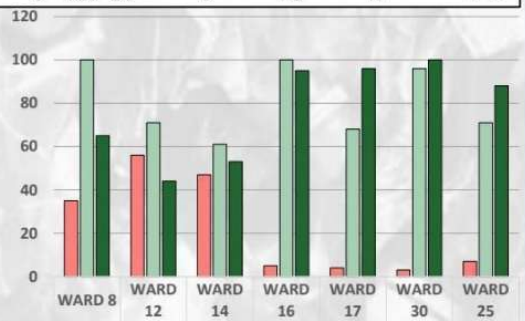


	WARD 8	WARD 12	WARD 14	WARD 16	WARD 22	WARD 24	WARD 25
Household waste collection %	85	95	92	85	23	0	12
Household (in 100)	100	71	61	100	132	61	71
Gap	15	5	8	15	77	100	88

- Presently, the MCF has given responsibility of Solid Waste Management **to Ecogreen Energy Company.**
- M/s Ecogreen Energy transports waste from Door to Door to secondary waste collection points and as well as to the waste transfer stations in the city.
- **150 vehicle for primary waste collection and 110 vehicle for secondary waste collection** including Mini Tippers and Rickshaws.

WASTE SEGREGATION



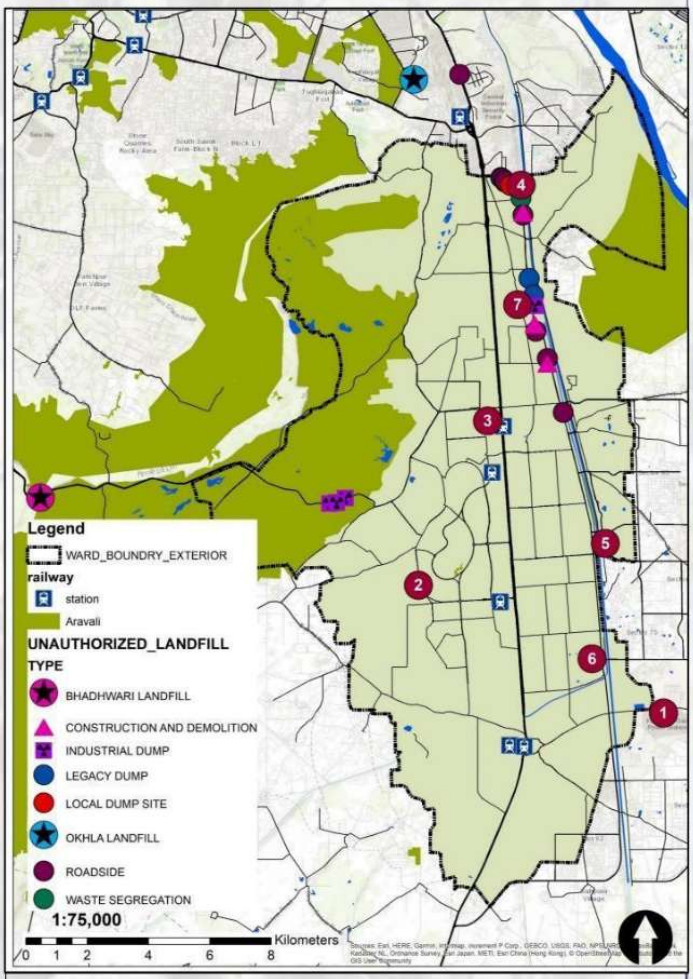


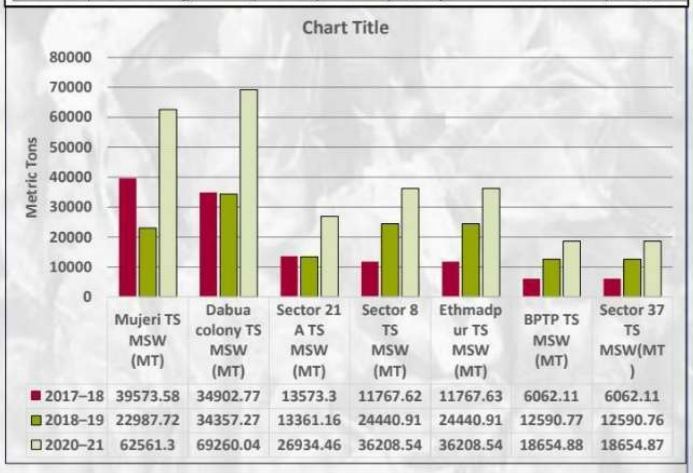
	WARD 8	WARD 12	WARD 14	WARD 16	WARD 17	WARD 30	WARD 25
Household waste collection %	35	56	47	5	4	3	7
Household (in 100)	100	71	61	100	68	96	71
Gap	65	44	53	95	96	100	88

- **30 % source segregation** is achieved in Faridabad.
- The major contributors for source segregation are **industrial areas**, because of **strict rules for waste disposal in industries.**
- Wards with major **residential** setup have only **achieved 0-10% of segregation.**
- The waste segregation activity is performed by **Safai Karamcharis** and loaded in tippers.

3 SITE ANALYSIS (EXISTING SOLID WASTE MANAGEMENT)

LANDFILL AND TRANSFER STATIONS





Waste transfer station (TS) at **Dabua vegetable market processes 72% of total waste of NIT zone**. Waste Transfer Station at sector **21A processes 28% of total waste of NIT zone.** The waste transfer station at sector 8, Etmadpur Faridabad, BPTP Faridabad and Sector 37 processes **33%, 33%, 17% respectively**

ILLEGAL LANDFILL SITES

GREEN BELT AT FARIDABAD BYPASS ROAD, D-BLOCK, MOLAR BANK EXTENSION, BADARPUR

C&D WASTE AT FARIDABAD BYPASS ROAD, POLICE LINES, SECTOR-30

GREEN BELT AT FARIDABAD BYPASS ROAD, E-BLOCK, MOLAR BANK EXTENSION, BADARPUR

BURNING OF INDUSTRIAL AND MUNICIPAL WASTE AT FARIDABAD- GURUGRAM ROAD

MUNICIPAL WASTE AT FARIDABAD BYPASS ROAD, SECTOR-33

MUNICIPAL WASTE AT FARIDABAD BYPASS ROAD, F-BLOCK, MOLAR BANK EXTENSION

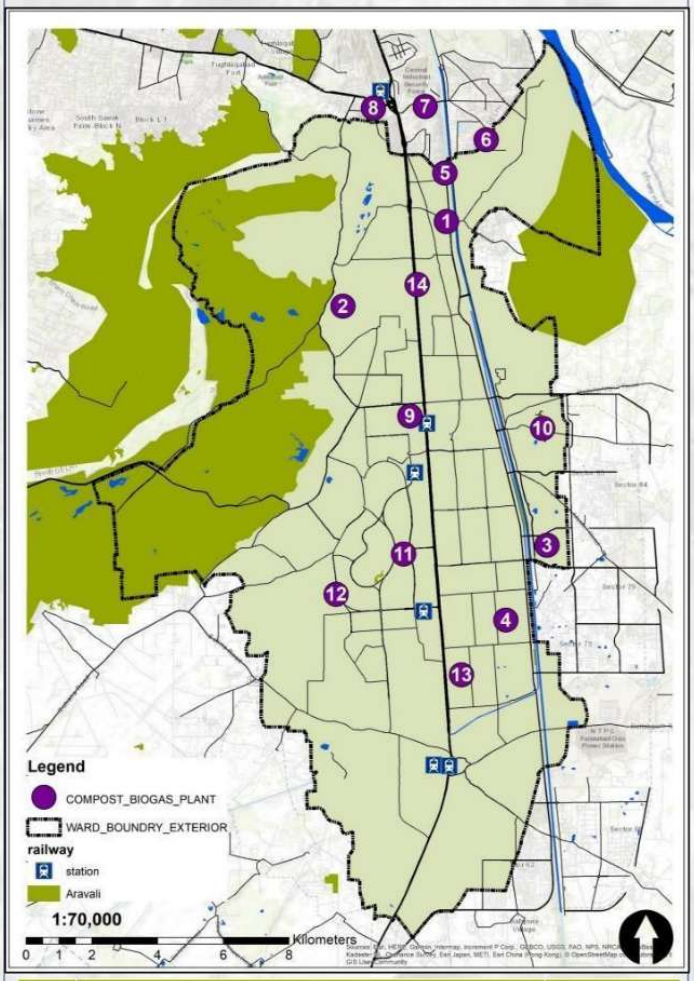
MUNICIPAL WASTE AT FARIDABAD BYPASS ROAD, SECTOR-33

