Exploring Waste Generation Dynamics: A Study of Villages in Salcete Taluka

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I hereby declare that the data presented in this Dissertation report entitled, "Exploring Waste Generation Dynamics: A Study of Villages in Salcete Taluka" is based on the results of investigations carried out by me in the Economics at the Department of Economics, Goa University/Goa Business School under the Supervision of Prof. (Dr.) Pranab Mukhopadhyay and the same has not been submitted elsewhere for the award of a degree or diploma by me. Further, I understand that Goa University or its authorities /Goa Business School will be not being responsible for the correctness of observations / experimental or other findings given the dissertation.

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COMPLETION CERTIFICATE

This is to certify that the dissertation report **"Exploring Waste Generation Dynamics: A Study of Villages in Salcete Taluka"**isa bonafide workcarried out by Miss.Jevera Morisha Rodrigues,under my supervision in partial fulfilment of the requirements for the award of the degree of **Masters in Arts** in the Discipline ofEconomicsat the Department of Economics, Goa University/ Goa Business School.

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ABSTRACT

This study explores waste generation dynamics in Salcete Taluka from 2020 to 2023 through a door-to-door waste collection system, investigating the influence of population growth, urban and rural villages, tourist and Non-tourist villages, and Daily and non-Daily waste collection. Through panel data analysis, the study finds a positive relationship between population size and waste production, highlighting the role of individual consumption habits. Urban areas tend to produce more waste than rural ones, while tourist villages generate higher waste quantities compared to non-tourist ones. Daily waste collection shows potential for reducing waste generation, although its significance is limited. These findings emphasize the need for tailored waste management strategies considering local demographic and environmental factors. Overall, the study contributes insights into waste generation trends and the importance of sustainable waste management practices in rapidly growing regions like Salcete Taluka.

INTRODUCTION

The home disposal of waste for a door to door collection system is one of the most sustainable methods of waste management for the environment. This strategy has laid the foundations for reducing the amount of waste in landfills, which are now creating economic and ecological problems and creating new circular economies. Solid waste refers to any type of waste. This waste can be classified by the area where the waste is produced, for example, as municipal solid waste, health waste and electronic waste. More than 2 billion tons of municipal solid waste are produced annually. Bad disposal can cause harmful health effects, for example due to water, soil and air pollution. Hazardous waste or unsafe waste treatment such as open combustion can directly harm waste workers or other people involved in waste combustion and neighboring communities. Vulnerable groups, such as children, are at increased risk of adverse health outcomes. Bad waste collection causes environmental and marine pollution and can block water drainage. The resulting flooding and other stagnant waste water favor cholera and vector-borne diseases such as malaria and dengue.

Growth economies, growth of urban populations, rise in living standards and rising consumption levels are common trends in emerging economies around the world. Similarly, in India, increasing purchasing power parity has led to greater affordability, easier use of resources, and rapid increases in the amount of waste.

SDG 12 includes targets to reduce pollution and health effects by environmentally sustainable management (ESM) of all waste throughout the product life cycle; promoting waste prevention, reduction, recycling and reuse. India, the second largest country in the world, is considered one of the fastest growing countries in urbanization, with an annual growth rate of 3.09 percent of the urban population. The proportion of the population living in urban areas increased from 17.35 percent in 1951 to 26.15 percent in 1991. Urban development in India has drawn considerable attention to MSW management areas. The growth of urban population and economic development are considered vital factors for MSW generation, as these factors not only accelerate consumption rates, but also increase its production.

The growth of the MSW generation has exceeded the growth of the population in recent years due to changes in the living standards of people with increasing income levels, changing lifestyles, food habits and consumption patterns with the set of "use and throwing" of products. Solid waste management is one of the basic services provided by the city authorities to maintain the cleanliness of urban centers, and it is necessary to develop an appropriate MSW management system to avoid future environmental health problems. India is the second most populated country that produces about 62 million tons of MSW annually, where waste disposal without energy recovery is common practice. Most cities lack precise MSW management statistics (MSWM), i.e. waste generation rate, waste composition, physiochemical characteristics and landfills. Unresentful handling of MSW, which usually contains high organic substances, can cause the growth of pathogenic microorganisms and lead to infectious and chronic diseases for waste workers, rag pickers and the inhabitants around dump yards /landfilling facilities. In addition, inappropriate MSWM also leads to greenhouse gas emissions (GHGs), which increase global temperatures and contribute to climate change.

In Japan, waste generation is controlled at the source by households, where citizens are required to separate waste into combustibles, non-combustibles, and recyclables. The municipalities and waste disposal agents then sort out useful components for recycling. Tokyo Metropolitan Government (TMG) introduced various campaigns and programs to encourage voluntary recycling activities, leading to a significant increase in recycling rates over the years. In India, door-to-door waste collection services are carried out through Resident Welfare Associations (RWAs), Non-Governmental Organizations (NGOs), and other private initiatives in cities like Ahmedabad, Hyderabad, Rajkot, Bangalore, Jaipur, and Chennai. For example, in Ahmedabad, a successful initiative involving RWAs and NGOs covers a significant percentage of households in the city, with subsidies provided by the municipality

The success of door-to-door collection is largely dependent on the effective coordination and collaboration between local authorities, waste management service providers, and the community. In cities like Indore and Surat, the implementation of this model has been accompanied by comprehensive awareness campaigns, educational programs, and the deployment of user-friendly collection infrastructure, such as color-coded bins and segregation bags. India's rapidly growing population, coupled with urbanization and changing consumption patterns, has led to a mounting waste management crisis that poses significant challenges to public health and the environment. Importantly, the door-to-door approach has also created employment opportunities and improved the working conditions of waste collectors.

By formalizing the sector and providing training, equipment, and fair wages, municipalities have been able to enhance the dignity and social status of these essential workers, who play a pivotal role in maintaining the cleanliness and sanitation of urban spaces. In the face of this pressing issue, the implementation of door-to-door waste collection has emerged as a crucial strategy to address the country's waste woes, with the state of Goa serving as a model for effective execution. The success of Goa's door-to-door waste collection scheme can be attributed to a multifaceted approach that combines technological innovations, effective policy implementation, and community engagement. The state has invested in specialized collection vehicles equipped with GPS tracking and compaction capabilities, allowing for efficient and streamlined operations. Moreover, the implementation of stringent policies, such as mandatory waste segregation at the source, has instilled a sense of responsibility among citizens, encouraging them to actively participate in the waste management process.

City solid waste is one of the major environmental problems of rapidly urbanizing cities in developing countries, where more than 90 per cent of waste is frequently disposed of in uncontrolled landfills or burned outdoors with harmful effects on human health. Faster population growth and economic growth, as well as the associated circumstances, have raised serious MSW management issues in cities in developing countries such as China, India, Malaysia, Thailand and Bangladesh. In China, for example, the proportion of food waste to MSW was around 56%, with no sources of segregation available, and management was mainly dominated by disposal and combustion. The increasing MSW in rapidly growing towns and cities in developing countries puts serious pressure on local governments. Effective waste management requires integrated systems that are effective, sustainable and socially supported, which are expensive and often account for 20 to50 per cent of municipal budgets.

