Examining the Impact of Financial Resources on Solid Waste Management Practices: A Cross-Country Analysis

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This research project scrutinizes the reciprocal relationship between a city's financial resources and the efficacy of its solid waste management practices. In a comparative study of 12 diverse cities, demographic factors like the Human Development Index (HDI) and gross national income (GNI) were juxtaposed with waste management indicators such as percentage of area serviced. Notably, the findings reveal a feedback loop where cities with effective waste management methods usually boast developed infrastructure, subsequently attracting more taxes and cleanup service funds which further enhance the waste management system. Conversely, cities struggling with waste management often fall short in providing proficient infrastructure, resulting in a less affluent demographic unable to support an efficient waste management system, exacerbating the issue. Effective waste management is crucial for environmental sustainability and public health, and understanding the factors influencing it can inform policy decisions and resource allocation. The urgency of addressing this cycle and the potential benefits of doing so at a larger scale underscores the significance of this study.

Keywords: Solid Waste Management, Income Inequality, Garbage Collection, Recycling, Waste Management Systems, Quality of Life, Garbage Collection Area, Waste Management Efficiency in Cities

Introduction

Waste management practices refer to the activities, methods, and procedures employed to collect, transport, process, treat, recycle, or dispose of waste materials in an environmentally-friendly, efficient, and sustainable manner. This includes reducing waste generation, promoting recycling and reuse, ensuring proper disposal of non-recyclable waste, and monitoring and regulating the waste management processes to ensure minimal impact on human health and the environment.

The effectiveness of solid waste cleanup programs hinges on an array of factors, and these programs can vary widely in terms of methods, targets, and goals. Some programs might emphasize waste reduction, others may concentrate on recycling or handling hazardous waste. The challenges and needs of the area also significantly influence the success of these programs, hence it is crucial to delineate evaluation criteria that reflect these factors and shed light on a city's waste management capacity. In developing urban regions, optimal waste management systems require a fusion of factors: effective collection and transportation infrastructure, adequate sorting and processing facilities, robust governmental policies for sustainable waste management, and public engagement programs to advocate waste reduction and recycling. Many low-income cities, however, lack standardized reporting of these waste management metrics, necessitating a broader approach. Consequently, this study emphasizes financial aspects of these cities, providing a clear and valuable perspective on waste management efficacy relative to economic resources.

The resource dependence theory provides a valuable lens through which to understand the intricacies of solid waste cleanup programs. These programs are inherently reliant on a complex web of external resources, ranging from financial support to technological infrastructure. The availability of financial resources enables investment in waste management infrastructure and technology, leading to improved waste collection and disposal practices [1].

Evidently, it is important to define criteria which focus on a limited number of factors, in order to evaluate those factors of development within a city which are affecting the city's ability to manage waste. As the research delves into the economic disparities inherent in waste management, resource dependence theory provides a framework for understanding how variations in funding availability can affect the implementation of waste management initiatives. Specifically, to investigate the connection between public spending on waste management and the percentage of waste disposed of properly in low-income nations. Additionally, to examine the influence of various demographic factors like population density on this relationship.

The Bidirectional Relationship Between Wealth and Waste Management

The level of waste management development of a city is affected by various factors such as economic development[2], environmental awareness[3], governmental policies[4], available infrastructure and technology[5], and public pressures[6]. These factors raise the question of how resource inequality in different cities may affect the possibility of improving the infrastructure and focusing on solid waste management specially?

One study, by Caniato et al., that elucidates the relationship between financial investments in waste management infrastructure and its outcomes is undertook an in-depth comparison of waste management systems in the Region of Umbria in Italy and the West Bank in Palestine. From an economic, legal, and political perspective, Umbria benefits from the backing of European Union Directives, providing it with a robust political, legal, and economic structure. Conversely, the West Bank mirrors the complexities typical of developing nations, especially in the facets of waste management. When considering the economic weight of waste management, Umbria's expenses equate to 0.82% of its per capita gross domestic product (GDP). The West Bank, though bearing a higher burden at 1.2%, still struggles with inadequate funds to maintain an efficient waste management framework.

