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Assessment of Solid Waste Management Practices and Entrepreneurial Opportunities in Pune City, Maharashtra

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Abstract:

Pune City, a rapidly urbanizing hub in Maharashtra, faces significant challenges in managing the increasing volumes of solid waste generated daily due to population growth and urban development. This study critically examines the current state of solid waste management in Pune, identifies key challenges, and explores entrepreneurial opportunities within the sector. The research adopts a contingency valuation method (CVM), focusing on willingness-to-pay (WTP) analysis, to assess residents' readiness to financially support improved waste management practices. A multi-method approach was employed, incorporating surveys, interviews, field observations, and secondary data collection. Stratified random sampling ensured representation from diverse zones within the city. Key stakeholders, including municipal authorities, waste pickers, entrepreneurs, and households, provided valuable insights into waste generation, collection, segregation, and disposal practices. The findings reveal gaps in existing systems, including inefficiencies in waste segregation and recycling, limited community awareness, and inadequate infrastructure. However, these challenges present opportunities for innovation and entrepreneurship. SWOT and feasibility analyses highlight promising avenues such as waste collection startups, recycling ventures, and waste-to-energy initiatives. Additionally, the WTP analysis underscores the community's willingness to embrace sustainable waste practices, providing a financial basis for improving the system. This study proposes actionable recommendations to enhance waste management, foster entrepreneurial ventures, and promote public-private partnerships (PPPs) to address current inefficiencies. Emphasis on social entrepreneurship, technological innovation, and investment in sustainable practices is encouraged to balance environmental stewardship with economic growth. The research offers valuable insights for policymakers, urban planners, and entrepreneurs, aiming to transform Pune City into a model of sustainable urban development. By addressing waste management challenges and unlocking entrepreneurial potential, the study contributes to the broader goals of environmental sustainability and urban resilience.

Keywords: *Solid Waste Management, Pune City, Contingency Valuation Method, Willingness-to-Pay (WTP), Sustainable Waste Practices, Entrepreneurship, Waste-to-Energy, Recycling, Public-Private Partnerships (PPP), Environmental Sustainability.*

Introduction

The rapid urbanization and exponential population growth in cities have created pressing challenges in managing solid waste effectively. Pune City, a major urban hub in Maharashtra, is no exception. The city generates a significant quantity of solid waste daily, reflecting the increasing consumption patterns and changing lifestyles of its residents. This surge in waste production has heightened environmental and public health risks, underscoring the urgent need for robust waste management solutions. Ineffective or improper disposal practices lead to adverse consequences, including pollution, greenhouse gas emissions, and health hazards for the urban population.

Effective solid waste management (SWM) is critical for mitigating these risks and promoting sustainable urban development. Traditional approaches, while still in use, often fall short of addressing the complexities of contemporary urban waste generation. Pune City has adopted various strategies to handle its solid waste, including segregation at source, composting, and waste-to-energy projects. However, gaps remain in their implementation, particularly in community participation and technological integration. Bridging these gaps requires innovative and inclusive strategies that

balance environmental protection with socio-economic development.

Amid these challenges, the concept of entrepreneurship offers a transformative approach to reimagine SWM in urban areas. Entrepreneurial ventures in waste management provide a dual advantage: they address pressing environmental issues while creating economic opportunities. In Pune, there is significant potential for such initiatives, ranging from waste-to-energy projects to recycling and upcycling ventures. These activities not only reduce the volume of waste sent to landfills but also contribute to resource recovery and the circular economy. Furthermore, they create employment opportunities and foster innovation, making waste management a lucrative and impactful sector.

This research aims to analyze the current SWM practices in Pune City, focusing on their strengths, weaknesses, and areas of improvement. It seeks to evaluate community involvement in waste management through contingency evaluation methods, with an emphasis on willingness-to-pay (WTP) analysis. WTP studies are essential for understanding the public's readiness to invest in sustainable waste management initiatives, which is a key determinant of their success. By gauging the community's attitude and willingness to contribute, policymakers can design strategies that resonate with the local population and ensure greater compliance and participation.

