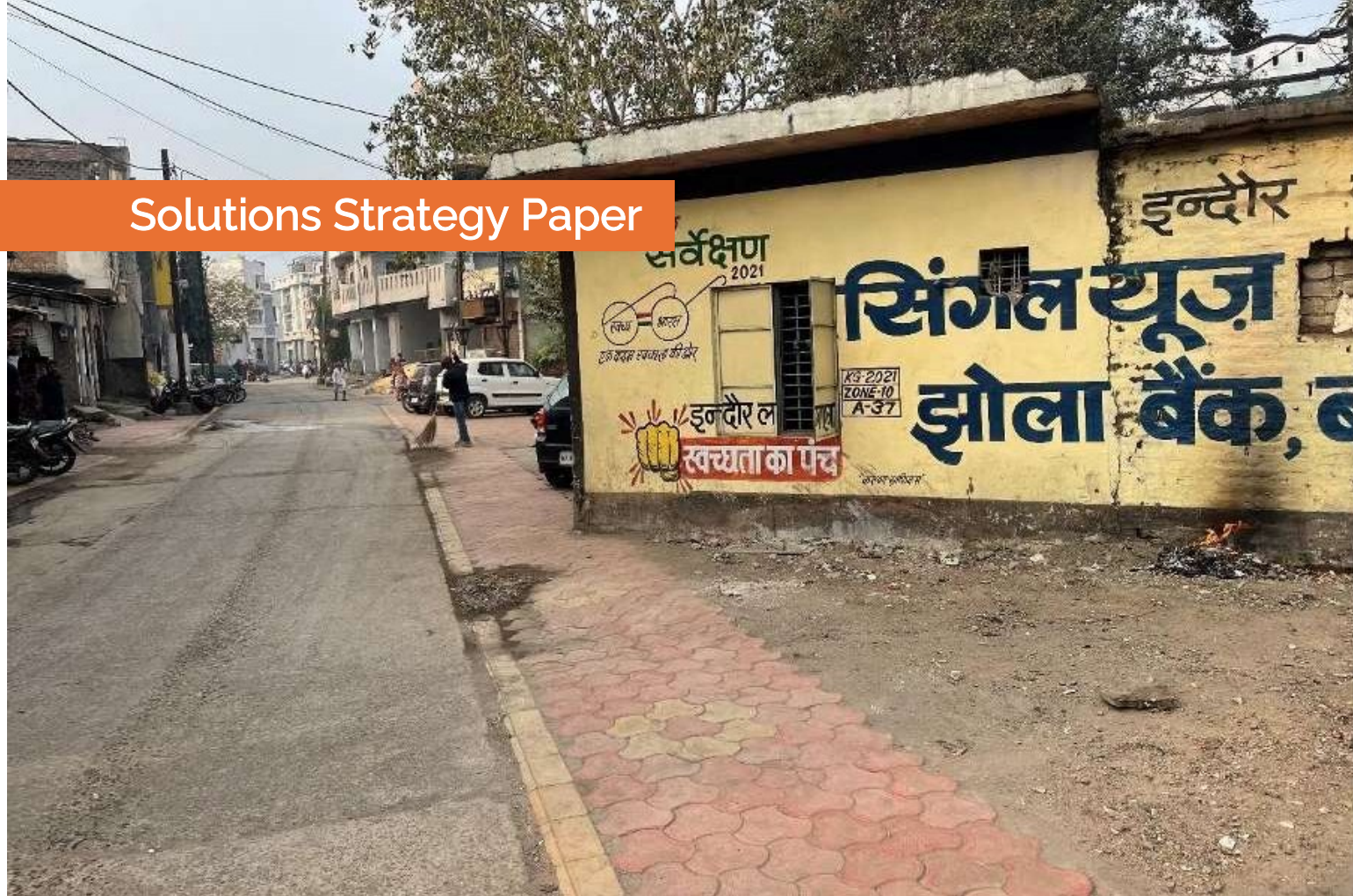




CLEAN AIR CATALYST

Opportunities to Reduce Open Burning of Municipal Solid Waste (MSW) in Indore Municipal Corporation Area

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1. INTRODUCTION

The Clean Air Catalyst (CAC) seeks to design and advance clean air actions that address the underlying drivers of pollution and deliver clean air along with climate, health, equity, and gender co-benefits.

The CAC functions across three pilot cities – Jakarta (Indonesia), Indore (India), and Nairobi (Kenya) – and works with local teams and stakeholders to implement clean air actions. Each pilot undertakes a source awareness process in which data is gathered on the sources of air pollution that are the most compelling to address. This is followed by a solutions process that comprises a root cause analysis. There is a lengthy list of clean air actions (grouped into broader clean air solutions categories, such as public transportation, waste burning, and industry) that will help address the root causes of pollution. The actions that are the most impactful and implementable (based on political feasibility and a “cross-cut” analysis of the impacts of an action on climate, gender, equity, and health) are shortlisted. Under gender diagnostics, data and information is analysed to understand which gender type is affected/impacted by air pollution and in what ways, while identifying any disparities or inequalities that may exist. This Solutions Strategy Paper outlines the clean air actions for the waste-burning sector and can be implemented by the coordination and coalition of relevant stakeholders and govt. agencies. The CAC is supported by a coalition of relevant stakeholders who can also support implementation.

Working in three different cities has forced the CAC to adapt its approach to each context while continuing to be true to its original purpose. The work of CAC builds on the progress that other actors have made in addressing air pollution and offers new and intersectional perspectives to air quality, climate, and gender spaces. We hope to encourage continued action in our pilot cities while simultaneously inspiring other cities to utilize the CAC approach.

In each pilot, the CAC works closely with stakeholders in order to a) understand and complement the existing ideas and initiatives; and b) stay aligned with the political and economic realities of implementing the clean air actions.

The CAC approaches clean air actions in a way that addresses the root causes of air pollution. Clean air action refers to an identified change that stakeholders in a community can make to transition from the status quo to a state that would result in reduced emissions or reduced exposure to pollution. The nature of this change is not fixed or definitive. It could either be a regulation of a fine on driving a vehicle with an outdated exhaust system or a change in building codes to improve passive cooling in buildings, reducing the need for energy intensive air conditioning and limiting the need for coal-powered peaker plants in a community. When considering what constitutes clean air action, it is necessary to have clarity on how the intervention will lead to emissions reduction or reduced exposure. An indicator measures the intent and potential impact of an action. In case an action is not implemented within the project time period, it will not be disqualified from being a part of the indicator.

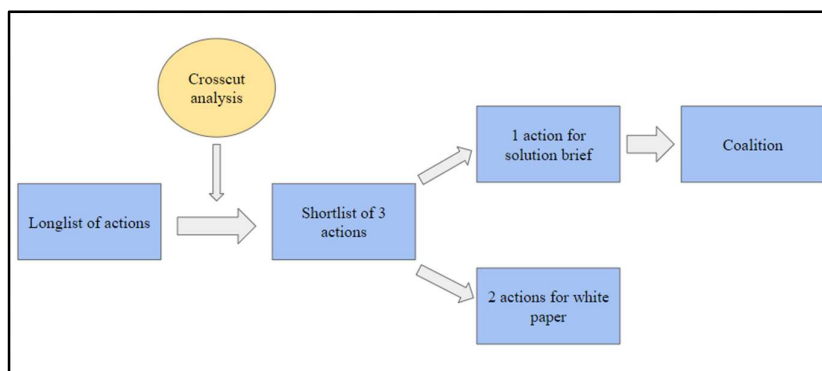


Figure 1: Overview of solutions narrowing process

The clean air solutions shortlisted for Indore are related to transport, industry, and waste burning. This Solutions Strategy Paper describes the root causes of waste burning in Indore Municipal Corporation (IMC) as well as the ways to mitigate it. The solution comprises three parts:

1. Identifying the root causes
2. Developing solutions at the city and ward levels
3. Outlining ground-level implementation and potential impacts

The Solutions Strategy Paper provides a potential road map for the implementation of the recommended actions for the waste sector. Selected excerpts and/or derivative products of the Solutions Strategy Paper will be presented to the stakeholders in order to build awareness of the solutions and as part of the engagement and advocacy strategy. This research also identifies the vulnerable communities disproportionately impacted by air pollution in Indore, including women, children, the elderly, and low-income populations. A survey on waste burning conducted across high, medium, and low socio-economic status (SES) areas as well as industrial zones of the city revealed significant disparities in instances of municipal solid waste (MSW) burning.

The highest intensity of MSW burning mass was observed in low SES and industrial areas during the summer season. In the winter season, it was the highest in industrial areas, followed by the low SES areas. These variations are influenced by limited waste management infrastructure and resources in the low SES areas. Understanding these disparities is crucial for designing targeted and context-specific waste management strategies that address the unique challenges faced by different socioeconomic strata and industrial zones.

However, there are significant gaps in the data on waste management and open burning practices. There is a lack of data on the exact number of women waste pickers in Indore, their distribution across different neighborhoods, and their socio-economic backgrounds. Without this data, it would be challenging to assess the scale of their involvement in waste picking activities and understand the specific challenges they face. Similarly, there are gaps in data on the income levels, livelihood strategies, and household dynamics of women waste pickers in Indore, as well as their role in waste disposal. Understanding their socio-economic circumstances is crucial for designing programs aimed at poverty alleviation, skill development, and alternative income generation opportunities.

In this Solutions Strategy Paper, a gender analysis framework has been used to understand the differential impacts. This framework considers the social, economic, and cultural factors that influence the gendered experiences of air pollution, facilitating the examination of disparities in exposure, susceptibility to health effects, access to resources, and participation in decision-making processes related to air pollution mitigation. The issues identified, including the significant impact of waste burning on women and marginalized communities, have been incorporated in the recommendations and their design (presented in subsequent sections 6 and 8 of this report). These actions aim to address the specific challenges faced by these groups, ensuring that interventions are equitable and effective in improving air quality and public health outcomes.

2. A Brief Analysis of Current Policy on Waste Management and Burning (National and City Levels)

Managing MSW in India is a significant challenge, driven not only by environmental and aesthetic considerations but also by the staggering volumes generated on a daily basis. According to the Census of India 2011, 31% (or 377 million) of the population resides in urban areas. In 2021, 160,038 metric tons of MSW was produced per day in urban India, according to the Central Pollution Control Board (CPCB). This MSW is managed mostly in an unplanned manner, leading to environmental degradation and significant health issues for all. Improper waste management leads to the burning of waste, which ultimately contributes to worsening air quality in the region and disproportionately impacts low-income communities, especially women, children and the elderly. Due to the growing concern over the years, the Central and state governments have introduced policies, programs, and regulations.

Indore City has made remarkable progress in solid waste management (SWM). However, during the primary survey, incidences of MSW burning were observed. The survey was carried out under CAC to understand incidences, quantities, locations, and causes of waste burning. MSW burning contributes around 2.5% of all PM 2.5 emissions in Indore, as per the estimates of the CAC Indore emissions inventory. This section is a thorough review of the existing policies and programs available at various governance levels, which has been conducted to better evaluate the possible strategies for the mitigation of air pollution from MSW burning.

2.1 Swachh Vayu Survekshan

Swachh Vayu Survekshan (SVS) is an initiative proposed by the Ministry of Environment, Forest & Climate Change (MoEF&CC), Government of India, to rank cities based on air quality and implementation of activities approved under city action plans in the 131 non-attainment cities. This ranking is determined by evaluating air quality and the effective execution of initiatives endorsed within the city action plans. SVS allocates percentages to each of the identified sectors (MSW/biomass burning, construction and demolition waste, household cooking, industries, vehicular emissions, and road dust) responsible for air pollution. These control measures for each sector are further subdivided into essential components to facilitate more manageable handling. For instance, the MSW/biomass burning sector is segmented into six distinct components: waste generation, waste collection, processing, legacy waste handling, the prohibition of municipal waste burning, and plastic waste collection.

Challenges: City rankings are determined on the basis of self-assessment reports submitted by Urban Local Bodies (ULBs). However, this method may occasionally prove less efficient due to inconsistent standards and lack of individual verification and efficiency assessment by third parties. Effective enforcement of these implementation measures remains a formidable task. For example, the SVS provides marks based on different waste management practices such as MSW collection, processing, and disposal without factoring in the actual execution of these control measures, as these are self-reported. Simply addressing collection, disposal, processing, and prohibition of waste burning does not guarantee the prevention of these incidents. Also, looking at the diverse culture and different languages spoken across India, the sensitization and capacity building awareness programs should be designed and disseminated in local languages.

Opportunities: SVS will create awareness among the public about air pollution and related health impacts due to air pollutant exposure. Healthy competition among the cities will lead to overall improvement in air quality, thereby achieving the goal of National Clean Air Program (NCAP), which is "Clean air for all". An annual assessment of the cities would help with continuous growth and overall improvement.

2.2 Swachh Bharat Mission

The Swachh Bharat Mission (SBM) is a national initiative of the Government of India to clean cities. It covers 4,041 statutory cities and towns. The mission's goal is to make India clean by providing sanitation facilities for all households, including toilets, solid and liquid waste disposal systems, and secure and sufficient drinking water supply. This policy targets waste collection and disposal, which directly impacts MSW burning.

In 2023, there was an increased focus on several key aspects of waste management (PIB, May 2022). These included prioritizing the segregation of waste at its source, boosting the capacity for waste processing in urban areas to align with the rate of waste generation, and minimizing the amount of waste being deposited in landfills. In addition, a set of new indicators have been introduced to underscore the importance of gradually reducing plastic usage, improving the management of plastic waste, promoting the creation of waste-to-wonder parks, and organizing zero-waste events.

Under SBM, an annual cleanliness survey Swachh Survekshan is conducted, which is led by the Ministry of Housing & Urban Affairs (MoHUA). It is the largest urban sanitation survey globally. The survey serves as a pivotal tool in accelerating governance, aiding India in achieving sustainable sanitation and waste management goals while transforming the Government of India's approach to key development goals. Through its comprehensive data collection and rigorous assessment methods, Swachh Survekshan fosters a spirit of competition among cities, driving improvements in urban sanitation and waste management to enhance service delivery for citizens. This ranking exercise evaluates both rural and urban areas on their cleanliness and the active implementation of Clean India Initiatives under SBM, promoting large-scale citizen engagement and raising awareness about the collective effort needed to make towns and cities better places to live in.

In 2018, the Department of Drinking Water and Sanitation (DDWS) initiated the Swachh Survekshan Grameen (SSG) to evaluate the sanitation parameters in rural India (Swachh Survekshan Grameen Toolkit, 2023). For the SSG 2023, a new self-assessment module for Gram Panchayats (GPs) is being proposed to encourage participation at the local level. Through this approach, more than 2.5 lakh GPs will have the opportunity to engage in the SSG 2023 process. Peer verification will take place at the block level, where villages selected will undergo further assessment at the district, state, and national levels. This comprehensive evaluation process aims to identify and recognize the most exemplary Panchayats across the country.

Challenges: SBM aims to reach 100% scientific disposal (managing various types of waste through diverse disposal methods) of MSW, which is yet to be achieved. Creating awareness among the residents and engaging the stakeholders to achieve this target is a time-consuming process and requires more rigorous efforts (SBM: We may be ODF, but not garbage free, 2021).

Opportunities: The main target of SBM is to improve the general quality of life in rural and urban areas, accelerate sanitation coverage, and provide management of solid waste. SBM reviews the hygiene, sanitation, and SWM of villages, cities, and towns across the country under Swachh Survekshan, thereby reaching all levels of society.

2.3 Solid Waste Management Rules, 2016

The SWM Rules, 2016, replaced the Municipal SWM Rules, 2000. The salient features are as follow:

- The segregation of waste at source is compulsory.
- Infrastructure must be provided for the collection of solid waste from all households with a door-to-door collection system.
- MSW should not be openly dumped, burned, or buried on the streets, open areas, public spaces, drains, and water bodies.
- Informal waste pickers and ragpickers must follow proper waste management practices endorsed by municipalities and urban local authorities.
- Urban local authorities can charge a user fee for bulk generators to collect and process their waste.
- Non-recyclable waste with a calorific value of 1,500 kilocalories (kcal) or more must not be disposed of into landfills and must be used solely to generate energy through either refuse-derived fuel from waste or distribution as feedstock.

Challenges: The main challenges that persist are open MSW burning due to behavioral issues, community awareness about open MSW burning, and waste collection issues in newly added wards. Streamlining and training of informal waste pickers about proper waste management and consequences of waste burning is missing.

Opportunities: Various interventions have been implemented as per SWM Rules, 2016, in many cities, such as preparation of MSW management plans, door-to-door collection, and establishment of refuse transfer stations and centralized waste processing treatment plants.

2.4 Plastic Waste Management Rules, 2016

The Government of India has notified the Plastic Waste Management Rules, 2016, (MoEF&CC) according to which every local body is responsible for setting up the infrastructure for segregation, collection, processing, and plastic waste disposal. The concept of Extended Producer Responsibility (EPR) was introduced as part of these Rules. EPR is a policy in which product manufacturers are responsible for collecting and processing their products at the end of the products' lifetime.