LARGE NO.OF ILLEGAL CAR WASHING AT FARIDABAD BYPASS ROAD, D-BLOCK, MOLAR BANK EXTENSION

MUNICIPAL WASTE AT FARIDABAD BYPASS ROAD, SECTOR-30

LANDFILL SITE AT BANDHWARI FARIDABAD- GURUGRAM ROAD

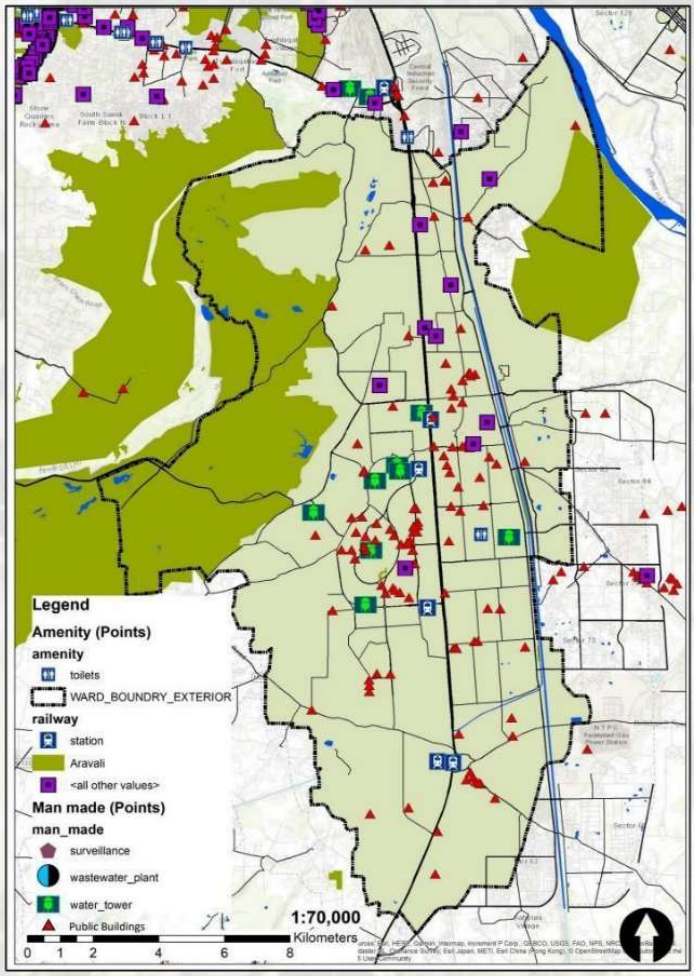
COMPOST PLANT AND BIO-GAS PLANTS



Sr. No.	Solid Waste Processing	Value
1	Total amount of solid waste generated within the ULB	750 MT to 850 MT
2	Quantity of dry waste generated (in TPD)	400 TPD (aprx.)
3	Quantity of Dry Waste processed	400 TPD (aprx.)
4	Existing Material Recovery Facilities	6 (MCF) 3 (Private)
5	Capacity of available Material Recovery Facilities	250 MT
6	Required Material Recovering Facilities	3 (100 MT each)
7	Quantity of wet waste generated (in TPD)	400 TPD (aprx.)
8	Existing compost pits provided for wet waste processing	N/A
9	Required compost pits	5 (80 MT each)

There are total **14 ongoing waste compost plants** and Bio-Gas projects in Faridabad, including public, RWA's and private contractors. The major amount of waste is received from industries, as the waste is segregated, while waste generated from household **are segregated at transfer stations and collected by waste recycler**

MASS SOLID WASTE GENERATORS



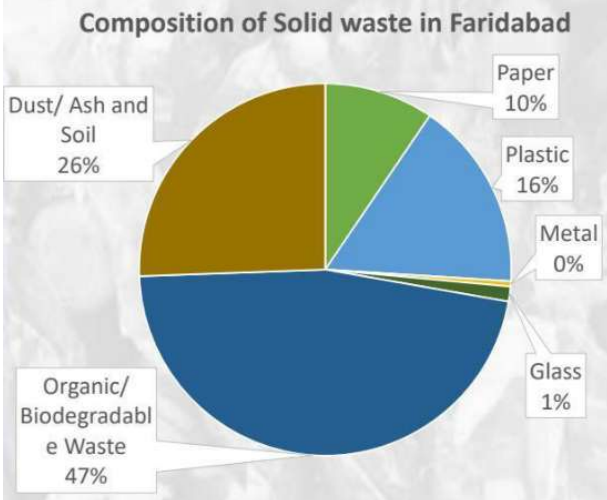
Sr. No.	Bulk Waste Generators (BWGs) identification and processing of solid waste	Value
1	Total No. of BWGs Identified a. With 100 Kg and above solid waste/day. b. with 50 Kg to 100 kg solid waste/day.	118
2	Quantity of solid waste generated by the identified BWGs (in TPD)	23 TPD
3	Total No. of BWGs processing waste within their premises alongwith percentage.	50 BWGs have installed machinery at their own premises for making compost
4	Total No. of BWGs processing waste outside their premises along with percentage	68 no BWGs are sending their wet waste to IOCL & NGO namely Human Kind Foundation.
5	Recovery and fine/penalty mechanisms on those BWGs who are not processing the waste either within their premises or outside their premises	N/A

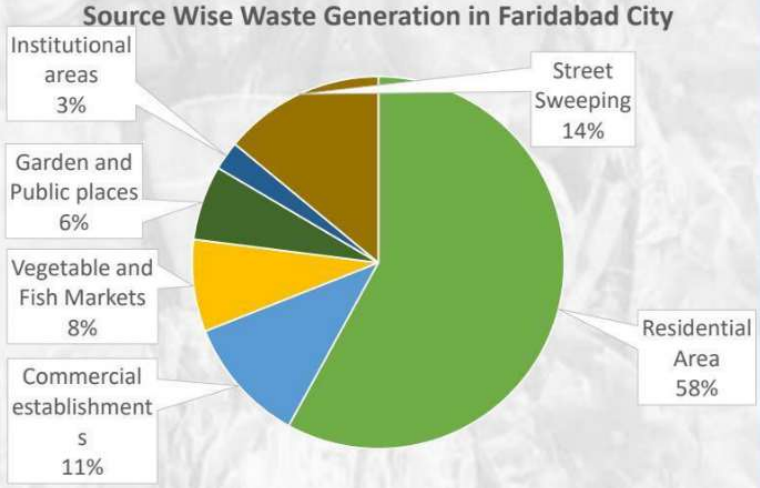
In present condition there is no waste segregation practiced by Bulk Waste generators, but source segregation at these bulk waste generation points can help to achieve 30% reduction in waste going to Landfill.

4 WASTE GENERATION PATTERN & STRATEGIES

LANDFILL AND TRANSFER STATIONS

Sr. No.	Year	Population in Lacs	Population in Lacs (including 10% floating population)	Per Capita Waste Generated (g/day)	MSW Quantity Generation MT/day	MSW Quantity Generation (including 10% floating population) MT/day	MSW Quantity Generation MT/Year	MSW Quantity Generation (including 10% floating population) MT/Year
1	1981	3.3	3.63	250	82	90	30112	32940
2	1991	6.25	6.87	250	156	171	57031	62586
3	2001	10.54	11.6	400	422	464	154452	169824
4	2011	14.14	15.55	400	565	622	206790	248800
5	2021	24.38	26.81	550	1340	1474	489100	538010
6	2031	38.86	42.74	650	2525	2778	921625	1013970





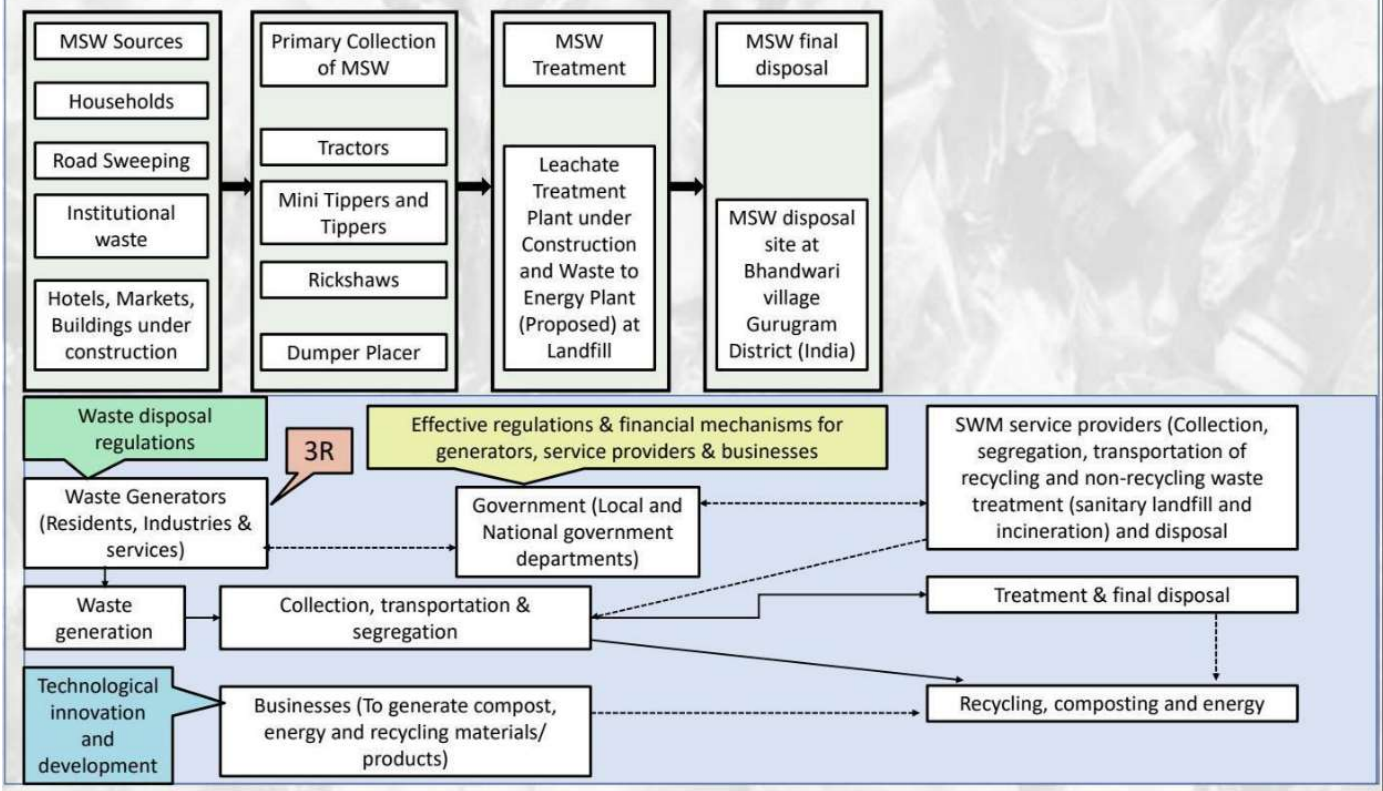
Sr.No.	Particulars	Number/ Quantity
1	240 Ltr LLDPE Bins	500
2	Littre Bin – 60 Ltr capacity with MS Frame	600
3	4.5 Cum capacity M.s. Container	70
4	1100 Ltr capacity Moble Bin	500
5	Tri – cycle Rickshaw with 6 nos LLDPE Bin	1164
6	140 Ltr capacity wheal Barrous	574
7	3000 Ltr capacity water tanker with pressure jetting system	3
8	Tripper Truck 6 cum capacity	5
9	Refuse Collector Truck	16
10	Dumper Placer Truck	18
11	Haulage Truck of 16 cum capacity	9
12	Animal Catcher Van	3
13	JCB 3DX Exvator - Loader	7
14	JCB 430Z Articulated front and Loader	2