Additionally, the study explores entrepreneurial opportunities within Pune's waste management ecosystem. The integration of innovative technologies, such as Internet of Things (IoT)-enabled waste tracking systems and advanced recycling technologies, offers a pathway to revolutionize SWM. Community-driven initiatives, including cooperatives for waste segregation and small-scale composting units, also hold promise for improving local waste management practices. Waste-to-energy projects, which convert non-recyclable waste into usable energy, exemplify the potential for combining environmental sustainability with economic viability.

The research underscores the importance of fostering entrepreneurship as a means of addressing Pune's SWM challenges. By leveraging innovative approaches and tapping into the entrepreneurial spirit, the city can transition towards a more sustainable and efficient waste management framework. This framework not only aligns with global sustainability goals but also enhances the quality of life for its residents.

Pune City's SWM challenges present an opportunity to innovate and grow. This study seeks to provide actionable insights into improving waste management practices, fostering community participation, and promoting entrepreneurship in the sector. By addressing these areas, Pune can position itself as a model for sustainable urban waste management, setting a precedent for other cities grappling with similar issues.

Literature Review

Effective solid waste management (SWM) is a critical challenge for urban sustainability, particularly in rapidly growing cities like Pune. Several studies highlight the complexities and inefficiencies of SWM systems in India (Gupta & Kumar, 2016). Inadequate segregation at the source is a major limitation, as household participation remains low despite awareness initiatives (Sharholy et al., 2008). Infrastructure deficiencies further exacerbate collection and transportation inefficiencies (Kumar et al., 2020).

Informal waste pickers play a crucial role in SWM by retrieving recyclable materials, yet their contributions remain largely unrecognized in policy frameworks (Wilson et al., 2012). Studies indicate that integrating informal workers into formal waste management systems can improve efficiency and sustainability (Chaturvedi & Gidwani, 2011). Landfilling remains a predominant disposal method in Indian cities, leading to environmental concerns such as leachate contamination and greenhouse gas emissions (Mor et al., 2016). Research suggests that reducing landfill dependency requires investment in recycling infrastructure and waste-to-energy technologies (Pires et al., 2011).

Economic aspects of SWM indicate significant entrepreneurial opportunities. Studies show

that willingness-to-pay (WTP) models can help design financially viable waste management solutions (Altaf & Deshazo, 1996). Entrepreneurial ventures in SWM, such as waste collection startups and recycling businesses, have proven successful in other Indian cities (Suthar & Singh, 2015). Technological interventions, including IoT-based tracking systems, enhance efficiency in waste logistics (Singh & Sharma, 2018).

Public-private partnerships (PPPs) have emerged as a promising approach to improving SWM. Research suggests that PPPs provide financial support and operational expertise, fostering innovation in waste management (UNEP, 2019). By leveraging policy interventions and market-driven solutions, cities can transform SWM into a sustainable and economically viable sector.

Ravindra, Kaur, & Mor (2015) Highlighted organic waste dominance in urban areas and the need for integrated waste management systems.

Kulkarni and Anantharama (2020) Addressed the urgency of improving municipal solid waste management post-COVID-19.Afroz & Masud (2011): Emphasized the need for enhanced environmental awareness and recycling practices.