Interestingly, both regions recorded almost identical figures in terms of annual organic waste per capita. Infrastructure-wise, the West Bank grapples with significant challenges. It lacks essential infrastructure such as composting facilities and proper waste collection systems. The presence of mechanical sorting facilities is minimal, and recycling endeavors in the West Bank yield a modest 6% rate. The study also hinted at potential sustainability concerns regarding Umbria's recycling and composting figures. The research accentuates the stark contrast in waste management practices between the two regions, with the disparities rooted in their respective economic, infrastructural, and political landscapes[7].

A different study by Patrick Karani and Stan Jewasikiewitz looked at the developing sector of waste management practices in South Africa where waste management stands as a critical frontier on the country's journey towards sustainable development. Historically dominated by the private sector, which primarily focused on recycling lucrative products like paper, plastics, and metals, the vast majority of waste, approximately 10.2 million tons, found its way into landfills. This approach is seeing a shift as global development agencies step in, identifying avenues for sustainable advancements. They spotlight opportunities such as methane emission capture and emphasize financing essential assets to bolster sustainability. Yet, the sector grapples with challenges rooted in a paucity of holistic understanding to create and execute programs marrying environment, sustainability, and developmental needs. Municipal capacities remain strained, hindering effective program administration and tax collections vital for landfill management. Despite South Africa's strides toward sustainability, progress remains gradual. The heart of this slow pace rests in the financial domain, underscoring that adequate capital investments are fundamental for the essential infrastructure pivotal to waste management. The study showed that, "overall, financial resources are imperative to waste management and sustainable development as the sector requires capital investments for necessary infrastructure[8]," highlighting the relevance of the resource dependence theory in the waste management sector.

However, if the initial challenges of creating a solid waste department are overcome, proper solid waste management practices can lead to cost savings and new economic opportunities for that city. For example, the implementation of waste-to-energy projects can generate electricity and provide a new source of income for the city[9]. In addition, waste recycling and composting can create new jobs and stimulate local economies. Sustainable solid waste management practices can reduce environmental impact and promote long-term sustainability[10]. The use of renewable energy sources for waste management can reduce the city's dependence on nonrenewable resources[9]. Socially, proper waste management practices can improve public health by reducing the risk of disease transmission and air pollution[11]. In addition, waste reduction and recycling can increase community engagement and promote environmental awareness[10]. The implementation of proper waste management practices can help cities meet cities' sustainability targets and comply with environmental regulations[9].

After discovering that the resources spent by a city on developing its waste management program may further aid that city's infrastructure, social welfare, and develop its economy, a clear bidirectional relationship between the two can be observed.

Resource Inequality

Low-income countries (LICs) struggle to create efficient waste management services. Due to a lack of technology, funding, and policy governance, many low-income countries have insufficient waste management systems. LICs are also limited by a lack of financial, physical, and educational resources. In addition to having a limited amount of resources for transportation and maintenance, many nations also lack the area necessary to carry out effective waste and recycling disposal procedures. As a result, these nations frequently employ alternative waste management techniques like incineration and unregulated disposal[12], which can worsen the waste management practices of the region in a number of ways.

Incineration can create a disincentive for waste reduction and recycling. Since incineration can generate energy, some

communities may rely on it as a source of electricity or heat rather than investing in sustainable waste reduction and recycling programs. This can lead to a higher volume of waste being produced and less emphasis on waste reduction and recycling efforts [13].

Unregulated disposal can lead to illegal dumping and littering, which can further degrade the environment and exacerbate the waste management problem. A lack of proper waste disposal infrastructure and regulations can result in people resorting to dumping waste in open spaces or water bodies, creating health hazards and unsightly areas. This can also result in a strain on local governments to allocate resources for cleaning and disposing of waste [14].