Sr. No.	Road, Drains and Collection Points	
1	Total length of roads and streets	1156 Kilometers
2	Total length of drains	907.84 Kilometers
3	Total number of collection Points	342

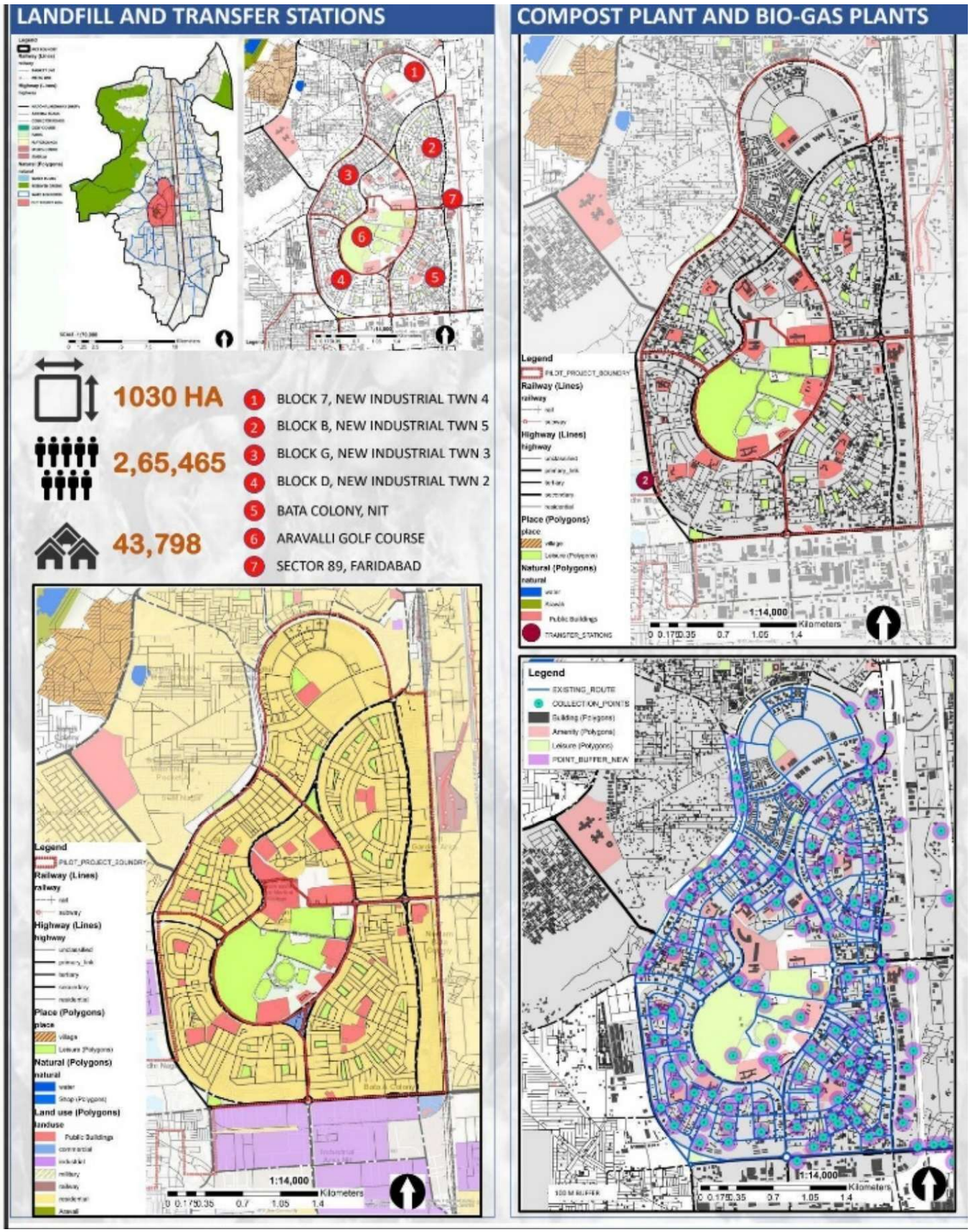
- **Residential waste** generation quantity is unusually higher **(58 %)** in Faridabad city.
- **Organic matter** consists of **46.78 %** and is the largest constituent.
- **Sweeping of the roads and streets** carried out daily by Safai Karamcharies in all MCF authorized area. Waste collected by sweeping and designated surface drains (up to 2 ft.) width is **lifted and transported daily** at designated dumping sites.

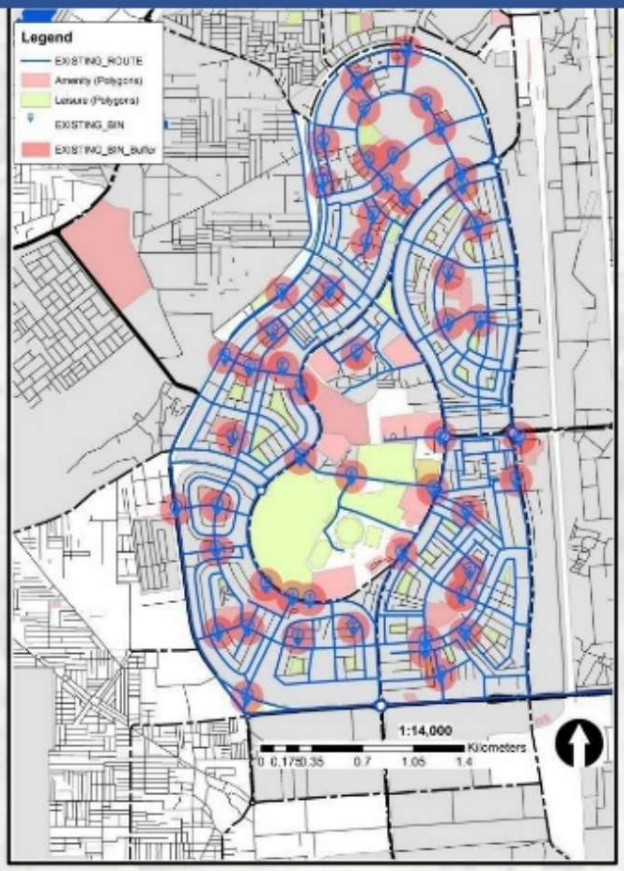
ACTION PLAN ACCORDING TO ISSUES IDENTIFIED

Sr.No.	Identification of Issues and Challenges	Infrastructure Requirement	Recommended Strategies
1	Currently, all the processing plants are working at 27% efficiency	Reduction in generation of waste quantity through social awareness programme	Promote house level and society level processing of wet waste
2	Eco-green processing plant process about 111 TPD of dry waste	On-Site disposal of wet-waste by bulk generators, producing more then 50Kg of wet waste per day	Increase processing efficiency of existing plants
3	No processing plants for wet waste or on-site processing by residential societies	Increase in source segregation level to 80% by 2025	Commission new processing plants to meet the gap in processing capacity
4	Mixing of wet and dry waste along with household e-waste, toxic waste and bio-medical waste	TO study the behaviour pattern of waste generation, waste type and disposal pattern	Decentralization of waste processing plants
5	Vehicle breakdown, foul smell and spillage due choking up of drains due to on street dumping of waste	Spatial analysis and data mapping through topography, raster, attribute data & features in GIS / Remote sensing applications.	Zero waste homes & 100% Door to Door collection of source segregated waste
6	In-efficient monitoring of routes and find an alternative site for landfill other then Bhandwari Landfill	RFID as identification technology for Solid Waste Management	Provision for separate collection of dry, wet, sanitary and hazardous waste at source.
7	In-efficient routing of collection vehicle , streets are covered twice due to irregular distribution of collection point	New vehicular movement pattern for primary and secondary transportation	Education and capacity building through community awareness and motivation programmes
8	Capacity of secondary transportation is only 70%. Also there is a lack of communication between primary collection, primary and secondary transportation	Application interface to keep monitoring of vehicular movement and amount of waste collected	Connect people through internet application in order to predict future generation of waste
9	Insufficient number of Bulk Refuse carriers leading to pile up of primary collection vehicle at transfer stations.	Inform, Involve, Incentivize	Enable smart transport system with GPS tracker, single interface for waste generator and waste collector
10		Solid Waste Management By-Laws to be drafted as per SWM Rule 2016	Provide service within a pre-defined time period (time bound service)



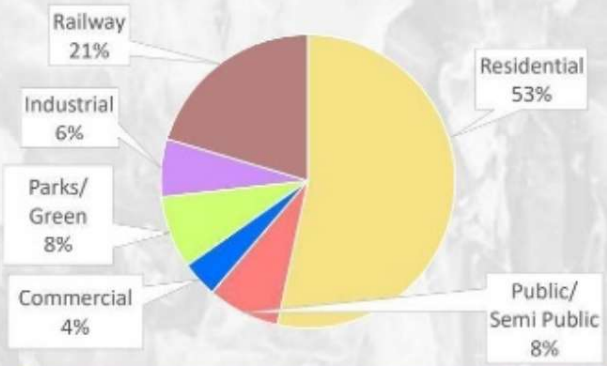
5 PILOT AREA STUDY (NEW INDUSTRIAL TOWN, FARIDABAD)





Total area of pilot project : 10.3 SqKm

Type of Land-use in Pilot project



Sr. No	Sources	Quantity	Percent
1	Total length of roads and streets covered by waste tippers	104 Km	67
2	Total no. of collection points	168	44
3	Total area covered by 100m buffer of collection point	3.22 SqKm	35
4	Waste generated per day in selected pilot area	146 Tons	19