For the creation of sustainable and live able cities, proper waste management is necessary. Public awareness of various waste management issues can reduce waste production and improve waste management techniques such as recycling. People's environmental attitudes and knowledge of the environment are influenced by the views and attitudes of others. Protection of the environment is implied by a favorable attitude towards the environment, which helps to change the behavior. A positive attitude towards the environment and awareness are essential to improve environmental sustainability and waste management. However, there may be a disconnect between conceptual understanding and actual environmental management practices and actual solid waste management practices.

In Goa, waste management is an essential element in maintaining the natural beauty of the State and preserving its attractiveness for tourism. The door-to-door waste collection programme implemented in Goa is aimed at reducing waste disposal processes. Through this initiative, waste is collected systematically from households, ensuring a more organized and efficient waste management approach. This not only improves cleanliness, but also contributes to overall environmental sustainability in the region. The waste-to-energy initiative in Goa has become increasingly relevant, addressing the dual challenge of waste disposal and energy demand. Waste conversion into energy, whether incinerated or anaerobic, is a sustainable solution that matches the state's commitment to environmental responsibility. In order to address waste problems further in Goa, various measures are being taken.

The 3Rs—reduction, reuse and recycling—form the basis for waste reduction strategies. Residents are encouraged to minimize consumption and choose sustainable practices that give priority to the reduction of waste generation. Reuse of materials is actively promoted, and community recycling programs aim to manage recyclable materials efficiently. Public awareness campaigns play a key role in Goa waste management efforts. It promotes a culture of sustainability by educating residents about responsible waste disposal practices, the importance of recycling separation, and the environmental impact of their choices. In addition, the promotion of sustainable packaging practices and support for local waste reduction initiatives contribute to the overall success of waste management in Goa.

The success of Goa's door-to-door waste collection scheme can be attributed to a multifaceted approach that combines technological innovations, effective policy implementation, and community engagement. The state has invested in specialized collection vehicles equipped with GPS tracking and compaction capabilities, allowing for efficient and streamlined operations. The Goa Waste Management Corporation Act (GWMC), 2016 (Goa Act 19 of 2016), was created by the Goa government to help manage all kinds of waste better. Its objective is to support the structured and scientifically informed management of waste by establishing the Goa Waste Management Corporation. GWMC has carried out more than 200 awareness sessions across Goa with stakeholders such as educational institutions, Village Panchayats, Government offices, etc.

OBJECTIVES

- To understand the trends in waste generated over the years 2020 to 2023 in Salcete Taluka using the door to door collection program.
- To analyze if population has led to increase in waste generated in salcete taluka over the years 2020 to 2023 using the door to door waste collection program
- To analyze the differences in waste generated between urban and rural areas
- to analyze the impact of tourism on waste generated in tourist villages compared to non-tourist villages.

1.2 RESEARCH PROBLEM

- Identifying the relationship between population density and waste generation.

- Assessing the effectiveness of waste collection frequency (daily vs. non-daily) in managing waste generation.

1.3 RESEARCH QUESTION

1. How has the quantity of waste generated changed over the years 2020 to 2023 in Salcete taluka?
2. What are the differences in waste generation between urban and rural villages and to know if there are significant variations in waste generation rates between tourist and non-tourist villages?

Limitation

The scope of the research extends only to the taluka of salcete, this was done given the time constraints, Firstly, the data I received had missing values, and there was a lack of records on garbage disposal practices in the villages. Additionally, the dataset only covered a span of three years, which didn't allow me to compare the trends seen before and after the door to door waste collection program.

CHAPTER 2

LITERATURE REVIEW

(Habib et al., 2021) investigates the waste management landscape in Rajshahi City Corporation (RCC) and explores the feasibility of waste-to-energy conversion. the study uses a comprehensive approach, combining household surveys, chemical and physical analyses of Municipal Solid Waste (MSW) samples, and energy potential estimations. Data collection involved surveys of fifty households to assess waste generation rates, supplemented by chemical and physical analyses of collected Municipal Solid Waste (MSW) samples. The study revealed RCC's daily MSW generation to be approximately 358.19 tons, with an average rate of 0.4214 kg per person per day. The research underscores the pressing need for effective waste management strategies in RCC, highlighting the potential for waste-to-energy conversion as a sustainable solution. By providing crucial data on waste generation rates and energy potential, the study lays the foundation for informed policy decisions aimed at promoting environmental sustainability and public health in urban Bangladesh.

(Pattnaik & Reddy, 2010) provides a comprehensive evaluation of MSW management practices in Puducherry, aiming to assess waste generation, collection, transportation, segregation, and propose improvement measures. Pattnaik and Reddy used a wonderful methodology involving in-depth analyses of waste generation patterns, segregation sources, collection methods, and disposal practices in Puducherry. The study revealed crucial insights into the composition of MSW in Puducherry, revealing that approximately 65% of waste is biodegradable, while the remaining 35% comprises non-biodegradable materials suitable for recycling. The study advocates for enhanced allocation of human and financial resources, improved machinery, and strategic planning to bolster waste management practices.

(Mani & Singh, 2016) provides a comprehensive review and critical analysis of government policies and programs aimed at addressing challenges within municipal solid waste management (MSWM) across Indian cities and towns. Mani and Singh conducted a thorough review and analysis of existing literature, government reports, and policies concerning MSWM in India. The methodology does not involve primary data collection or empirical research but rather focuses on synthesizing and evaluating available information. The paper shows the current state of MSWM in India, outlining challenges related to waste generation, collection, transportation, treatment, and disposal. Additionally, they analyse the legal and policy framework, including the Municipal Solid Waste (Management and Handling) Rules 2000 and the draft Solid Waste Management Rules 2015, offering recommendations for refining the proposed regulations. While the paper offers valuable insights into MSWM policies and challenges in India, its reliance on secondary sources may limit the depth of analysis.

(Degli Antoni & Vittucci Marzetti, 2019) investigates the impact of recycling programs on waste generation, focusing on the source reduction effect. The study delves into estimating how recycling policies contribute to reducing total urban waste. Employing econometric models, they estimate the impact of recycling on waste generation and the effectiveness of curbside collection programs in increasing recycling rates and reducing waste generation.The study reveals that a 10% increase in recycling rate correlates with a 1.5–2% decrease in total urban waste, indicating a source reduction effect of recycling policies. Notably, curbside collection programs are found to enhance recycling rates by 8–14% and reduce waste generation by approximately 4%. These findings challenge the notion that recycling may already be operating above its socially optimal level in developed countries, highlighting the dual benefits of reducing residual waste and total waste through increased recycling efforts.

