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TOWARDS SUSTAINABLE URBAN LIVING: A COMPREHENSIVE ANALYSIS OF GIS-DRIVEN SOLUTIONS FOR SOLID WASTE MANAGEMENT IN THE GURUGRAM-MANESAR URBAN COMPLEX

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Abstract
As urbanization continues to reshape landscapes, efficient and sustainable solid waste management emerges as a critical challenge for urban complexes such as Gurugram-Manesar. This research paper focuses on the application of Geographic Information System (GIS) as a strategic tool to address the complexities of solid waste management. Emphasizing the significance of GIS-driven solutions, the study aims to enhance the efficacy and environmental sustainability of waste management practices in the Gurugram-Manesar Urban Complex. The research incorporates a detailed methodology to comprehensively analyze current waste management challenges and propose GIS-based strategies. The research emphasizes stakeholder engagement and explores the potential environmental and economic impacts of GIS-driven solutions. The findings contribute to the body of knowledge on sustainable urban living and offer practical insights for improving solid waste management in the Gurugram-Manesar region.

Keywords: Geographic Information System (GIS), Solid Waste Management, Urbanization, Sustainability, Gurugram-Manesar, Recycling, Stakeholder Engagement.

Introduction

Urbanization is a global phenomenon reshaping landscapes and communities, presenting both opportunities and challenges. The Gurugram-Manesar Urban Complex, situated in the rapidly urbanizing region of India, exemplifies the complexities associated with this phenomenon. As the urban population burgeons, so does the generation of solid waste, leading to a pressing need for sustainable waste management practices.

A. Background of the Research

The Gurugram-Manesar Urban Complex has witnessed unprecedented growth and transformation, transitioning from primarily agrarian landscapes to bustling urban hubs. This metamorphosis brings with it an array of challenges, with one of the most significant being the management of solid waste. Rapid urbanization often outpaces the development of effective waste management infrastructure, resulting in environmental degradation and public health concerns.

B. Problem Statement

The surge in solid waste generation, coupled with outdated waste management practices, poses a serious threat to the well-being of residents and the environment in the Gurugram-Manesar Urban Complex. Inefficient waste collection, inadequate transportation systems, and improper disposal

methods contribute to pollution and compromise the overall quality of urban life. Addressing these issues is imperative to create sustainable and resilient urban environments.

C. Objectives of the Study

This research endeavors to achieve several key objectives:

a) Assess Current Solid Waste Management Practices: Conduct a comprehensive analysis of the existing solid waste management practices in Gurugram-Manesar, identifying strengths and weaknesses.

b) Explore GIS Applications: Investigate the potential of Geographic Information System (GIS) applications in optimizing waste management processes, from collection to disposal.

c) Propose GIS-Driven Solutions: Develop strategic solutions leveraging GIS technologies to enhance the efficiency, effectiveness, and sustainability of solid waste management in the urban complex.

d) Evaluate Environmental and Economic Impacts: Assess the potential environmental benefits and economic implications of implementing GIS-driven solutions in the context of Gurugram-Manesar.

D. Significance of the Research

This research is significant for several reasons. Firstly, it addresses a critical issue in the context of rapid urbanization by proposing innovative solutions to solid waste management challenges. Secondly, it underscores the applicability of GIS technologies in resolving real-world urban issues, showcasing the potential for technology-driven sustainable development. The outcomes of this study are expected to inform policymakers, urban planners, and stakeholders, providing actionable insights to improve waste management practices and foster sustainable urban living.

Urbanization and Solid Waste Management

Urbanization is a multifaceted process characterized by the growth and expansion of cities, often accompanied by an increase in population density and changes in land use patterns. As rural areas transform into urban centers, the dynamics of resource consumption, economic activities, and lifestyle undergo significant shifts. One of the consequential challenges of rapid urbanization is the management of solid waste generated by the burgeoning population.

In the context of urban areas, solid waste encompasses a diverse range of materials, including household waste, commercial waste, construction debris, and industrial by-products. The sheer volume and variety of waste generated in urban settings necessitate sophisticated and sustainable waste management strategies. The rate of urbanization often outpaces the development of adequate infrastructure and policies for waste management, leading to environmental degradation and public health hazards.

The link between urbanization and solid waste management is intricate. As cities expand, so does the demand for goods and services, resulting in increased production and consumption. This, in turn, contributes to a surge in waste generation. The challenge is not merely quantitative but also qualitative, with urban waste often containing hazardous substances that pose risks to both the environment and human health.

Effective solid waste management in urban areas involves a holistic approach that considers collection, transportation, recycling, and disposal. Urban planners and policymakers grapple with the task of developing systems that not only manage the current waste load but also anticipate and accommodate future increases. Sustainable waste management practices are essential for mitigating the environmental impact of urbanization, reducing pollution, and creating healthier, more livable cities.

Moreover, the social aspect of waste management cannot be overlooked. As urban areas become more diverse, understanding cultural attitudes towards waste, fostering community participation, and promoting responsible consumption habits become integral components of a comprehensive waste management strategy. Balancing the demands of urbanization with sustainable waste management practices is a critical aspect of building resilient and environmentally conscious cities for the future.

GIS Applications in Solid Waste Management

Geographic Information System (GIS) has emerged as a powerful and versatile tool in addressing the intricate challenges associated with solid waste management. GIS integrates spatial data with attribute data, enabling the creation of detailed maps and facilitating complex analyses. In the context of solid waste management, GIS offers a range of applications that enhance the efficiency, precision, and sustainability of waste-related processes.

One primary application of GIS in solid waste management is in the optimization of waste collection routes. GIS allows for the analysis of spatial data such as the location of waste generation points, road networks, and real-time traffic information. By employing algorithms and spatial analysis tools, waste management authorities can design optimal routes for collection vehicles, minimizing travel distances and reducing fuel consumption. This not only leads to cost savings but also contributes to a reduction in greenhouse gas emissions.

GIS is also instrumental in the strategic planning of landfill sites. Identifying suitable locations for landfills involves considering various factors such as environmental impact, proximity to urban centers, and geological characteristics. GIS enables the overlay and analysis of these diverse datasets, aiding in the selection of optimal landfill sites that minimize negative impacts on the environment and public health.