Challenges: Some of the challenges associated with plastic waste management include setting up material recovery facilities at a decentralized level and limited reuse of plastic. Informal workers operate outside regulatory frameworks, leading to uncontrolled waste disposal practices. Integrating them in formal waste collection is not a part of the plastic waste management rules so far.

Opportunities: Under the Plastic Waste Management Rules, 2016, single-use plastic was banned. As a replacement, coconut shells and clay pots were used to replace glass and bowls, and cloth bags were promoted to carry the items (grocery, vegetables, fruits, other items).

2.5 Plastic Waste Management Bylaw, 2021

As per the Plastic Waste Management Bylaw, 2021, (Urban Development and Housing Department, Government of Madhya Pradesh), IMC established and maintains the infrastructure dedicated to the segregation, storage, collection, transportation, processing, and disposal of plastic waste. In addition, awareness is generated by involving stakeholders and communities, civil societies, and self-help groups. Conducting cleanliness campaigns combined with efforts to prevent the open burning of plastic waste are some of the tasks under this bylaw.

2.6 Safaimitra Suraksha

On November 19, 2020, a national-level competition called the Safaimitra Suraksha Challenge (SSC) was launched, with the primary objective of ensuring zero human casualties during hazardous sewer and septic tank operations (PIB, March 2023). The aim was to eliminate manual entry in such environments, whenever possible and, when unavoidable, ensure that workers were equipped with proper Personal Protective Equipment (PPE) and safety kits. The focus areas of the SSC for all participating cities across all states and Union Territories included the following:

- (a) Promoting mechanized cleaning of sewers and septic tanks to reduce the need for manual entry
- (b) Ensuring the availability of protective gear and equipment for workers in cases where manual entry cannot be avoided
- (c) Training a skilled workforce capable of handling sanitation tasks safely
- (d) Establishing a 24x7 helpline with extensive outreach to citizens to report sanitation-related issues and emergencies

Challenges: Managing and implementing such a large-scale operation, efficient work integration, and use of tools, equipment, and safety gears in a structured manner is a challenge. It is important to note that manual scavenging is an informal sector, with jobs segregated along gender lines and, therefore, any intervention requires a gender-aware approach to improve the working conditions. Manual scavenging broadly takes two forms split along gender lines. These are men who are engaged in cleaning of sewers and women going from house to house, clearing waste from deep holes used as toilets (Rahman, 4 March 2018). These gender-based disparities, especially for female manual scavengers facing disproportionate risks and discrimination in the sanitation sector, and marginalized communities, in addition to caste-based discrimination in the manual scavenging sector may pose barriers to accessing the benefits of the scheme, highlighting the need for inclusive participation and representation. Furthermore, it is important to acknowledge and address the broader socioeconomic factors contributing to manual scavenging, such as limited economic opportunities and social stigma, necessitating a more comprehensive approach to promote gender equality, empower marginalized communities, and address systemic inequalities in the sanitation sector.

Opportunities: This program aimed to drive improvements in sanitation practices, enhance worker safety, and promote the overall well-being of those involved in sanitation work while working towards the goal of eliminating manual entry into hazardous environments. This program directly and indirectly promotes cleanliness in the city and workers' health.

Occupational segregation by gender in the manual scavenging sector and among ragpickers presents a unique opportunity to integrate a gender-responsive approach in programs, schemes, and policies, which addresses the specific needs and challenges

faced by women and men in this field. Women, particularly female manual scavengers and ragpickers, often bear the brunt of the health hazards associated with exposure to pollutants in this sector, including toxic gases and contaminated waste. Their experiences are further compounded by societal norms and gender roles, which may limit their access to protective gear, healthcare, and economic opportunities. In contrast, men may face different but equally significant health risks and challenges. For example, the issues faced by female ragpickers include harassment by strangers and teasing on the streets as well as physical intimidation by territorial families. Lack of protection affects all informal pickers, as they often receive cuts from glass and metal. Dog bites and pig bites are problematic, especially because most waste pickers do not have the money for medical treatment (International Alliance of Waste Pickers). Therefore, tailored approaches to address these gender-specific and equity related issues is essential for promoting the safety, health, and dignity of all sanitation workers. This entails providing gender-sensitive training and support services that recognize and respond to the distinct needs and vulnerabilities of women and men in the sector.

3. Profile of Waste Management in Indore

Indore, located at coordinates 22.7196° N latitude and 75.8577° E longitude, is renowned for being the cleanest city in India for the past seven years (2017-2023) in the annual Swachh Survekshan. With a current population of approximately 3 million, the city faces the formidable task of managing over 1,176 metric tonnes (MT) of daily waste generation and per day/person generation of 397 grams (0.39 kg). The city is geographically divided into 19 zones and further subdivided into 85 wards.

The first step towards setting up the SWM in Indore City involved coordinating the establishment of formal systems and facilities to handle waste collection, segregation, and transportation. This also encompassed the acquisition of vehicles for waste collection and transportation, as well as the provision of training for municipal and sanitation personnel. The next step was to engage the community through awareness building initiatives at multiple levels, including Resident Welfare Associations (RWAs), commercial establishments, and social organizations. Large-scale awareness campaigns were facilitated with the active mobilization of various non-governmental organizations (NGOs).

Since 2020, there has been an increased emphasis on strengthening public participation and awareness. Additionally, technological advancements have been introduced to enhance waste management. There has been a transition from the traditional three-bin segregation system at home to a more comprehensive six-bin system. Furthermore, initiatives such as harnessing waste for economic benefit through carbon credits, the establishment of bio-CNG plants, and the implementation of dry waste processing plants at landfill sites have been initiated.

The waste is gathered directly at its source, be it residential or commercial areas. Started in 2016, the collection process employs specialized vehicles called "tippers" to execute door-to-door waste collection. More than 1,700 vehicles have been deployed for the transportation of waste in a segregated manner. Around 624 vehicles are used for door-to-door waste collection and transportation. The entire collection and transportation vehicle fleet is equipped with GPS-enabled tracking systems, which are continuously monitored by a dedicated monitoring cell (Smart City - IMC).

While the formalization of waste management is undoubtedly a welcome step, it is imperative to acknowledge and address upfront the potential loss of livelihoods for ragpickers, especially informal waste collectors who play a significant role in the waste management ecosystem. In Indore, the informal waste management sector, comprising predominantly female ragpickers, faces numerous challenges, despite the city's strides in formalizing waste management practices. With an estimated 7,500-8,000 informal waste pickers earning meager wages of around ₹100 per day, often less than US \$2, their livelihoods are precarious. While the IMC initiated a pilot project in 2007 to integrate waste pickers with door-to-door collection, it was short-lived due to conflicts with existing systems. Many ragpickers excluded from the project continue to cover vast areas daily, collecting recyclables such as plastic, glass, metal, and paper, with metal fetching the highest price. The formalization of waste management in Indore is undoubtedly a positive step forward, but it underscores the urgent need to address the potential loss of livelihoods for informal ragpickers, especially women ([International Alliance of Waste Pickers](#)).

The domestic waste collected is carefully sorted into distinct categories, including wet, domestic hazardous, plastic, non-plastic, electronic, and sanitary waste, within these tippers. Subsequently, the waste is transported to a central facility called the garbage transfer station (GTS). There are presently 8 GTS in Indore (Figure 2), strategically located throughout the city to ensure efficient waste collection and processing. The city boasts six strategically located recycling centers, collectively processing 544 tons of waste per day (TPD). Additionally, five composting plants, distributed across the city, handle 24.5 TPD of organic waste, transforming it into valuable compost. The daily generation of wet waste is estimated at around 680 TPD (60-65%). Indore generates an average of 477 TPD (35-40%) of dry waste.

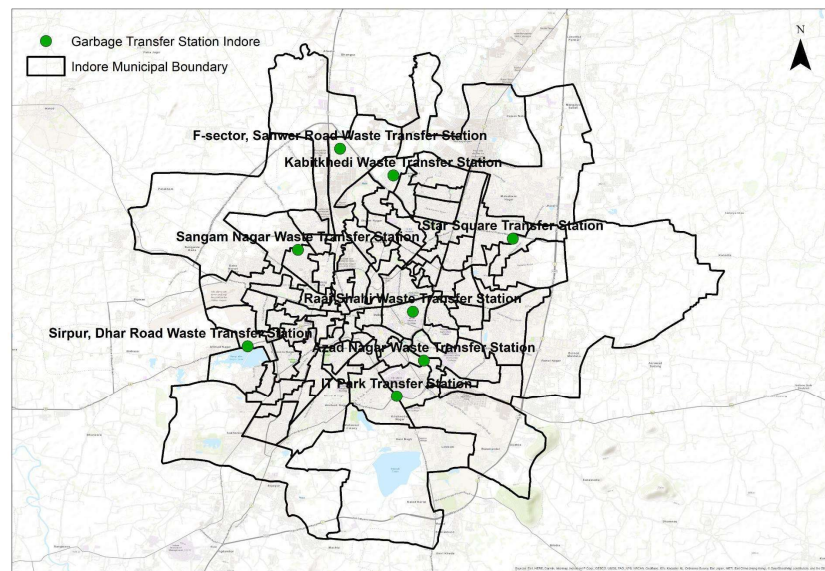


Figure 2: Location of garbage transfer station in IMC

The overall composition of waste in the IMC consists primarily of food and garden waste, accounting for 40% of the total waste volume. Following close behind are paper waste (27%), plastic/rubber waste (4%), textiles (5%), metals (3%), glass and ceramics (5%), and inert (glass, metal, C&D) waste (15%) (Singh, 2021) (Figure 3 and 4).

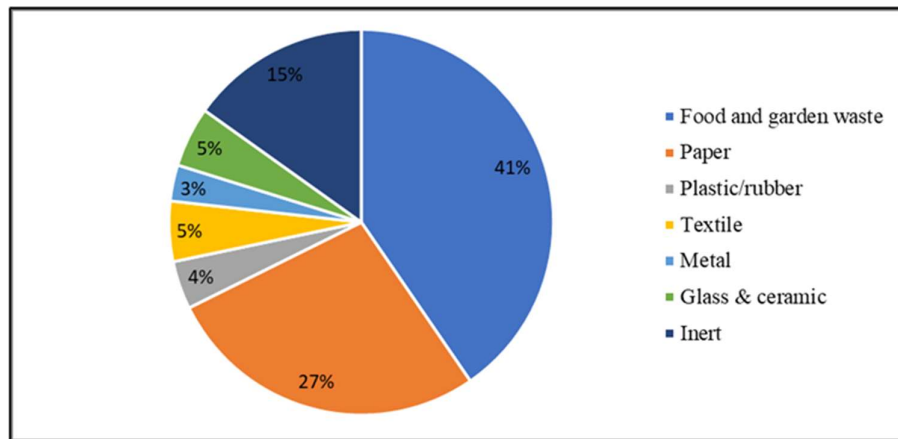


Figure 3: Composition of daily generated MSW in IMC

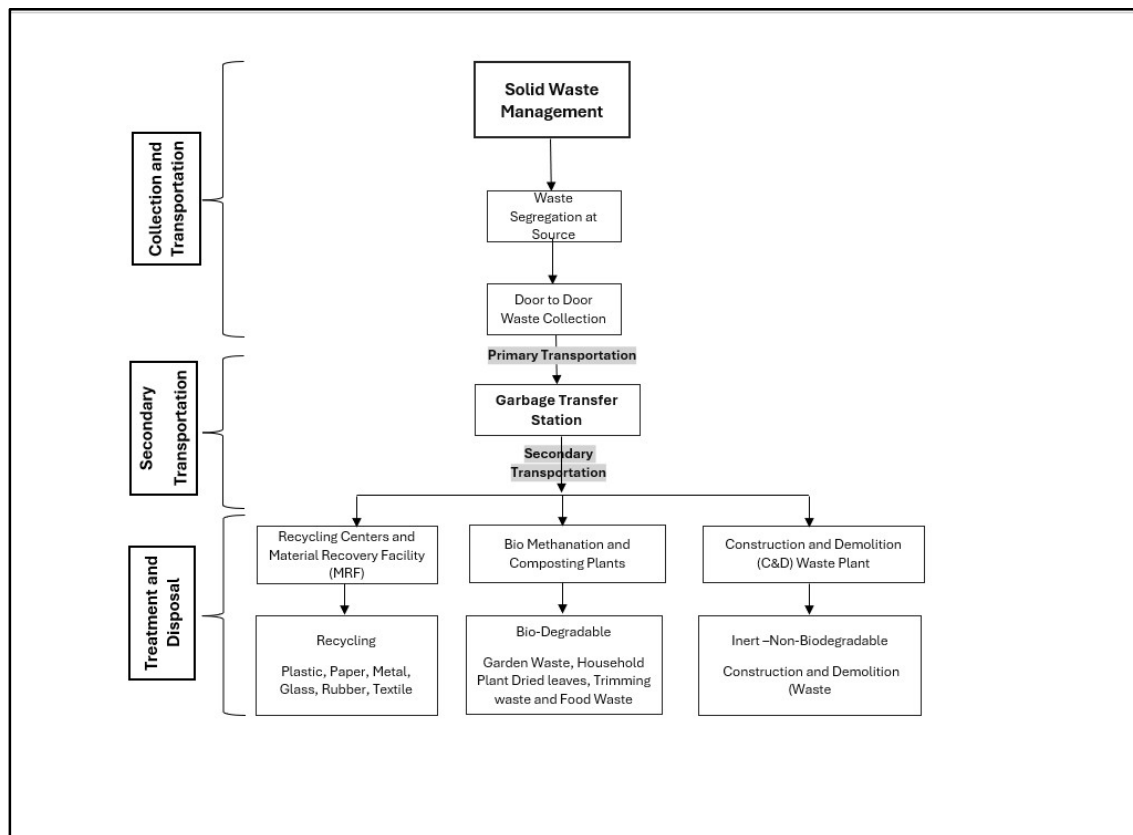


Figure 4: Process in Solid waste management in Indore city

The Information, Education, and Communication (IEC) initiative to promote awareness and understanding proved instrumental in laying the groundwork for the SBM in Indore. In IEC, various tools and methods are used, such as brochures, posters, community outreach activities (workshops, events, videos), digital platforms (websites, social media), and interpersonal communication (peer education, counseling). The IEC initiative took the challenge of instigating the necessary behavioral changes and impact the mindset of all stakeholders, from ordinary citizens to government authorities. Their efforts encompassed a diverse range of activities, including cultural event promotions through street plays, vibrant wall paintings, and effective mass communication strategies through content dissemination via FM stations, social and digital media campaigns, and more.

With a commitment to process the entirety of its waste output, the IMC underwent a remarkable transformation of its Devguradia trenching site. Once known for constant fires and noxious odors, this site was revitalized into a beautifully landscaped garden. The IMC enclosed the area with a protective boundary wall and meticulously planted more than 60,000 saplings.

In Indore, waste collection has improved since 2016, with interventions such as the successful full coverage of door-to-door collection through partitioned vehicles for wet, dry, and domestic hazardous waste, organized system for waste processing, and adoption of many IEC activities. However, it is also important to underscore some of the equity issues associated with the existing MSW management interventions. Marginalized communities, including those in informal settlements and urban slums, often face unequal access to waste management services, perpetuating health risks and environmental hazards. Financial barriers, such as the affordability of waste collection fees and compliance with regulations, disproportionately affect economically disadvantaged communities, widening the gap in access to these services. Social stigma and discrimination persist in the waste management sector, particularly affecting waste pickers, underscoring the need for targeted interventions to address systemic inequalities. Additionally, inadequate capacity building and awareness efforts in underserved communities exacerbate equity challenges, highlighting the importance of targeted education and awareness campaigns. Gender issues further compound the equity challenges in the waste management sector. Female waste pickers often face higher levels of discrimination and are vulnerable to exploitation and unsafe working conditions. Moreover, women are disproportionately involved in less skilled and lower-paying jobs within the waste management sector, perpetuating gender disparities in employment opportunities and income. While 700 informal waste pickers are currently engaged with IMC, efforts must still be made to integrate those who remain outside the system.

Biomethanation: The IMC, as part of its strategy to promote decentralized organic waste treatment, has established a bio-methanation plant of capacity 20 TPD. Through this initiative, the IMC is actively involved in the production and utilization of bio-CNG, a sustainable and renewable fuel generated from the processing of MSW. A biomethanation facility has been established at Choithram Mandi, in the heart of Indore. This wholesale fruit and vegetable market is a significant source of wet waste, making it an ideal location for this innovative initiative (Purohit, 2021). The biomethanation plant produces around 17,000 kg of CNG on a per day basis. This CNG is employed as a fuel to power approximately 30 buses and 1,500 private vehicles. Furthermore, the digested slurry undergoes a solid-liquid separation process, with the filtered liquid being utilized in slurry production, while the remaining solids are dried and transformed into organic compost, which is approximately 100 tonnes.