(Pujara et al., 2019) focusing on reducing environmental impacts for sustainable development goals. Their study seeks to analyse existing challenges in MSW management, propose sustainable solutions, and evaluate the environmental implications of various waste management options, utilizing Life Cycle Assessment (LCA). The authors conduct an extensive literature review encompassing studies on MSW management practices in India, examining aspects such as waste generation, transportation systems, segregation methods, treatment technologies, and disposal practices in urban and metro cities. Additionally, data analysis from sources such as census reports aids in forecasting future trends in population growth and waste generation rates. Furthermore, LCA serves as a tool to assess the environmental impacts of different MSW management scenarios, including landfilling, biogas recovery, waste sorting, and incineration. The study reveals significant environmental consequences associated with various MSW management options, with landfilling identified as the least sustainable due to its high emissions of greenhouse gases, acidification potential, eutrophication potential, and dioxin releases.

(*Quantification of Environmental Impacts Associated with Municipal Solid Waste Management in Rajkot City, India Using Life Cycle Assessment - ScienceDirect*, n.d.) The study aims to devise environmentally sound and cost-effective practices for MSWM in the city, examining four integrated scenarios comprising various waste management techniques, including open dumping, anaerobic digestion, composting, incineration, landfilling with or without energy recovery, and the utilization of a material recovery facility (MRF).The study focuses on assessing environmental emissions from different waste management practices within Rajkot, with LCA studies utilizing environmental emissions as the primary criteria. Waste composition in Rajkot is analyzed, revealing significant constituents such as biodegradable matter, plastics, paper, textiles, construction and demolishing waste, and inert (non-recyclable) waste. Current waste management practices, including collection, transportation, and disposal methods, are also detailed.The findings highlight the environmental impacts of the tested scenarios, with Scenario 4 (SC4) demonstrating the least environmental burdens, thus presenting it as the most suitable practice for reducing environmental impacts in Rajkot city. Additionally, challenges such as behavioral and infrastructural barriers to waste segregation and recycling may impact the feasibility of implementing recommended practices. In conclusion, the study provides valuable insights into MSWM practices in Rajkot city, India, emphasizing the importance of adopting environmentally sound and economically viable approaches. By quantifying environmental impacts through LCA, the study identifies Scenario 4 as the most suitable option for reducing environmental burdens.

(Goutam Mukherjee et al., 2021). provides a thorough review of innovative waste management technologies and processes, spanning solid, liquid, gaseous, and radioactive waste management, with a specific focus on addressing escalating waste disposal challenges and finding economic and eco-friendly waste management solutions for India. The objective is to incorporate successful methods from various countries into India's waste management practices. The methodology involves reviewing and analyzing a range of innovative waste management technologies, including plasma gasification, transmutation, incineration, bio-refineries, microbial fuel cells, Mr. Trash Wheel, and the Smart bin approach. Additionally, the document presents findings encompassing a wide array of innovative waste management technologies and approaches. These include the use of bio-refineries for converting biomass into liquid fuels and electricity, incineration for solid waste management and energy production, and the development of inorganic ion exchange materials and verification techniques for handling radioactive waste. It also discusses the potential of microbial fuel cells in wastewater treatment and energy recovery, as well as the benefits of waste management models such as the Swedish model. Moreover, it highlights the efficacy of new techniques like Mr. Trash Wheel and the Smart bin approach for effective waste management Additionally, challenges such as cost implications, regulatory frameworks, and social acceptance may impact the adoption of these technologies. Authored by A. Goutam Mukherjee et al. in 2021, the document underscores the importance of finding alternative energy sources and innovative waste management techniques to address the growing pollution and waste management challenges, particularly in India.

(Malek et al., 2023) The article titled, Assessing the Impact of Waste Management Policies on Municipal Waste Flows in European Countries, aims to analyze the long-term effects of waste management policies on the treatment and disposal of municipal waste across 14 European countries from 1996 to 2018. With a focus on contributing to existing literature on waste management policies, the study endeavors to provide insights for policymakers to enhance future waste management strategies. The methodology involves compiling a panel dataset for 14 European countries, incorporating data on various waste management policies such as landfill tax, landfill bans, incineration tax, and Deposit Return Schemes (DRS), along with other relevant characteristics.

Econometric analysis, specifically utilizing the Seemingly Unrelated Regression (SUR) approach, is employed to examine the impact of these policies on waste treatment methods including landfill, incineration, energy recovery, and recycling. Published in Waste Management in 2023, the study reveals significant insights into the effectiveness of waste management policies in influencing municipal waste flows. Notably, the earliest policy adopted was the DRS by Sweden in 1984, while the most recent was the landfill ban by Croatia in 2017.

Analysis indicates a negative correlation between landfill tax and waste sent to landfill in 2018, suggesting that higher landfill taxes may divert waste away from landfills. Summary statistics of waste treatment and policy variables for the countries studied are also provided. While insightful, potential limitations of the study may include the reliance on aggregated data, which may overlook nuanced regional variations within countries. Additionally, the study's focus on European countries may limit the generalizability of findings to other regions or countries with different waste management contexts and policy frameworks. By employing econometric analysis, the study provides evidence of the effectiveness of certain policies, offering implications for policymakers and guiding future waste management strategies towards more sustainable practices.

(Nair et al., 2023) The article titled,Enhancing Waste Management Efficiency through GIS-based Spatial Mapping: A Case Study of Panaji City, Goa, published in the International Journal of Innovative Science and Research Technology in September 2023, addresses the challenge of managing biodegradable waste from bulk generators faced by the Corporation of the City of Panaji. The study aims to map bulk waste generators across the 12 zones of Panaji City using Geographic Information System (GIS) technology. The research methodology involves the digitization of bulk waste generators and the creation of map layouts using GIS tools. Spatial distribution analysis is conducted to identify zones with high concentrations of bulk waste generators. The study reveals that zones 2, 3, 7, and 8 in Panaji City exhibit a high concentration of bulk waste generators. This information is crucial for the City Corporation of Panaji to devise efficient waste collection and transportation routes. The findings underscore the importance of GIS-based spatial mapping in waste management planning, emphasizing its potential to enhance overall waste management efficiency by identifying sources of waste generation and optimizing waste collection strategies. While GIS-based spatial mapping offers valuable insights, potential limitations of the study may include the need for periodic updates to reflect changes in waste generator locations and characteristics. The review emphasizes that addressing these challenges is vital for creating sustainable and healthy urban environments.In conclusion, the review article serves as a valuable resource for researchers, policymakers, and practitioners involved in waste management. It emphasizes the significance of addressing the challenges associated with municipal solid waste to safeguard public health and environmental integrity, thereby promoting sustainable development and ensuring the well-being of present and future generations.