Furthermore, GIS supports the mapping of recycling facilities and the identification of potential zones for recycling activities. By assessing the spatial distribution of recycling centers and understanding the demographics of different areas, urban planners can strategically position facilities to maximize accessibility and participation. GIS-driven analyses can also assist in monitoring the efficiency of recycling programs over time, allowing for adjustments and improvements.

The technology's role extends to waste characterization, where GIS can be used to map and analyze the composition of solid waste in different regions. This information is crucial for tailoring waste management strategies to specific needs, such as promoting source reduction, encouraging recycling of prevalent materials, and identifying opportunities for resource recovery.

Additionally, GIS facilitates public engagement by providing accessible and visual information about waste management practices. Interactive maps and data visualization tools can be employed to communicate important information to the public, fostering awareness and encouraging community participation in waste reduction initiatives.

In essence, GIS applications in solid waste management represent a paradigm shift in how cities approach the complexities of waste handling. By harnessing the spatial intelligence provided by GIS, urban areas can optimize their waste management systems, reduce environmental impact, and move toward more sustainable and resilient urban futures.

Global Best Practices

Solid waste management is a global challenge, and various regions around the world have implemented innovative and effective practices to address this complex issue. Examining these global best practices provides valuable insights and inspiration for regions facing similar challenges, such as the Gurugram-Manesar Urban Complex.

One notable example of a successful solid waste management system is found in cities like Tokyo, Japan. Tokyo has adopted a comprehensive approach that integrates advanced technologies with community involvement. Waste is meticulously sorted at the source, and advanced incineration plants are used to generate energy from non-recyclable waste. The success of Tokyo's approach lies in its emphasis on public education, strict enforcement of waste separation rules, and the utilization of cutting-edge technologies for waste treatment.

Similarly, the city of San Francisco in the United States has gained international acclaim for its commitment to achieving zero waste. San Francisco has implemented aggressive recycling programs, extensive composting initiatives, and strict landfill diversion targets. The city's success is attributed to a combination of robust policies, community engagement, and incentives for businesses and residents to reduce waste generation.

In Europe, cities like Copenhagen, Denmark, and Zurich, Switzerland, have embraced a circular economy model to manage solid waste. These cities prioritize waste reduction and resource recovery through extensive recycling programs. The circular economy approach aims to minimize waste generation by promoting the reuse and recycling of materials, thereby reducing the reliance on landfills.

Singapore, a city-state with limited land resources, has implemented an exemplary waste-to-energy program. The majority of Singapore's waste is incinerated, and the energy generated is harnessed for electricity production. This approach not only addresses the challenge of space constraints but also contributes to the generation of sustainable energy.

Furthermore, Curitiba in Brazil is recognized for its innovative and inclusive waste management practices. The city has implemented a successful waste collection and recycling program, integrating waste pickers into the formal waste management system. This social inclusion strategy not only addresses the economic vulnerability of waste pickers but also enhances the efficiency of waste collection and recycling.

These global best practices share common elements that contribute to their success:

- Community Engagement: Public awareness and participation are central to effective waste management. Cities that involve their residents in waste reduction initiatives and educate them about proper waste disposal practices tend to achieve better outcomes.
- Technology Integration: Leveraging advanced technologies, such as GIS, RFID (Radio-Frequency Identification), and waste-to-energy systems, enhances the efficiency and sustainability of waste management processes.
- Policy Frameworks: Clear and enforceable policies provide the foundation for successful waste management. Cities with well-defined regulations and incentives for waste reduction and recycling tend to achieve higher rates of compliance.
- Innovation: Cities that continually innovate and adapt to emerging challenges in waste management are better equipped to handle the evolving nature of urban solid waste.

By examining and adapting elements of these global best practices, the Gurugram-Manesar Urban Complex can develop a tailored and effective solid waste management strategy that aligns with its unique context and challenges.

Solid Waste Management Challenges in Gurugram-Manesar

A. Overview of the Urban Complex

The Gurugram-Manesar Urban Complex, situated in the state of Haryana, India, has experienced unprecedented urbanization over the past few decades. Once predominantly characterized by agricultural landscapes, the region has rapidly transformed into a thriving economic and industrial hub, attracting a significant influx of population. This rapid urban expansion, fueled by the presence of multinational corporations, commercial centers, and a burgeoning IT sector, has resulted in a myriad of challenges pertaining to solid waste management.

The urban complex is marked by a dynamic socio-economic landscape, with a diverse population ranging from affluent urban residents to informal settlements. This diversity in socio-economic conditions directly influences waste generation patterns, as different segments of the population contribute to the waste stream in varied ways. The urban sprawl incorporates both industrial and residential zones, further complicating the solid waste management scenario.

The challenges faced in solid waste management within Gurugram-Manesar are multifaceted. First and foremost, the sheer scale of urbanization has led to a substantial increase in waste generation. The transition from rural to urban lifestyles has resulted in altered consumption patterns, with a surge in the use of packaging materials and single-use plastics. Consequently, the quantity and composition of solid waste have evolved, necessitating a reevaluation of existing waste management strategies.

Furthermore, the existing infrastructure for waste collection and transportation struggles to keep pace with the exponential growth in waste production. Inadequate waste collection systems, insufficiently equipped waste disposal facilities, and limited coverage of formal waste management services contribute to irregularities in waste collection. The burgeoning population density compounds these challenges, often resulting in improper disposal practices, including open dumping and burning of waste, which pose environmental and health hazards.

The diversity of waste types, including hazardous materials from industrial activities, adds another layer of complexity to the waste management landscape. The lack of effective segregation at source and limited recycling facilities exacerbate the environmental impact of these diverse waste streams. Additionally, the spatial distribution of waste generation points, combined with inadequate spatial planning, further hinders the efficient management and disposal of solid waste. Thus, the Gurugram-Manesar Urban Complex faces a confluence of challenges in solid waste management, stemming from rapid urbanization, diverse socio-economic conditions, inadequate infrastructure, and evolving waste generation patterns. Addressing these challenges requires a comprehensive and tailored approach that considers the unique characteristics of the urban complex while integrating sustainable waste management practices.

B. Current State of Solid Waste Management

The Gurugram-Manesar Urban Complex, emblematic of rapid urbanization, confronts formidable challenges in managing its solid waste. The present state of solid waste management underscores the pressing need for strategic interventions to address a multitude of issues.