In most of the industrialized world since 1990, measures of inequality based on the Gini coefficients, "a summary measure of income inequality," [15], of gross and net incomes have significantly increased. Inequality in emerging markets and developing countries (EMDCs) has generally remained consistent, although being substantially higher than that seen in industrialized nations. However, there are significant differences between EMDCs, with Latin American nations showing considerable drops in inequality and Asia and Eastern Europe seeing noticeable increases (although the region remains the most unequal in the world). Market income disparity in industrialized nations was significantly reduced, albeit in part, by redistribution, as measured by the gap between market and net inequality. By reallocating resources to more productive businesses and facilitating company restructuring, institutions that support the labor market can be more flexible to promote economic dynamism. A key factor in understanding the rise in inequality is increasing flexibility, which can provide difficulties for workers, particularly those with low skill levels [16]. So countries with less developed economies, centered around resource gathering and processing or agriculture, will by definition struggle to promote economic dynamism, thus leaving the service sector less developed as a result.

The effects of income inequality have been linked to reduced access to social services and decreased rates of social goods [16]. That is why the metric of gross national income (GNI) made sense when comparing the countries of the cities, if a link between mean house price and GNI was established, this would point out a clear indicator of how services provided by the government struggled in a less developed economy.

Resource inequality can also impact the waste management departments in different cities, which can subsequently affect the humane development index (HDI). Inadequate resources allocated to waste management can lead to environmental pollution and health hazards for citizens, particularly in low-income areas. In this response, we will explore how resource inequality may affect waste management departments in different cities and provide citations and references to support our claims.

In cities with high resource inequality, access to garbage collection services may be limited, particularly in low-income areas. This can lead to increased environmental pollution and health hazards for citizens, which can negatively impact HDI. A study conducted in India found that inadequate garbage collection services were associated with poor sanitation and high rates of diarrhea among children, which can negatively affect their health and wellbeing [17].

Garbage collection workers are exposed to hazardous working conditions, including exposure to toxic substances and physical strain. In cities with high resource inequality, garbage collection workers may not have access to protective equipment or adequate healthcare resources, which can lead to increased work-related injuries and illnesses. This can also affect HDI by reducing the productivity of workers and their ability to contribute to the economy. A study conducted in Mexico found that garbage collection workers had a high incidence of work-related injuries and illnesses due to inadequate resources [18].

Resource inequality can affect waste management departments in different cities and subsequently impact their HDI. Improving access to garbage collection services and providing adequate resources for garbage collection workers can have positive effects on the environment, health, and productivity of citizens, ultimately contributing to higher HDI scores.

Solid Waste Management Practices

Countries and cities with advanced waste management systems tend to have better waste segregation, collection, processing, and disposal practices, leading to improved environmental and health outcomes. However, countries and cities facing challenges in managing their waste need to invest in infrastructure, policy, and cultural change to improve their waste management practices.

There is a bidirectional relationship between waste management practices and the income level of a country. Income level affects the quality and effectiveness of waste management practices. Countries with higher income levels can invest in better infrastructure, technology, and education, leading to more advanced and efficient waste management practices. In contrast, countries with lower income levels may not have the resources to invest in waste management infrastructure, leading to inadequate and unsustainable waste management practices.

Waste management practices can also affect the income level of a country. Poor waste management practices, such as open dumping, can lead to environmental pollution, health hazards, and loss of economic opportunities, such as tourism and agriculture. In contrast, efficient waste management practices, such as recycling and waste-to-energy, can create eco-

nomic opportunities, such as the creation of jobs, the production of recycled materials, and the generation of energy.

While income level can affect the quality of waste management practices, waste management practices can also impact the income level of a country by creating economic opportunities or environmental and health hazards. Therefore, it is crucial for cities to invest in sustainable waste management practices that consider both environmental and economic factors. However, as described in the resource inequality section, some cities lack resources to fund sustainable waste management programs; this leads to a less developed economic infrastructure which is unable to provide sufficient job opportunities for its citizens. As a result, these citizens are unable to follow sustainable recycling practices and provide less fiscal return towards the city — both of these factors create a less efficient garbage management system. This is how the bidirectional relationship between the financial resources or a city and its waste management efficiency is formed.