(Adnan et al., 2020) In the PDF titled "Municipal Solid Waste Management and its Impact: A Review," authored by Mohd Adnan, Ayushi Jha, and Dr. Sanjeev Kumar from the Department of Civil Engineering at Graphic Era Deemed to be University in Dehradun, Uttarakhand, India, the objective is to offer a thorough evaluation of existing research pertaining to Municipal Solid Waste (MSW) management. Published in May 2020, the study delves into the characterization, collection, management, treatment, disposal, and repercussions of MSW. The authors conducted an extensive literature review, synthesizing information from various studies to present a holistic understanding of the challenges and potential solutions related to MSW management. Through this approach, they aimed to highlight the critical importance of efficient MSW management practices and their impact on public health and the environment. The findings show the l need for proper characterization, collection, treatment, and disposal of solid waste to mitigate negative consequences such as infectious diseases, land and water pollution, drain obstruction, and biodiversity loss.

(Thilakam, 2023) The PDF titled "Comparative Study of the Solid Waste Disposal Practices of Households in Coimbatore" investigates and contrasts solid waste disposal practices in town panchayat and urban households within Coimbatore. Conducted from April to June 2021, the study focuses on understanding homemakers' behaviors in managing solid waste in these distinct residential settings. The study employed a purposive sampling method to select 100 households, ensuring representation of homemakers. Data collection utilized an interview schedule with eight statements to gather insights into solid waste disposal practices and behaviors. Chi-square analysis was then utilized to examine the relationship between these practices and various demographic and socioeconomic factors. The findings highlight significant differences in solid waste disposal practices between town panchayat and urban households, with urban households demonstrating more effective segregation of household waste.

(Ajith, 2016) The PDF titled "A Study on the Solid Waste Collection, Treatment and Disposal System of Municipalities in Kerala" by P S Ajith, an Associate Professor of Commerce at SAS SNDP Yogam College in Konni, Pathanamthitta, Kerala, and published in December 2016 in the Journal of Emerging Technologies and Innovative Research, investigates the effectiveness of waste management systems in municipalities across Kerala. The study aims to assess the efficiency of waste collection, treatment, and disposal systems in Kerala municipalities. Employing a mix of primary and secondary data collection methods, secondary data was gathered from various government departments, agencies, and municipal authorities. Nine municipalities were selected using simple random sampling, divided into three regions: South, Central, and North. Primary data was collected through structured questionnaires administered to one expert from each municipality's Health Wing, providing insights into waste management practices.

Findings revealed significant issues, including a lack of professionalism and commitment among municipal authorities, challenges in funding and space for waste treatment and disposal, and public reluctance to engage in sustainable waste management practices.In conclusion, the study emphasized the urgent need for improved solid waste management practices in Kerala to mitigate health risks and environmental damage. It called for collaborative efforts from government bodies, agencies, and the public to address the pressing issue of solid waste mismanagement in the state.

(Niyati, n.d.) The PDF titled "Solid Waste Management in India and Japan" aims to conduct a comparative study of municipal solid waste management practices in these two countries, analyzing their effectiveness and shortcomings. The document focuses on highlighting key differences in waste generation rates, composition, and management strategies between India and Japan. The study employs a comprehensive approach involving literature review, data analysis, and case studies on waste management practices in both nations Findings from the study underscore the disparities between India and Japan in waste generation rates, composition, and management approaches. It highlights challenges faced by India due to deficiencies in the existing system, while acknowledging Japan's more organized and sustainable waste management practices.Although the author of the PDF is not explicitly mentioned, references cited in the document suggest a publication date around 2014-2015, given references to reports and articles from that period.In conclusion, the study emphasizes the need for India to address shortcomings in its solid waste management system and learn from Japan's effective waste management strategies to achieve more sustainable and efficient waste management practices.

(Chisika & Yeom, 2022) The paper titled "Improving Household Waste Management through a Door-to-Door Collection" by Sylvester Ngome Chisika and Chunho Yeom investigates waste management in Ruaka Town, on the outskirts of Nairobi City, Kenya. Its objectives include assessing the effectiveness of door-to-door household waste collection, identifying challenges faced by residents, and proposing solutions to improve waste management.

A mixed-methods approach is employed, combining primary qualitative data collection through a household survey questionnaire with secondary data collection through literature reviews, office visits, and desktop searches. The primary data collection involves observations, interviews, and photographic documentation of waste management practices.

(Vaz et al., n.d.) The paper titled"Enhancing Waste Management in Rural Areas: Insights from Door-to-Door Separate Collection"The Authors were,João Vaz, Vitor Sousa, Celia Dias-Ferreira.The paper explores the efficacy of door-to-door separate collection in rural areas, focusing on dry recyclable waste fractions. Through a pilot test in a small rural site, individual waste containers and bags were introduced at households, with once-a-week door-to-door collection implemented. Findings revealed a significant increase in recyclable waste, tripling from 23 kg/inhab/year to 73 kg/inhab/year, alongside a reduction in residual waste from 230 kg/inhab/year to 180 kg/inhab/year. This strategy served as a positive incentive for households and services to segregate waste effectively, resulting in less residual waste being disposed of. Notably, the composition of residual waste shifted, with a notable decrease in paper/cardboard content, leading to a diminished presence of recyclable materials in residual waste. The study underscores the effectiveness of door-to-door collection in rural areas, offering valuable insights for improving waste management practices and boosting recycling rates.

CHAPTER 3

DATA, VARIABLES AND METHODOOGY

The data has been collected from Goa waste management corporation saligao. The data ranges from the year 2020-2023. The variable included in the study are, quantity of waste generated, population, and year. The data collected is from 30 villages and they are later classified from, rural/urban, tourist/non tourist villages (which includes beaches, hotels, restaurants, site seeing etc.) The door to door waste collection is classified into daily/non-daily waste collection.

3.1 VARIABLES

Population- Population data has been collected from online sources (census 2011).

Quantity of waste generated- The data collected from the GWM (Goa waste management) gives the quantity of waste generated in kg. The data collected is of 30 villages from the salcette taluka.

3.2 Methodology

Descriptive analysis was conducted using a combination of tables, pie charts, bar graphs, and line graphs to know key patterns and trends in the dataset. The dataset was classified into different category: The villages were classified into rural urban villages, tourist non tourist villages. The variables included in this study were population, quantity of waste generated and the year. We examined the data through graphics like bar graphs, line graphs, pie chart which gives us the daily and non-daily waste collection. Panel data linear regression was used to get results on how these factors contribute to waste generation across different groups.

3.3 Data sources

1. The data collected is from the Saligao goa waste management corporation.
2. Daily or monthly door to door waste collection data is taken from panchayat, through phone calls.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

The door-to-door collection program initiated by Village Panchayats is a system where they go from house to house to collect dry, non-biodegradable, and non-hazardous waste, which is stored at designated waste handling areas or Material Recovery Facilities (MRF). When these storage areas reach capacity, Panchayat officials register a pickup request through online platforms or mobile apps, which is then relayed to GWMC. Within 48 hours, GWMC dispatches a vehicle to collect the waste.

Dry waste collected from various sources, including Village Panchayats, schools, and other organizations, is deposited at Solid Waste Management Facilities. The non-biodegradable and non-recyclable waste, baled as RDF, is then transported to cement plants in Karnataka for co-processing. GWMC facilitates this transportation, aiding municipalities and Panchayats with baling facilities. Each day, GWMC transports around 4-6 trucks of RDF, each weighing approximately 14-15 tons, from Goa to cement plants.