LANDFILL AND TRANSFER STATIONS

Primary collection of segregated dry waste

Collection of waste from public buildings in tractors

Kabadiwala moving waste to local recovery centre

Un-used public bins in due to lack of demand

Overflow of waste from community bins

Overflow of waste from public bins, unhygienic

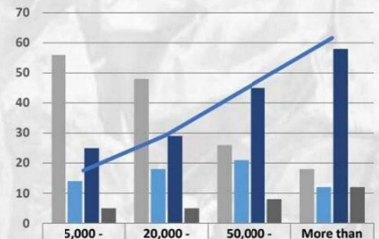
Primary collection of waste from households in pushcart

Ecogreen tipper vehicle to transfer station

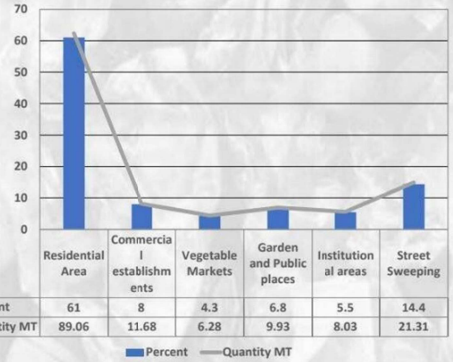
Overflow of community bins

Unloading of waste from tipper to compactor

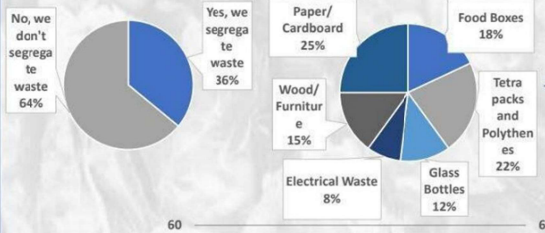
WASTE GENERATION PATTERN

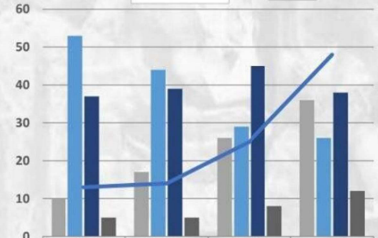


	5,000 - 20,000	20,000 - 50,000	50,000 - 1,00,000	More than 1,00,000
Kitchen Waste	56	48	26	18
Paper	14	18	21	12
Plastic	25	29	45	58
Solids (Glass/Metals)	5	5	8	12
Solid waste generated per day (in Grams)	250	420	650	880



	Residential Area	Commercial establishments	Vegetable Markets	Garden and Public places	Institutional areas	Street Sweeping
Percent	61	8	4.3	6.8	5.5	14.4
Quantity MT	89.06	11.68	6.28	9.93	8.03	21.31





	5,000 - 20,000	20,000 - 50,000	50,000 - 1,00,000	More than 1,00,000
Food Packaging	10	17	26	36
Paper/ Cardboard	53	44	29	26
Glass/Metal/Wood	37	39	45	38
Solids (Glass/Metals)	5	5	8	12
Household segregation %	13	14	25	48

REMARKS

The graph compares the **type of solid waste generation to the income level**, it shows lower income people generates more organic waste, whereas higher income people generates more plastic waste, this is because of higher purchasing power

The graph compares the **garbage service adopted by different income level**. While higher income people had access to municipal services while lower income people dump their waste in open areas or community bins

74% of total people have access to municipal waste collection service. A 8 litre standard home bins take one-two two day fill completely.

The graph shows the **highest source of waste generation in NIT area.** Residential area alone produce 58% of waste as compared to others

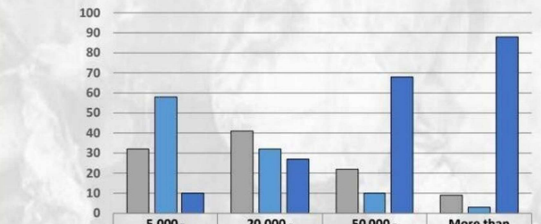
The pie chart shows the **segregation pattern**, 56% of people do segregate their waste, but it anyway ends up in waste after it get's re-used, because it is not collected separately by service provider

The pie chart shows, **36% of people do segregate their waste from regular waste**. Milk tetra packs, food delivery boxes and paper are the most segregated object, because of their re-usable properties

The pie chart shows the **choice of architecture of people in public or commercial spaces**. 35% people throw their waste in any bin they found in their way and there are no separate bins in these areas. Also most of the bins are not emptied so the waste keeps on pilling up in same bin

Lower income people segregates more paper and cardboard, while higher income people segregates more solids like glass, metal or wood. As **higher income people** order more food online, so **segregation of food packaging boxes** are also high

GARBAGE COLLECTION SERVICES



	5,000 - 20,000	20,000 - 50,000	50,000 - 1,00,000	More than 1,00,000
Community Bin	32	41	22	9
Open Dump	58	32	10	3
Municipal Van	10	27	68	88

Figure: Income slab vs garbage disposal methods

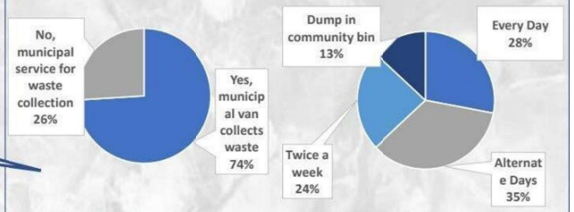


Figure: Frequency of municipal service accessed

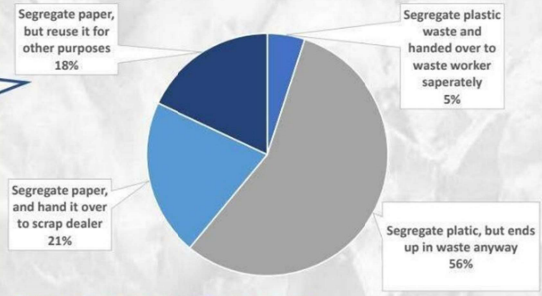


Figure: Garbage segregation pattern

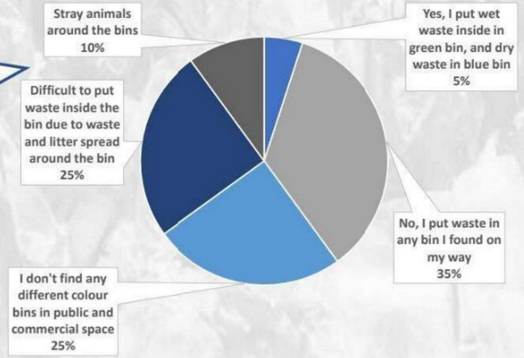
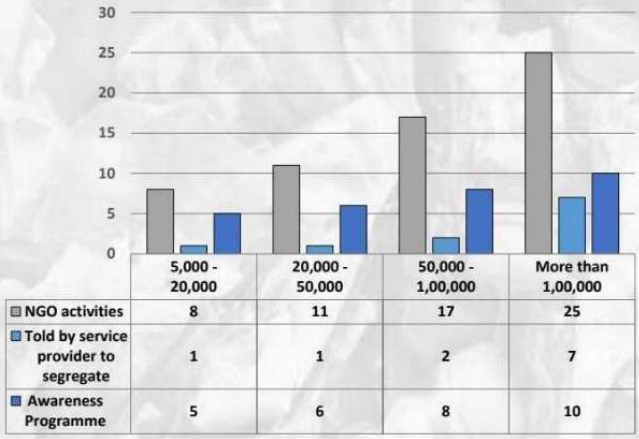


Figure: Garbage disposal pattern in public and comm. spaces

ENVIRONMENTAL AWARENESS



	5,000 - 20,000	20,000 - 50,000	50,000 - 1,00,000	More than 1,00,000
NGO activities	8	11	17	25
Told by service provider to segregate	1	1	2	7
Awareness Programme	5	6	8	10

Figure: Expose to waste management campaigns by government and NGO's and their participation

NGO programmes are active in high class societies, also the awareness level is very low.

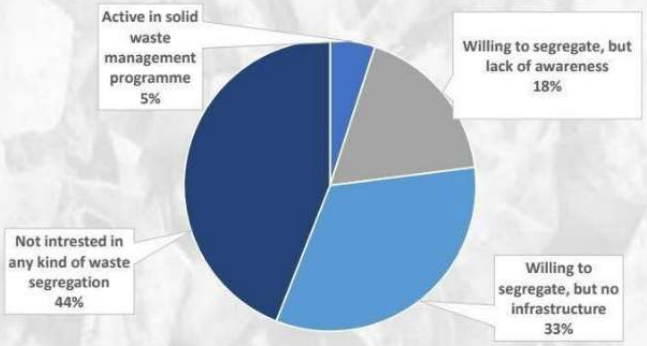


Figure: Willingness to participate in waste management programme

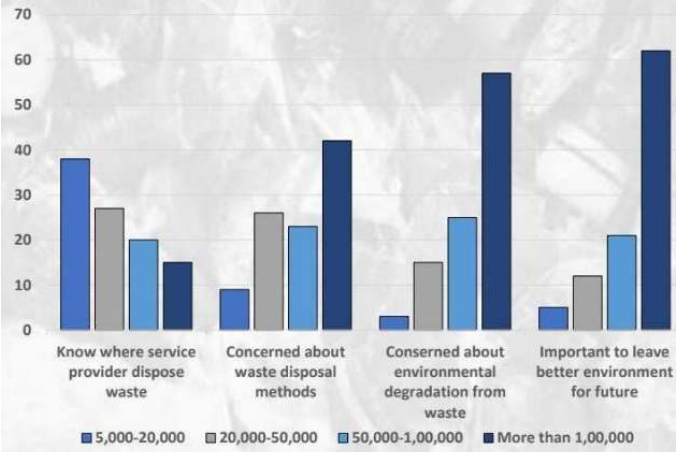


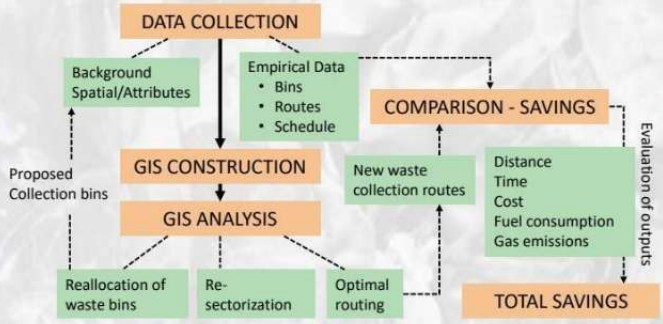
Figure: Awareness of their garbage disposal method