Waste management practices can vary from place to place depending on factors such as cultural norms, economic conditions, and local regulations. However, there are some general best practices that are widely recognized as effective in reducing waste and minimizing its impact on the environment. Here are the core practices in solid waste management also known as the three Rs: Reduce, Reuse, and Recycle. The first step in effective waste management is to reduce the amount of waste generated in the first place. This can be achieved through measures such as reducing packaging, using reusable products, and choosing products with less packaging. The next step is to encourage the reuse of products wherever possible. This can involve repairing, refurbishing, or repurposing products to extend their lifespan and reduce the amount of waste generated. Recycling is an important element of waste management, and involves the processing of waste materials to create new products. This reduces the need for new resources to be extracted and processed, and helps to conserve energy.

In contrast, managing waste that does not get reused or recycled is another crucial process in keeping a city clean. Landfills are still an important part of waste management, particularly for nonrecyclable and noncompostable waste. However, effective landfill management is critical to minimize the impact on the environment. Historically, large cities like New York City have faced challenges in managing its solid waste, particularly with regard to landfill mismanagement. New York City has limited landfill capacity, leading to increased transportation costs and reliance on landfills outside the city.

The Effect of Resource Inequality on Solid Waste Management

Solid waste management practices vary greatly across different countries and cities due to differences in economic development, cultural attitudes, regulatory frameworks, and infrastructure. Some cities and countries have advanced waste management systems, while others struggle to manage their waste effectively.

Poor Planning and Underdeveloped Infrastructure

Rio de Janeiro faces significant challenges in managing its waste, with only 60% of the waste collected and processed, and the remaining 40% dumped illegally in landfills or open spaces[19]. Similarly, only 50% of India's waste is collected, and less than 30% of that is processed, leading to significant environmental and health hazards[20]. One of the main reasons for this is the lack of a comprehensive waste management plan. The lack of infrastructure, informal waste pickers, and cultural attitudes towards waste contribute to the challenges as well.

Singapore's Success

Singapore is known for its innovative waste management system, which includes a combination of waste-to-energy incineration, recycling, and waste reduction initiatives. The city-state has one of the highest waste-to-energy ratios in the world and has reduced its landfill waste to less than 2% of total waste generated[21].

Relationship Between Home Price and Waste Management

Income can play a significant role in the way individuals and communities manage their waste. Generally, higher income individuals and communities have better access to waste management services and infrastructure, and are more likely to be able to afford to properly dispose of their waste. This can result in less littering and illegal dumping of waste, which can have negative impacts on the environment and public health.

On the other hand, lower income individuals and communities may not have access to adequate waste management services and infrastructure, leading to a greater reliance on illegal dumping or burning of waste. This can result in environmental degradation and public health hazards, particularly in developing countries where waste management infrastructure is limited.

Income can indeed play a significant role in the way individuals and communities manage their waste. Several studies have examined the relationship between income and waste management practices, and the evidence suggests that income can impact waste generation, disposal, and recycling behaviors.

Households with higher incomes tend to generate more waste than those with lower incomes. The study analyzed waste generation data from 109 municipalities in Japan and found that households in higher income brackets tend to produce more waste, particularly nonburnable waste. This may be because households with higher incomes have more purchasing power and may consume more products that generate waste. However, the same study also found that households with higher incomes tend to have better waste disposal practices than those with lower incomes. This includes proper sorting and separation of waste, as well as using appropriate waste collection services. This may be because households with higher incomes have greater access to resources and information about waste disposal practices [22].

Income also impacts recycling behaviors. The study analyzed data from a survey of 600 households in Turkey and found that households with higher incomes tend to recycle more than those with lower incomes. This may be because households with higher incomes have greater access to recycling programs and may be more willing to pay for recycling services [23].