4. Study/Intervention Area Profiles – Lasudiya Mori

This Solutions Strategy Paper presents a few recommendations and interventions based on the results of the survey on waste burning as well as a stakeholder consultation. As discussed later in this section, the findings of the primary survey revealed that waste burning incidents were high in low SES wards in comparison to high and medium SES wards. Also, during the stakeholder consultation, several waste burning incidents were mentioned in Lasudiya Mori, one of the low SES wards. In this section, Lasudiya Mori ward serves as a representative case study to help IMC conceptualize the potential outcomes of implementing the proposed waste management measures in a pilot setting. By analyzing the impacts of these interventions within this ward, IMC can gain valuable insights into achieving zero/minimal waste burning and reducing air pollution, ultimately paving the way for broader implementation across Indore City.

4.1 Location and Physical Characteristics

The Lasudiya Mori (Figure 5) ward is located in the northern part of Indore. It is connected with Agra-Bombay Road, which is National Highway 3 (NH 3) and a major road of the city, connecting the northern and southern parts of the city. The total area of the ward is around 13.16 sq. km.

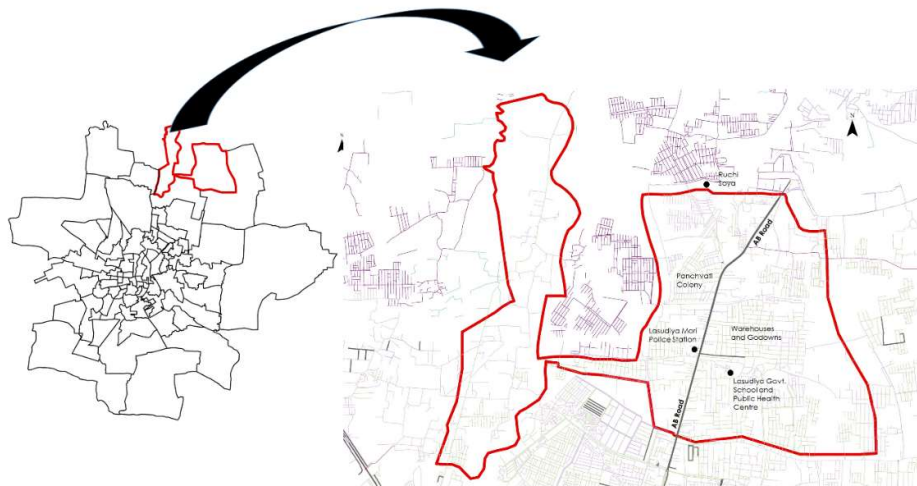


Figure 5 Location Map of Lasudiya Mori Ward

4.2 Population and Household

The Lasudiya Mori ward was initially a Census Town (CT), with a population of 10,225 and 2,122 households (Census of India 2011). The total literacy rate is 67.53%. Male and female literacy rates are 77.07% and 56.81%, respectively. In 2013, IMC decided to increase its area and boundary and added the nearby villages and CT towns inside the municipal limits. Hence, Lasudiya Mori (CT) was converted as Lasudiya Mori ward, with the addition of Talawali Chanda outgrowth (OG) wards and Shakkar Khedi village. In 2022, Lasudiya Mori was ward no. 35, with a population of 33,244 and 6,642 households (IMC).

4.3 Socioeconomic Status, Land Use Profile, and Commercial Activities

According to an internal analysis made as part of the survey, the Lasudiya Mori ward is mostly of low-medium SES. The land use (Figure 6) of the ward is mixed and consists of agriculture, residential, commercial, industries, transport, and public and semi-public spaces. Around 27% of the land use is for agriculture, followed by residential units (21%) and warehouses and godowns (16%) (Figure 7). The ward has several large townships, such as Panchavati, DB Pride, and Ansal, and a few informal settlements (Figure 8). There are several warehouses and godowns for storage and transportation to other parts of the state and country (Figure 8). Thus, every day, loading and unloading of items generates waste and dust. There are a few industries located in this ward along with public utilities, such as power grids. The development of this ward is ongoing, and due to its diverse land use, it has its own challenges. In addition, since this area came under IMC boundary limits 8-10 years ago, it has a rural setting and the presence of agricultural land.

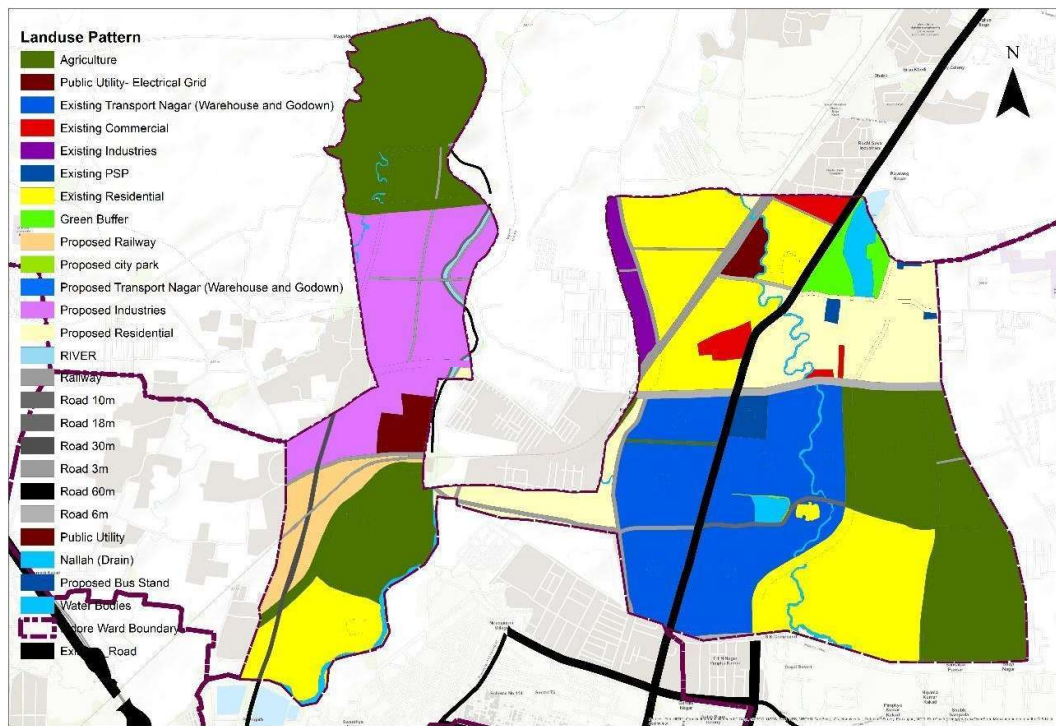


Figure 6: Existing and Proposed Land Use of Lasudiya Mori (Development plan- Indore, 2021-22; CAC primary survey).

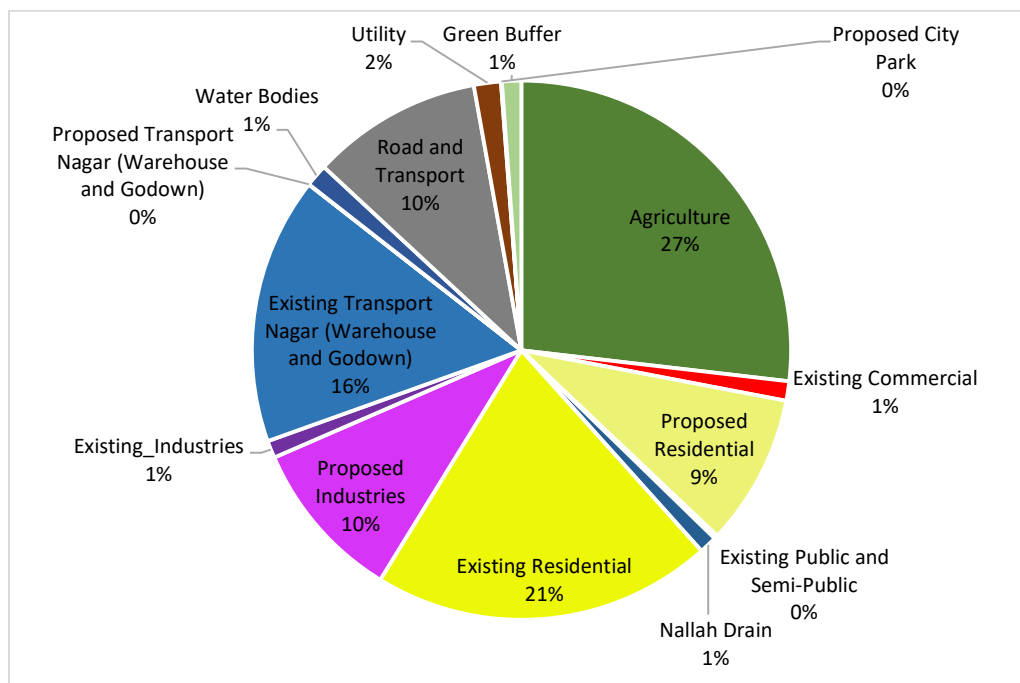


Figure 7: Land Use Distribution in the Lasudiya mori ward (Development plan- Indore, 2021-22; CAC primary survey).



Figure 8: Street views of Lasudiya Mori area showing godowns and warehouse (Left) and residential area (Right)

4.4 Overview of Waste Management

Presently, the waste generated in Lasudiya Mori ward is 13.19 TPD, with wet waste around 7.63 TPD, dry waste 3.48 TPD, plastic 1.87 TPD, sanitary 0.14 TPD, domestic hazardous 0.04 TPD, and e-waste around 0.03 TPD (Figure 9). Section 3 described the waste management process of Indore city, including Lasudiya Mori. Though waste management practices are the same throughout Indore city (waste segregation at the source, door-to-door collection, and processing of collected waste including wet and dry waste), each ward has its own challenges that lead to waste burning.

In Lasudiya Mori ward, areas including Bajrang Nagar, Kakad, Sant Ravidas Nagar, Shri ram Nagar, Shakar Khedi, Rahul Gandhi Nagar, Talawali Chanda, Panchavati Colony, and Kailash Kuti belong to low and medium SES. These areas have mixed activities, with

commercial setups such as godowns (warehouses) and iron work, small vendors such as fruit sellers, food shops, tea shops, and a few small industries. Both tenants and house owners live in these areas. In some cases, tenants who do not wish to pay or cannot afford the waste collection fees of ₹720 per year levied by IMC dump the waste on the streets and street corners and then burn it. There are some areas that lack proper roads and narrow lanes where IMC vehicles do not collect waste. In these areas, the residents either feed the wet waste to cattle or throw the waste in open areas and adjoining areas, which is ultimately burned.

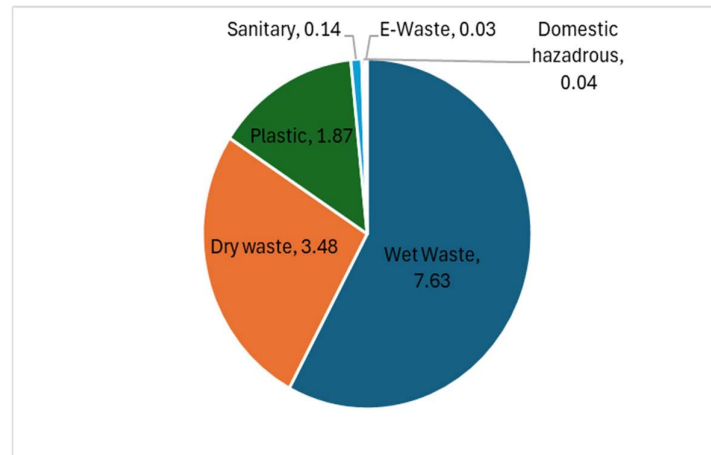


Figure 9: Composition of daily generated MSW in Lasudiya Mori

4.5 Health and Gender: A Closer Look at Ward Level

Based on the available data for Lasudiya Mori CT Town (Census of India 2011), the area relies on a government Primary Health Centre (PHC) (Figure 10) to cater to outpatient (OPD) consultations and minor surgical needs. However, residents requiring major medical attention must seek treatment at larger hospitals in Indore. There is only one bed available for every 10,000 residents in the local PHC (Census 2011).



Figure 10: Primary Health Centre (Left) and High School (Right) in Lasudiya Mori Area

The total female population in Lasudiya Mori CT ward is 4,796, of which only 911 (18%) are working. A significant proportion of females, approximately 3,885 (81%), are non-workers (Census of India 2011). In comparison to 2,861 males, the general workforce

participation among females in the Lasudiya Mori CT ward is comparatively low, with only 16.5% (792) involved in main work.

The number of men and women who are employed on a temporary basis (less than 6 months) are 64 and 119, respectively (Census of India 2011). These numbers indicate that due to the temporary nature of jobs, women receive low wages and social security benefits. Women who are unable to work due to family obligations often face financial dependence and reduced household income (Sundari, 2020). As a result, air pollution, especially in low-income neighborhoods, may disproportionately impact non-working women due to their limited mobility and higher likelihood of spending extended periods of time in the vicinity of their homes. In these areas, reliance on solid fuels for cooking and heating is more common due to limited access to clean energy sources, leading to heightened exposure to indoor air pollution and exacerbating health risks. Additionally, waste burning is a practice prevalent in low-income neighborhoods where proper waste disposal services may be inadequate. This burning of household and community waste releases a variety of harmful pollutants, including particulate matter, toxic chemicals, and heavy metals, which contribute to both indoor and outdoor air pollution. Non-working women, who often manage the household and are responsible for unpaid domestic work such as cooking, cleaning, and caring for family members, spend a significant amount of time in environments where pollution from waste burning is present. This prolonged exposure to polluted air can lead to severe health issues, including respiratory problems, cardiovascular diseases, and other long-term health conditions. Furthermore, because these women are typically at home more often than their working counterparts, they are more consistently exposed to the harmful effects of both indoor air pollution from solid fuels and outdoor pollution from waste burning, compounding their overall health risks.

With family obligations often restricting their ability to work outside the home, non-working women may have fewer opportunities to leave the area and escape exposure to pollutants. Additionally, their limited financial autonomy may constrain their access to transportation options, further restricting their mobility and increasing their reliance on walking or using informal public transportation, which can expose them to higher levels of vehicular emissions. As a result, non-working women may experience greater exposure to air pollutants in their immediate surroundings, exacerbating health risks and vulnerabilities as compared with their counterparts with greater mobility and financial independence. Addressing these challenges requires targeted interventions to improve air quality in residential areas and enhance access to affordable and sustainable transportation options, particularly for marginalized and economically disadvantaged women. Efforts should also focus on reducing pollution from waste burning, which significantly contributes to air quality issues in low-income neighborhoods. To combat this, it is essential to implement robust waste management systems that offer safer alternatives to burning, such as organized waste collection, recycling programs, and community education on the health risks associated with waste burning. Additionally, providing resources and infrastructure for cleaner cooking and heating options can further reduce the reliance on solid fuels, thereby improving indoor air quality. Also, to overcome the low literacy rate, women require more inclusive and effective public communications for all, regardless of gender or literacy levels.

5. Survey on Waste Burning - Methodology and Findings

5.1 Waste Burning Primary Survey

In the IMC area, the primary data on solid waste burning was collected using the transect method developed by Nagpure et al. (2015). In this method, the wards of the IMC area were classified as per their SES and land use pattern (Figures 11 and 12). Then, the transect routes were laid out across the entire IMC area into different streets and roads, representing the survey area's SES (low, middle, and high) and land-use characteristics (residential, commercial, industrial, public spaces).