Table 4.1: Total villages in salcete taluka

Total villages in Salcete Taluka	
Sr No.	Village
1	Cana Benaulim
2	Varca
3	Ambelim
4	Aquem-Baixo
5	Assolna
6	Betalbatim
7	Camorlim (Salcete)
8	Carmona
9	Cavelossim
10	Chandor-Cavorim
11	Chinchinim-Deussua
12	Colva
13	Curtorim
14	Davorlim-Dicarpale
15	Dramapur-Sirlim
16	Guirdolim
17	Loutolim
18	Macazana
19	Navelim (Salcete)
20	Nuvem
21	Orlim
22	Paroda
23	Rachol
24	Raia
25	Rumdamol-Davorlim
26	Sao-Jose-de-areal
27	Seraulim
28	Sarzora
29	Telaulim
30	Velim

Source :secondary data

Table 4.2:Classification of villages into Tourist and Non-Tourist

Classification of villages into tourist and non-tourist	
tourist Village	**non-tourist Village**
Cana Benaulim	Ambelim
Cavelossim	Aquem-Baixo
Chinchinim-Deussua	Assolna
	Camorlim (Salcete)
	Carmona
	Chandor-Cavorim
	Curtorim
	Davorlim-Dicarpale
	Dramapur-Sirlim
	Guirdolim
	Loutolim
	Macazana
	Navelim (Salcete)
	Nuvem
	Orlim
	Paroda
	Rachol
	Raia
	Sao-Jose-de-areal
	Sarzora
	Seraulim
	Telaulim
	Velim
	betalbatim
	Colva
	varca

Source :secondary data

Table 4.3:Classification of villages into Rural and Urban

Classification of villages in rural and urban	
rural	urban
Aquem	Cana Benaulim
camorlim	Varca
Curtorim	Ambelim
Davorlim-Dicarpale	Assolna
Dramapur-Sirlim	Betalbatim
Guirdolim	Carmona
Loutolim	Cavelossim
Macazana	Chandor-Cavorim
Nuvem	Chinchinim-Deussua
Orlim	Colva
Paroda	Navelim (Salcete)
Rachol	velim
Raia	
Rumdamol-Davorlim	
Sao-Jose-de-areal	
Seraulim	
Sarzora	
Telaulim	

Source :secondary data

Table 4.4: Classification into Daily and Non-Daily waste collecting villages

Daily and non-daily waste collecting villages	
Daily villages	Non-Daily villages
ambelim	chinchinim
assolna	telaulim
aquem	varca
carmona	orlim
cavelossim	chandor
davorlim	colva
velim	curtorim
benaulim	loutolim
camorlim	paroda
nuvem	raia
rumdamol	sarzora
	betalbatim
	guirdolim
	dramapur
	sao jose de areal
	Seralium
	Navelim

Source :secondary data

4.2 Hypothesis

1. Population Hypothesis:

H0: There is no significant relationship between population size and waste generation.

HA: Population size has a significant effect on waste generation.

2. Urban/Rural Hypothesis:

H0: There is no significant difference in waste generation between urban and rural villages.

HA: there is significant difference in waste generation between urban and rural villages.

3. Tourist/Non-Tourist Hypothesis:

H0: There is no significant difference in waste generation between tourist and non-tourist villages.

HA: there is significant difference in waste generation between Tourist villages and non-tourist villages.

Table 4.5 Regressing Population on Waste Generated

Variable	Coefficient	p-Value
Dependent variable is waste generated		
Population	3.5559 (0.0798)	0.000002728
Per capita	1652.2 (27.317)	0.0000000000464
Urban & Rural	-5777.9 (695.7_)	0.4060
Tourist & non tourist	-1534.4 (9519.4)	0.1070
Daily & Non daily	-5004.1 (6.2917)	0.4264

The analysis conducted is based on a random effects model, specifically the Swamy-Arora transformation. The dataset comprises a balanced panel with 28 entities observed over 4 time periods, totaling 112 observations. The model examines the factors influencing waste generation, with variables including Population, Per Capita Waste, Urban/Rural villages , Tourist/Non-Tourist villages, and Daily/Non-Daily waste collection villages.

Examining the coefficients, we find that Population and Per Capita Waste exhibit statistically significant positive effects on Waste generated, with Population having a coefficient estimate of approximately 3.556 ($p < 0.001$) and Per Capita Waste around 1652.2 ($p < 0.001$). This suggests that both higher population levels and greater per capita waste production contribute significantly to overall waste generation. The coefficients for Rural villages on an average generate 5777.9 (kgs) less waste than the urban villages, Non-Tourist villages on an average will generate 15344(kgs) less than the wste generated by the tourist villages, and Non-Daily waste collection villages on an average is collecting 5004.1(kgs) less than the villages that do daily waste collection . but they do not appear statistically significant at conventional levels ($p > 0.05$), indicating that these factors may not have a significant direct impact on waste generation in this model.

The overall fit of the model is assessed using the R-squared and adjusted R-squared values, which stand at approximately 0.3482 and 0.3175, respectively. This indicates that the model explains around 34.82% of the variance in waste generation, suggesting a moderate level of explanatory power.

In summary, this analysis suggests that population size and per capita waste production are significant drivers of waste generation, while other factors such as urban/rural villages, tourist/non-tourist villages , and daily/non-daily waste collection villages do not appear to have a significant direct impact .So the first hypothesis which states that there is no significant relationship between population size and waste generated is rejected .

Table 4.6 Regressing Urban/Rural villages on waste Generated

Variable	Coefficient	p-Value
Dependent variable is waste generated		
Population	3.6669 (0.06706)	0.0000000456
Per capita	1.6669 (261.041)	0.0000000001
Urban & Rural	-1109.2 (5802.8)	0.05594

The analysis conducted employs a random effects model.The dataset consists of a balanced panel with 30 entities observed over 4 time periods, yielding a total of 120 observations. This model investigates the factors influencing waste generation, focusing on Population, Per Capita Waste, and Urban/Rural villages.

The coefficients, Population and Per Capita Waste demonstrate statistically significant positive effects on Waste generated, with Population having a coefficient estimate of approximately 3.6669 ($p < 0.001$) and Per Capita Waste around 1652.2 ($p < 0.001$). This suggests that both higher population levels and greater per capita waste production significantly contribute to overall waste generation. The coefficient for Urban/Rural villages exhibits a negative relationship with Waste generated, though it is marginally significant ($p = 0.05594$). People living in rural villages produce less waste compared to those living in urban, although the significance level is not very strong.

The overall model is assessed using the R-squared and adjusted R-squared values, which stand at approximately 0.33792 and 0.32079, respectively. This indicates that the model explains around 33.79% of the variance in waste generation, suggesting a moderate level of explanatory power.