Overall, these studies suggest that income can impact waste generation, disposal, and recycling behaviors. However, the relationship is complex and depends on a variety of factors, including access to resources, knowledge about waste management practices, and cultural norms.

Cultural Awareness through Policy Making

Effective waste management policies and regulations can significantly improve waste management outcomes. There are several physiological factors that can affect a city's demographic to properly dispose of waste, including: age, health conditions, physical ability, education, cultural norms, and policies enacted in that city. Older adults may have physical limitations that make it difficult for them to dispose of waste properly, such as mobility issues that make it difficult to carry heavy waste bags or walk to a waste can. Individuals with certain health conditions, such as chronic pain or respiratory issues, may have difficulty disposing of waste properly due to physical limitations. Physical ability can play a significant role in an individual's ability to dispose of waste properly. Individuals with physical disabilities or impairments may require special accommodations or assistance to properly dispose of waste. Education and awareness campaigns can help to promote proper waste disposal practices and encourage individuals to dispose of waste in a responsible manner. Cultural and social norms can also play a role in an individual's willingness to dispose of waste properly. For example, in some cultures, there may be less emphasis placed on the importance of properly disposing of waste. Additionally, policies enacted in the city play a large role in making sure that people of all demographics properly dispose of waste.

Japan's no contact waste policy, also known as the "Clean Japan Center" has been credited with helping to improve the cleanliness of the region. This policy was implemented in the 1990s as a way to encourage individuals to take more responsibility for their waste and reduce the amount of litter on the streets. One of the key aspects of this policy is the emphasis on separating and sorting waste into different categories, such as burnable and nonburnable waste, as well as recyclable materials. The government has also implemented strict regulations on how waste is collected and disposed of, including requiring households and businesses to use designated waste bags and bins for different types of waste. The no contact waste policy has been successful in reducing the amount of waste produced by households and increasing the amount of waste that is recycled. In 2017, Japan's overall recycling rate was 20% higher than the average for Organisation for Economic Co-operation and Development (OECD) countries [24]. Additionally, a study published in the journal Waste Management and Research found that the no contact waste policy has also helped to reduce litter and improve the cleanliness of public spaces in Japan. The study surveyed residents in Tokyo and found that the majority of respondents felt that the policy had a positive impact on the cleanliness of the city. Japan's success in expanding their waste management program is a clear indicator that, when coupled together, policies, education, and cultural integration will have a major impact on waste management outcomes.

In an analysis of Taiwan's solid waste policies over the decade of 1997-2007, one study identifies consistent uncertainties in policy execution. These uncertainties persist despite accounting for various determinants like environmental, economic, social, technological, and managerial facets. The study found that "respecting public opinions and social perspectives in decision-making and decreasing the impacts of policy implementation," proved most effective when implementing new waste management policies [25].

These two studies indicate that either a gradual approach to policy implementation or rigid governmental restrictions on waste management and disposal prove most effective. In higher income cities, where more budget is available, rigid requirements and a total rework of the waste management system might prove more effective; but in lower income cities, where budget can only be allocated gradually, it may prove pivotal to implement waste management changes gradually, as the sector grows or as the budget allocation increases. In

both cases, technological advancement and increases in fleet would correlate with the budget allocated, and wouldn't alone be enough to solve ineffective waste management.

Results

There is limited reliable and consistent data that can be used to compare waste management systems; certain cities do not provide basic metrics, such as collection schedules or facility count. As a result it was chosen to take broad statistics that were available for a large sample of cities like percentage of land serviced and the percentage of that collected garbage being properly disposed of. These metrics were compared against GNI capita and the mean property valuation of residential homes in those cities to find a potential effect that those waste management systems were affected. A bidirectional relationship between these variables was discovered.