6 SWOT

Strengths	Weaknesses
• Established location of the solid waste management centre • Regular waste collection • Establishment of waste purchase centres • Establishment of recycling centers • Strong information and training programmes to promote waste management in the division. • Waste Taxation • Financial Availability	• Poor dumping management • Inefficient sorting of food waste • Shortcomings in the composting process • Lack of processing capability for lunch production • Failures in sludge fertilizer production
Opportunities	**Threats**
• Installation of a biogas plant in a solid waste management center • Receiving external support from government and industry associations • Five waste separation bins are presented • Application of new technologies for MSW processing	• Insufficient attention to promote environmental research • Invalidity of compost standardization • Filtrate poisoning

7 KEY FINDINGS AND PROPOSAL

PROPOSAL METHODOLOGY



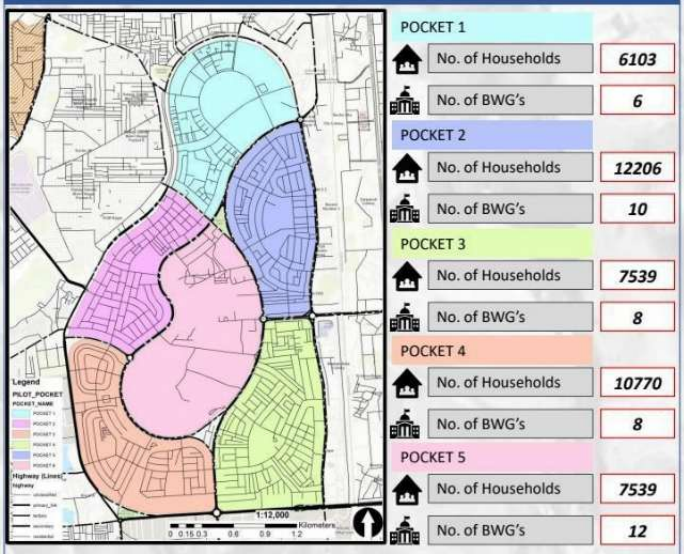
RE-LOCATION OF WASTE COLLECTION POINTS AND BINS

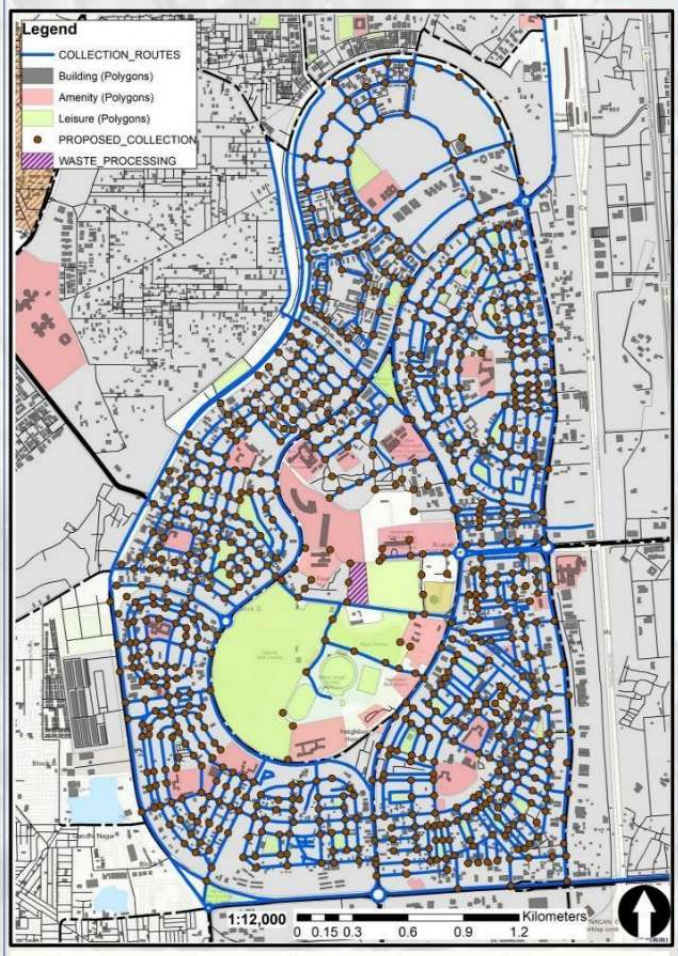
The allocation of waste collection points in their newly proposed locations was based on the following criteria /restrictions:

- On the basis of the population density and the type of buildings in the study area, Electric Waste Disposal Vehicle of loading Capacity: 1800 kg were considered preferable, in order to minimise the number of vehicle trips and stops.
- The required number of points (N) was calculated to cover the waste production of the sector for a five trips per week schedule (D=7/5), assuming a waste density in the bin of ρ=150 kg.m-3, and a coefficient of filling the bin, ε = 0.80 of its capacity, according to the equation : **N = WDx D / (V x ρ x ε)** where WD (kg) is the daily waste quantity and V (m3) is the tipper capacity. A 10% safety margin was added to this number
- these bins are allocated in the study area according to the following rules:
  - allocate collection point on the road network (intersections are preferable)
  - Propose two collection points after the buffer of minimum 100m buffer
  - allow the placement of more than one collection point in the same intersection

Sr. No	Sources	Quantity
1	Total length of roads and streets to be covered by waste tippers and push carts	155 Km
2	Total no. of collection points	382
3	Total number of trips to be covered by tippers per day	80
4	Waste generated per day in selected pilot area	146 Tons

ROUTING FOR PRIMARY COLLECTION

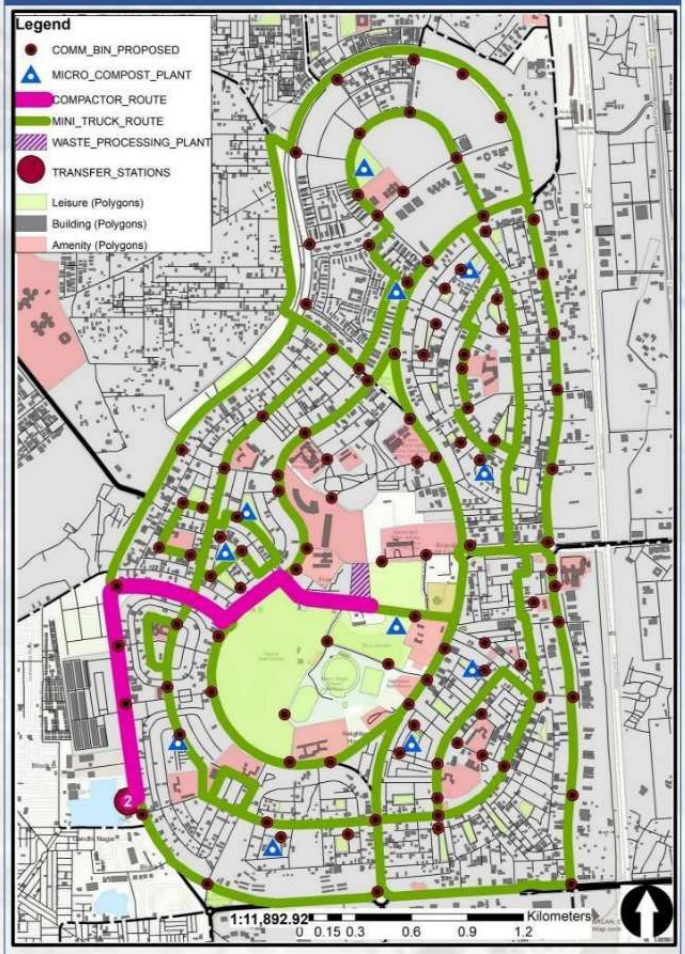




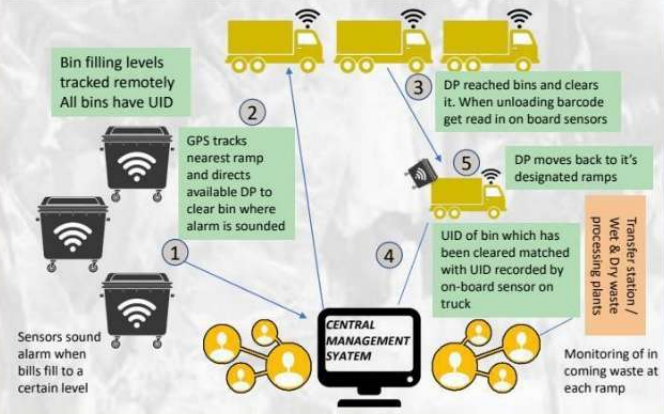
Following are the considerations kept in while proposal:

- Routes are continuous and non-overlapping
- Equal division of households in each pocket
- Collection time of 80% routes are equal
- Congested areas will not be collected during rush hours.
- Consistent collection pattern