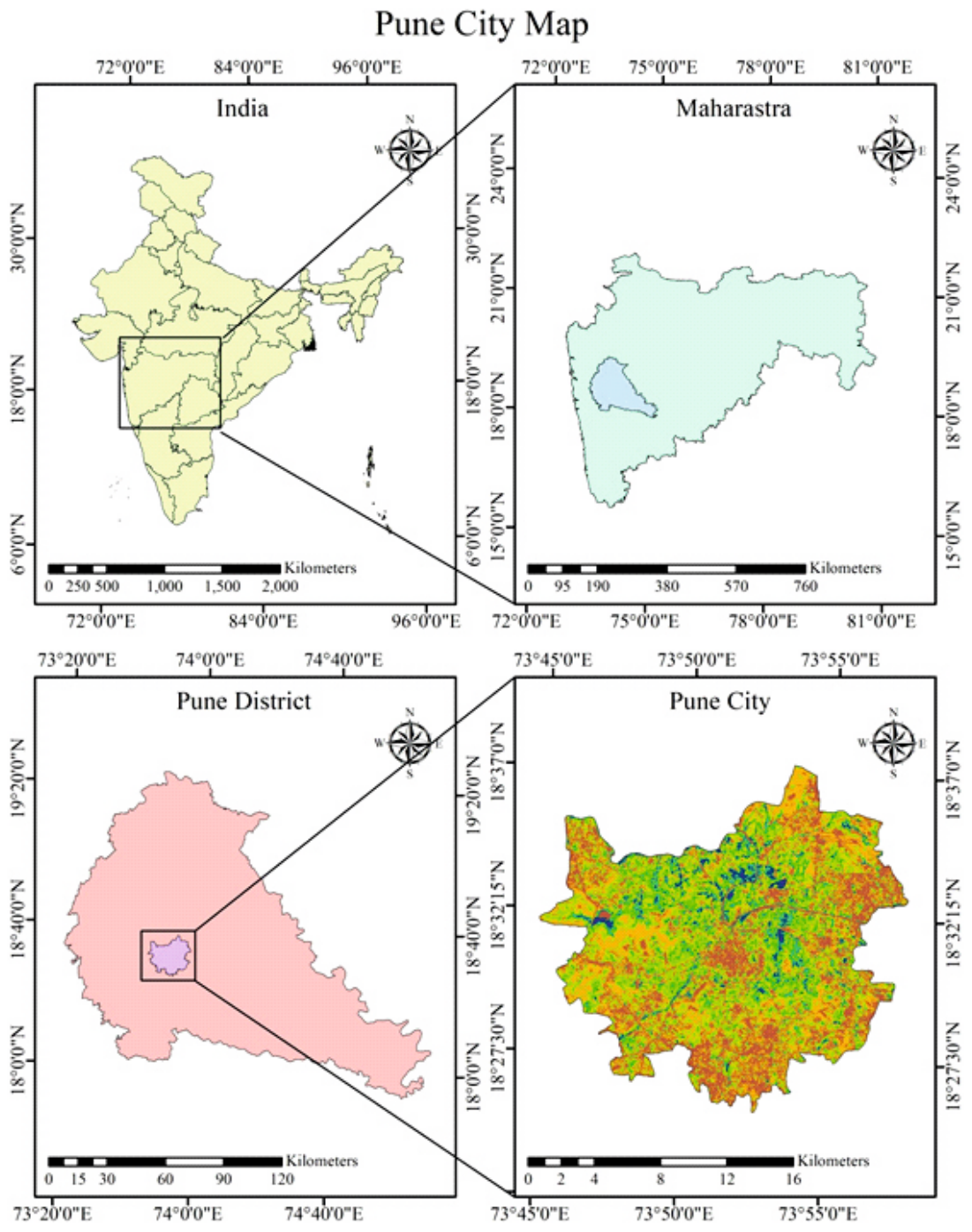
Studies on Indian cities like Mumbai, Pune, Kanpur, Indore, and Varanasi have provided comparative insights into waste management scenarios.

Study Area

The city of Pune is located in the state of Maharashtra, India. It is situated about 560 kilometers southeast of Mumbai, the state capital. Pune is nestled in the Deccan Plateau, at an elevation of approximately 559 meters above sea level. The city is bounded by the Mula and Mutha rivers to the east and west, respectively. It is the second-largest urban center in Maharashtra and the eighth most populous city in India, experienced a 7.8% population growth between 2001 and 2011 (Census of India, 2011). Known for its rich cultural and historical heritage, Pune has earned the title of the 'Cultural Capital' of Maharashtra. Additionally, the city is a renowned educational hub, often called the 'Oxford of the East,' due to its prestigious institutions and highly skilled workforce.

Geographically, Pune is situated between 18°25′N to 18°37′N latitude and 73°44'E to 73°57' E longitude, covering an area of approximately 251 square kilometers. It has a population of around 3.1 million and is administratively divided into 76 general electoral wards, which were later reorganized into 14 administrative wards under the Pune Municipal Corporation (PMC) (Jaybhaye et al., 2014). Pune lies on a plateau near the western edge of the Deccan Plateau, at an elevation of 560 meters above sea level. The city is bordered by hills to the west and south, with the Sinhagad-Katraj-Dive Ghat range forming its southern boundary. Vetal Hill is the highest point in the region.