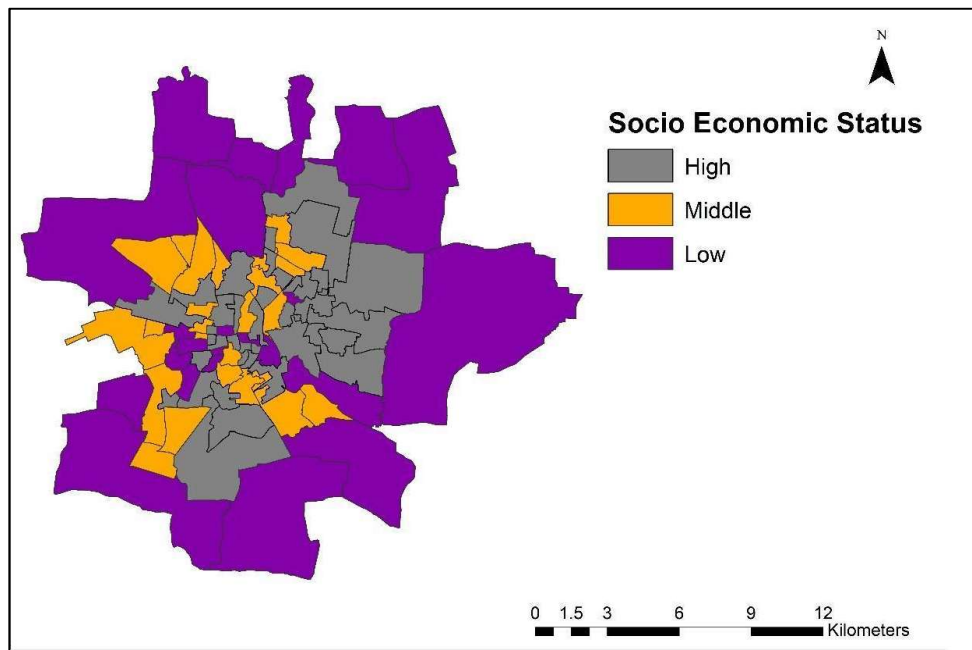


Figure 11: Classification of IMC boundary as per the Socio economic status (SES)

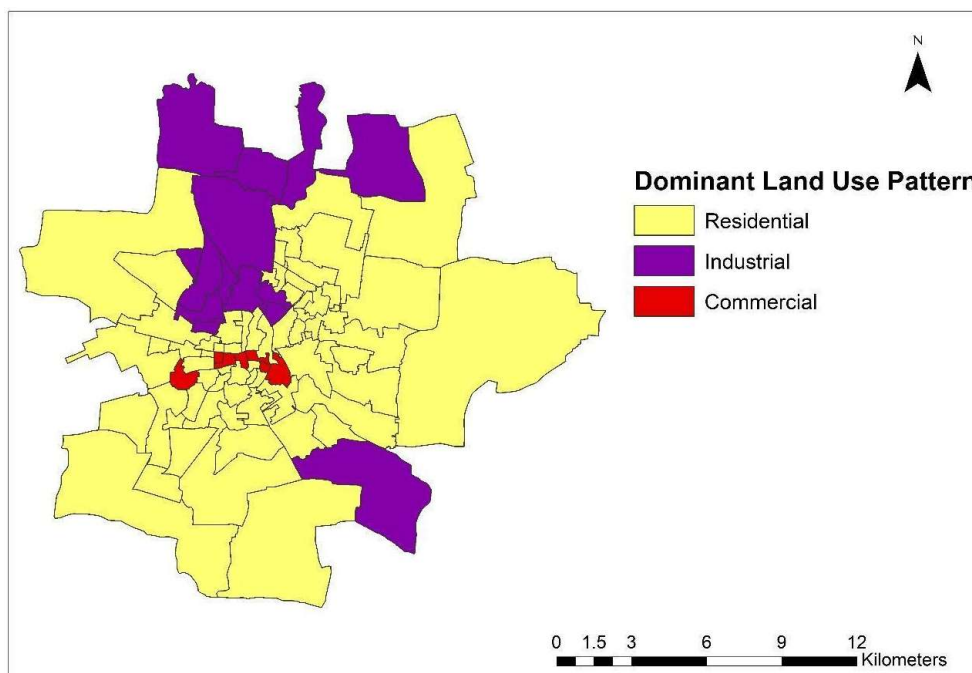


Figure 12: Classification of IMC boundary as per the land use pattern

Five transect routes were covered in the IMC boundary (Figure 13). All transect routes in the sample wards were covered either on foot or by a vehicle in the morning and evening hours for three consecutive days during the winter (January - February 2022) and summer (May - June 2022) seasons. The number of MSW burning incidences were recorded as part of each day's transect sampling, including latitude and longitude waypoints of each MSW burning incident, rough mass, and composition. By considering the number of MSW burning incidences, transect length, and width (including street width and building length of each side of the street), MSW burning frequencies per sq. km. for each zone of the IMC area for both winter and summer time were estimated. MSW burning incidences and mass (per capita) were calculated for each zone and then applied to the population of the rest of the similar zones in the IMC area to scale up the results.

As it is not possible to weigh burning MSW, the samples of MSW were weighed before and during burning by extinguishing it by sprinkling water on it and then subtracting the added water weight. The composition was measured by spreading out the extinguished MSW and observing the incompletely burned components.

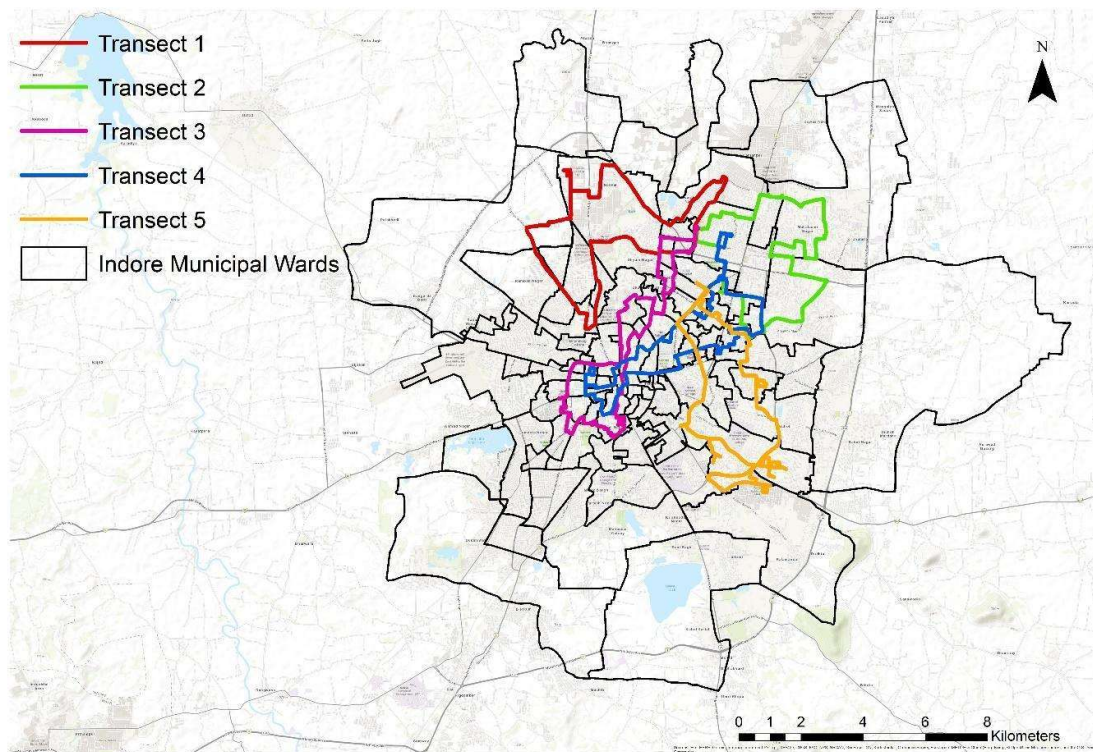


Figure 13: MSW burning survey transect routes during winters and summer (2022) in IMC area

5.2 Findings of Survey

The waste burning survey was carried out in the high, medium, and low SES areas along with the industrial areas. Out of the 54 wards surveyed, waste burning was observed in 19 wards in summer (May 2022) and 23 in winter (from December 2021 to January 2022). The waste incidents observed during the CAC primary survey were mostly high during the winter season. In winter, the low SES area had the most MSW incidents, with 61 incidents per sq. km., followed by industrial areas with 56 incidents per sq. km., high SES areas with 24 incidents per sq. km., and medium SES areas with 16 incidents per sq. km. In summers, industrial areas had the highest number of MSW burning incidents, with 46 incidents per sq. km., followed by low SES areas (43 incidents per sq. km.), medium SES areas (33 incidents per sq. km.), and high SES areas (21 incidents per sq. km.). Figure 14 illustrates these estimates.

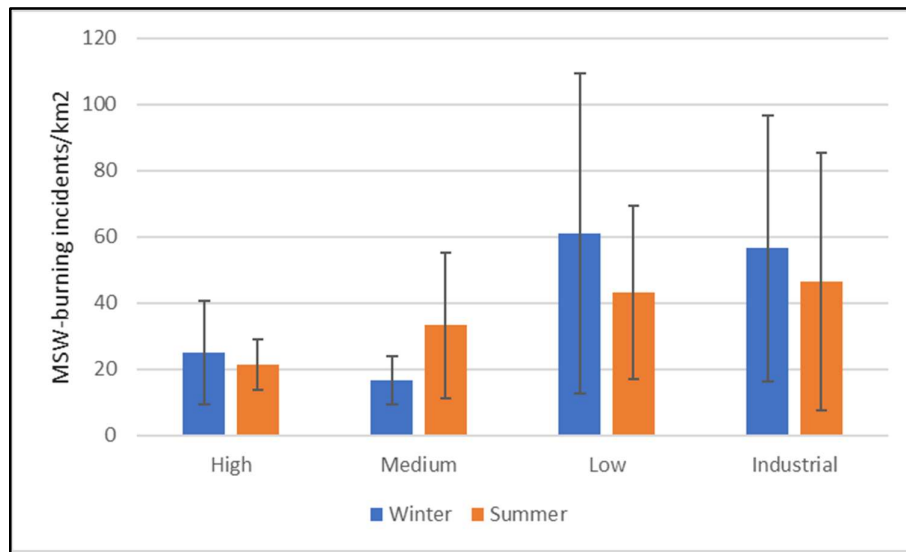


Figure 14: MSW burning incidences per km² observed

The highest MSW burning mass (kg per sq. km.) observed was almost the same (115 kg per sq. km.) in low SES and industrial areas during summer, while in winter it was high in the industrial (196 kg per sq. km.), followed by low SES area (Figure 15).

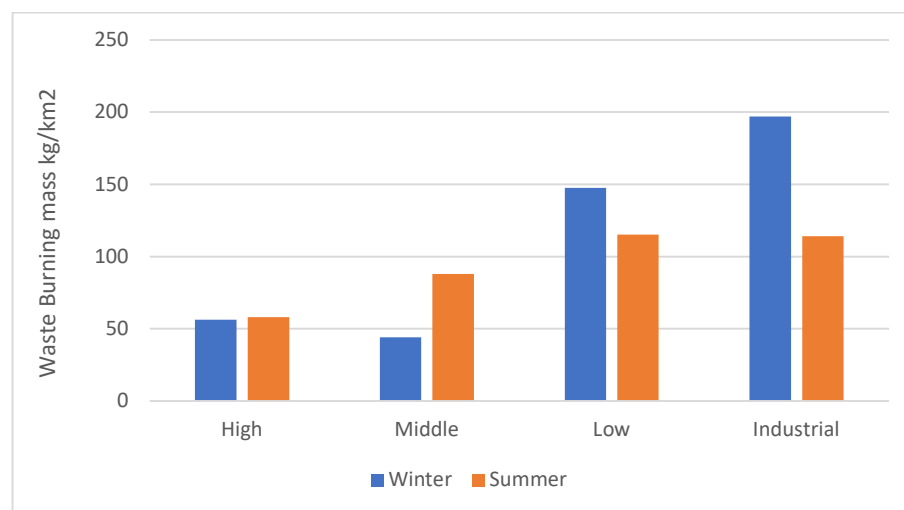


Figure 15: Municipal Solid Waste burning mass (kg/km²)

In low SES areas, waste burning reaches 18 tonnes per day during winter and 14 tonnes per day during summer, the highest levels as compared with all other SES and industrial areas across both seasons. The narrow lanes in some neighborhoods hinder waste collection efforts, prompting people to resort to waste burning. Additionally, financial constraints and limited awareness contribute to this practice. Consequently, communities with low SES bear a disproportionate burden of waste burning and its resultant air pollution. In the industrial areas, daily waste burned was 11 tonnes and 6 tonnes during winter and summer, respectively (Figure 16). The reason for the higher waste burned in high SES areas was the plastic and paper waste, which was higher in comparison to the medium SES.

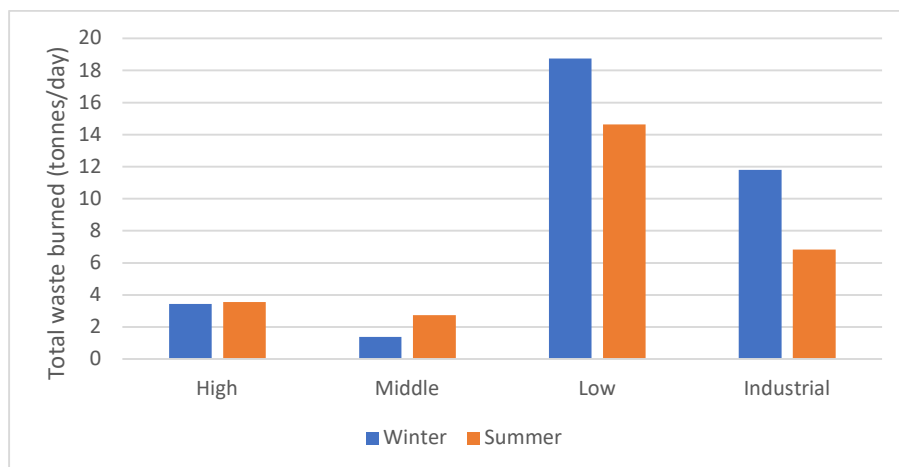


Figure 16: Total MSW burned (tonnes/day)

As part of the survey on waste burning, open-ended informal interviews were conducted to better understand the causes of waste burning. The main objective was identifying focus areas (by understanding the reasons and perceptions) and possible interventions, as listed in Table 1. The respondents included randomly selected households, shopkeepers, municipal waste workers, scrap dealers (*kabadiwala*), and industry workers from the different areas of IMC.

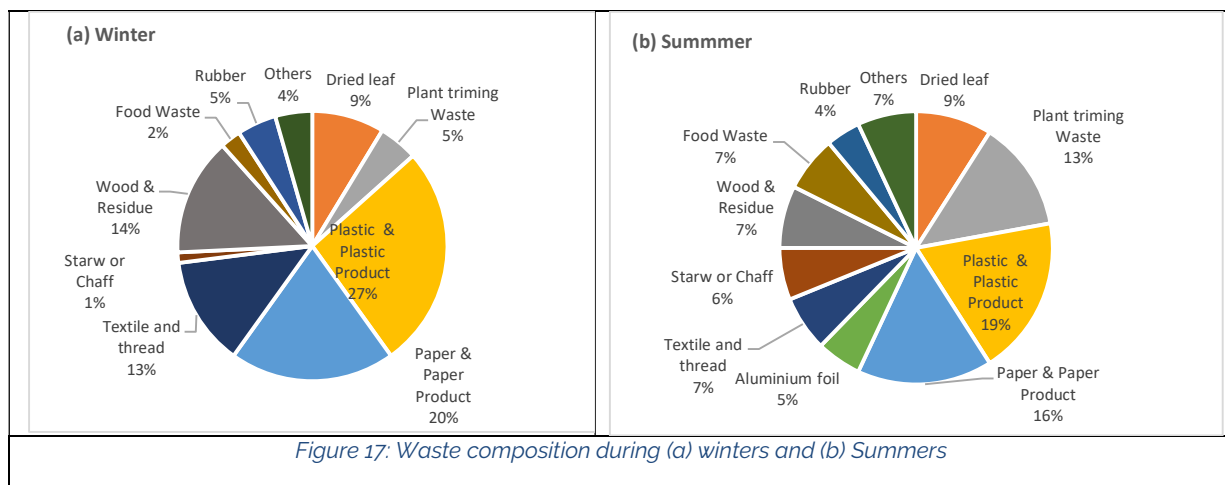
Table 1 Causes of waste burning behaviors and drivers by stakeholder

Focus Area	Key Stakeholders	Where	How	Why	Possible Interventions
Behavioral issue	Households, waste collectors	Streets, kerbside, outside and inside housing premises and society	Open burning	Waste reduction, heating	Mass awareness against harmful consequences of waste burning. All awareness and capacity building interventions should be designed to address underlying socio-economic and cultural factors contributing to waste burning practices. These efforts should be tailored to the diverse needs of different communities within Indore. Provide alternative to heating solution

Increase collection efficiency	Municipal Corporation, waste collectors and inspectors	Roadside, street	Open burning	To reduce the number of waste collection trips	Actions toward improving collection efficiency in informal settlements, educational institutions, government offices, parks, and other public places and deployment of vehicles suited to narrow lanes
Collection of dried leaves and plant-trimming waste	Municipal Corporation, waste collectors and inspectors	Household, park, school, hospital	Open burning	No collection of dried leaves especially in case of large amounts	Separate collection system for dried leaves and plant trimming waste in households, offices, schools, parks hospital, and other public spaces
Commercial burning	Small shops and scrap dealers, ragpickers	Outside shop, narrow alleyways, and confined places	Open burning	Material/resource recovery, such as burning electric wires to recover different metals	Awareness building and personalized training. Using scientific techniques to recover metal. Ensure large involvement of this stakeholder in mainstream waste management. It is also essential to acknowledge the complex and interconnected barriers contributing to this problem. Merely implementing awareness raising and personalized training may not suffice due to the presence of various overlapping challenges, such as corruption, gender norms, and socio-economic marginalization
Industrial area burning	Factories and workshops	Inside and outside of industry premises	Open burning	Waste reduction	Separate solid waste collection system in industrial area

For all the interventions listed in Table 1, especially related to awareness generation, it is essential to acknowledge the complex and interconnected barriers contributing to this problem to effectively address the issue of open waste burning in Indore. Merely implementing awareness generation and personalized training may not suffice due to the presence of various overlapping challenges, such as waste mishandling, gender norms, and socio-economic marginalization. Understanding the challenges involved is crucial for developing effective strategies to address waste burning.