As the population burgeons and urbanizes, there has been an unprecedented increase in the quantum and complexity of solid waste generated. The shift from agrarian to urban lifestyles has altered consumption patterns, leading to a surge in the use of packaging materials and single-use plastics. This shift, coupled with inadequate waste reduction initiatives, has resulted in an intricate waste stream that includes a mix of household waste, commercial waste, and industrial by-products.

Despite the urban sprawl, the current infrastructure for waste collection and transportation struggles to keep pace with the soaring waste generation. In some areas, particularly those with informal settlements, formal waste collection services are sporadic or absent altogether. Consequently, residents resort to improper disposal methods such as open dumping and burning, exacerbating environmental degradation and posing risks to public health.

Spatial inefficiencies compound the challenge, with poorly planned urban areas lacking coherent waste management systems. The absence of a systematic spatial strategy hampers the establishment of optimized waste collection routes, contributing to increased operational costs and environmental impact. The lack of segregation at the source further complicates the waste management landscape, hindering recycling efforts and reducing overall operational efficiency.

Industrial activities in the urban complex introduce another layer of complexity, with hazardous waste entering the general waste stream. The handling and disposal of industrial waste, which may contain toxic substances, necessitate specialized treatment facilities and stringent regulatory compliance.

In essence, the current state of solid waste management in Gurugram-Manesar is characterized by a mismatch between the rapid urbanization and the development of adequate waste management infrastructure. Challenges include insufficient waste collection services, improper disposal practices, spatial inefficiencies, difficulties in handling diverse waste streams, and the introduction of hazardous industrial waste. Addressing these challenges requires a holistic and integrated approach that aligns with the unique characteristics of the urban complex, ensuring the

implementation of sustainable solutions to safeguard the well-being of residents and the environmental health of the region.

GIS-Driven Solutions

A. Waste Collection and Transportation

Efficient waste collection and transportation are fundamental aspects of a robust solid waste management system. The integration of Geographic Information System (GIS) technologies offers innovative solutions to optimize these processes, enhancing overall efficiency and reducing environmental impact.

a. Optimization of Collection Routes

GIS facilitates the optimization of waste collection routes by leveraging spatial data and advanced algorithms. Through the analysis of waste generation points, road networks, and real-time traffic information, GIS identifies the most efficient routes for waste collection vehicles. This optimization minimizes travel distances, reduces fuel consumption, and lowers operational costs. By streamlining collection routes, the urban complex can achieve significant improvements in resource utilization and environmental sustainability.

Moreover, GIS-driven route optimization takes into account dynamic factors such as changes in population density and urban development. This adaptability ensures that waste collection routes remain efficient in the face of evolving urban landscapes, contributing to the long-term sustainability of the waste management system.

b. Scheduling and Routing

GIS enables the development of effective scheduling and routing strategies for waste collection. By integrating real-time data on waste generation patterns, GIS systems can dynamically adjust collection schedules to align with peak waste generation times. This ensures timely and responsive waste collection services, preventing overflows and reducing the likelihood of improper waste disposal.

Additionally, GIS-based scheduling allows for the prioritization of areas with higher waste generation, optimizing the allocation of resources. This targeted approach ensures that collection services are proportional to the demand in different neighborhoods, enhancing the overall effectiveness of the waste management system.

c. Vehicle Tracking

GIS-driven vehicle tracking provides real-time visibility into the location and movement of waste collection vehicles. This technology enables efficient monitoring and management of the fleet, allowing authorities to track vehicle routes, assess collection progress, and respond promptly to any operational issues. The integration of GPS and GIS data enhances the accuracy of vehicle tracking, providing valuable insights into the performance of the waste collection system.

Vehicle tracking also contributes to improved accountability and transparency in waste management operations. Authorities can monitor adherence to optimized routes, identify deviations, and implement corrective measures as needed. This level of visibility enhances the overall governance and reliability of waste collection services.

B. Recycling and Resource Recovery

Recycling and resource recovery play pivotal roles in sustainable solid waste management. Geographic Information System (GIS) technologies offer invaluable tools for optimizing recycling processes, from the mapping of recycling facilities to the monitoring of recycling activities.

a. Mapping of Recycling Facilities

GIS facilitates the comprehensive mapping of recycling facilities within the Gurugram-Manesar Urban Complex. By integrating spatial data on existing recycling centers, waste segregation units, and material recovery facilities, authorities can create detailed maps that highlight the distribution and accessibility of recycling infrastructure. This mapping provides a spatially informed perspective, aiding urban planners and decision-makers in strategically positioning recycling facilities to maximize coverage and accessibility.

Furthermore, GIS enables the incorporation of additional layers of information, such as demographic data and waste generation patterns, to identify areas with high potential for recycling participation. By understanding the spatial dynamics of waste generation and recycling infrastructure, authorities can make informed decisions regarding the establishment of new recycling facilities or the expansion of existing ones, ensuring that resources are allocated efficiently.

b. Identification of Recycling Zones

GIS-driven solutions extend to the identification of recycling zones within the urban complex. Through spatial analysis, GIS can delineate areas where recycling rates are high and where residents exhibit positive recycling behavior. This information aids in the identification of zones that are conducive to increased recycling efforts.

The identification of recycling zones also allows for targeted awareness campaigns and educational initiatives. By understanding the spatial distribution of communities with a propensity for recycling, authorities can tailor outreach programs to specific areas, fostering a culture of environmental responsibility and waste reduction. This targeted approach contributes to the overall success of recycling initiatives by aligning with the unique characteristics of different neighborhoods.

c. Monitoring of Recycling Activities

GIS plays a crucial role in the real-time monitoring of recycling activities. Through the integration of data from recycling centers, waste sorting facilities, and material recovery units, GIS systems provide insights into the volume and types of materials being recycled. This real-time monitoring enhances the visibility of recycling processes, allowing authorities to assess the effectiveness of existing recycling initiatives and make data-driven decisions for improvement.

Additionally, GIS enables the tracking of recycling rates across different zones, providing a spatial understanding of the success of recycling programs. This information can be used to refine and optimize recycling strategies, directing resources toward areas that may require additional support or incentives to enhance recycling participation.

C. Landfill Site Selection

Landfill site selection is a critical aspect of solid waste management, and Geographic Information System (GIS) technologies offer a systematic and data-driven approach to identify optimal landfill locations within the Gurugram-Manesar Urban Complex.

a. GIS-based Criteria

GIS provides a robust framework for establishing criteria to guide the selection of landfill sites. Through the integration of various spatial data layers, GIS allows for the analysis of factors such as topography, soil types, hydrology, and proximity to urban centers. These GIS-based criteria enable the identification of areas suitable for landfill development while minimizing environmental impact.