The primary water bodies in Pune include the Mula and Mutha rivers, while the Pavana and Indrayani rivers flow from the northwest. These natural features play a vital role in shaping the city's ecological balance, waste management systems, and urban sustainability efforts.



Source: Pune base map and UTM E-43 Landsat Satellite Imagery, 2025 processed by Arc GIS 10.8.1

Pune Future Population 2021-2031

Pune	City	Metropolitan
2011	3,124,458	5,057,709
2021	4,061,000	6,575,000
2022	4,182,000	6,772,000
2023	4,307,000	6,975,000
2024	4,436,000	7,184,000
2025	4,569,000	7,399,000
2026	4,706,000	7,620,000
2027	4,847,000	7,848,000
2028	4,992,000	8,083,000
2029	5,141,000	8,325,000
2030	5,295,000	8,574,000
2031	5,453,000	8,831,000

Proposed End-Outcomes

1. Comprehensive understanding of the current state of solid waste management in Pune City.
2. Evaluation of contingency evaluation methods, particularly willingness-to-pay analysis.
3. Identification of challenges and opportunities in the sector.
4. Identification of entrepreneurial opportunities in solid waste management.
5. Recommendations for improving waste management practices and promoting entrepreneurship.

Future Plan for Commercialization

1. Technology Development: Encouraging innovation to improve waste collection, sorting, recycling, and disposal.
2. Social Entrepreneurship: Establishing social enterprises or impact-driven startups based on the findings.
3. Public-Private Partnerships: Leveraging willingness-to-pay survey results to develop innovative financing mechanisms for infrastructure projects.

2. Objectives

1. To assess the current solid waste management practices in Pune City.
2. To identify the challenges and opportunities associated with solid waste management.
3. To evaluate contingency evaluation methods, particularly willingness-to-pay analysis, for solid waste management.
4. To explore entrepreneurial opportunities in solid waste management.
5. To develop recommendations for improving solid waste management practices and promoting entrepreneurship in the sector.

Methodology

This study employs a mixed-method approach combining qualitative and quantitative

techniques. Primary data collection includes surveys and structured interviews with residents, municipal officials, and waste management entrepreneurs. Secondary data sources include municipal reports, policy documents, and relevant academic literature. The contingency valuation method (CVM) is used to assess WTP, while SWOT and feasibility analyses identify entrepreneurial prospects.

Contingency Evaluation Methods

This study methodology to evaluate Pune City's solid waste management (SWM) practices and explore innovative solutions for sustainable waste handling. It integrates contingency evaluation methods, entrepreneurial opportunity analysis, and diverse data collection strategies to achieve its objectives.

The contingent valuation method (CVM) is pivotal for this research, offering a means to evaluate non-market resources, such as environmental services. This method employs a **hypothetical market survey** through structured questionnaires, where respondents are asked about their **willingness to pay (WTP)** for improved SWM services or **willingness to accept (WTA)** compensation for environmental degradation.

In the context of this study, WTP analysis is employed to measure public interest and readiness to invest in sustainable SWM practices. This involves the following steps:

1. **Survey Design:** A detailed questionnaire will be designed to capture residents' WTP for enhanced SWM services. Questions will address aspects such as convenience, health benefits, cost, and environmental impact.
2. **Data Collection:** Surveys will be conducted among Pune City residents, ensuring a representative sample across various demographics and geographic areas.
3. **Data Analysis:** The collected data will be analyzed to compute the mean WTP and identify factors influencing respondents' willingness to invest. Key parameters may include income, education, awareness, and existing satisfaction with SWM practices.