The data collected demonstrated how certain metrics of development within cities, whether that be general demographic factors like GNI or HDI or the specific metrics of the garbage recycling departments of those cities played a role in the efficiency at which waste was being recovered in those cities. Surprisingly, GNI classification showed a small correlation (Pearson's r = 0.46) with the percentage of waste that was being properly disposed of, meaning that the income level within cities did not play a role in how well those cities organized their garbage collection services. The low correlation leads us to believe that tax payments do not affect garbage collection services specifically: this can happen for a number of reasons - anything from cities neglecting the garbage collection process in order to focus on other areas of development to those cities being corrupt and improperly distributing their taxes. Further research is required to draw a specific conclusion as to why the level of income does not affect the percentage of garbage being collected.

HDI however showed a much higher correlation to the amount of garbage that was being collected by cities (r = 0.68). This was expected as HDI is a metric that reflects a country's ability to meet the basic needs of its citizens in health and standard of living, so the higher rates of garbage collection were expected as HDI rating went up. The garbage collection services in each respective city are governmentally run agencies so the funding they receive directly impacts the HDI rating of that country, so it is easy to draw a link between the two. The percentage of the collection coverage within each city demonstrated a high correlation with the amount of garbage that was being collected (r = 0.77). This is interesting because this correlation is a direct result of resource inequality within the LICs on the list. Every country that had a GNI income classification of High (Netherlands, USA, Australia) as well as one county ranked Upper-middle (Bulgaria), all had a percentage collection coverage of 100%. Out of that serviced area all the countries that ranked High on the GNI scale also had a disposal percentage of 100% and Bulgaria's percentage was at 99%. This means that cities with better infrastructure were able to service 100% of their public space which led to the entirety of the waste in that area to be cleaned off the streets. Counties on the opposite end of that scale classified at Low on the GNI: Bangladesh, Tanzania, and Nepal all had cities in which the area that was being serviced was 55%, 60%, and 46% respectively for each of their cities shown above. The low access of waste management services to rural areas within those cities is a direct reflection of the resources that city has for the development of its infrastructure, so access to suitable roads will always be a limitation to the garbage collection services within those cities no matter how effective the system itself may be, it will never be able to service some of the areas within the city unless the resource inequality is resolved.

The most prominent correlation was demonstrated between the percentage of Recycled Materials in cities and the Mean Home Prices within those cities (r = 0.83). This result suggests that there is a bidirectional relationship between home prices and the development of garbage departments within cities. On one hand, the development of efficient and reliable garbage departments can increase the desirability of a neighborhood or city, which may in turn drive up home prices. Residents may be willing to pay a premium to live in an area with clean streets and well-maintained garbage services, which can improve quality of life and overall livability. On the other hand, higher home prices may also lead to increased demand for better garbage services, as residents expect higher levels of cleanliness and service quality. This may in turn incentivize city officials to invest in better garbage departments in order to meet the needs of their constituents.

However, the relationship between home prices and garbage department development may not always be straightforward. For example, some areas with high home prices may already have well-established and efficient garbage departments, while others may not see significant improvements in garbage services even with increasing home values. Additionally, the relationship may be influenced by other factors such as local regulations and available funding for city services which circles back to the resource inequality between different cities. However, other factors like population density showed little correlation with the percentage of controlled disposal within cities (r = -0.4640). This relationship reveals an interesting discovery about the operation of most garbage departments - as long as an area of a city is being serviced, most of the citizens in that area will receive waste management, no matter the density of that area. A potential explanation for this is that if a garbage department is unable to handle an are of operation at full capacity or close to it, it will not expand its area of operation (Coverage%) further, meaning that population density does not affect the efficiency at which depart-