ROUTING OF SECONDARY COLLECTION

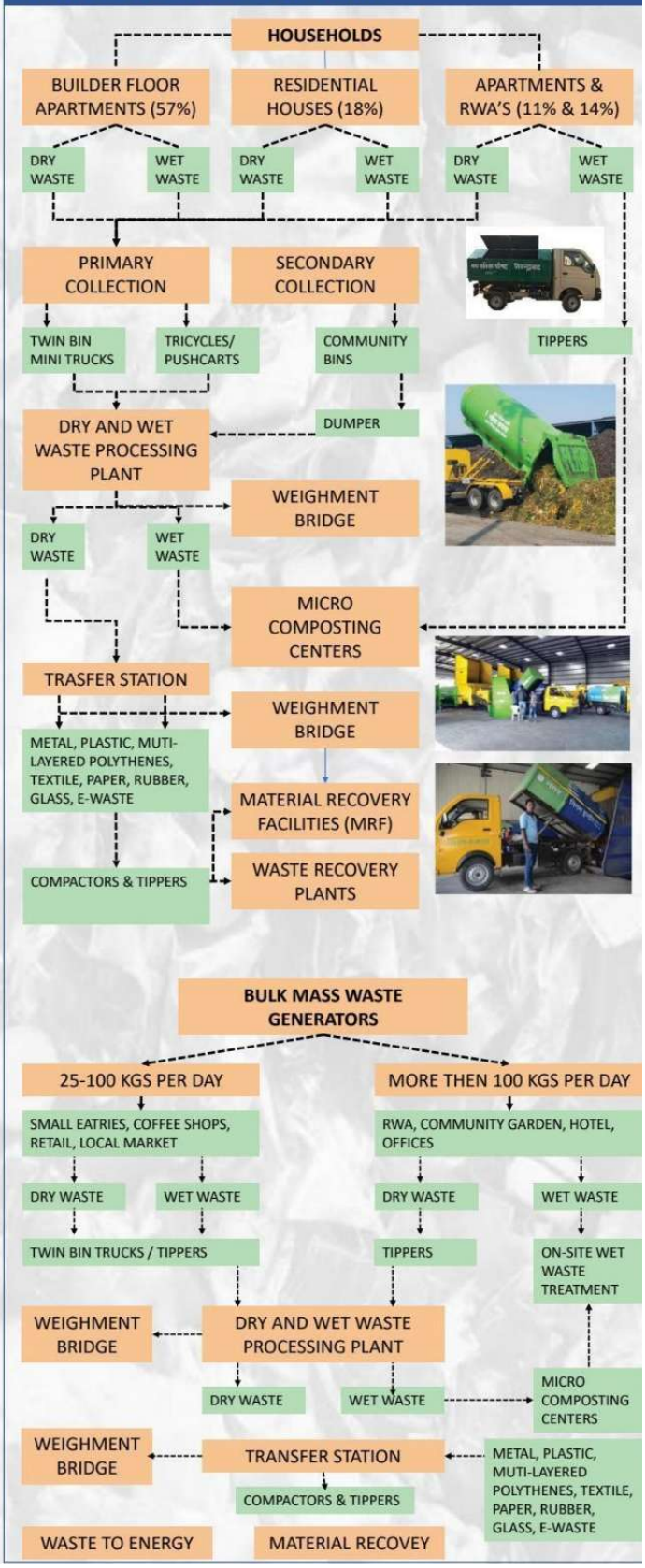


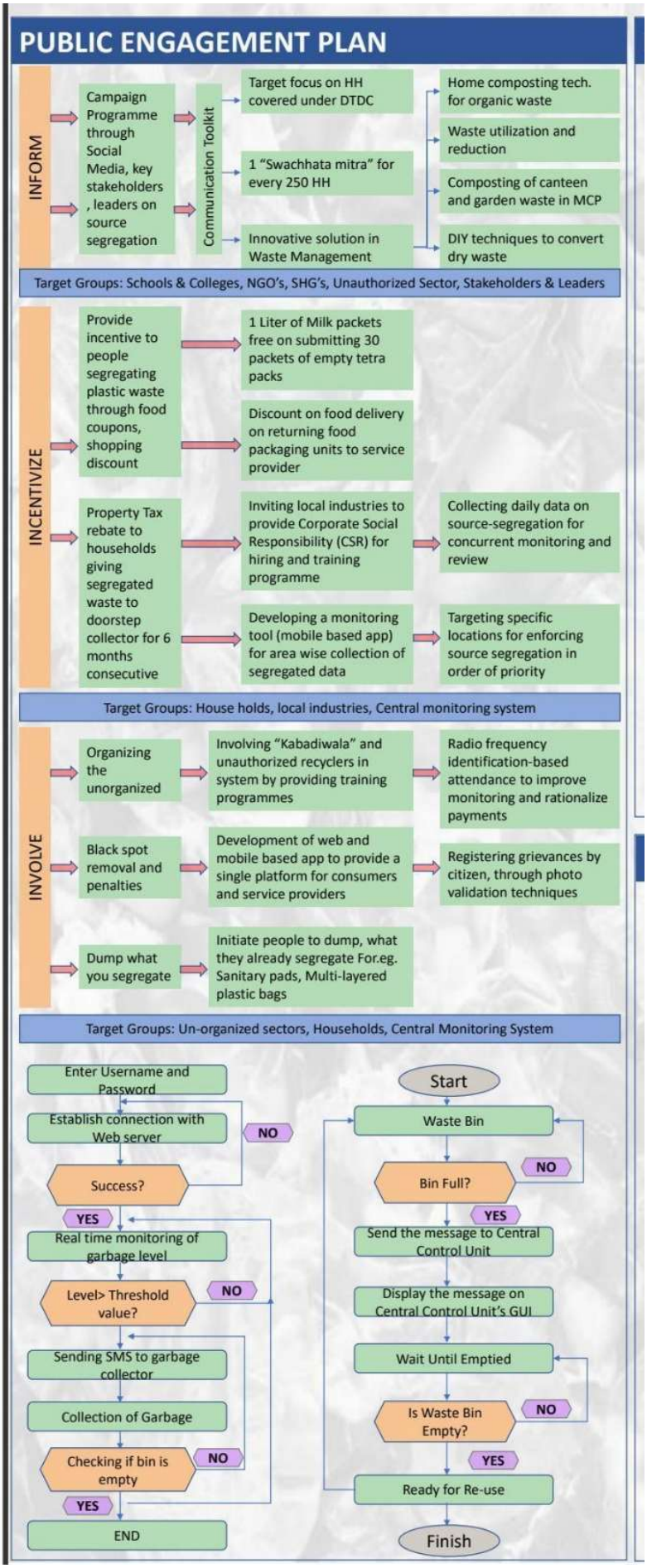
The reallocation of bins was based on travel distance from each person from public zone to the nearest bin and the general intention to decrease the total number of bins. A maximum travel distance of 60 meters from each public place is proposed.



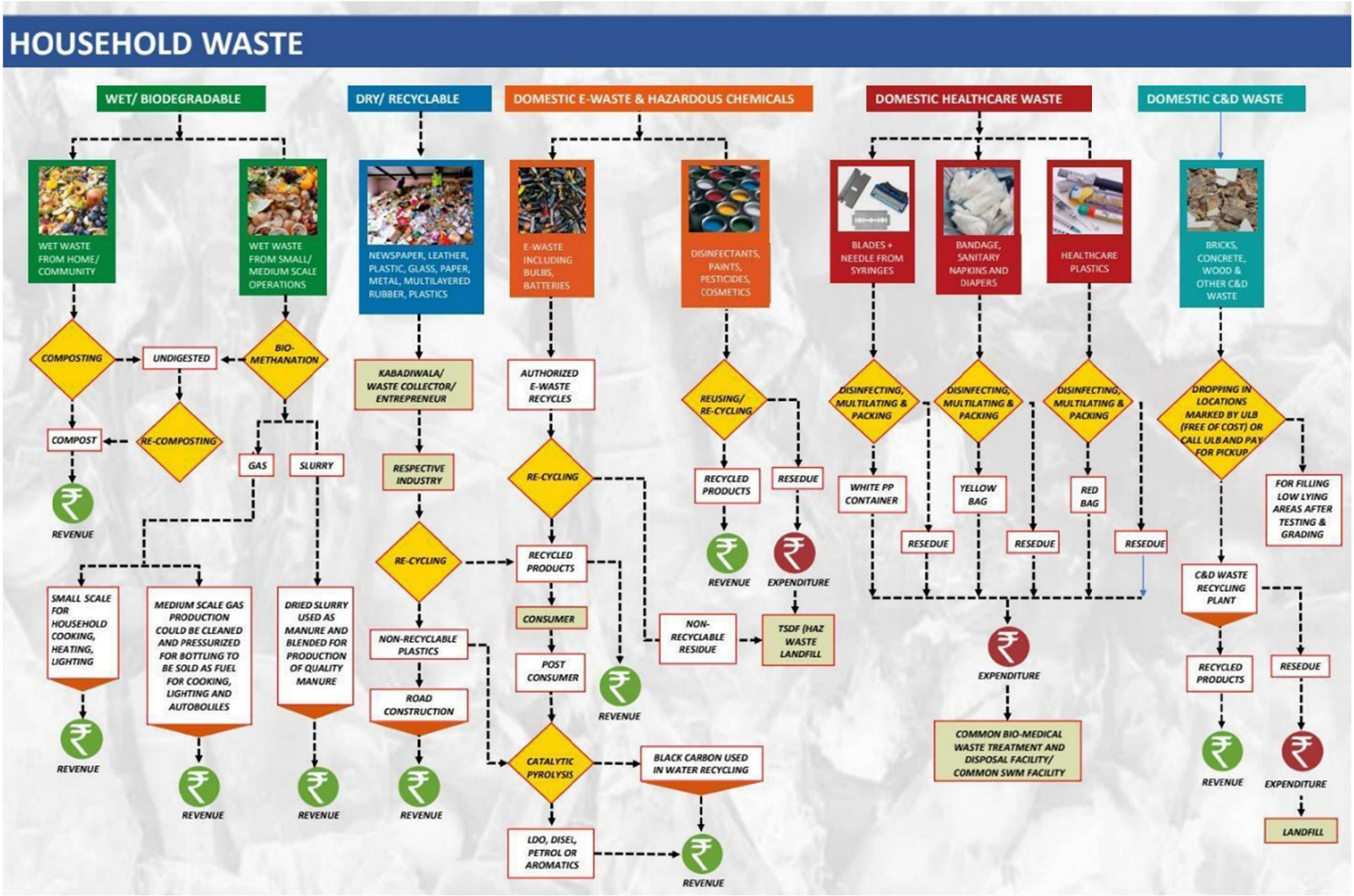
IT SWM monitoring system to track all types of waste streams from a centralized monitoring system.
Creation of a dashboard to provide information on all