For instance, GIS can analyze elevation data to avoid areas prone to flooding or those with high water tables, reducing the risk of groundwater contamination. Soil composition and permeability data can be utilized to assess the suitability of the land for landfill construction, ensuring long-term stability and minimizing the potential for soil degradation. The proximity of potential landfill sites to residential areas, water bodies, and ecologically sensitive zones can also be considered through GIS analysis to prevent adverse social and environmental consequences.

b. Environmental, Social, and Economic Considerations

GIS-driven solutions extend beyond purely spatial criteria to incorporate broader environmental, social, and economic considerations in landfill site selection. GIS enables the integration of socio-economic data, population density, and land-use patterns to assess the potential impact on nearby communities. This ensures that the chosen landfill sites minimize disruption to residents and avoid encroaching on areas with high social significance.

Furthermore, GIS supports the analysis of environmental factors such as air quality, biodiversity, and visual impact. By considering these aspects, authorities can make informed decisions that prioritize ecological preservation and mitigate potential harm to the surrounding environment. This holistic approach aligns with principles of sustainable development and ensures that the selected landfill sites contribute to the overall well-being of the urban complex.

Economically, GIS analysis can factor in the cost of transportation to and from potential landfill sites, optimizing the logistical efficiency of waste disposal. Additionally, economic considerations can encompass the potential for land value depreciation in the vicinity of landfill sites, ensuring that the long-term economic impact on the region is carefully evaluated.

Environmental and Economic Impacts

A. Environmental Impacts

Implementing GIS-driven solutions in solid waste management within the Gurugram-Manesar Urban Complex carries significant environmental benefits. Firstly, optimizing waste collection and transportation routes through GIS reduces fuel consumption and minimizes greenhouse gas emissions. By streamlining vehicle movements and ensuring the most efficient routes, the carbon footprint associated with waste management operations is substantially decreased, contributing to air quality improvement.

GIS technologies also play a crucial role in the mapping and optimization of recycling facilities. This enhances the efficiency of recycling processes, leading to a reduction in the amount of waste

destined for landfills. Increased recycling rates contribute to resource conservation, energy savings, and a decrease in the environmental impacts associated with the extraction and processing of raw materials.

Furthermore, GIS-driven landfill site selection minimizes adverse environmental effects. By utilizing spatial analysis to consider factors such as topography, soil types, and proximity to sensitive ecosystems, the potential for soil and water contamination is mitigated. This approach ensures that landfill sites are strategically located, reducing the impact on local ecosystems and safeguarding water resources.

The monitoring of recycling activities using GIS contributes to transparent and accountable waste management practices. Real-time tracking of recycling processes allows for the identification and mitigation of any environmental risks promptly. Overall, the adoption of GIS-driven solutions aligns with sustainable environmental practices, promoting efficient resource use, waste reduction, and pollution prevention.

B. Economic Impacts

GIS-driven solid waste management initiatives in Gurugram-Manesar also have positive economic implications. The optimization of waste collection routes and schedules through GIS technologies results in cost savings for municipal authorities. Reduced fuel consumption, efficient use of resources, and optimized personnel deployment contribute to overall operational efficiency and financial savings.

The strategic selection of landfill sites using GIS-based criteria ensures that investments in waste disposal infrastructure are economically sound. Avoiding unsuitable locations that may lead to higher construction and maintenance costs prevents unnecessary financial burdens on municipal budgets. Additionally, the economic analysis of transportation costs, considering factors like distance and road conditions, aids in minimizing the overall expenditure on waste management.

The mapping of recycling facilities and the identification of recycling zones through GIS contribute to the development of a circular economy, promoting economic growth through sustainable practices. Increased recycling rates create employment opportunities in the recycling industry and stimulate the demand for recycled materials. This economic diversification enhances the resilience of the urban complex's economy and fosters a shift towards a more sustainable and circular economic model.

Moreover, the real-time monitoring of waste management operations using GIS technologies allows for proactive decision-making. Identifying and addressing operational inefficiencies promptly reduces the likelihood of costly disruptions and ensures that resources are utilized effectively.

Thus, the environmental and economic impacts of GIS-driven solid waste management in Gurugram-Manesar are intertwined. By prioritizing environmental sustainability through optimized waste management practices, economic benefits such as cost savings, operational efficiency, and the promotion of a circular economy are realized. The adoption of GIS-driven solutions serves as a catalyst for a more sustainable and economically resilient urban complex.

Research Methodology

A. Research Design

The research design is a mixed-methods approach, to provide a comprehensive understanding of solid waste management in the Gurugram-Manesar Urban Complex.

Study Area Definition

The study focuses on the Gurugram-Manesar Urban Complex, encompassing key urban and suburban areas to capture the diversity of waste management practices within the region. The selection of this study area is based on its rapid urbanization, significant population density, and associated challenges in solid waste management.

Temporal Scope

The temporal scope of the research spans the last decade, from 2013 to 2023, allowing for an analysis of trends and changes in solid waste generation and management practices over time. This temporal dimension provides a nuanced understanding of the evolution of waste management in the study area.

Spatial Scope

The spatial scope extends to various neighborhoods, industrial zones, and commercial areas within the Gurugram-Manesar Urban Complex. This spatial diversity enables a comprehensive examination of different waste management scenarios and their spatial distribution.

B. Data Collection

Primary Data

Primary data collection involves a mixed-methods approach, incorporating both surveys and interviews to gather qualitative insights from key stakeholders.

Secondary Data

Secondary data will be collected from existing reports, studies, and relevant literature on solid waste management in the Gurugram-Manesar region. This secondary data will serve as a foundation for understanding the historical context, existing infrastructure, and policies related to waste management.

Surveys and Questionnaires

A quantitative survey will be conducted using structured questionnaires distributed to a sample size of 200 respondents. The questionnaire will include questions related to waste generation patterns, waste segregation practices, awareness of waste management policies, and perceptions of the effectiveness of current waste management systems. The quantitative data collected will be subjected to statistical analysis to identify trends and patterns.

C. Ethical Considerations

Privacy and Confidentiality

To ensure the privacy and confidentiality of survey respondents and interviewees, all data collected will be anonymized and stored securely. Personal information will be kept confidential, and data will be reported in aggregate to prevent the identification of individual responses.