Table 1 Source Cities' Indicators

City	Country	Home Price Mean (in thousands of USD)	Income Classification	GNI Capita	HDI	Population Density (km)	Percentage collection coverage(%)	Percentage controlled disposal (%)	Percentage materials recycled or recovered (valorized) (%)
Rotterdam	Netherlands	$203	High	48460	0.964	2831	100	100	30
San Fancisco	USA	$1,300	High	46360	0.954	847	100	100	72
Adelaide	Australia	$459	High	43770	0.97	1295	100	100	54
Varna	Bulgaria	$280	Upper-middle	6060	0.84	3925	100	99	27
Canete	Peru	$315	Upper-middle	4200	0.806	95	71	81	12
Belo Horizonte	Brazil	$53	Upper-middle	8040	0.813	7411	85	100	1.5
Quezon City	Philippines	$136	Lower-middle	2050	0.751	17758	99	98	39
Delhi	India	$403	Lower-middle	1180	0.612	9340	75	87	33
Managua	Nicaragua	$145	Lower-middle	1000	0.699	3470	82	97	19
Dhaka	Bangladesh	$133	Low	580	0.543	19178	55	50	24
Mohsi	Tanzania	$182	Low	500	0.53	3164	60	87	18
Ghorahi	Nepal	$65	Low	440	0.553	795	46	81	11

ments are able to properly dispose of collected waste, but it may affect the area coverage of those agencies.

The positive correlation between financial resources and waste management outcomes indicates that higher financial resources are associated with better waste collection and disposal practices. Overall, while there may be some degree of bidirectional relationship between home prices and the development of garbage departments within cities, it is important to consider a range of factors when examining this relationship in more detail.

Limitations

One of the principal limitations of this research lies in the scope of the sample size. This study relied on a sample of only 12 cities, a decision that was driven by the availability of reliable data. The following rationale underpins this sampling choice:

One set of limitations is regarding data availability and income disparities. Reliable data pertaining to solid waste management practices is predominantly available for cities in high-income and upper-middle-income brackets. As the income category declines, there's a noticeable reduction in the data accessibility. This discrepancy is congruent with the resource dependence theory. Countries and cities within the lower-middle to low-income brackets often face constraints in access to essential infrastructure and advanced software. Such limitations can potentially restrict their ability to record, maintain, and share comprehensive data on waste management practices.

Another set of limitations is regarding proportional representation. To ensure that the study offers a balanced cross-sectional view, it was paramount to maintain proportionality in the representation of cities across different income categories. As a result, three cities were selected from each of the four defined income categories: High Income, Upper-Middle Income, Lower-Middle Income, and Low Income. It's essential for readers to recognize that while the sample provides a cross-sectional insight, the limited number of cities, particularly within the lower income brackets, might not capture the full spectrum of challenges and practices in solid waste management. Future research may benefit from exploring more diverse data collection methodologies or collaborating with local agencies in lower income regions to address this data gap.

Additionally, the units of analysis used — cities — can accommodate neighborhoods which vary in income and solid waste management efficiency, which would make neighborhoods a more effective unit of comparison; however, organizing the various data points proved increasingly challenging as many cities provided general overviews of the cities as a whole. For neighborhoods within Ghorahi, information like weekly cleanup was provided, however no specific area being serviced was outlined and information on specific scheduling of the cleanups was not available. These types of limitations made it difficult to work with more precise units of measurements like neighborhoods within those cities. For those reasons the city was used as a unit of analysis. Although cities proved effective in establishing a link between the data points described above, using specific neighborhoods as units

of analysis could yield more accurate results as neighborhoods provide a more synonymous level of measurement due to the similar level of income of residents within that neighborhood and the level of service received by that neighborhood.

Factors like population density, technological advancements, and specific government policies, while acknowledged, could not be extensively explored in our current framework. However, it is essential to note that our study is observational in nature, and not an experimental design. This inherently means there are limitations to the depth and breadth of data available, which restricts our ability to definitively establish or control for all potential confounding variables. That said, recognizing and further investigating these confounding factors is a valuable avenue for future research. Doing so could significantly enhance the development of policy-making in the realm of waste management. We believe that a more refined understanding of these factors will pave the way for more comprehensive and effective interventions in the future.