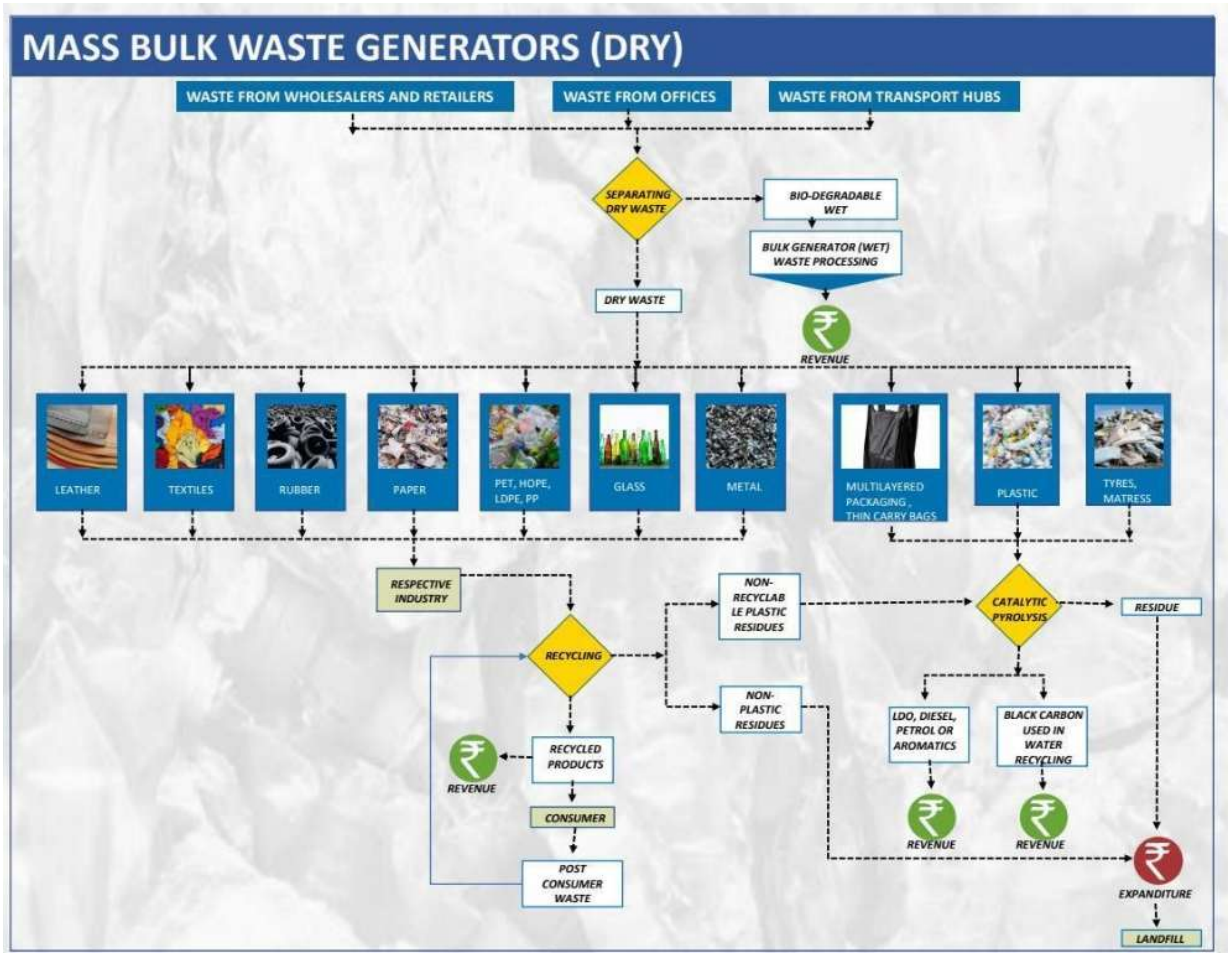
PROPOSED PLAN FOR SWM

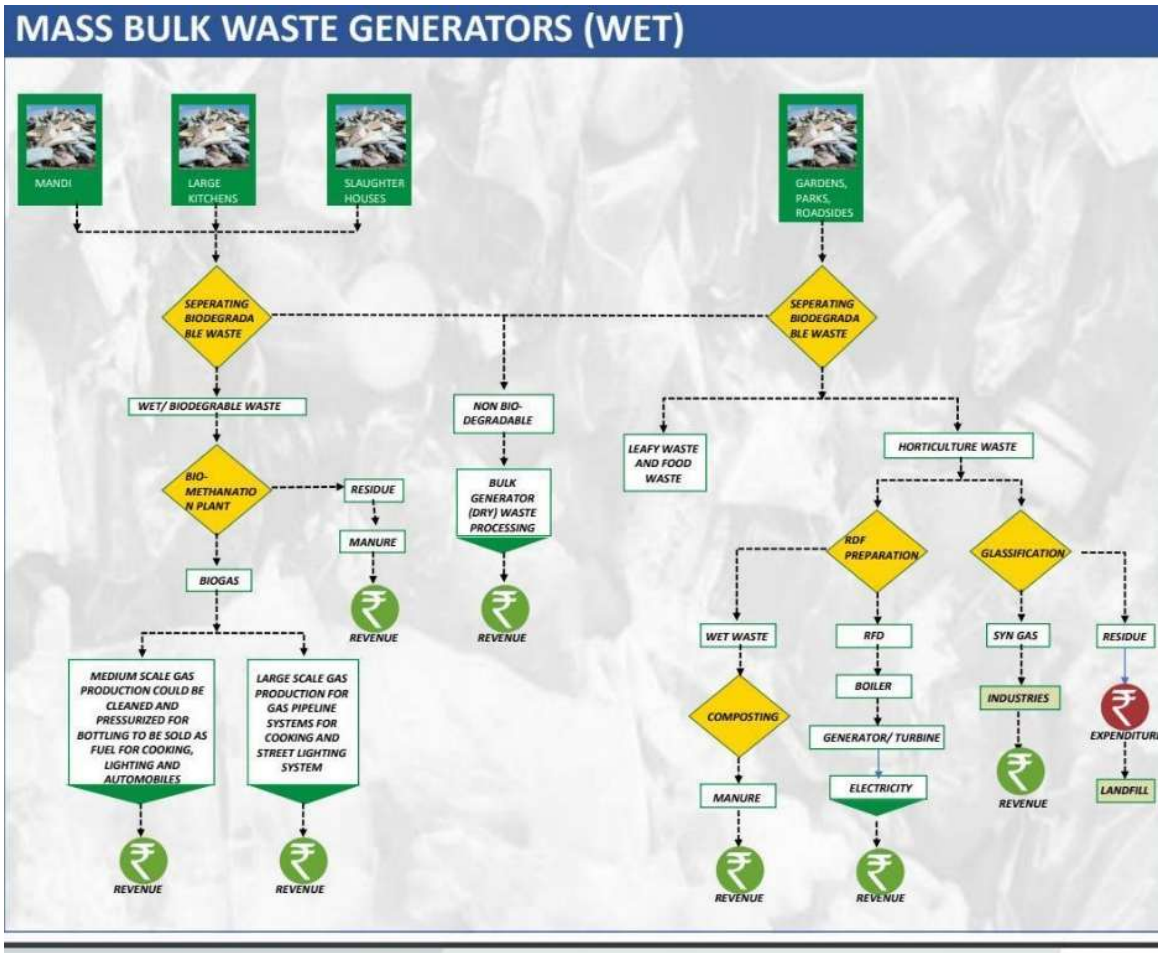



PUBLIC ENGAGEMENT PLAN
INFORM
Campaign Programme through Social Media, key stakeholders , leaders on source segregation
Communication Toolkit
Target focus on HH covered under DTDC
1 "Swachhata mitra" for every 250 HH
Innovative solution in Waste Management
Home composting tech. for organic waste
Waste utilization and reduction
Composting of canteen and garden waste in MCP
DIY techniques to convert dry waste
Target Groups: Schools & Colleges, NGO's, SHG's, Unauthorized Sector, Stakeholders & Leaders
INCENTIVIZE
Provide incentive to people segregating plastic waste through food coupons, shopping discount
1 Liter of Milk packets free on submitting 30 packets of empty tetra packs
Discount on food delivery on returning food packaging units to service provider
Property Tax rebate to households giving segregated waste to doorstep collector for 6 months consecutive
Inviting local industries to provide Corporate Social Responsibility (CSR) for hiring and training programme
Collecting daily data on source-segregation for concurrent monitoring and review
Developing a monitoring tool (mobile based app) for area wise collection of segregated data
Targeting specific locations for enforcing source segregation in order of priority
Target Groups: House holds, local industries, Central monitoring system
INVOLVE
Organizing the unorganized
Involving "Kabadiwala" and unauthorized recyclers in system by providing training programmes
Radio frequency identification-based attendance to improve monitoring and rationalize payments
Black spot removal and penalties
Development of web and mobile based app to provide a single platform for consumers and service providers
Registering grievances by citizen, through photo validation techniques
Dump what you segregate
Initiate people to dump, what they already segregate For.eg. Sanitary pads, Multi-layered plastic bags
Target Groups: Un-organized sectors, Households, Central Monitoring System
Enter Username and Password
Establish connection with Web server
NO
Success?
YES
Real time monitoring of garbage level
Level> Threshold value?
NO
Sending SMS to garbage collector
Collection of Garbage
Checking if bin is empty
NO
YES
END
Start
Waste Bin
Bin Full?
NO
YES
Send the message to Central Control Unit
Display the message on Central Control Unit's GUI
Wait Until Emptied
Is Waste Bin Empty?
NO
YES
Ready for Re-use
Finish