In summary, this analysis suggests that population size and per capita waste production are significant drivers of waste generation, while residing in rural villages, compared to urban villages, might also play a role, although the significance is not very strong in this model. So the second hypothesis which states that there is no significant difference in waste generation between urban and rural villages is rejected.

Table 4.7 Regressing Tourist/Non-Tourist villages on Waste Generated

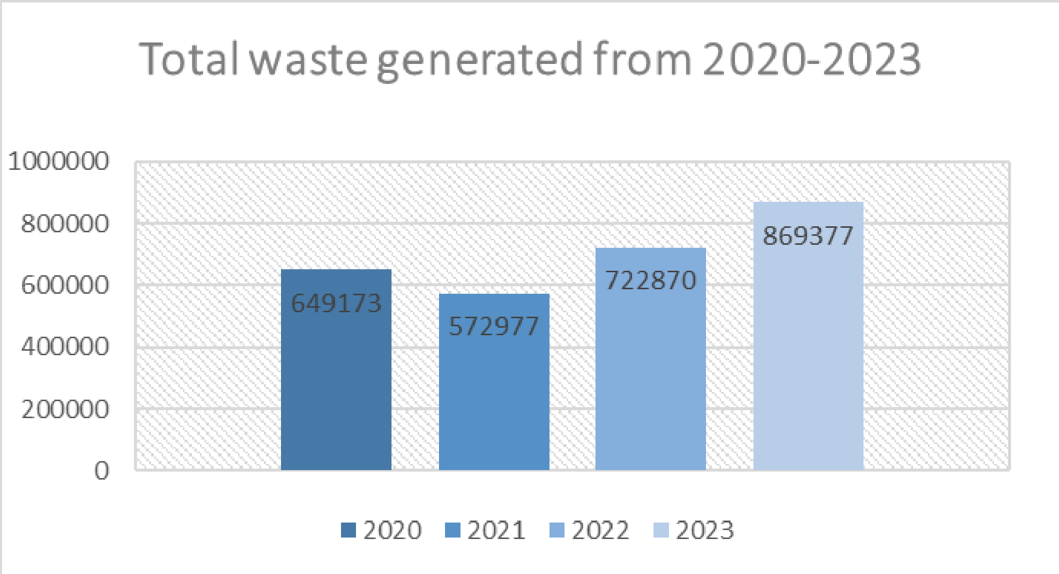
Variable	Coefficient	p-Value
Dependent variable is waste generated		
Population	3.5052 (0.06493)	0.305
Per capita	1658.1 (257.20)	0.0145
Tourist & non-Tourist	-1945.59 (804.86)	0.01562

The analysis uses a random effects model, to investigate waste generation across villages, considering Population, Per Capita Waste, and tourist or non-tourist villages. The dataset comprises a balanced panel with 30 entities observed over 4 time periods, total of 120 observations. The coefficients, Population and Per Capita Waste emerge as significant predictors of waste generation. Population demonstrates a positive association, with a coefficient estimate of around 3.5052 ($p < 0.001$), indicating that higher population levels correspond to increased waste generation. Similarly, Per Capita Waste exhibits a positive effect, with a coefficient estimate of approximately 1658.1 ($p < 0.001$), highlighting the influence of individual consumption habits on overall waste production. The coefficient for Tourist/Non-Tourist suggests a negative relationship with waste generation, with an estimate of -19459 ($p = 0.016$). This implies that regions characterized as non-tourist villages tend to have lower waste generation levels compared to tourist villages.

The model R-squared and adjusted R-squared values, indicate that the model explains approximately 35.02% of the variance in waste generation, suggesting a moderate level of explanatory power.

In summary, the analysis highlights the significant influences of population size, Per capita waste consumption, and the distinction between tourist and non-tourist villages on waste generation. So the third hypothesis which states that there is no significant difference in waste generation between tourist and non-tourist villages is rejected.

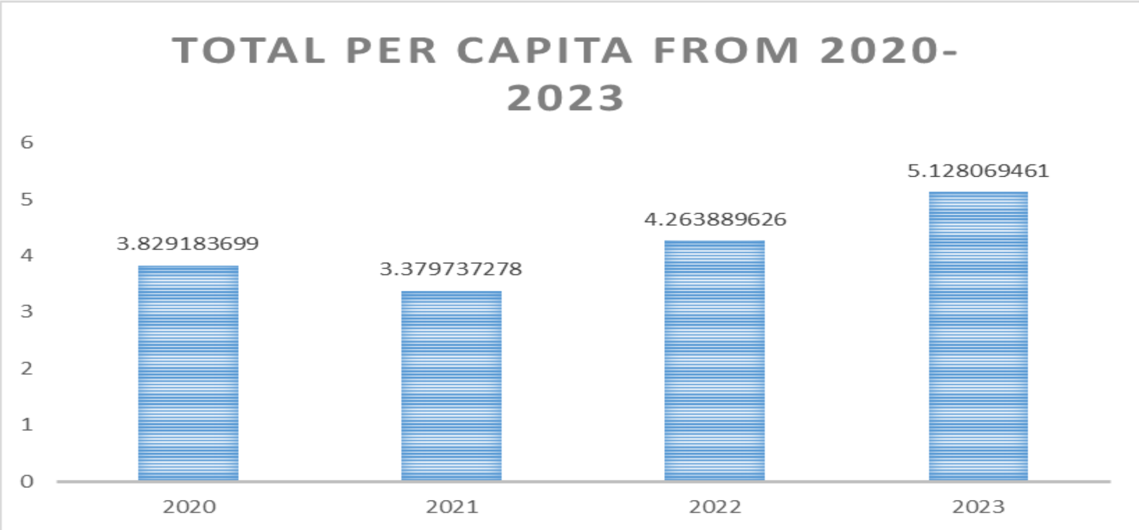
Figure 4.1: Total waste generated in Salcete taluka from 2020-2023



(Source: secondary data)

The figure 4.1 illustrates the total waste generated in the Salcete Taluka from 2020 to 2023, with the x-axis representing the years and the y-axis denoting the quantity of waste generated in kilograms. In 2020, the waste generated amounted to 649,173 kg, which decreased to 572,977 kg in 2021. This decline suggests a reduction in waste production during that period, possibly influenced by the COVID-19 pandemic. However, there was an increase in waste generation from 2021 to 2023, with quantities rising to 722,870 kg in 2022 and further to 869,377 kg in 2023. This upward trend indicates the effectiveness of initiatives such as the door-to-door waste collection program. Overall, the data portrays a rising trend in waste generation over the years.