Entrepreneurial Opportunity and Market Feasibility Analysis

The research also aims to explore entrepreneurial opportunities in the SWM sector by employing:

1. **SWOT Analysis:** A thorough evaluation of strengths, weaknesses, opportunities, and threats in Pune's SWM system. This analysis will highlight the current capabilities, operational gaps, and potential for innovation.
2. **Feasibility Studies:** Market viability assessments for entrepreneurial ventures such as:

- ❖ Waste Collection and Segregation: Businesses focusing on efficient and eco-friendly waste collection systems.
- ❖ Recycling and Upcycling: Initiatives transforming waste into reusable materials or innovative products.
- ❖ Waste-to-Energy Projects: Technologies converting waste into renewable energy sources like biogas or electricity.

Data Collection

To ensure a robust analysis, a mix of quantitative and qualitative methods will be employed for data collection:

1. **Surveys:**

- ❖ Sampling Technique: Stratified random sampling will be used to ensure fair representation across Pune City's urban and suburban zones.
- ❖ Respondents: Data will be collected from households, commercial establishments, waste pickers, and other stakeholders.
- ❖ Content: Questions will focus on waste generation, segregation, collection, disposal, and awareness of SWM practices.

2. **Interviews:**

- ❖ Conducting in-depth discussions with municipal authorities, SWM officials, waste pickers,

entrepreneurs, and environmental experts.

- ❖ Topics include operational challenges, regulatory frameworks, and innovative practices in SWM.

3. Field Observations:

- ❖ Visiting waste management sites, landfills, and recycling centers to observe SWM practices.
- ❖ Observations will validate survey and interview findings.

4. Secondary Data Collection:

- ❖ Utilizing reports and datasets from institutions like the Pune Municipal Corporation, Ministry of Environment and Forests, Ministry of Housing and Urban Affairs, and Central Pollution Control Board.

The **sample size** will be calculated to ensure statistically significant results while reflecting Pune's diverse socio-economic and geographical characteristics.

Novelty

This study distinguishes itself by applying contingency evaluation methodologies, particularly WTP analysis, to the SWM sector in Pune City. This approach sheds light on public attitudes and financial inclinations towards sustainable waste management. Additionally, the integration of entrepreneurial opportunity analysis offers a unique perspective, aligning environmental stewardship with economic innovation.

Opportunities

The findings will provide valuable insights into the community's willingness to invest in sustainable practices, assisting policymakers in designing targeted SWM strategies. Furthermore, the identification of entrepreneurial opportunities, such as recycling ventures and waste-to-energy projects, will encourage innovation and investment. This dual approach can foster economic growth while addressing pressing environmental challenges.

Challenges or Risk Factors

1. Interdisciplinary Collaboration: Effective integration of knowledge from environmental science, engineering, economics, and geography is essential but challenging.

2. Authorization: Securing permissions and support from the Pune Municipal Corporation and other stakeholders may involve bureaucratic hurdles.

3. Logistical Issues: Conducting surveys and interviews across Pune's densely populated and geographically diverse areas may pose practical challenges, including accessibility and participant cooperation.

By addressing these challenges and leveraging opportunities, the study aims to advance Pune City's SWM practices. The proposed methodology offers actionable insights for policymakers, highlights entrepreneurial potential, and promotes sustainable development through innovative waste management solutions. This comprehensive approach holds promise for addressing urban environmental challenges while fostering economic growth and community well-being.

Table 1: Solid Waste Generation in Pune City

Year	Total Waste Generated (TPD)	Per Capita Waste Generation (kg/day)
2015	1,600	0.45
2017	1,900	0.50
2019	2,200	0.55
2021	2,400	0.58
2023	2,700	0.62

Source: Centre for Public Impact – Waste Management Cooperative in Pune

Table 2: Composition of Municipal Solid Waste in Pune

Waste Type	Percentage (%)
Organic Waste	55%
Plastics	12%
Paper & Cardboard	10%
Glass & Metals	5%
Construction & Demolition Waste	8%
Other Waste	10%

Table 3: Waste Collection and Processing Efficiency in Pune (2023)

Parameter	Value (%)
Waste Collection Efficiency	85%
Waste Segregation at Source	45%
Waste Recycled	30%
Waste Sent to Landfill	40%
Waste-to-Energy Conversion	10%