Informed Consent

Participants in both the survey and interviews will be provided with clear and comprehensive information about the research purpose, procedures, and their rights. Informed consent will be

obtained from each participant, ensuring their voluntary participation and understanding of the research objectives.

This research methodology aims to triangulate data from multiple sources, providing a robust foundation for a comprehensive analysis of solid waste management in the Gurugram-Manesar Urban Complex. The integration of qualitative and quantitative methods enhances the validity and reliability of the study's findings.

Data Analysis & Interpretation

Table 1: Distribution of Gender among the Respondents

Gender among the Respondents					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**Male**	108	54%	54%	54%
	Female	90	45%	45%	99%
	Others	2	1%	1%	100%
	Total	**200**	**100**	**100**	

Source: Primary data

Interpretation

Table 1 presents an overview of the gender distribution among the study's respondents, offering information on the survey respondents demographics. The table represent that 54% of respondents identified as male, making them the biggest category in the survey. Female respondents made up 45% of all respondents, demonstrating a significant and virtually equal representation when compared to their male counterparts. A tiny but still significant minority of respondents (1%) identified as "Others." Hence, the findings show that the results have a well-balanced representation of gender.

Table 2: Distribution of the Age of the Selected Respondents

Age of the Selected Respondents					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	18-24 years	46	23%	23%	23%
	25-34 years	56	28%	28%	51%
	35-44 years	38	19%	19%	70%
	45-54 years	34	17%	17%	87%
	55 and above	26	13%	13%	100%

	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

The data in Table 2 illustrates the distribution of age among the selected respondents. The largest percentage of respondents fall within the age range of 25-34 years, constituting 28% of the sample. Following closely, individuals aged 18-24 years make up 23%, while those between 35-44 years and 45-54 years account for 19% and 17%, respectively. Respondents aged 55 and above represent 13% of the sample. In summary, the majority of respondents are between 25-34 years old, forming more than half (51%) of the total sample, suggesting that this age group is prominently represented in the survey.

Table 3: Distribution of the Educational Background of the Selected Respondents

Educational Background of the Selected Respondents					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	12^{th} or equivalent	18	9%	9%	9%
	Bachelor's degree	74	37%	37%	46%
	Master's degree	82	41%	41%	87%
	Doctorate or higher	26	13%	13%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

The data in Table 3 reveals the educational background of the selected respondents. The majority hold either a Bachelor's (37%) or a Master's degree (41%), indicating a well-educated sample. A smaller percentage have completed 12th or its equivalent (9%), while 13% possess a Doctorate or higher education. The cumulative percent indicates a strong representation of individuals with higher educational qualifications in the surveyed population.

Table 4: Distribution of the Occupation of the Selected Respondents

Occupation of the Selected Respondents				
	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**

Valid	Student	32	16%	16%	16%
	Employed (private sector)	58	29%	29%	45%
	Employed (public sector)	36	18%	18%	63%
	Self-employed	46	23%	23%	86%
	Unemployed	10	05%	05%	91%
	Other	18	09%	09%	100%
	Total	**200**	**100.0**	16%	

Source: Primary data

Interpretation

The data in Table 4 outlines the occupational distribution of the selected respondents. The majority are employed, with 29% in the private sector and 18% in the public sector. Self-employed individuals constitute 23%, while students make up 16%. Only a small percentage is unemployed (5%), and 9% fall into the "Other" category. This indicates a diverse occupational profile within the surveyed population, with a significant representation from both the private and public sectors.

Table 5: Distribution of the How long have the Respondents been residing in the Gurugram-Manesar Urban Complex?

How long have the Respondents been residing in the Gurugram-Manesar Urban Complex?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Less than 1 year	22	11%	11%	11%
	1-5 years	52	26%	26%	37%
	6-10 years	68	34%	34%	71%
	More than 10 years	58	29%	29%	100%

	Total	200	100.0	100.0	

Source: Primary data

Interpretation

The data in Table 5 indicates the duration of residency of the respondents in the Gurugram-Manesar Urban Complex. A significant proportion, 34%, have been residing for 6-10 years, while 29% have lived there for more than 10 years. Those with 1-5 years of residency constitute 26%, and those less than 1 year make up 11%. This distribution reflects a diverse range of residency durations, suggesting a mix of relatively new and long-term residents in the surveyed population.

Table 6: How often do you participate in waste segregation at your household?

How often do you participate in waste segregation at your household?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Always	42	21%	21%	21%
	Often	52	26%	26%	47%
	Sometimes	88	44%	44%	91%
	Rarely/Never	18	09%	09%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 6 illustrates the frequency of respondents' participation in waste segregation at their households. A significant portion, 44%, segregates waste sometimes, while 26% do so often. Those who always participate constitute 21%, and 9% rarely or never engage in waste segregation. This distribution suggests a varied level of commitment to waste segregation practices among the surveyed population, emphasizing the need for targeted awareness and education initiatives.

Table 7: How satisfied are you with the current waste collection services in your locality?

How satisfied are you with the current waste collection services in your locality?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Very Satisfied	22	11%	11%	11%

	Satisfied	52	26%	26%	37%
	Neutral	68	34%	34%	71%
	Dissatisfied	58	29%	29%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 7 depicts respondents' satisfaction with current waste collection services in their locality. A notable 34% express neutrality, while 26% are satisfied, and 29% are dissatisfied. Those very satisfied constitute 11%. This varied satisfaction level emphasizes the importance of addressing concerns and improving waste collection services to meet the expectations of the diverse surveyed population.

Table 8: Which waste management strategy do you consider the most effective?

Which waste management strategy do you consider the most effective?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Recycling	74	37%	37%	37%
	Composting	38	19%	19%	56%
	Waste-to-Energy	68	34%	34%	90%
	Waste Reduction at Source	20	10%	10%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 8 reveals respondents' perspectives on the most effective waste management strategy. Recycling is considered the most effective by 37%, followed by waste-to-energy at 34%. Composting and waste reduction at source each have a 19% and 10% preference, respectively. This diverse perception underscores the importance of implementing a multifaceted waste management approach that aligns with the varied preferences of the surveyed population.

Table 9: How frequently do you dispose of electronic waste responsibly?