Discussion

The relative analysis of the 12 cities with different economies ranked by the World Bank's GNI classification[26] shows a well-correlated bidirectional relationship between the financial resources available to a city and the effectiveness of that city's solid waste management department. The collection and recycling of solid waste appeared to be highly correlated with the mean home price within cities, demonstrating how financial resources used to improve quality of life can create favorable economic conditions to develop the solid waste management sector; this in itself would improve quality of life and provide fiscal value for the economy of the city. This study also analyzed specific factors that may impact the efficiency of solid waste systems, and interestingly enough, population density did not correlate to the area of coverage of the cleanup department; this is contrary to previous research which suggests that high population density in low income countries may lead to better coverage of waste collection services because it increases the demand for such services[26]. Going forward, this discovery may eliminate population density as a factor that affects the efficiency of solid waste collection, no matter the level of income. These findings only took into account 12 cities around the world — taking a bigger sample or focusing on more specific regions may be beneficial for establishing more definitive conclusions about the correlation between cities' waste management and their financial resources.

A crucial insight from our research is the pressing need to address resource inequality. Ensuring a fair distribution of resources could enhance waste management across all sectors of a city. Moving forward, potential interventions in waste management should focus on increasing budget allocation towards lower income areas, increasing the service area of waste management programs, implementing policies in a way that either drastically changes or very gradually introduces new waste management reforms, and promoting public participation. For low-income cities, where financial constraints are pronounced, prioritizing budget allocation towards areas like public education, equipment upgrades, and improving workplace conditions might be pivotal. In sum, a holistic approach, encompassing a city's financial standing, infrastructure, and resource distribution, is imperative for advancing waste management practices and, by extension, enhancing urban life quality.

A longitudinal study tracking the long-term impacts of increased budget allocation in low-income areas might provide insights into the sustainability and ripple effects of such interventions. There's also an opportunity to explore the sociocultural aspects of waste management. How do local communities perceive and respond to changes in waste management practices? How can public participation be effectively harnessed to drive more sustainable practices at the grassroots level? Additionally, as mentioned in the "limitations" section, further investigating confounding factors could be crucial for policy makers. Furthermore, examining the efficacy of different policy implementation rates - from drastic changes to gradual reforms - could provide policymakers with nuanced recommendations tailored to the specific needs and capacities of cities. In the bigger picture, understanding the interplay between financial constraints, resource allocation, and public perception can pave the way for more adaptive, resilient, and sustainable urban waste management systems.

Methods

This study examined the correlation between the serviced area of different cleanup programs and the percentage of correctly managed waste. The Human Development Index (HDI) and gross national income (GNI) served as criteria to categorize cities based on their income levels. The HDI notably showed a strong correlation with the controlled disposal percentage within cities. Low and lower-middle GNI Capita cities presented challenges in data collection due to less developed waste management agencies and technology gaps, underscoring the pervasive resource inequality in this sector. This obstacle was overcome by resorting to broader metrics such as the serviced area percentage[27].

Following convention, countries were categorized based on gross national income (GNI capita), as determined by the World Bank[28]. The Human Development Index (HDI) further assessed the basic needs provision for citizens[29]. Wilson and colleagues' data showed a positive correlation between a nation's waste creation per capita and its HDI and GNI capita income levels. After assigning the cities to income categories, data was gathered from government agency websites regarding collection, disposal, and recycling percentages. The

cross-examination of GNI per Capita and HDI with these percentages sought to identify a correlation between income and a city's waste management abilities[27]. Pearson's correlation analysis was used to cross examine these factors. This type of statistical analysis method is used to measure the strength and direction of the linear relationship between two continuous variables. It provides a numerical value called the correlation coefficient (r) that ranges between -1 and +1. A positive correlation coefficient (r) indicates a positive linear relationship, meaning that as one variable increases, the other tends to increase as well. A negative correlation coefficient indicates a negative linear relationship, where as one variable increases, the other tends to decrease. A correlation coefficient close to 0 suggests a weak or negligible linear relationship between the variables.

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