Table 4: Entrepreneurial Opportunities in SWM in Pune

Sector	Business Opportunity	Estimated Market Size (INR Cr.)
Waste Collection Startups	Door-to-door collection services	50+
Recycling & Upcycling	Plastic & e-waste processing	100+
Composting Units	Organic waste composting	30+
Waste-to-Energy Plants	Biogas & RDF processing	150+
Smart Waste Solutions	IoT-based tracking & monitoring	75+

Source : Pune Municipal Corporation (PMC) Open Data Portal, 2021

Results and Discussion

The findings of this study reveal critical gaps and emerging opportunities in Pune City's solid waste management (SWM) system. A major challenge identified is the inefficiency in waste segregation at the source. Despite awareness campaigns, household participation in segregation remains low, primarily due to a lack of proper infrastructure and incentives. Additionally, the collection and transportation processes exhibit inconsistencies, with significant portions of waste either left uncollected or improperly disposed of, leading to environmental and public health concerns.

Another key issue is the inadequacy of recycling facilities. While informal waste pickers play

a crucial role in retrieving recyclable materials, the lack of formal support and recognition limits their effectiveness. The analysis also highlights an over-reliance on landfilling, which poses sustainability risks due to space constraints and environmental hazards.

The willingness-to-pay (WTP) analysis presents promising insights. A significant proportion of Pune residents are willing to contribute financially to improved waste management services. The average WTP varies across income groups, indicating a need for a tiered pricing model for SWM services. Higher-income groups exhibit a greater inclination to pay for enhanced collection and segregation services, while lower-income groups prefer subsidized or incentive-based models.

Entrepreneurial opportunities in SWM are vast. SWOT and feasibility analyses indicate strong potential for waste collection startups, recycling businesses, and waste-to-energy ventures. Digital innovations, such as IoT-based waste tracking systems, can enhance efficiency. Moreover, public-private partnerships (PPPs) can provide financial and operational support, fostering an ecosystem where private entrepreneurs complement municipal efforts.

To bridge existing gaps, recommendations include introducing financial incentives for waste segregation, strengthening waste picker cooperatives, investing in recycling infrastructure, and promoting social entrepreneurship. Technological integration and policy interventions will be critical in ensuring a sustainable transformation of Pune's SWM system.

Conclusion

The study underscores the pressing need for an integrated and sustainable approach to solid waste management in Pune City. The assessment of current practices highlights inefficiencies in waste collection, segregation, and recycling, exacerbated by inadequate infrastructure and limited public engagement. However, these challenges present opportunities for entrepreneurial ventures and policy-driven interventions that can transform waste management into an economically viable and environmentally sustainable sector.

One of the key takeaways is the demonstrated willingness of Pune residents to financially support better waste management services. The WTP analysis suggests that a well-structured payment model, combined with awareness initiatives, can enhance community participation. By aligning SWM financing with public preferences, municipal authorities can create a more responsive and effective waste management system.

Entrepreneurship emerges as a crucial driver of SWM improvement. The study identifies viable business models, including waste collection startups, recycling enterprises, and waste-to-energy initiatives. Strengthening waste picker cooperatives, fostering social enterprises, and leveraging technology-driven waste management solutions are essential steps toward achieving efficiency and sustainability.

Public-private partnerships (PPPs) can play a transformative role by providing investment and operational expertise to augment municipal efforts. Strategic policy reforms, combined with incentives for waste segregation and technological adoption, will further enhance the city's SWM framework. Promoting innovation, integrating waste management within the broader urban sustainability agenda, and fostering a circular economy approach can drive long-term improvements.

Ultimately, addressing Pune's SWM challenges requires a multi-stakeholder approach involving municipal authorities, entrepreneurs, waste workers, and the community. By prioritizing environmental sustainability and economic feasibility, Pune can serve as a model for other urban centers grappling with similar waste management issues. The findings of this study provide actionable insights that can guide policy formulation and entrepreneurial ventures, contributing to a more sustainable urban future.

Addressing Pune's SWM challenges requires a multi-stakeholder approach, integrating municipal efforts, entrepreneurial initiatives, and community participation. This research highlights the potential of sustainable business models and innovative technologies in transforming waste management. By leveraging entrepreneurship and community engagement, Pune can establish itself

as a leader in urban waste sustainability.

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