The composition of waste during winter was mostly plastic products, followed by paper and its products, wood and residue, textile, and thread. In summer, apart from plastic and paper waste, plant trimming waste is also a part of the waste burned (Figure 16).



Based on the highest number of waste burning incidences found during the primary survey and stakeholder consultation, some high priority wards were identified to work on waste burning sectors. During on-ground surveys to inform a bottom-up integrated emissions inventory, the CAC further observed sporadic instances of open waste burning in the wards of Niranjapur (8), Bhamori (12), Nipaniya (71), Residency (64), Bhagat Singh Nagar (7), Sheel Nath Camp (16), and Lasudiya Mori (72). Among these wards, Niranjapur lies in the high SES, while Bhamori is in the medium SES; Nipaniya and Residency in the low SES and Bhagat Singh Nagar, and Sheel Nath Camp in the industrial area. Figure 18 shows the high, medium, and low priority wards, as per the waste burning incidences.

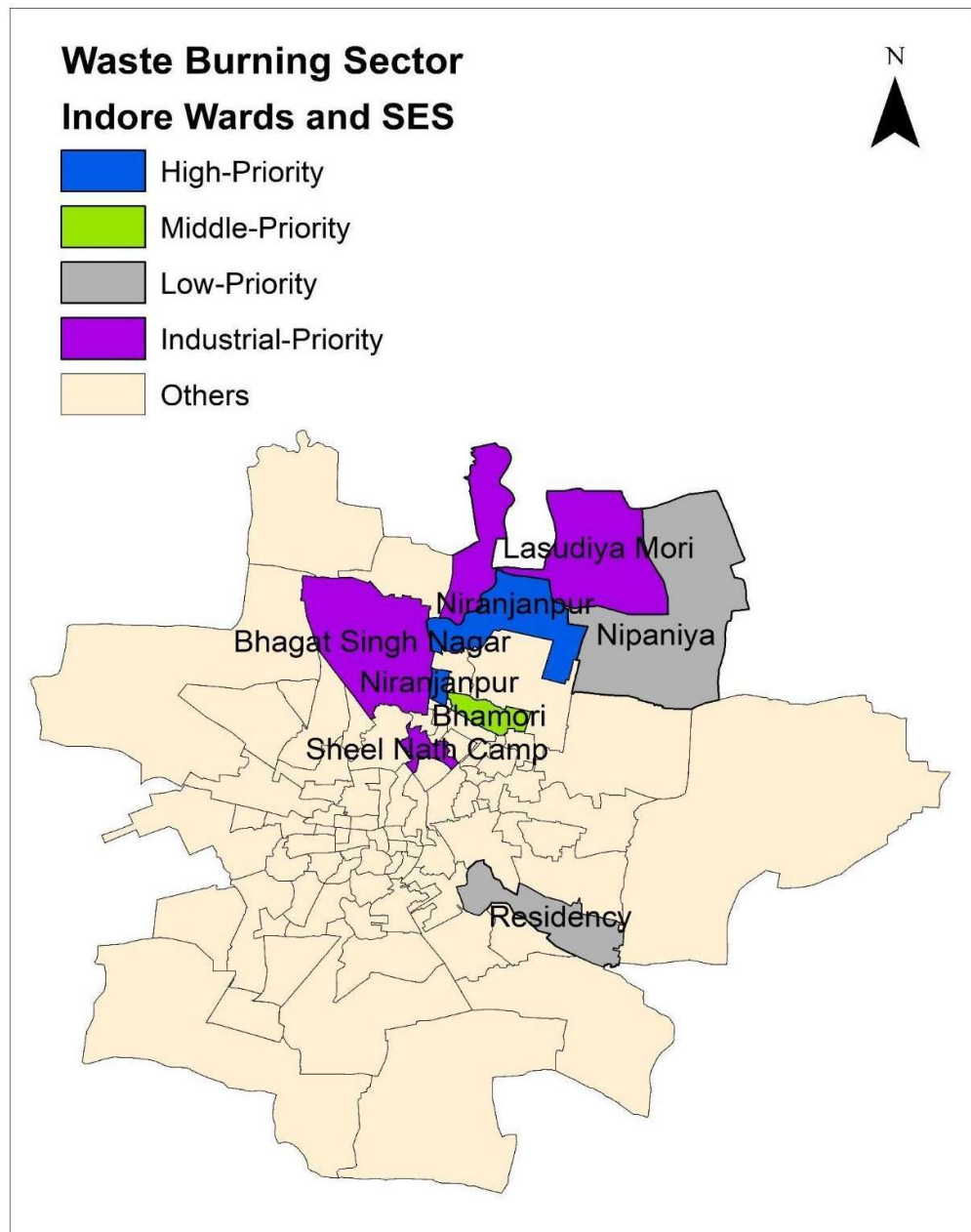


Figure 18: Prioritization of wards as per the MSW burning incidences

6. Recommendations and Actions

6.1 Recommendations for Efficient Waste Collection and Management to Curb Waste Burning Issues

Indore has distinguished itself in efficiently managing the diverse solid and liquid waste generated by its residents, commercial entities, industries, and educational and medical institutions (PIB, October 2022). However, the practice of open burning of solid waste remains a pressing issue within the sector. During the primary survey, it was found that paper, plastics, and dry leaves were the main forms of waste being burned. Pollutants released during open waste burning emit particle-bound metals that have a higher carcinogenic potential than wood combustion. Therefore, people who live around places with regular waste burning episodes have a higher risk of cancer (Ramadan et al. 2022). Although the impact of this activity on the city's particulate matter levels is estimated to be under 2.5%, this can still be reduced as it comes under the jurisdiction of IMC (Guttikunda, S. K., 2019).

After extensive work on the long list of solutions and the key focus areas mentioned in Table 1, derived from the CAC [primary survey](#) aimed at reducing emissions from waste burning, six recommendations are finalized. On implementing these, penalizing continuous violations, strict enforcement, and monitoring can help achieve minimal or zero waste burning:

1. Awareness program targeting citizens of the IMC area on the health impacts of open burning of MSW
2. Increasing waste collection efficiency
3. Action towards the proper collection of dried leaf and plant trimming waste
4. Actions toward providing alternative and affordable/subsidized heating, especially for low-income communities who rely on cheap sources of fuel
5. Enhanced SWM in industrial zones
6. Mainstreaming scrapers, scrap dealers and ragpickers in the waste management process will help stop commercial burning.

The recommendations presented in this paper are tailored to include an action plan, levels of intervention in terms of spatial considerations, and implementation periods categorized as short-term (2 years), mid-term (5 years), long term (10 years and more), and continuous period. Furthermore, emphasis is placed on the scope of various implementing agencies involved in executing these recommendations for the city of Indore.

By incorporating these recommendations in a comprehensive plan, along with designated implementation periods and the involvement of various implementing agencies, Indore can make substantial strides toward curbing open waste burning and reinforcing its status as the cleanest city (Figure 18). While the proposed interventions in this Solutions Strategy Paper apply broadly to the entire city of Indore, as a start, these interventions can be implemented in a pilot ward, such as Lasudiya Mori. A participatory approach to engagement should include conducting public awareness workshops, gender-inclusive and responsive focused group discussions (FGDs), and other targeted initiatives.

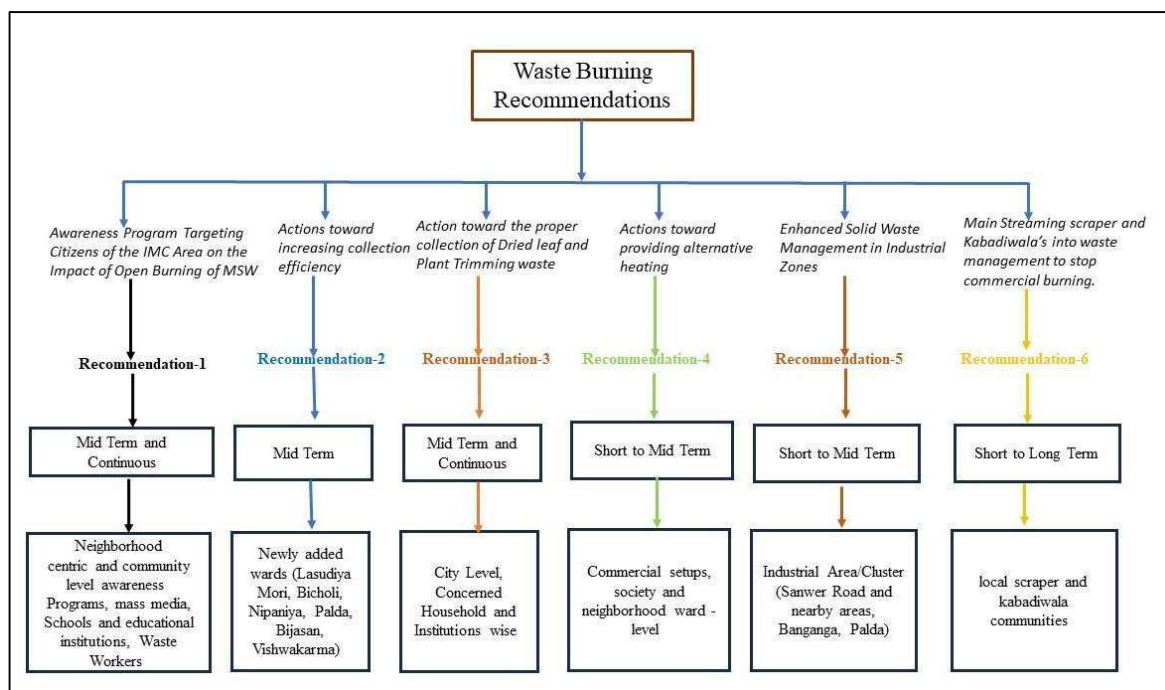


Figure 19: Flowchart Shows the recommendation, Timelines, and level of Interventions

Recommendation 1: Awareness program targeting citizens of the IMC area on the impact of open burning of MSW

The data from the primary survey on MSW burning in the IMC area shows that residents are continuing to burn MSW in wards that have proper waste disposal infrastructure in place, including segregation, collection, transportation, and processing.

There are various reasons for the continuation of this practice ([CAC primary survey](#)):

1. Some residents find it convenient to burn waste, as a quick way to reduce the amount of waste they have at home.
2. The waste collector declines to collect waste such as dried leaves/plant trimming waste.
3. Waste collectors burn waste to reduce their travel trips.
4. Less or infrequent collection of waste.
5. Industries mix the MSW and industrial waste and burn it.
6. During winter, people burn waste for heating.

A significant finding from the analysis is that many citizens and IMC waste workers are unaware of the harmful consequences of air pollution from MSW burning and its impact on human health. Instead of taking alternative actions, such as waiting for the collection truck, collecting waste such as dried leaves and trimmed plants, and reporting issues to the relevant authorities, they opt for burning the waste.

Further examination of social, educational, and land-use factors in the IMC area highlights the need for a comprehensive awareness campaign within the city in terms of waste burning. Given the socioeconomic disparities, awareness raising may be sufficient

only for people who have the financial and other means to find an alternative to MSW burning. Therefore, authorities should prioritize equitable solutions that address the financial and logistical barriers faced by those residents who are unable to access alternatives. To effectively address the issue of open MSW burning in the IMC area, it is crucial to design an awareness program that targets and engages various segments of the population and creates an understanding of the responsibilities among all. Table 2 presents a detailed plan for an effective awareness campaign:

Table 2: Proposed actions, strategies, intervention levels, implementation period and agency for an awareness program in IMC area on impact of open burning of MSW

Mitigation Strategies	Level of Intervention	Proposed Actions	Implementation Period	Implementing Agency
Multi-channel awareness Strategy	Neighborhood-centric awareness program, as per different SES and land use characteristics	Organize interactive workshops and seminars in different localities of the IMC area. These sessions should focus on the health hazards of open burning, emphasizing the adverse effects of air pollution on human health and the environment. Since women and low-income communities are the most impacted with health hazards and limited access to healthcare, a targeted strategy can be designed including – trainings of local health ambassadors and collaboration with healthcare providers for accessible services, developing multilingual awareness materials, implementing mobile health clinics and integrating waste management education into school programs especially those in low-income neighborhoods	Mid-term (but repeat after every 2-3 years)	IMC (with help of multiple stakeholders such as Clean Air Catalyst, NGOs, RWAs, Women's Association, local leaders, educational institutions and SHGs)
	Communicate through mass media to the citizens	Utilize various communication channels, including social media, local newspapers, radio, and television, to disseminate information about the impacts of open burning. Use infographics, videos, and real-life case studies to effectively communicate the consequences of this harmful practice Care should be taken to design communication strategies, keeping in mind the vulnerable populations. Information ecosystem analysis (IEA) from Year 1 highlighted that women, especially from low-income communities, are more dependent on face-to-face communication as a means for getting information, and more women than men have access to newspapers and radio as mediums of information. Hence, in addition to running campaigns via digital and traditional media, there should be an equal amount of emphasis on face-to-face communication.	Mid-term	

	Community-level program	Collaborate with RWAs local community centers, local women's associations, voluntary organizations, and local NGOs and religious institutions to organize community engagement programs. Encourage community members to take ownership of the issue and actively participate in creating a cleaner and healthier environment. In the waste management sector, women are primarily responsible for waste disposal in the households. Yet, their voices in waste management are not heard due to lack of decision-making powers within households and societies. To address this, gender equality awareness campaigns at the community level to challenge stereotypes and highlight the crucial role of women in waste management can be taken up. Similarly, actively involving women in establishing community forums or committees that include diverse voices will be helpful.	Mid-term	
Tailored Messaging for different stakeholders	Schools and educational institutions	Conduct specialized educational workshops in schools and educational institutions to educate students about the harmful consequences of open burning and their role in reducing waste generation and its burning. For this, small projects can be organized as part of extra-curricular activities.	Continuous after certain Interval	
	Waste worker (formal and informal)	Organize training sessions for waste workers to raise their awareness about the hazards of open burning. Equip them with the necessary knowledge and skills to handle different types of waste, including dried leaves and plant trimmings, effectively		
	Local authorities and policy makers	Engaging with local authorities. Facilitate regular dialogue and engagement sessions with local authorities and policymakers to discuss the challenges and potential solutions related to waste management. Advocate for policy reforms and the implementation of stricter regulations to discourage open burning and promote sustainable waste disposal practices.		

Recognizing that women often play a central role in household waste disposal, awareness programs can be tailored to empower and elevate their voices. This includes targeted awareness campaigns that not only emphasize women's pivotal role, but also underscore their expertise in waste management. Engage women as ambassadors in these campaigns to amplify their influence and provide relatable role models. Design outreach materials in formats accessible to diverse audiences and languages, ensuring inclusivity. Moreover, establish community-driven platforms where women can actively contribute to waste management decision-making processes, bridging the gap between their responsibilities and their involvement in shaping sustainable solutions. By integrating these gender-sensitive recommendations, public awareness campaigns can become catalysts for empowering women and fostering more inclusive and effective waste management practices.

Recommendation 2: Increasing collection efficiency

The city's expansion and inclusion of new wards have urban/peri-urban characteristics, low-income neighborhoods, and informal settlements. These areas are underserved by municipal trucks deployed for waste collection as they are unable to access narrow and congested by lanes. According to the IMC, a total of 2508 complaints were registered in the year 2022 regarding issues related to waste collection. Further, while conducting the waste burning survey, the CAC team recorded complaints about infrequent service in some of these neighborhoods, which highlights significant challenges faced in managing waste collection.

Improvement of collection frequency: Suitable vehicles should be deployed for areas such as informal settlements with narrow lanes, educational institutions, government offices, parks, and other public places. There are a number of general challenges that have impeded waste collection in low-income areas of the city. For example, narrow lanes may not always be accessible by the standard collection vehicles. One way to catalyze such a change would be to initiate a pilot in a low-income area of the city, learn, and scale across the broader fleet. The focus should be to eliminate waste burning as an activity while offering pathways to viable alternatives. Engaging informal workers as last-mile collection agents in areas with narrow lanes and confined spaces can enhance collection efficiency, while simultaneously providing job opportunities. Vehicles suited for narrow lanes, such as electric two-wheelers, three-wheelers, and hand carts, would help ensure that residences, particularly in low-income and informal settlements, are not left out of the municipality's waste collection services (Table 3).