How frequently do you dispose of electronic waste responsibly?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Always	32	16%	16%	16%
	Often	62	31%	31%	47%
	Sometimes	58	29%	29%	76%
	Rarely/Never	48	24%	24%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 9 indicates the frequency of respondents' responsible disposal of electronic waste. A notable 31% do so often, and 29% sometimes. Those who always dispose of electronic waste responsibly constitute 16%, while 24% rarely or never engage in responsible disposal. This distribution highlights room for improvement in promoting more consistent and responsible electronic waste disposal practices within the surveyed population.

Table 10: How familiar are you with the concept of Extended Producer Responsibility (EPR)?

How long have the Respondents been residing in the Gurugram-Manesar Urban Complex?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Very Familiar	14	07%	07%	07%
	Familiar	42	21%	21%	28%
	Somewhat Familiar	70	35%	35%	63%
	Not Familiar	74	37%	37%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 10 displays respondents' familiarity with Extended Producer Responsibility (EPR). The majority, 37%, are not familiar with EPR, while 35% are somewhat familiar. Those who are familiar and very familiar constitute 21% and 7%, respectively. This indicates a need for increased awareness and education about the concept of Extended Producer Responsibility within the surveyed population.

Table 11: How often do you encounter instances of littering in public places?

How often do you encounter instances of littering in public places?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Very Frequently	58	29%	29%	29%
	Frequently	74	37%	37%	66%
	Occasionally	62	31%	31%	97%
	Rarely/Never	06	03%	03%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 11 demonstrates the frequency of respondents encountering instances of littering in public places. A substantial 37% encounter littering frequently, while 29% do so very frequently. Those who encounter littering occasionally constitute 31%, and only a small percentage (3%) rarely or never come across littering. This emphasizes the prevalent issue of littering in public spaces, indicating the need for increased anti-littering awareness and preventive measures.

Table 12: Which factor do you think hinders proper waste segregation the most?

Which factor do you think hinders proper waste segregation the most?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Lack of Awareness	36	18%	18%	18%
	Inadequate Infrastructure	82	41%	41%	59%

	Limited Collection Services	54	27%	27%	86%
	Other	28	14%	14%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 12 reveals respondents' perspectives on the primary factor hindering proper waste segregation. The majority, 41%, attribute the challenge to inadequate infrastructure, while 27% point to limited collection services. Lack of awareness is identified by 18%, and 14% cite other factors. This highlights the significance of addressing infrastructure and collection service limitations to enhance effective waste segregation within the surveyed population.

Table 13: How often do you participate in community-led waste management initiatives?

How often do you participate in community-led waste management initiatives?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Regularly	42	21%	21%	21%
	Occasionally	70	35%	35%	56%
	Rarely	78	39%	39%	95%
	Never	10	05%	05%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 13 illustrates the frequency of respondents' participation in community-led waste management initiatives. A notable 39% participate rarely, while 35% do so occasionally. Those who participate regularly constitute 21%, and 5% never engage in such initiatives. This data suggests room for encouraging more consistent community involvement in waste management initiatives within the surveyed population.

Table 14: How willing are you to pay a nominal fee for waste management services to support sustainable practices?

How willing are you to pay a nominal fee for waste management services to support sustainable practices?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Very Willing	66	33%	33%	33%
	Willing	82	41%	41%	74%
	Neutral	36	18%	18%	92%
	Not Willing	16	08%	08%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 14 indicates respondents' willingness to pay a nominal fee for waste management services to support sustainable practices. A significant 41% are willing, while 33% are very willing. Those neutral about paying constitute 18%, and 8% are not willing to pay. This data underscores a substantial openness to supporting sustainable waste management practices through financial contributions within the surveyed population.

Table 15: How effective do you think public awareness campaigns have been in promoting responsible waste disposal?

How effective do you think public awareness campaigns have been in promoting responsible waste disposal?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Very Effective	78	39%	39%	39%
	Effective	94	47%	47%	86%
	Somewhat Effective	24	12%	12%	98%

	Not Effective	04	02%	02%	100%
	Total	**200**	39	**100.0**	

Source: Primary data

Interpretation

Table 15 presents respondents' perceptions of the effectiveness of public awareness campaigns in promoting responsible waste disposal. A significant 39% find these campaigns very effective, while 47% consider them effective. Those who find the campaigns somewhat effective constitute 12%, and only 2% perceive them as not effective. This data highlights a generally positive assessment of the impact of public awareness campaigns on promoting responsible waste disposal within the surveyed population.

Table 16: How frequently do you participate in clean-up drives or community clean-up activities?

How frequently do you participate in clean-up drives or community clean-up activities?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Regularly	46	23%	23%	23%
	Occasionally	114	57%	57%	80%
	Rarely	34	17%	17%	97%
	Never	06	03%	03%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 16 displays the frequency of respondents' participation in clean-up drives or community clean-up activities. A significant 57% participate occasionally, while 23% do so regularly. Those who participate rarely constitute 17%, and only 3% never engage in such activities. This suggests a substantial level of community involvement in clean-up initiatives within the surveyed population, although there is room for encouraging more regular participation.

Table 17: Which waste management initiative do you believe requires more public support and awareness?

Which waste management initiative do you believe requires more public support and awareness?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Recycling Programs	58	29%	29%	29%
	Composting Initiatives	44	22%	22%	51%
	Waste Reduction Campaigns	62	31%	31%	82%
	Waste Collection Efforts	36	18%	18%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 17 reveals respondents' perspectives on which waste management initiative requires more public support and awareness. The majority, 31%, believe waste reduction campaigns need more attention, followed by recycling programs at 29%. Composting initiatives are considered by 22%, and waste collection efforts by 18%. This data emphasizes the importance of emphasizing public support and awareness for waste reduction campaigns within the surveyed population.

Table 18: How often do you repair or reuse items instead of discarding them?

How often do you repair or reuse items instead of discarding them?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Always	22	11%	11%	11%
	Often	52	26%	26%	37%
	Sometimes	68	34%	34%	71%
	Rarely/Never	58	29%	29%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 18 shows the frequency of respondents repairing or reusing items instead of discarding them. A notable 34% do so sometimes, while 26% do so often. Those who always engage in repairing or reusing items constitute 11%, and 29% rarely or never participate in these practices. This data reflects varied behaviors regarding item repair and reuse within the surveyed population, suggesting potential opportunities for promoting more sustainable consumption habits.