HOUSEHOLD WASTE




MASS BULK WASTE GENERATORS (DRY)
WASTE FROM WHOLESALERS AND RETAILERS
WASTE FROM OFFICES
WASTE FROM TRANSPORT HUBS
SEPARATING DRY WASTE
BIO-DEGRADABLE WET
BULK GENERATOR (WET) WASTE PROCESSING
REVENUE
DRY WASTE
LEATHER
TEXTILES
RUBBER
PAPER
PET, HOPE, LDPE, PP
GLASS
METAL
MULTILAYERED PACKAGING , THIN CARRY BAGS
PLASTIC
TYRES, MATRESS
RESPECTIVE INDUSTRY
RECYCLING
NON-RECYCLABLE PLASTIC RESIDUES
NON-PLASTIC RESIDUES
CATALYTIC PYROLYSIS
RESIDUE
LDO, DIESEL, PETROL OR AROMATICS
BLACK CARBON USED IN WATER RECYCLING
REVENUE
REVENUE
REVENUE
RECYCLED PRODUCTS
CONSUMER
POST CONSUMER WASTE
EXPANDITURE
LANDFILL


MASS BULK WASTE GENERATORS (WET)
MANDI
LARGE KITCHENS
SLAUGHTER HOUSES
GARDENS, PARKS, ROADSIDES
SEPERATING BIODEGRADABLE WASTE
SEPERATING BIODEGRADABLE WASTE
WET/ BIODEGRABLE WASTE
NON BIO-DEGRADABLE
LEAFY WASTE AND FOOD WASTE
HORTICULTURE WASTE
BIO-METHANATION PLANT
RESIDUE
MANURE
BIOGAS
BULK GENERATOR (DRY) WASTE PROCESSING
REVENUE
REVENUE
RDF PREPARATION
GLASSIFICATION
WET WASTE
RFD
SYN GAS
RESIDUE
COMPOSTING
BOILER
INDUSTRIES
EXPENDITURE
GENERATOR/ TURBINE
MANURE
ELECTRICITY
REVENUE
LANDFILL
MEDIUM SCALE GAS PRODUCTION COULD BE CLEANED AND PRESSURIZED FOR BOTTLING TO BE SOLD AS FUEL FOR COOKING, LIGHTING AND AUTOMOBILES
LARGE SCALE GAS PRODUCTION FOR GAS PIPELINE SYSTEMS FOR COOKING AND STREET LIGHTING SYSTEM
REVENUE
REVENUE
REVENUE
REVENUE

IMAPCT EVALUATION

Keeping in view the restraints and challenges posed by the improper and inefficient solid waste management and its ensuing impact on the environment and human health, the following suggestions have been proposed to minimize the magnitude of solid waste problems and to tackle the existing crisis for a sustainable environment and healthy living in FARIDABAD city.

- The door-to-door collection efficiency must be improved for sustainable management of solid waste.
- Ensuring the segregation of solid waste preferably at household level.
- Transport facilities involved in door-to-door collection system should be improvised and made efficient as per the quantity and complexity.
- Secondary waste storage bins in FARIDABAD city should be evenly distributed based on the population density and extent of ward. Traditional sweeping tools and practices need technical change to improve the work productivity.

Vehicles for collection, transportation and disposal should be opted considering the types and amount of waste, distance, and nature of roads.

- Use of green energy resources or alternatives to fuel the large fleets of vehicles involved in solid waste management. This will greatly minimize the emission of Green House Gases.
- Use of Geoinformatics e.g. GIS, GPS and Artificial Intelligence for rationalizing and optimizing the entire process of solid waste management.
- A centralized Sustainable Material Recovery Facility (SMRF) is suggested to establish at FARIDABAD city for sorting, baling plastic, mixed waste paper, paperbased cartons, metals and glass.
- FARIDABAD Municipal Corporation should strictly ban the use of single-use plastic carrier bags in the city.
- The urban local authority should install advance technology to capture the landfill gases, which can be converted into energy production.
- Active participation of the citizens is necessary for proper and efficient management of solid waste.
- Community-based program should be organized to bring awareness among the citizens through awareness devices and also through different print and electronic media.
- It should be made obligatory for everyone to reduce, reuse, recover and recycle the waste for a neat and clean environment and healthy living.
- Older core areas and newly emerging parts of the cities are more vulnerable and hence needs sustainable handling of wastes in comparison to other developed areas.
- Master plan should be strictly followed.
- Extension of basic amenities and services to urban poor.
- Schemes for waste management should be prioritized and quality of sanitation should be focused.
- Create effective, reliable, and socially acceptable SWM systems.
- Promote new technologies and financing mechanism.
- Update the legislative framework, strengthen the asset and technical base and

INDICATORS	IMPACT EVALUATION
1. Inclusiveness	The program, through awareness and capacity building, covers all stakeholders critical for ensuring segregated waste at source. These includes residents, housekeeping staff, domestic help, waste workers and unorganized sector (Kbadiwala).
1. Relevance	The program is aligned to the SWM Rules (2016) and will help to met its objectives. In addition, it contributes in achieving Sustainable Development Goals 3,6, 8, 11 and 13 which deal with well being, clean water and sanitation, economic growth, sustainable cities and communities and climate action respectively.
1. Effectiveness	In this case, effectiveness evaluation was determined through behavioral change and capacity building of the stakeholders
1. Convergence	The program will facilitate the range of stakeholders. It will include private players, national agencies, non-profit organizations, Municipal Corporation and citizens. Through this strategy, the program will help to achieve certain waste management objectives and provided policy inputs for the Swachh Bharat Mission, a national mission under the Ministry of Housing and Urban Affairs (Government of India).
1. Sustainability	It was essential to build an enabling environment to sustain the program. Its continuance had to be ensured even after the direct involvement of the implementation agency and the withdrawal of support from the donor. This will help putting in place a governance structure, finance model and operating system.
1. Environmental impact	If on an average 21 societies, will compost 8.9 tons of wet waste everyday. This will lead to reduction of GHG emissions by 12,000 tons CO2 equivalent per year, with an estimated social cost of INR 42 million.
1. Economic benefit	It economically empowers the waste workers by increasing their monthly income. It helps in reducing the number of injuries among waste workers while collecting and sorting trash. It will save time and money on accessing healthcare. At the city-level, there will be saving on tipping fee which is now paid by the MCF to vendors to clear waste from societies. All these residential complexes will now have an onsite compost facility
1. Social benefit	Sensitize and enhance knowledge of residents, volunteers and housekeeping staffs towards environment. Increase economic benefit and quality of life. Fostering social entrepreneurship growth in waste management sector Economic benefits to the on-site compost workers.

3 REFERENCES

References

Agrawal, A, (2017), Solid Waste Management in Indore City: A Review, International Research
Journal of Engineering and Technology, Vol. 4 (11), pp. 1906-1909
Alam ,T. , Kumar, A., Tiwari, A. and Shukla S.P., (2018), Recent Progress In Waste Management
System Of FARIDABAD: A Minor Review, International Conference On Recent Innovations In
Science And Engineering, Buddha Institute Of Technology , Gida Gorakhpur, India
Al-Delaimy W.K., Larsen C.W. and Pezzoli K., (2014), Differences in Health Symptoms Among
Residents Living Near Illegal Dump Sites in Los Laureles Canyon, Tijuana, Mexico: A Cross
Sectional Survey. International Journal Environment Res Public Health. Vol.11(9), pp. 9532–
52.
Annepu, R.J. and Themelis, N.J., (2012), —Sustainable Solid Waste Management in Indiall, Sponsered
by Waste-to-Energy Research and Technology Council, Columbia University, Earth Engineering Centre.
Archana, Ali, D., Yunus, M. and Dutta, V.(2014), Assessment Of The Status Of Municipal Solid Waste
Management (MSWM) IN FARIDABAD- Capital City Of Uttar Pradesh, India, IOSR Journal Of
Environmental Science, Toxicology And Food Technology, Vol. 8, pp. 41-49
Asnani, P.U. (2006), Solid Waste Management, in India Infrastructure Report, 2006, pp. 161-189.
Basel Convention (1986), The Control of Trans boundary Movement of Hazardous Waste and Their
Disposal, Basel, Switzerland
Benson,N.U., Bassey D.E. and Palanisami T. (2021), Covid Pollution: Impact of Covid-19 Pandemic on
Global Plastic Waste Footprint.
Bhat, R.F., DAR, S.H. et al., (2018), Municipal Solid Waste Generation and current Scenario of its
Management in India, International Journal Of Advance Research in Science and Engineering,
Vol. 07 (2), pp. 419-431.
Bhide A.D. and Sundersan, B.B. (1983), Solid Waste Management in Developing Countries, Indian
National Scientific Documentation Centre, New Delhi.
Bhide, A D and Sundaresan, B B (1983), Characteristics of Solid Waste, Solid Waste Management in

Developing Countries, Indian National Scientific Documentation Centre,New Delhi, pp 17-23
Bhide, A. D. and Ittwala, P. S. (1973), Studies of Settlement of Refuse. Proceeding Symposium of
Environmental Pollution, CPHERI, Nagpur17-19th January, pp.229-235
Boadi K.O., Kuitunen M., (2005), Environmental and health impacts of household solid waste handling
and disposal practices in third world cities: the case of the Accra Metropolitan Area, Ghana. J
Environ Health.
Boojh, R. (1986), Promoting Waste Management- Issues and Strategies Proceeding Nation Seminar on
Waste Management, march 25-26, FARIDABAD University and Centre for Environmental
Education FARIDABAD.
Burlea-Schiopoiu A, Ogarca RF, Barbu CM, Craciun L, Baloi IC, Mihai LS (2021), The impact of
COVID-19 pandemic on food waste behaviour of young people. J Clean Prod 294:1263
Bundela, P.S., Gautam, S.P., Pandey, A.K., Awasthi, M.K., & Sarsaiya, S., (2010), Municipal solid
waste management in Indian cities. Int. J. Environ. Sci. 1 (4), 591–605.
Celis JE, Espejo W, Paredes-Osses E, Contreras SA, Chiang G, Bahamonde P (2021), Plastic residues
produced with confirmatory testing for COVID-19: classification, quantification, fate, and
impacts on human health. Sci Total Environ 760:144167
Central Pollution Control Board (2012) Consolidated Annual Review Report on Municipal Solid