Table 3: Proposed actions, strategies, intervention levels, implementation period and agency for improving collection frequency in IMC area to reduce open burning of MSW

Mitigation Strategies	Level of Intervention	Proposed Actions	Implementation Period	Implementing Agency
Increased collection frequency in informal settlements with narrow lanes, educational institutions, government offices, parks, and other public places	Newly added wards (Lasudiya Mori, Bicholi, Nipaniya, Palda, Bijasa, Vishwakarma)	Higher number of trips and collection of waste generated in neighborhoods that report infrequent services prevent that waste from being burned.	Short- and mid-term	IMC (Waste collecting agencies)
Streamlining informal worker/ ragpickers in waste collection		Informal and low-income settlements with narrow lanes are often unreachable by tipper trucks deployed by the city. Therefore, smaller vehicles, hand carts enable the collection of waste from these settlements, preventing waste burning. Involving informal workers as last mile collection agent (area with narrow lanes and confined places) will help in improving collection efficiency and also generate livelihood.		

Recommendation 3: Action towards the proper collection of dried leaf and plant trimming waste

During the waste burning survey and interaction with citizens it was found that municipal waste collectors refuse to collect the waste when the amount of dried leaf and plant trimming waste is large. In such cases, citizens are compelled to burn the waste to get rid of it. According to municipal collectors, they do not have the capacity to carry large amounts of waste as it would mean an increase in the number of trips they make to collect waste.

This situation exists in office premises, school and college campuses, hospitals, neighborhood, city, and regional level parks, and other public spaces. In the case of offices, institutions, hospitals, parks, and other public spaces, it would be advisable to collect this waste and send it back to the respective processing unit. While Indore currently utilizes a bio methanation and composting plant with a capacity of 24.5 TPD across five locations, the city requires additional decentralized composting facilities at the neighborhood level. This shift towards smaller, local plants aims to efficiently manage organic waste and prevent the harmful practice of waste burning. This composting plant provides economic benefits as they can use the organic manure produced in their existing gardens and parks so that it increases the soil quality and micronutrient content and enhances water retention in the soil. Composting is the third choice in the integrated SWM hierarchy. It ensures that waste is processed appropriately to facilitate material recovery.

During consultations, stakeholders also pointed to education institutions, government offices, and parks with high volumes of dried leaves that are not eliminated from the streets, resulting in the waste being burned. Based on the information provided, it is crucial to address the proper collection of dried leaf and plant trimming waste to mitigate the issue of burning organic waste. Here is a comprehensive recommendation for your consideration (Table 4):

Table 4: Proposed actions, strategies, intervention levels, implementation period and agency for proper collection of dried leaf and plant trimming waste in IMC area to reduce open burning of MSW

Mitigation Strategies	Level of Intervention	Proposed Actions	Implementation Period	Implementing Agency
Separate collection mechanism	City level - Collection of green waste can be on alternate days	Specialized separate waste collection mechanism for dried leaves and plant trimming waste from households, offices, schools, parks, hospitals, and other public spaces. Allocate dedicated resources and vehicles specifically for the collection of this type of organic waste of the city.	Continuous	IMC (waste collecting agencies with help of RWAs, NGOs, SHG, concerned institutions)
Collaboration with existing biomethanation and composting plants	household and institutions	Collaboration with existing biomethanation and composting plants to accommodate the increased volume of organic waste, including dried leaves and plant trimmings. Ensure that the waste collected from households, offices, schools, parks, hospitals, and other public spaces is efficiently transported to these facilities for proper processing.	Mid-term	IMC (with help of RWAs, NGOs, SHG, concerned institutions)
Promotion of on-site composting		Encourage the installation of small to medium-scale composting units in various institutions, parks, and public spaces. Provide necessary support and guidance to facilitate the setup and maintenance of these composting units.	Mid-term	
		Educate stakeholders about the benefits of using the resulting organic manure for	Short-term	

		enhancing soil quality and promoting sustainable gardening practices.		
Incorporation of different composting techniques	Household and Institutions	Promote the adoption of anaerobic composting techniques that ensure the efficient decomposition of organic waste.	Mid-term	
		Organize training sessions and workshops for stakeholders involved in waste management to familiarize them with the best practices among composting techniques.	Continuous	

Recommendation 4: Actions toward providing alternative heating

A primary survey conducted across wards in Indore revealed that members of household staff, such as security personnel, employed in the middle and high-income residential neighborhoods of the city burn waste owing to the lack of affordability or lack of access to heating and sufficient insulation, especially during the winter months.

Raise source awareness about waste burning for heating and alternatives: It is assumed that once residents understand the full scale of the health and environmental impacts of waste burning and are simultaneously provided with alternatives for winter heating, the dependence on waste burning would reduce, thereby, directly reducing the volume of emissions from waste burning as well as exposure from this activity (Table 5).

Provide alternatives to waste burning for heating: Homeowners and employers of household staff and security personnel should ensure that their staff receive access to heating and insulation at the staff quarters, outpost, and other places of employment. This could be achieved by providing insulation through the deployment of portable heating devices suitable for small areas and the distribution of appropriate winter clothing, potentially sourced through government-led distribution programs, including provisions for reusing secondhand products, where appropriate (Table 5).

Table 5: Proposed action, strategies, intervention level, implementation period and agency to raise awareness about waste burning for heating and alternatives, and provide alternatives for waste burning

Mitigation Strategies	Level of Intervention	Proposed Actions	Implementation Period	Implementing Agency
1. Raise source awareness about waste burning for heating. 2. Provide insulation in the form of winter clothing and heating devices or alternative fuels, for staff employed in waste burning hotspots identified by the CAC.	Commercial setups, society and neighborhood ward	Homeowners, residential complex management, public educational and administrative institutions, and city staff choose alternatives for winter heating, reducing dependence on waste burning	Short and mid-term	Individual dwellings, housing societies, RWAs, IMC

Recommendation 5: Enhanced SWM in industrial zones

The primary survey found that waste burning in industrial areas is prevalent, which is second highest after low SES areas in the city. A few industries burned their solid waste and, at times, mixed it with industrial waste. It is necessary to dispose of solid and industrial waste separately and stop burning these. It is essential to address this issue and establish an effective waste management system. Although the responsibility of managing Industrial Solid Waste (ISW) lies with the industries themselves, collaborative efforts between the Madhya Pradesh Pollution Control Board (MPPCB), the IMC, and the industries can significantly improve the situation.

If the industrial solid waste is deemed non-toxic and non-hazardous, it can be managed in a way similar to household waste. However, it is still crucial to ensure that proper waste management practices are in place to prevent any environmental degradation or health risks. Table 6 presents a few specific steps that can be taken to manage this type of waste effectively.

Table 6: Proposed actions, strategies, intervention levels, implementation period and agency for SWM in industrial zones

Mitigation Strategies	Level of Intervention	Proposed Actions	Implementation Period	Implementing Agency
Ensure proper collection and infrastructure development	Industrial Area/Cluster (Sanwer Road and nearby areas, Banganga, Palda)	Ensure proper and strict door-to-door collection of solid waste from the industries to prevent burning. Establishing proper infrastructure for waste collection, segregation, and disposal can facilitate the effective management of industrial solid waste.	Short term	Industries Association (with the help of MPPCB and IMC)
Strengthen collaborative initiatives for waste management		Working in collaboration with the MPPCB and the IMC to develop specific guidelines and initiatives for managing non-hazardous (cardboard, wood, packaging materials) industrial solid waste can lead to the formulation of effective waste management strategies. This can involve sharing best practices, technologies, and resources for improved waste handling.	Short to mid-term	Industries Association (with the help of MPPCB and IMC)
Strict adherence to the guidelines and educational programs		Strict adherence to the existing guidelines of waste disposal in the industrial area. Awareness campaigns, meetings, and seminars among industries to stop MSW burning and dispose of industrial and solid waste separately.	Continuous	Industries Association and industry owner
Incentivize and promote sustainable practices	Industries	Offering incentives such as tax benefits or subsidies for the use of eco-friendly packaging materials and implementing advanced waste management technologies can motivate industries to invest in sustainable waste management practices and minimize the generation of non-hazardous industrial solid waste.	Short to mid term	MPPCB and state government

Recommendation 6: Mainstreaming scrappers, *kabadiwalas*, and ragpickers in waste management to stop commercial burning

The informal waste sector consists of small scrappers/*kabadiwalas* who are among the enablers of recycling, reusing, and recovering from discarded waste. However, during the recovery process, they also burn some of the waste material, to extract metals and other useful items. Burning any discarded waste causes air pollution, especially when it is done in open and confined spaces without any use of appropriate technology/equipment that controls emissions during the process. During the primary survey in Indore, it was found that these informal workers and small scrappers burn waste to extract metals and other valuable items. It is essential to mainstream these scrappers in the conventional waste management system, making it crucial for them to adapt to more sustainable practices to stop waste burning.

For ragpickers, authorities can develop and implement supportive legal frameworks and policies that recognize and protect the rights of informal waste/ragpickers. This can include enacting legislations that guarantee their right to decent work, access to social protection, and fair remuneration. Additionally, training programs can be deployed to enhance the skills and capacities of informal waste pickers, equipping them with the knowledge and tools needed to participate effectively in formal waste management activities.

Currently, 729 dedicated ragpickers are working with the IMC. They contribute significantly to the city's cleanliness by being deployed at material recovery facilities (MRFs), compost pits in gardens, and GTS. There are a huge number of ragpickers who remain marginalized and are not formalized/employed by the IMC. Therefore, similar to integrating scrappers and *kabadiwalas*, recommendations should be made for integrating ragpickers. Table 7 presents a detailed recommendation of how IMC can reduce/eliminate commercial burning and integrate scrapers and *kabadiwalas* in waste management, while also emphasizing the use of technological methods to recover metal. In order to address the issue of open burning of waste by informal waste sector workers and to integrate them into sustainable waste management practices, the recommendations presented in Table 7 can be considered.

Table 7: Proposed actions, strategies, intervention levels, implementation period and agency for mainstreaming scrapeprs and kabadiwalas in waste management to stop commercial burning

Mitigation Strategies	Level of Intervention	Proposed Actions	Implementation Period	Implementing Agency
Gender-responsive collaboration with local scrapper and <i>kabadiwala</i> communities	Local scrapper and <i>kabadiwala</i> communities	Establish a structured partnership with local scrapper and <i>kabadiwala</i> communities. This can involve partnerships with IMC or private waste management companies to provide them with a stable source of income.	Short to Mid Term	IMC (with help of NGOs)
Incentives for sustainable practices		Create a framework that incentivizes them to collect and manage recyclable waste from commercial entities. This could involve financial support for the installation of eco-friendly equipment (small material recovery facilities), as well as offering better prices for properly segregated and recycled waste.		
Target awareness program		Launch targeted awareness campaigns that educate the community about the hazards of commercial burning and the benefits of proper waste disposal.		
Technology integration		Facilitate access to appropriate technology and equipment for metal recovery. This could include the provision	Mid to Long Term	IMC (Private Sector)

		of small-scale incinerators and shredders to aid in the extraction of metals without resorting to harmful burning practices.		
Policy advocacy and support		Advocate for policies that support the integration of informal sectors into the formal waste management system. Work with local authorities to create a conducive regulatory environment that recognizes the important role of scrappers and <i>kabadiwalas</i> in sustainable waste management.	Long term	IMC and State and Central Govt.

A majority of the issues related to waste management and its disproportionate impacts on low SES, especially women, are due to their lack of participation at the policy and governance level and in planning and decision-making activities. To address this and to make waste management more inclusive, targeted strategies can be deployed. This includes introducing gender quotas in jobs, promoting gender-responsive policies (both for waste management and recruitment in various related sectors), and initiating capacity building and mentorship programs to enhance women's technical leadership skills. Flexible work arrangements would help to accommodate diverse responsibilities, and awareness campaigns emphasizing the importance of women's contributions can foster a supportive environment. Within households and societies, undertaking awareness campaigns and initiatives that empower women economically, socially, and politically will support fostering an environment where women's contributions are recognized and valued. Collaboration with women's organizations, regular gender audits, and promoting inclusive education are crucial for building an inclusive waste management sector that values and encourages women's active participation in decision-making and leadership roles. Addressing the structural and societal barriers will help integrate the women's perspectives in shaping sustainable practices across the waste sector.

For long-term impacts and viability, there is a need to establish a system for continuous monitoring and evaluation of the effectiveness of the awareness program. Gather feedback from participants and stakeholders to assess the program's impact on reducing the practice of open burning. This data can be further used to refine the campaign strategies and improve overall effectiveness.

7. Impact and Outcomes

Implementing effective waste management strategies can significantly reduce the occurrences of waste burning, thereby decreasing the release of harmful toxins and particulate matter into the atmosphere. This would directly contribute to the improvement of air quality in the surrounding areas, particularly for low SES communities, who bear the overwhelming burden of poor air quality due to MSW burning. Reduced exposure to harmful pollutants would lead to lower rates of respiratory illnesses, cardiovascular diseases, and other health issues associated with poor air quality. This would result in a healthier population, with improved overall well-being and a lower burden on the healthcare system.

Effective waste management practices, such as waste reduction, recycling, and proper disposal, contribute to the reduction of greenhouse gases (GHG) emissions. This would contribute to mitigating climate change by curbing the overall carbon footprint and fostering a more sustainable and eco-friendly approach to waste management, thereby promoting environmental conservation and contributing to long-term climate stability.

7.1 Improvement in air quality

Prior to 2016, the waste management in IMC was not adequate ([Smart city- Indore](#)). A study by Guttikunda et al. (2019) revealed that approximately 25% of the waste generated in the IMC area in 2015 was being burned daily. However, a survey conducted by the CAC during 2021-2022 (Refer to Section 5 of this report for details) indicated that this percentage had reduced to 3%. This notable decrease can be attributed to the proactive measures implemented by the IMC, including improved waste collection, source segregation, efficient processing, and robust IEC initiatives (Refer to Section 2 for details).

As a result of the stringent measures employed by the IMC, incidents of waste burning have reduced by approximately 88%, from 25% in 2015 to 3% in 2022, translating to an annual reduction of 10-12% within the IMC over the course of 7 years.

The scenarios analyzed have been divided into:

- (a) **City-level** initiatives, encompassing citizen awareness programs, the collection of dried leaves, promotion of heating alternatives, and the integration of scrap collectors in the mainstream
- (b) Measures targeting waste burning in **industrial areas**
- (c) Efforts aimed at enhancing waste collection efficiency in the **newly added, low SES wards**

1. City level: While designing the scenarios, it was estimated that with stringent implementation of the above recommendations (a,b, and c), a reduction almost doubles to 10-12% annually, i.e., around 40% can be achieved in 2-3 years. Consequently, based on IMC's track record of managing waste, a 60-70% reduction over 5 years, eventually reaching an estimated 97-100% reduction within 10 years, is expected. Considering its continuous expansion and development, the city may have challenges to fully eliminate burning. However, with stringent enforcement and continuous awareness programs, the city could be on the path to zero burning (Table 8).

2. Industrial areas: Achieving the target is expected to be more feasible in the short term, as these industries are established entities that would primarily require the introduction of a systematic waste collection system in collaboration with Madhya Pradesh Pollution Control Board (MPPCB) and IMC. Hence, a 60% reduction in waste burning incidents is assumed in the short term, progressing to a 97% reduction within the medium term (Table 8).

3. Newly added wards: Categorized as low SES areas, it is assumed that the suggested interventions would lead to a waste-burning incident reduction similar to that of the current medium SES areas, which is 81% less compared to the former. Therefore, it is projected that by 2028, waste burning incidents would reduce by 81%, with a further reduction of 97% by 2032 (Table 8).

Table 8 Emissions trend and reduction in comparison with Business-as-usual of PM 2.5

Years	Business as Usual (BAU)				Emissions after Interventions			
	City Level	Industrial Zones	Newly added wards	All Recommendations	City Level	Industrial Zones	Newly added wards	All Recommendations
	Baseline PM _{2.5} Emissions (MT/Year)				PM _{2.5} Emissions after Interventions in MT/Year (% Reduction)			
2021-22	65	27	17	109	65 (0%)	27 (0%)	17 (0%)	109 (0%)
2025	71	29	19	119	42 (41%)	9 (69%)		61 (49%)
2028	75	31	20	125	22 (71%)	2 (94%)	4 (77%)	28 (78%)
2032	80	33	21	133	2 (97%)		1 (95%)	3 (98%)

Based on the assumptions made regarding the recommendations and three scenarios, the baseline PM_{2.5} emissions and the reduced PM_{2.5} emissions for the years 2025 (short term), 2028 (mid-term), and 2032 (long term) were calculated. Table 8 illustrates the actual business-as-usual (BAU) and reduced PM 2.5 emissions, along with their percentage reductions. By combining all the scenarios and recommendations, it is estimated that PM 2.5 emissions would be reduced by approximately 98% or higher, based on the extent of adoption amidst a growing population (Table 8).