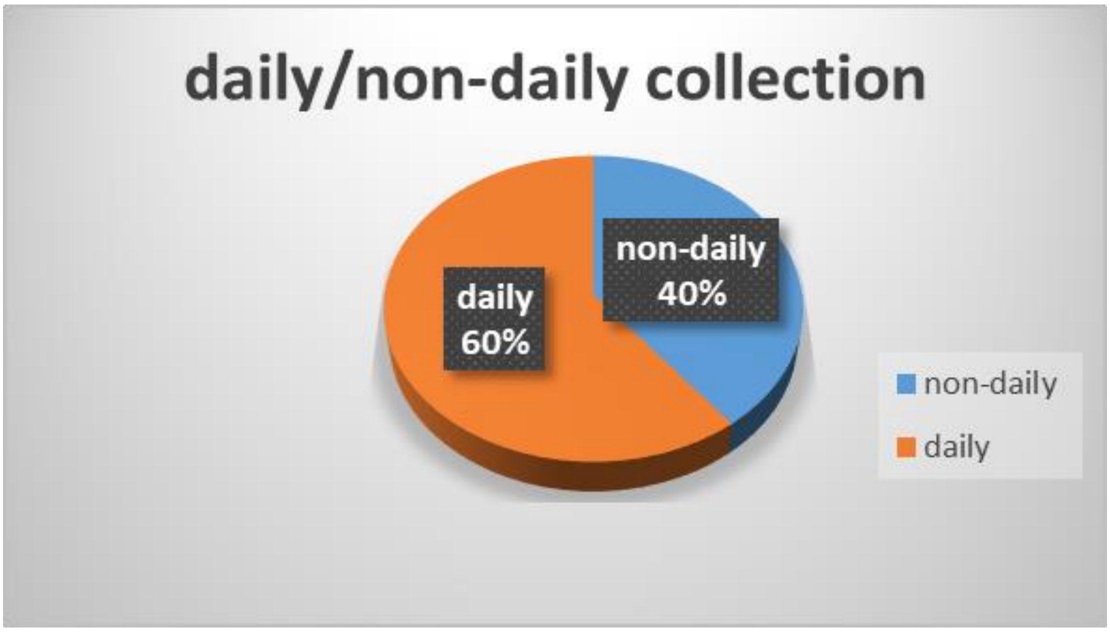
Figure 4.2: Total per capita from 2020-2023



(Source: secondary data)

The provided figure 4.2 illustrates the total per capita waste generated in the Salcete Taluka from 2020 to 2023. The x-axis represents the years, while the y-axis depicts the per capita waste generated in kilograms by each household. In 2020, the per capita waste generated stood at 3.829183699 kilograms. This figure decreased to 3.379737278 kilograms in 2021, signaling a reduction in waste production per household during that period. The observed decline in per capita waste generation from 2020 to 2021 suggests that the impacts of external event such as the COVID-19 pandemic, which may have had influenced waste generation patterns. However, from 2021 to 2023, there was an increase in per capita waste generation, with figures rising to 4.263889626 kilograms in 2022 and further to 5.128069461 kilograms in 2023. This upward trend indicates that initiatives like the door-to-door waste collection program have been effective in managing waste at the household level.

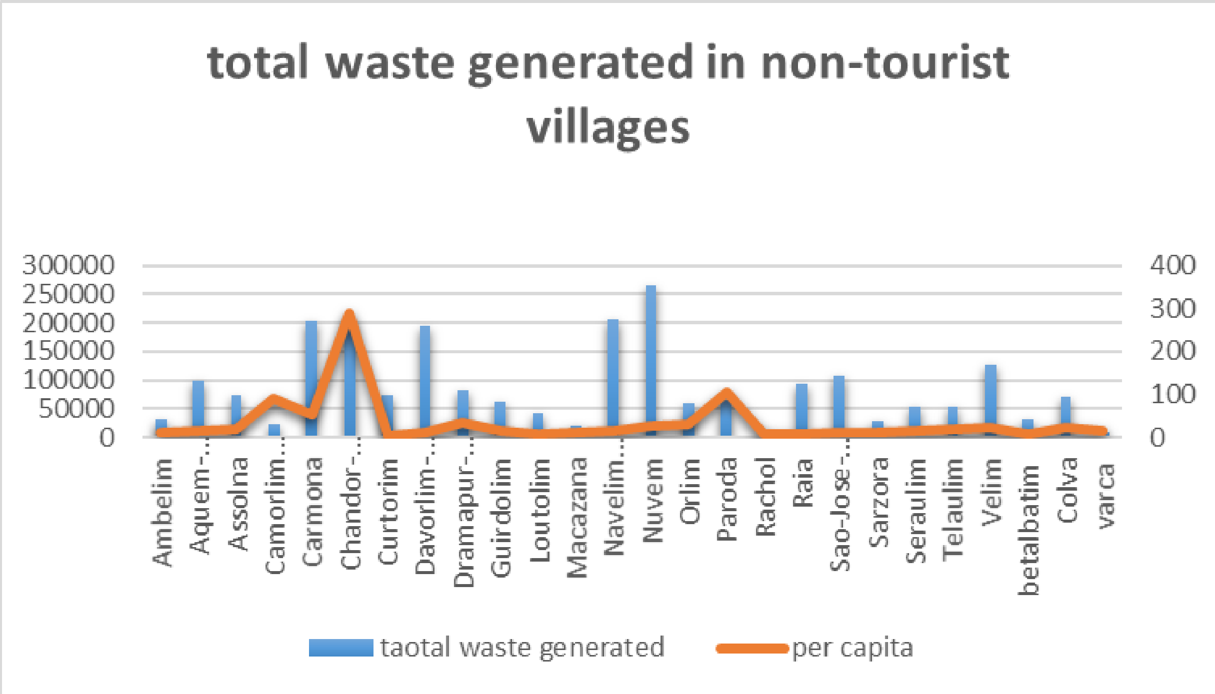
Figure 4.3: Daily and Non-Daily waste collected villages



(Source: secondary data)

The pie chart illustrates how waste is managed in villages. According to the data, 60% of waste collection in villages occurs on a daily basis through programs like door-to-door waste collection. The remaining 40% of waste collection is categorized as non-daily, meaning it's collected less frequently. Well, the fact that 60% of waste is collected daily highlights the significance of regular waste removal to maintain cleanliness and hygiene in villages. However, the 40% categorized as non-daily collection indicates that some villages may not have their waste collected as frequently as needed.

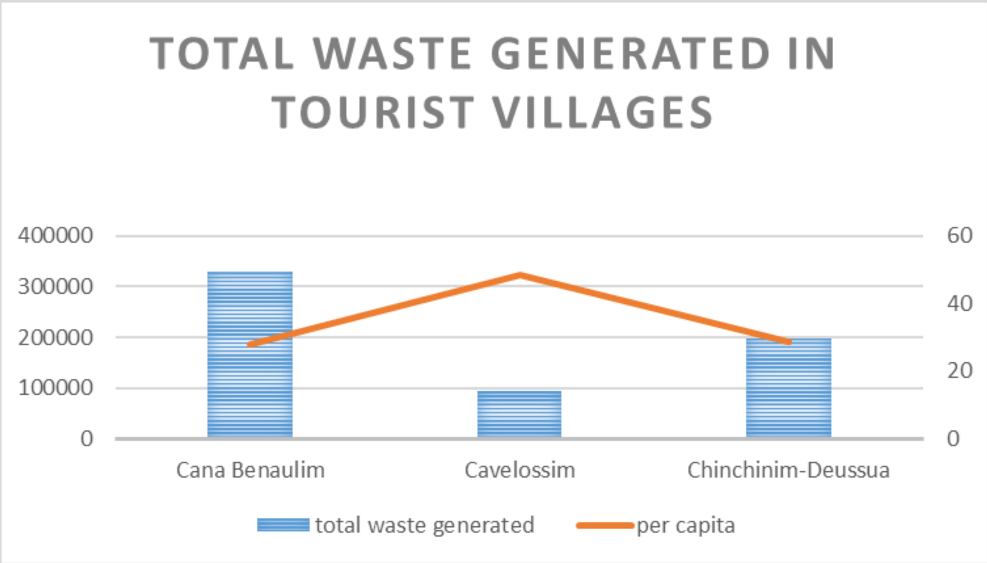
Figure 4.4: Total waste generated in Non-Tourist villages