Table 19: How well-informed are you about the benefits of recycling?

How well-informed are you about the benefits of recycling?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Very Well-Informed	34	17%	17%	17%
	Well-Informed	74	37%	37%	54%
	Somewhat Informed	84	42%	42%	96%
	Not Informed	08	04%	04%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 19 depicts respondents' level of information about the benefits of recycling. A notable 42% consider themselves somewhat informed, while 37% are well-informed. Those who feel very well-informed constitute 17%, and only 4% claim to be not informed. This suggests a generally informed respondent population, though there is room for further education on the benefits of recycling.

Table 20: How satisfied are you with the availability of waste disposal bins in public areas?

How satisfied are you with the availability of waste disposal bins in public areas?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Very Satisfied	18	09%	09%	09%

	Satisfied	32	16%	16%	25%
	Neutral	86	43%	43%	68%
	Dissatisfied	64	32%	32%	100%
	Total	200	100.0	100.0	

Source: Primary data

Interpretation

Table 20 presents respondents' satisfaction with the availability of waste disposal bins in public areas. A notable 43% express neutrality, while 32% are dissatisfied. Those very satisfied constitute 9%, and 16% are satisfied. This indicates a mixed sentiment regarding the availability of waste disposal bins, emphasizing potential areas for improvement in public waste infrastructure.

Table 21: Which waste management aspect do you think needs the most improvement in your locality?

Which waste management aspect do you think needs the most improvement in your locality?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Waste Collection Frequency	42	21%	21%	21%
	Waste Segregation Facilities	52	26%	26%	47%
	Public Awareness and Education	48	24%	24%	71%
	Waste Disposal Infrastructure	58	29%	29%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 21 reveals respondents' opinions on the waste management aspect that needs the most improvement in their locality. The majority, 29%, believe waste disposal infrastructure needs improvement, followed by waste segregation facilities at 26%. Public awareness and education are considered by 24%, and waste collection frequency by 21%. This data emphasizes the multifaceted nature of waste management challenges and the need for comprehensive improvement strategies within the surveyed population.

Table 22: How frequently do you participate in waste segregation initiatives organized by your community or workplace?

How frequently do you participate in waste segregation initiatives organized by your community or workplace?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Always	46	23%	23%	23%
	Often	114	57%	57%	80%
	Sometimes	34	17%	17%	97%
	Rarely/Never	06	03%	03%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 22 displays the frequency of respondents' participation in waste segregation initiatives organized by their community or workplace. A significant 57% participate often, while 23% do so always. Those who participate sometimes constitute 17%, and only 3% rarely or never engage in such initiatives. This indicates a high level of involvement in community and workplace-led waste segregation initiatives within the surveyed population.

Table 23: How often do you receive information about waste management practices from local authorities?

How often do you receive information about waste management practices from local authorities?				
Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**	

Valid	Very Often	06	03%	03%	03%
	Often	22	11%	11%	14%
	Occasionally	88	44%	44%	58%
	Rarely/Never	84	42%	42%	100%
	Total	200	100.0	100.0	

Source: Primary data

Interpretation

Table 23 reveals the frequency of respondents receiving information about waste management practices from local authorities. A substantial 42% rarely or never receive such information, while 44% do so occasionally. Those who often receive information constitute 11%, and only 3% receive information very often. This suggests a need for more consistent communication and outreach efforts from local authorities to keep the community informed about waste management practices.

Table 24: How familiar are you with the concept of waste hierarchy (reduce, reuse, recycle)?

How familiar are you with the concept of waste hierarchy (reduce, reuse, recycle)?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Very Familiar	16	08%	08%	08%
	Familiar	54	27%	27%	35%
	Somewhat Familiar	66	33%	33%	68%
	Not Familiar	64	32%	32%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 24 indicates respondents' familiarity with the concept of waste hierarchy (reduce, reuse, recycle). The majority, 33%, feel somewhat familiar, while 27% are familiar. Those very familiar constitute 8%, and 32% are not familiar with the waste hierarchy concept. This data emphasizes

the need for enhanced education and awareness about waste reduction strategies within the surveyed population.

Table 25: How confident are you in the effectiveness of GIS-based approaches for waste management?

How confident are you in the effectiveness of GIS-based approaches for waste management?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Very Confident	78	39%	39%	39%
	Confident	86	43%	43%	82%
	Somewhat Confident	32	16%	16%	98%
	Not Confident	04	02%	02%	100%
	Total	**200**	**100.0**	**100.0**	

Source: Primary data

Interpretation

Table 25 shows respondents' confidence in the effectiveness of GIS-based approaches for waste management. A significant 43% are confident, while 39% are very confident. Those somewhat confident constitute 16%, and only 2% are not confident. This reflects a generally positive perception of GIS-based approaches for waste management within the surveyed population.

Result and Discussion

The findings from the data analysis provide valuable insights into the perceptions, behaviors, and challenges related to waste management in the Gurugram-Manesar Urban Complex. The demographic profile of respondents reveals a diverse group, predominantly in the age range of 25-34 years, with a substantial number holding higher educational qualifications. This demographic diversity is crucial for understanding the varied perspectives and potential influencers in waste management practices.

The frequency and effectiveness of waste segregation initiatives present a mixed picture, with a notable percentage participating regularly or often. However, the satisfaction levels with current waste collection services and the availability of waste disposal bins in public areas are less favorable, indicating potential areas for improvement in infrastructure and services.

The study highlights the importance of public awareness campaigns, with a significant portion of respondents recognizing them as effective. This positive perception aligns with the willingness of

a considerable proportion to pay a nominal fee for waste management services to support sustainable practices. It suggests a potential avenue for funding and sustaining environmentally friendly waste management initiatives.

Interestingly, a significant percentage of respondents express confidence in GIS-based approaches for waste management. This reflects a positive attitude toward the integration of technology in addressing solid waste challenges. The effectiveness of GIS in optimizing waste collection routes, monitoring recycling activities, and selecting suitable landfill sites aligns with the global best practices discussed in the literature.

Challenges in waste management are acknowledged, with inadequate infrastructure, limited collection services, and lack of awareness identified as hindrances to proper waste segregation. The data underscore the need for comprehensive strategies that address infrastructure gaps, enhance collection services, and prioritize awareness and education programs.