7.2 Health benefits of better waste collection and air quality

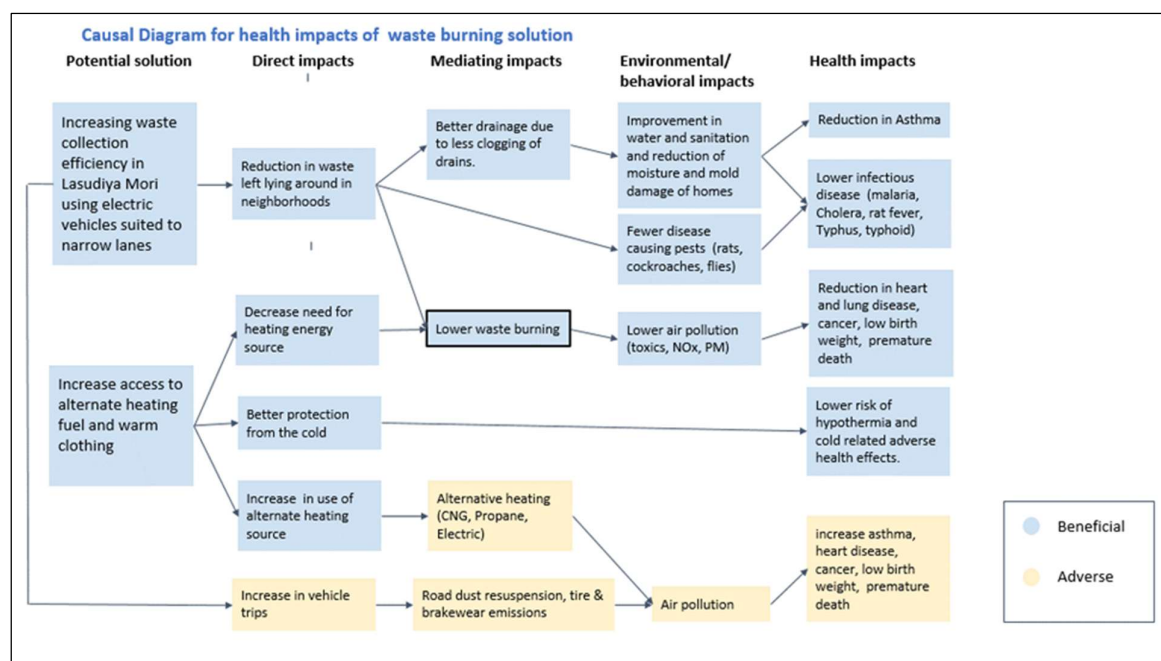


Figure 20: Diagram for Health Impact of waste burning solution

Health benefits of reduction in air pollution :

- Waste burning contributes to fine particle air pollution (PM_{2.5}), nitrogen dioxide, black carbon (BC), and ozone (Kumari, K., 2019). Exposure to these pollutants is known to cause and worsen heart and lung diseases, such as asthma, Chronic Obstructive Pulmonary Disease (COPD), stroke, and heart attack, and increases the risk of diabetes and cancer (WHO, 2021). Women, infants, and children are particularly vulnerable. Women's exposure to air pollution during pregnancy increases the risk of pregnancy complications, such as preeclampsia, with serious implications for the health and well-being of the mother and the child (Pedersen, M. et al., 2014, Randhir, K. et al., 2020). Air pollution also hinders the growth of the baby in the womb and is associated with preterm birth and infant mortality (Parchure, R, 2024., Desouza, P. N., 2022). It also decreases lung function and causes stunting in children (Pun, V. C., 2021). Recent evidence suggests that higher air pollution exposures are linked to infertility and menstrual irregularities among women, conditions that are often stigmatized, which in turn can increase the risk of domestic violence and poor mental health (Mahalinagaiah et al., 2018, Bonade, S. et al., 2018).
- Waste burning, particularly electronic, industrial, plastic and non-organic waste, is a source of hazardous air pollutants such as toxic volatile organic compounds, dioxins, furans, and heavy metals. These are known to increase the risk of cancer, immunological dysfunction, neurodevelopmental delays, and endocrine disruption.
- Reduction in emissions from waste burning will reduce hotspots of air pollution in the neighborhoods, decreasing the exposure of those residents who are likely to be present in the neighborhood during periods of waste burning. Often, this includes women, young children, and the elderly who are housebound and particularly vulnerable to the health impacts of air pollution due to pregnancy, existing diseases, or developmental life stage.

Other pathways of health benefits:

- Uncollected waste is a breeding ground for pests that are associated with infectious diseases (Kumar, S., 2017). Increasing the efficiency of waste collection will decrease habitats and food sources for pests. Reduction in flies and rat populations in the area reduces the transmission of typhoid, cholera, leptospirosis (rat fever), typhus, salmonella, etc.
- Drainage impeded by uncollected waste creates habitats for the breeding of rats, mosquitoes and sewage contamination of the areas surrounding the water collection points. This, in turn, increases the health risk of mosquitoes and waterborne diseases, such as malaria, dengue, zika, chikungunya, plague and diarrhea (Alirol, El, 2011). Improved awareness among the locals and collection efficiency of waste will aid water and sanitation by facilitating drainage, reducing the risks of infectious disease in the community.
- Increasing access to warm clothing and heat decreases the health risks of prolonged exposure to cold, which includes hypothermia, loss of coordination, confusion, and exacerbation of existing diseases.

Health risks from solution implementation are likely to be small and outweighed by benefits:

- The solutions proposed will increase vehicle trips for waste collection. It is anticipated that while these are likely to increase road dust resuspension and tire and brake wear emissions, the magnitude will be small because of the brief duration of the presence of these vehicles in the neighborhood.
- Alternative heating energy sources can also cause emissions. However, since the proposed heating sources use cleaner fuels and are being combined with protective clothing, it is hypothesized that the emissions will be lower in comparison to waste burning.

7.3 Black Carbon Emissions Reduction (Short-lived Climate Pollutants)

Emissions for pollutants such as BC, which contribute to the warming of the atmosphere, were estimated as part of this study. In the IMC area, the BC emissions were found to be 8.36 MT per year. In the Lasudiya Mori ward, the BC emissions were estimated to be 0.17 MT per year for 2021-22. The same scenario was considered for PM 2.5 (Section 7.1) for calculating BC emissions reduction (Refer Table 9).

Table 9 Emissions trend and reduction in comparison with Business-as-usual of BC

	BAU				Emissions after Interventions			
Years	City Level	Industrial Zones	Newly added wards	All Recommendation	City Level	Industrial Zones	Newly added wards	All Recommendation
	Baseline BC Emissions (MT/Year)				BC Emission after Interventions in MT/Year (% Reduction)			
2021-22	5.0	2.1	1.3	8.4	5.0 (0%)	2.1(0%)	1.3 (0%)	8.4 (0%)
2025	5.4	2.2	1.4	9.1	3.2 (41%)	0.7 (69%)		4.7 (49%)
2028	5.7	2.3	1.5	9.6	1.7 (71%)	0.1 (93%)	0.3 (77%)	2.2 (78%)
2032	6.2	2.5	1.6	10.3	0.1 (98%)		0.1 (95%)	0.2 (98%)

Table 10 Emission trend and reduction in comparison with Business as Usual of CO

	Business as Usual				Emissions after Interventions			
Years	City Level	Industrial Zones	Newly added wards	All Recommendation	City Level	Industrial Zones	Newly added wards	All Recommendation
	Baseline CO Emissions (MT/Year)				CO Emission after Interventions in MT/Year (% Reduction)			
2021-22	346	144	92	582	346 (0%)	144 (0%)	92 (0%)	582 (0%)
2025	378	156	101	634	220 (42%)	49 (69%)		323 (49%)
2028	398	164	105	667	116 (71%)	9 (94%)	24 (77%)	149 (78%)
2032	427	176	112	714	9 (98%)		6 (95%)	15 (98%)

7.4 Representing Lasudiya Mori ward with highest waste collection efficiency and few/no waste-burning incidents

The Lasudiya Mori ward, as a newly added area, has unique challenges due to its peri-urban context, i.e., a blend of low to medium SES, diverse land use, and infrastructure constraints. However, even with these complexities, the implementation of the recommended strategies is expected to yield a significant reduction in waste burning incidents and an overall improvement in air quality. If the intervention strategies outlined in this Solutions Strategy Paper are implemented over the course of 2-5 years, Lasudiya Mori is likely to achieve maximum waste collection efficiency, consequently mitigating its waste burning issues. The sustained and comprehensive series of awareness programs will play a pivotal role in educating the residents about the adverse consequences of waste burning, thereby leading to a gradual reduction in waste burning incidents attributable to behavioral factors.

If the implementation phase progresses over 5-10 years here, it can be expected to become a ward with an environment free of waste burning. Successful implementation and continuous monitoring can help this ward to become a model for other Indian cities, showcasing how a ward coping with various challenges, including infrastructural limitations, behavioral obstacles, and socio-economic diversity, can successfully overcome waste burning and revitalize its surrounding environment.

8. Gender and Equity in Waste Management and Burning

In Indore city, the source awareness research has highlighted transportation, waste burning, and pollution from industries as the significant sources of air pollution. In addition to identifying priority sectors, vulnerable communities have also been identified, which are disproportionately impacted by air pollution in Indore. These include women, children, and the elderly, as well as low-income populations. The waste burning survey that was carried out in the high, medium, and low SES areas along with the industrial areas revealed the disparity in MSW burning instances (Figure 20). The highest MSW burning mass was observed in low SES and industrial areas during the summer season, while in winters, it was high in the industrial, followed by low SES area. This distinction is largely influenced by factors such as limited waste management infrastructure and resources in low SES areas. Understanding these variations is crucial for designing targeted and context-specific waste management strategies that address the unique challenges faced by different socioeconomic strata and industrial zones. However, there are huge data gaps in data related to waste management and open burning practices. There is a lack of precise figures on the number of women waste pickers in Indore, their distribution across different neighborhoods, and their socio-economic backgrounds. Without this data, it is challenging to assess the scale of their involvement in waste picking activities and understand the specific challenges they face. Similarly, there are gaps in data on the income levels, livelihood strategies, and household dynamics of women waste pickers in Indore and the role of women in waste disposal. Understanding their socio-economic circumstances is crucial for designing programs aimed at poverty alleviation, skill development, and alternative income generation opportunities.

According to the Global Alliance of Waste Pickers, a networking process supported by Women in Informal Employment: Globalizing and Organizing (WIEGO), there are 7,500-8,000 informal waste pickers in Indore, earning around ₹100 per day (less than US \$2). A majority of these waste pickers are women (more than 90%) and belong to the low-income groups. An article published in *The Wire* in 2017 mentions that before formalization of the waste collection process by IMC, waste pickers used to collect garbage from houses in addition to sifting through waste, charging ₹40 per house. Post formalization, corporation workers charge anything between ₹60 and ₹90 and independent waste pickers are left without a livelihood. Almost all waste collectors belong to the impoverished communities, and, in most cases, entire families were found to be engaged in the work. In 2016, a few waste collectors had approached the District Collector to seek his intervention to halt the Swachh Bharat Mission work. Following this, in January 2017, 250 of them were provided identity cards and recognised as corporation workers under the Swachh Bharat Mission Rules. However, several continue to remain unemployed (Sukanya Shantha, 02 October 2017).

As per a media article published in 2021, IMC has employed 700 garbage pickers on its trenching ground and another 300 have been employed in processing compost manure (ANI, April 09, 2021). As per IMC, these workers now earn ₹400 per day. However, with approximately 7,000 rag pickers estimated to be working in Indore, the employment of only 1,000 leaves a significant portion without formal employment opportunities. For the remaining ragpickers, the lack of alternative livelihood options could exacerbate their economic vulnerability. Moreover, the formalization of waste management processes may further marginalize informal waste pickers, as they contend with reduced access to waste streams and increased competition from corporation workers.

This study aims to understand the differential impacts of air pollution on various gender groups within the context of urban environments, with a focus on Indore. The foundation of this study is a comprehensive literature review, including academic databases and peer-reviewed articles, reports, and studies related to air pollution, gender, and urban environments. In addition to academic sources, reports on air quality, public health, and gender issues from governmental bodies and NGOs in Indore were also included. A gender analysis framework was used to structure the analysis. This framework considers the social, economic, and cultural factors that influence the gendered experiences of air pollution. It facilitates the examination of disparities in exposure, susceptibility to health effects, access to resources, and participation in decision-making processes related to air pollution mitigation.



Figure 21: Women, elderly, and children associated with waste burning in Indore

Laws, policies, regulations, and institutional practices

In India, laws and policies such as the SWM Rules, 2016, the National Urban Sanitation Policy, and the SBM provide overarching frameworks for waste management. The lack of explicit gender and equity inclusion in these policies and practices has significant implications for women and marginalized communities, particularly those from low-income backgrounds. Furthermore, decision-making processes within waste management institutions often lack gender and equity considerations, with male-dominated leadership structures overlooking the diverse needs and perspectives of women and marginalized groups. This exclusionary approach can result in policies and programs that do not adequately address the specific challenges faced by these communities, perpetuating inequalities and hindering progress towards sustainable and inclusive waste management practices.

Gendered Norms and Beliefs

Waste management roles are often segregated along gender lines, with men dominating higher skilled positions, such as truck drivers and supervisors. Women, on the other hand, are more likely to be engaged in lower skilled roles, such as waste picking and sorting, which may expose them to hazardous conditions. Additionally, cultural norms may discourage men from participating in waste picking due to the associated social stigma, while women face barriers because of their lack of involvement in decision-making processes.

Waste picking, predominantly carried out by women, poses significant gendered risks, particularly concerning safety and security. Women ragpickers are disproportionately impacted by these risks due to the nature of their work, which often takes place in isolated or unsafe environments. The vulnerability of women waste pickers to harassment, violence, and exploitation is heightened as they navigate through dimly lit streets, garbage dumps, and secluded areas in search of recyclable materials.

Patterns of Power, Participation, and Decision-making

Men tend to be overrepresented in decision-making processes at various levels of waste management, from policy formulation to community planning, while women's lack of representation in decision-making, both at household and institutional levels, results in policies that are neither inclusive nor fully address the gender-specific needs and concerns. In community engagement, women's engagement is often focused on household waste management. Additionally, women ragpickers and women engaged in other informal jobs in the waste management sector consistently earn less than their male counterparts. A significant contributor to this wage gap is the additional caregiving and household responsibilities that women typically shoulder, leaving them with less time and energy to dedicate to waste-picking activities. Balancing caregiving duties with work in the waste management sector can limit women's ability to work longer hours or take on higher-paying opportunities, resulting in lower overall earnings. Furthermore, societal expectations and norms often dictate that women prioritize caregiving over income earning activities, further perpetuating their economic disadvantage. As a result, women waste pickers find themselves trapped in a cycle of poverty, struggling to make ends meet despite their essential contributions to waste management and recycling efforts.

Access to and Control of Resources

Men typically have greater access to resources, training, and education in waste management, facilitating their entry into higher paying and skilled positions. Conversely, women may have limited access to resources, restricting them to lower skilled roles and

contributing to the gender wage gap within the waste management sector. The ownership and control of waste management enterprises are often in the hands of men, denying women the economic benefits and decision-making power associated with such ventures.

Women and children in low-income families are often involved in waste collection, making them more vulnerable to health hazards, social stigma, and economic vulnerability. Similarly, open burning disproportionately impacts women and low-income families, exposing them to harmful pollutants and health risks. Higher income groups typically have better access to waste disposal services, reducing their reliance on open burning practices. Even the health impacts associated with open burning are more pronounced for women and low income families due to their exposure to emissions and improper waste-handling practices. High-income groups, on the contrary, have greater access to healthcare, mitigating the health impacts associated with poor waste management practices.

Personal safety and security

Safety and security are critical issues in the waste management sector, reflecting broader systemic inequalities and vulnerabilities faced by marginalized communities. In many contexts, women, who comprise a significant portion of waste pickers and informal recyclers, confront heightened risks of harassment, violence, and exploitation while carrying out their work. The nature of waste picking often exposes individuals to hazardous conditions, including navigating through dimly lit streets, garbage dumps, and secluded areas, where they are susceptible to verbal abuse, physical assault, and sexual harassment. Moreover, the lack of formal recognition and protection for waste pickers, particularly women, leaves them without recourse or support mechanisms to address these risks. Initiatives such as improved lighting in waste collection areas, community policing efforts, and access to legal and social support services can help mitigate risks and enhance the safety and well-being of waste pickers, particularly women.

8.1 Priority Communities Exposure

Along with transport and industries, the Indore pilot team identified waste burning, especially industrial, biomedical, and household solid waste burning and illegal dump sites, as a priority source of air pollution in the city. The priority impacted communities are women, children, the elderly, and other impacted workers, especially in areas across Indore and specific wards where waste burning is more prevalent. Waste burning is most common in Ward No. 7 (Sanwer industrial Area), Ward No.10 (Baanganga Community - Sanwer Road area), Ward No. 71 (Nipaniya), Ward No. 8 (Niranjanpur), Ward No. 65 (Musakhedi), Ward No. 35 (Lasudia area - Dewas Naka), and Ward No. 80 (Buddh Nagar near Sudama Nagar). All of these wards are mixed in terms of SES. Municipal waste burning has been a contributor to air pollution and a polluting activity for a long time, as revealed by various stakeholders during workshops.