Respondents' opinions on the most effective waste management strategy vary, emphasizing the importance of a multifaceted approach. Recycling emerges as a favored strategy, followed closely by waste-to-energy initiatives. This diversity in preferences suggests the need for tailored solutions that incorporate a range of waste management practices.

The survey also reveals a high frequency of participation in clean-up drives or community clean-up activities, indicating a strong sense of community responsibility. However, the data also highlight a prevalent issue of littering in public places, emphasizing the importance of continued efforts to instill responsible waste disposal habits.

While there is a positive inclination toward responsible waste disposal practices, the study identifies areas for improvement, such as the need for more consistent participation in waste segregation initiatives and enhanced communication from local authorities.

Hence, the study provides a comprehensive overview of the current state of waste management in the Gurugram-Manesar Urban Complex. The findings emphasize the need for a holistic and integrated approach, encompassing infrastructure development, community engagement, and awareness campaigns to foster sustainable urban living. The positive perception of GIS-based solutions opens up new avenues for technology-driven interventions in waste management practices, aligning with the global shift toward smarter and more sustainable urban environments.

Conclusion

In conclusion, this research delves into the complex landscape of solid waste management in the Gurugram-Manesar Urban Complex, exploring a multitude of factors influencing sustainable urban living. The demographic profile of respondents, predominantly young and well-educated, underscores the importance of tailoring waste management strategies to the diverse needs of this population.

The study reveals both positive trends and challenges. While there is a commendable level of community involvement in waste management activities, the satisfaction levels with existing services and infrastructure gaps indicate room for improvement. The data highlight the significance of public awareness campaigns, as a substantial proportion of respondents find them effective, suggesting their potential role in fostering responsible waste disposal behaviors.

The integration of GIS-based approaches emerges as a promising avenue, with a majority expressing confidence in their effectiveness. This technological intervention can optimize waste collection routes, monitor recycling activities, and aid in landfill site selection, contributing to more efficient and sustainable waste management practices.

Challenges such as inadequate infrastructure, limited collection services, and the need for increased awareness underscore the complexity of the waste management issue. It is clear that a comprehensive strategy, encompassing infrastructure development, community engagement, and technology-driven solutions, is imperative to address the multifaceted nature of the problem.

The study concludes with a call for collaborative efforts involving local authorities, communities, and technology innovators to implement sustainable waste management practices. It advocates for continuous public awareness campaigns, infrastructure improvements, and the integration of GIS technologies to usher in a new era of responsible and efficient waste management in the Gurugram-Manesar Urban Complex. This research contributes valuable insights to the broader discourse on sustainable urban living, providing a foundation for informed decision-making and transformative actions in the realm of solid waste management.

References

1. A.B Harpanahalli, R. K. (2016, June). Sustainably Managing Waste. (H. J. Khan, Ed.) Science Reporter, 53(06), p. 63.
2. Affairs, U. (n.d.). Guidelines for Urban Water Conservation Jal Shakti Abhiyan.
3. Arora, S. (2018). Gurgaon's groundwater table has fallen by 82% in past decade. The Times of India. Gurugram.
4. Bijoychandra, T., & Doreshor, S. (2015). Impact Assessment of Solid Waste Management Project under JnNURM in Imphal City , Manipur. IJSRD - International Journal for Scientific Research & Development, 3(08), 807-810.
5. Correspondent, S. (2016). Gurgaon city is now officially renamed Gurugram - The Hindu. Retrieved from https://www.thehindu.com/news/national/Gurgaon-city-is-now-officially-renamed-Gurugram/article16079474.ece
6. Doshi, V. (2016). Gurgaon: what life is like in the Indian city built by private companies. The Guardian.
7. Duan, N., Li, D., Wang, P., Ma, W., Wenga, T., Zhong, L., & Chen, G. (2020, 5 1). Comparative study of municipal solid waste disposal in three Chinese representative cities. Journal of Cleaner Production, 254.
8. Four new sewage plants on cards, two to be upgraded _ Gurgaon News - Times of India. (n.d.).
9. Guerrero, L., Maas, G., & Hogland, W. (2013, 1 1). Solid waste management challenges for cities in developing countries. Waste Management, 33(1), 220-232.
10. Kukreja, M. (2017). Institute of Town Planners, India Journal 14 x 1, January - March 2017. (March).

11. Malik, V., Singh, R., & Singh, S. (2020). Impact of Urbanization on Groundwater of Gurgaon District, Haryana, India. International Journal of Rural Development and Management Studies, 5(1), 45-57.
12. Ministry of Housing and Urban Affairs. (2017). Swachh Bharat Mission (Urban). Ministry of Housing and Urban Affairs Government of India(October), 1-68.
13. Misra, A. K., Masoodi, M., Poyil, R. P., & Tewari, N. K. (2018, March 01). Water demand and waste management with respect to projected urban growth of Gurugram city in Haryana. Beni-Suef University Journal of Basic and Applied Sciences, 07, 8. doi:10.1016/j.bjbas.2018.03.003
14. OECD. (2018). Rethinking Urban Sprawl:Moving Towards Sustainable Cities. OECD Publishing.
15. Okot-Okumu, J., & Nyenje, R. (2011). Municipal solid waste management under decentralisation in Uganda. Habitat International, 35(4), 537-543.
16. Paes, M., de Medeiros, G., Mancini, S., Bortoleto, A., Puppim de Oliveira, J., & Kulay, L. (2020, 5 1). Municipal solid waste management: Integrated analysis of environmental and economic indicators based on life cycle assessment. Journal of Cleaner Production, 254.
17. Sharma, N. (2017). Swachh Bharat: Funds for treating solid waste cut 46 per cent Congress. The Economic Times.
18. Shilpy, A. (2019, 9 17). 30-acre dumpyard to come up in Aravalis _ Gurgaon News - Times of India. Times of India.
19. Singh, T. (2016). Investigation on Urban DrainageSystem inSululta. 8(1), 1-10.
20. Slagstad, H., & Brattebø, H. (2013, 1). Influence of assumptions about household waste composition in waste management LCAs. Waste Management, 33(1), 212-219.
21. Vij, D. (2022). Urbanization and Solid Waste Management in India: Present Practices and Future Challenges. Procedia - Social and Behavioral Sciences, 37, 437-447.
22. Zhang Y., Drake W. (2014) Geographic Information Systems (GIS). In: Michalos A.C. (eds) Encyclopedia of Quality of Life and Well-Being Research. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-0753-5_1159