As per a WHO report titled "Different Air Under One Sky", the greatest proportion of people living in India are exposed to PM 2.5 concentrations more than five times the WHO annual average guideline (Chen et al., 2022). The report also mentions that 62% of pregnant women in the country live in the most polluted areas as compared with 56% of the entire population. The report lists older adults, infants, and pregnant women as the most vulnerable groups who are exposed to worse air.

The types of occupations in which women in the low-income category are often employed lead to enhanced exposure to air pollution. For instance, most street sweepers in India are women. They are vulnerable to respiratory tract irritations and health issues, such as asthma and bronchitis, because of occupational exposure to street dust, which is a mix of soil, sand particles, dust, motor vehicle emissions, bioaerosols, and plant particles. A study was conducted in which 30 female sweepers were matched with 30 healthy females. A key finding was that sweeping streets led to a reduction in lung function among the female sweepers on several parameters. Findings also showed that decreased lung function was related to the extent and duration of exposure to street dust (Johncy et al., 2014). A related cross-sectional study found the risk of chronic respiratory morbidity among street sweepers was 4.24 times higher than that in the comparison group, and the risk increased significantly as the length of service increased. Similar studies among street sweepers in Chennai, Nigeria, and Bangalore produced in similar results (Sabde et al 2008).

The number of women street sweepers in Indore was not readily available. It is important to determine the number of both women and men employed and their levels of exposure as the health effects are serious. Also, they are borne by the poorest and most vulnerable people most likely to have the least access to health care. In the interim, simple protective measures can be readily adopted namely, the provision and use of protective equipment such as a simple face mask, long brooms that create distance from stirred dust, and periodic lung function tests.

People living in the vicinity of waste burning sites are most affected by emissions from municipal waste burning or open waste burning. These are often the low-income neighborhoods or residential areas closer to open dumping and burning sites. Mebratu and Mbandi (2022) revealed that children living near dump sites are exposed to a mix of toxic substances because of open waste burning (OWB). The particulate matter emitted in the air causes lung and heart disease, cancer, infertility, low birthweight, premature birth, cognitive development problems, and premature death. Dump sites are a significant source of GHGs, emitting roughly 20% of the world's methane and 11% of BC. To mitigate the impacts of climate change, drastic reductions in emissions are essential (Mebratu and Mbandi, 2022). A study on an MSW dump in Kolkata (Calcutta), where MSW is regularly burned either intentionally or spontaneously, found high levels of dioxin-like polychlorinated biphenyls (PCBs) and other persistent organic pollutants (POPs) in the breastmilk of mothers in the area due to the consumption of fish from a local pond (Someya et al. 2010).

Majority of the waste-pickers are women and belong to the low-income groups. As per a media article published in 2021, IMC has employed 700 garbage pickers on its trenching ground and another 300 have been employed in processing compost manure (ANI, April 09, 2021). As per IMC these workers now earn INR 400 per day.

Studies have revealed that in the informal waste economy, women are often limited to low-income tasks, such as waste picking, sweeping, and waste separation, whereas men are able to assume positions of higher authority, such as dealing with the purchase and resale of recyclables. When informal or voluntary waste-related activities become formalized with pay, men often engage in the work, thereby displacing women. In the formal waste economy, women are typically excluded from high-income, decision-making, and policymaking positions, indicating that gender norms and opportunities shape people's livelihood options in this sector. Health impacts and safety needs also differ for women and men, since the labor involved in formal and informal waste

management and task handling is differentiated by both gender and age, thus exposing these populations to different health risks (UNEP-IETC and GRID-Arendal, 2019). At the household level too, women tend to be responsible for care and maintenance activities, which also extends to managing household waste. In some places, this responsibility also falls on women in public spaces, placing them at the center of community cleanliness. Moreover, in many societies, men and women have different perceptions of what is considered waste, which can influence preferences for waste management services (IETC, 2015). Therefore, it becomes important to consider households' social and economic aspects when planning waste management systems that provide services. Unfortunately, the participation of women at the policy and governance levels and in planning and decision-making activities remains low in most countries in the world.

8.2 Data Gaps in Waste Management Sector

Waste collection rates all over India have increased after the introduction of SBM, "Clean India Mission", Smart Cities, and Atal Mission for Rejuvenation and Urban Transformation (AMRUT), emphasizing technology and Public Private Partnership (PPP) models. However, the collection rate varies, from as low as 25% in the state of Kerala up to nearly full coverage in the state of Maharashtra. However, the waste generation rate reported at the state level does not include waste material picked up by informal workers from waste generators and the street. Given that the contribution of the informal sector is high (it constitutes 80-85% of the dry waste handled in Bengaluru), this can mean a large difference in the amount of waste generated. However, the SWM legislation acknowledges the contribution of the informal sector to the cleanliness of the city and recommends the inclusion of informal recycling collectors in waste management services. The law enforcement is low (Ocean Conservancy, 2019).

Involvement in waste management at the community level has a gender dimension. Removal of waste involving recycling scrap from the streets is an informal job, with no long-term income. Studies reveal that men are employed in equipment-based roles that involve loading and unloading of materials for recycling that are manually picked up by women. The jobs assigned to men and women vary significantly, with women taking up the time consuming and repetitive job of collecting and sorting the materials manually sourced for recycling. Statistics show that women make up 90% of the laborers who work as recycling waste pickers, with a considerable number being widows and single mothers (Lavanya, R., July 9, 2021). The prevalence of widows and single mothers among waste pickers is an indication of their socioeconomic vulnerabilities. Deprived of traditional support structures and facing heightened financial pressures, widows and single mothers are compelled to seek livelihoods in informal sectors, such as waste picking, despite the associated risks and challenges. This phenomenon underscores the intersectionality of gender, poverty, and widowhood, exacerbating the marginalization experienced by these categories of women and their dependents.

Women's participation in the waste management sector tends to be limited to basic jobs and preliminary levels of the value chain, including sweeping the streets, collecting mixed waste, and supporting partners in carrying and disposing of waste into bins. As the nature of participation in processing and recycling factories is unregulated, data on the number of women involved in the sector and nature of work undertaken is not available. Women are also engaged primarily as daily wage workers in the sector. As a result, women on an average earn half that of men in the sector. Because of a lack of data, specific health risks that women may be exposed to in this process are neglected and they are often left out from the workforce when this process becomes mechanized.

8.3 Gender Considerations When Designing New Clean Air Solutions that Equally Protect Women & Girls and Men & Boys

There are significant gaps in information and data on the gendered impacts of air pollution exposure due to the limited collection of data disaggregated by sex, age, and diversity. The lack of gender equality in social, economic, and political spheres influences the differentiated impacts of air pollution exposure. By addressing the underlying gender inequalities and sex and gender discrimination, air pollution mitigation and adaptation actions too can promote gender equality. Improving women's access to land and resources can make a significant positive social and environmental impact and support women's resilience to the exposure impacts. It has been observed that in many countries, including India, in several national laws and policies, women and gender equality are rarely referred to. Even if there is a reference to women, it is mostly in terms of a vulnerable group and not expressly mentioned as active participants and decision makers.

Financing mechanisms must be flexible enough to reflect women's priorities and needs when designing solutions for air pollution mitigation. The active participation of women in the development of funding criteria and allocation of resources for air quality initiatives is critical, particularly at local levels. Gender analysis of all budget and financial instruments is needed to ensure gender-sensitive investments in air quality programs for mitigation, technology transfer, and capacity building. Women should also have equal access to training, credit, and skills development to ensure their full participation in air quality initiatives.

Targeted efforts must be based on certain considerations. Firstly, the efforts must be sensitive to the differences in the situation of women and men. Secondly, technologies should be designed in such a way as to be relevant to women's circumstances, and, thirdly, it must be ensured that women receive full access to knowledge, information, and technologies related to adaptation.

Women's participation

Women are primarily responsible for waste disposal in households, but their voices remain unheard in the waste management sector due to the lack of decision-making powers within households and societies. With respect to employment in the waste management sector, women lack representation as they are often employed in low skill jobs whereas high skill and high paying jobs are held by men.

8.4 What this means for CAC Solutions

In practice, culturally acceptable and context-specific solutions should consider several factors, including a combination of interventions. Certain opportunities and recommendations for CAC, drafted on the basis of conversations with stakeholders as well as findings from available research, are presented in this section.

1. **Focus and Inclusion of Gender Analysis:** Inclusion of gender-specific issues and data in surveys is crucial in understanding the on-ground conditions and gaps. Additionally, for collecting data disaggregated by gender and specific to gender and equity issues, it is critical to ensure enumerators and data analysts are trained in gender-sensitive approaches as well as in the safeguarding and do-no-harm principles. The inclusion of gender analysis in various sectors is an evolving process. It may help unravel some gender-related impacts on overall well-being

and may merit further exploration in various fields, such as environmental epidemiology and social equity.

2. **Collection of Gender-disaggregated Data:** Reporting sex-stratified results is more informative than adjustment for sex and can identify associations differing broadly between males and females. However, sex stratification often confounds tightly correlated gender and sex effects, obscuring true sources of difference. Preferably, researchers may stratify data separately by multiple sex- and gender-associated factors (such as body size, working outside the home, time spent on household tasks) to elucidate the sources of difference. Most epidemiologic data sets are not adequately powered to perform multiple stratifications simultaneously, so these multiple stratifications usually need to be performed separately. Stratification variables should reflect time–activity patterns or meaningful biological factors, rather than stereotypical attributes, to identify the true factors relevant to the cohort under study.
3. **Population-specific exposure modeling:** This may improve the cultural and behavior-specific exposure assessment, clarifying gendered exposure differences. Residential exposure metrics may be more accurate for women who spend more time near their home on average, especially when caring for children or other family members. Residential activities may require microenvironmental exposure assessment (LaRosa et al., 2002), because gendered activities (such as cooking, cleaning, lawn care) produce different exposure patterns. Exposure measurement may benefit from gendered exposure measurement, comparison of gendered activities across communities (Berhane et al., 2004), or foci on temporal exposure characteristics (such as diurnal trends in residential exposures and activities, critical life-course periods related to hormonal composition or roles) (Gilliland et al., 2005). However, assignment of gendered exposures, broadly to sex-stratified groups, should be generally avoided because this practice obscures the sources of variability between men and women, further confounding sex effects in subsequent epidemiologic analyses.

Empower women and facilitate positive human development outcomes for individuals in the formal and informal waste collection sector:

Waste management and segregation is typically performed by women, be it within the family or as part of work. A majority of the roles related to domestic work are taken up by women from less privileged social backgrounds. Women lack inclusion when it comes to the formal and informal waste management sectors, given the gendered division of labor in waste collection and disposal. While men are engaged in more skilled, equipment-based roles, women's jobs in the sector are limited to the bottom end of the value chain, in tasks such as sweeping the streets, manual collection of waste, and supporting partners in carrying and disposing of the waste into bins. Therefore, improving collection efficiency necessitates a careful look into women's jobs in the sector and addressing the constraints in empowering their roles in the waste collection value chain.

9. Conclusions

The CAC initiative seeks to address air pollution while considering its broader impacts on climate, health, equity, and gender. CAC collaborates closely with local teams and stakeholders to design and implement clean air actions tailored to the unique challenges and opportunities in each city. The CAC has identified specific areas of intervention in Indore city, which are addressed through a multi-step process, including root cause analysis, the development of actionable solutions, and a careful selection of the most impactful and implementable actions. The initiative aims to create lasting change by not only focusing on a few actions but also by building awareness, engaging stakeholders, and advocating for these solutions within the communities.

This Solutions Strategy Paper recommends a number of measures for reducing waste burning in Indore. While policies such as the Swachh Bharat Survekshan (SBS) have made notable progress, there remains a pressing need for comprehensive and sustainable solutions that address the specific nuances of each locality, including gender and equity considerations. The proposed recommendations for the IMC include capacity building programs and increasing waste collection efficiency, specifically in the areas with narrow lanes and low SES, newly added wards and industrial areas. A comprehensive framework would include the provision of heating alternatives to the security and household staff, mainstreaming of scrappers and *kabadiwalas* in the city waste management, and the establishment of a monitoring mechanism. The policies proposed here can result in an estimated reduction of approximately 96% (3 MT per year) of PM_{2.5} emissions from waste burning by the year 2032, as compared with 108 MT per year in the year 2021-22.

An in-depth analysis of the Lasudiya Mori ward proved that efficient waste collection and management practices, coupled with a focus on gender and equity inclusivity, can yield positive outcomes. The concerted efforts to curb waste burning in Lasudiya Mori as a pilot aimed not only to improve the immediate environmental and health conditions but also to contribute to the overall well-being and sustainable development of the community and the city at large.

It is imperative for policymakers and stakeholders to recognize the importance of sustained efforts in waste management and to prioritize the implementation of gender-inclusive and equitable strategies. By addressing the gaps in waste management practices and fostering community engagement, there is a substantial opportunity to create a sustainable model for waste management, which can serve as a blueprint for other regions facing similar challenges across the country.

9.1 Way forward

The progress made by Indore city in managing its municipal solid waste is commendable. However, there is scope for further improvements, particularly in the context of reducing waste burning emissions in a way that is gender-responsive and does not place additional burden on low SES communities. The multifaceted approach outlined in this paper, involving government regulations, industry innovation, public education, and individual actions, holds promise in mitigating the adverse environmental and health impacts associated with waste burning.

While the IEC initiatives have played a significant role in the city's cleanliness efforts, the absence of ward-wise data and information poses a challenge to the development of more effective, micro-level plans tailored to specific areas. Addressing this gap is critical to refining strategies that can yield more impactful and targeted outcomes.

At the national level, there is a pressing need for comprehensive policies that prioritize waste burning issues, along with a robust framework for implementing and monitoring these policies. Building the capacity of national organizations to effectively address these challenges is crucial for sustained progress and impact on a broader scale.

The collaborative efforts demonstrated by the CAC serve as a valuable model for addressing air pollution. By taking a holistic approach and engaging with local stakeholders, the CAC exemplifies how addressing environmental concerns can not only benefit the ecosystem but also contribute to the well-being of the communities it serves. This inclusive and collaborative approach paves the way for a more sustainable and effective strategy in tackling waste burning and its associated consequences.

9.2 Waste burning reduction, a low-hanging fruit

Focusing on mitigating waste burning offers a straightforward and impactful investment opportunity, with the potential for immediate and visible improvements in air quality, public health, and the overall environment. By prioritizing efforts to reduce waste burning, citizens can effectively tackle air pollution and its associated health risks while building resilience to climate change.

The implementation of solutions in this domain is relatively straightforward as the IMC holds complete ownership. The recommended measures, such as enhancing waste collection efficiency in areas with limited accessibility and lower socioeconomic status, newly incorporated wards, and industrial zones, can prove to be effective. Providing alternative heating options for security and household staff, integrating informal waste collectors into the city's waste management system, and establishing a robust monitoring mechanism form a comprehensive framework to significantly reduce instances of waste burning.

The waste management system in IMC is effective and has the capacity to manage the challenges of waste infrastructure. Addressing the challenges requires targeting the underlying behavioral aspects. In this section, the costs required to carry out the capacity building and awareness programs are estimated, specifically for the newly added wards of Sant Kabir, Nipaniya, Lasudiya Mor, Bichol, Vishwakarma, Palda, Bijasan, Bilawli, Prajapati Nagar, Sukh Niwas, Dr. Rajendra Prasad, Nandbagh, and Kushwah Nagar in the IMC area (Table 11). These programs can be disseminated through diverse channels, including mass media platforms such as newspapers, and radio, as well as through street plays. Leveraging social media platforms, such as Facebook, Twitter, and Instagram, can also amplify awareness efforts. Additionally, conducting annual awareness programs, encouraging citizen participation, organizing public meetings, and involving community leaders in spreading the message are crucial strategies in fostering sustainable waste management practices within the IMC area. Approximately ₹79 lakhs is estimated as the total expenditure for the mass media coverage, IEC awareness material, door-to-door awareness programs, capacity building seminars, and street plays. This costing has been calculated for a time span of 2-5 years depending upon different categories.

Table 11 Economic Implication of Proposed Mass Awareness Programs

Sl. No	For Newly Added Wards (Total Population below ₹5 Lakhs)	Duration	Amount (In ₹lakhs)
1	IEC Awareness Materials	Continuous (Initially 3-5 years)	15
2	Mass Media (newspaper, radio), social media	2-3 years	16
3	Seminars with Women's Associations/Local leaders/RWA's, School and Colleges	3 years	10
4	Door-to-door Awareness Programs	2 years	20
5	Streets Play	2 years	2.5
	Sub-total		63.5
	10% Inflation Charges Annually for 3 Years		14.64
	Total		78.14
	Rounded off		79

These community awareness programs and educational campaigns can encourage behavioral shifts, fostering a culture of responsible waste management among residents. By strategically allocating resources to address waste burning, the city can promptly demonstrate its commitment to environmental sustainability and the well-being of its citizens. This focused approach not only addresses immediate challenges but also lays the foundation for more comprehensive and sustainable waste management strategies in the future.

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