(Source: secondary data)

According to the data depicted in Figure 4.4, which illustrates the total waste produced in non-tourist villages from 2020 to 2023, each non-tourist village is represented on the x-axis, with the per capita waste generated in kilograms per household on the y-axis. Additionally, the total waste generated from 2020 to 2023 is represented on the secondary axis. Nuvem village stands out for having the highest quantity of waste generated among the villages surveyed. In particular, Chandor village exhibits the highest per capita waste generation, reaching 288.31kilograms per household.

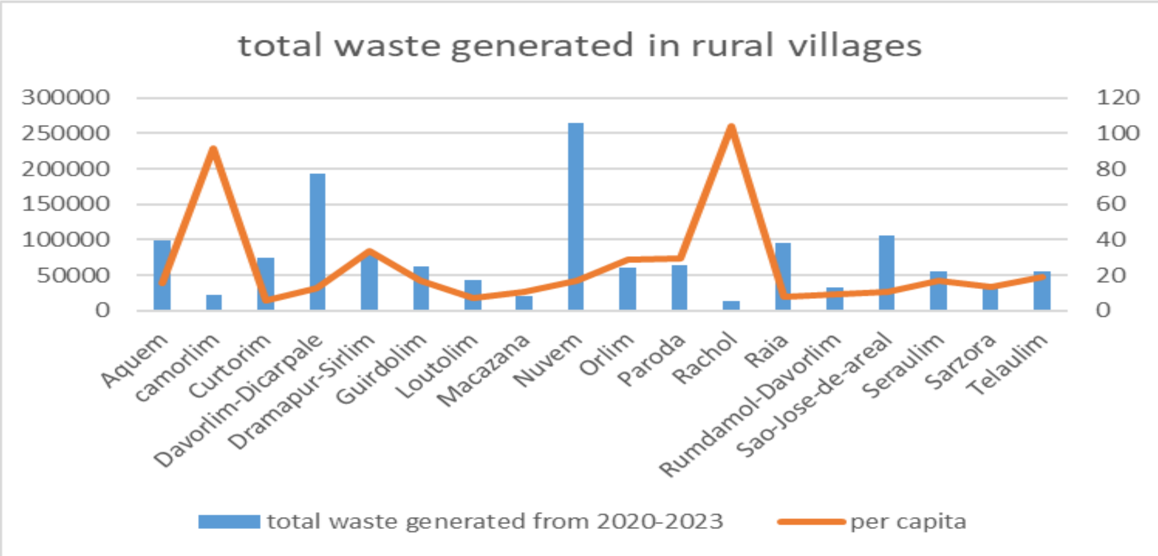
Figure 4.5: Total waste generated in Tourist villages



(Source: Secondary data)

According to the data provided in Figure 4.5, which portrays the total waste output in tourist villages from 2020 to 2023, each tourist village is represented along the x-axis. The y-axis illustrates the per capita waste generated in kilograms per household, while the secondary axis showcases the cumulative waste generated from 2020 to 2023. Benaulim village emerges as the leading contributor to waste production, boasting the highest total waste quantity recorded at 330,870 kilograms. Cavelossim village exhibits the highest per capita waste generation rate, reaching 48.60460358 kilograms per household.

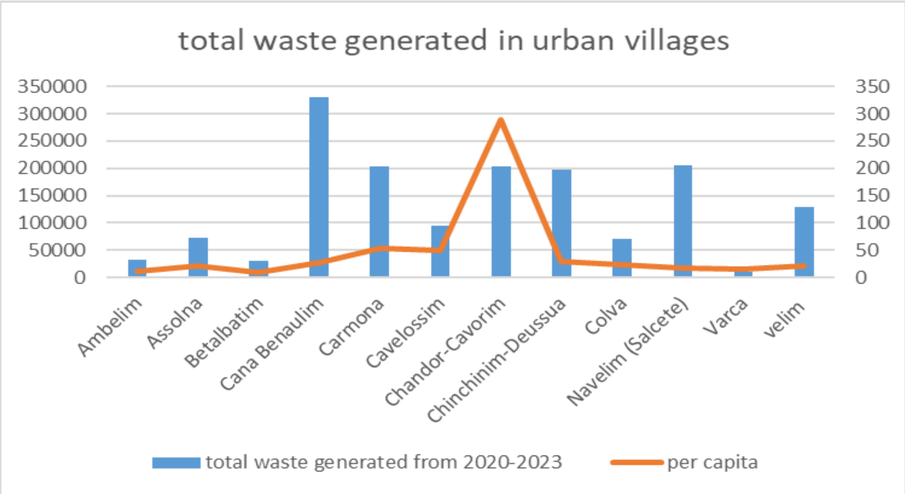
Figure 4.6:Total waste generated in Rural villages



(Source: Secondary data)

According to the data illustrated in Figure 4.6, which showcases the total waste production in rural villages from 2020 to 2023, each rural village is depicted along the x-axis. The y-axis represents the per capita waste generated in kilograms per household, while the secondary axis portrays the cumulative waste., Nuvem village emerges as the top contributor to waste generation, recording the highest total waste quantity at 264,723 kilograms. Conversely, Rachol village stands out for having the lowest total waste output, reporting only 13,684 kilograms. examining the per capita waste generation within rural villages, Rachol village exhibits the highest rate, followed closely by Camorlim village. This suggests that, despite Rachol's relatively low total waste output, its households generate a significant amount of waste per capita.

Figure 4.7: Total waste generated in Urban villages



(Source: Secondary data)

The data depicted in Figure 4.7, presents the total waste output in urban villages from 2020 to 2023, with each urban village represented on the x-axis. Per capita waste generated in kilograms per household is plotted on the y-axis, while the secondary axis illustrates the cumulative waste generated. Benaulim village emerges as the primary contributor to waste production, reporting the highest total waste quantity at 330,870 kilograms. Conversely, Varca village stands out for having the lowest total waste output, recording only 10,155 kilograms. The per capita waste generation within urban villages, Chandor village exhibits the highest rate. This observation suggests a significant individual waste burden borne by households in Chandor village compared to other urban areas. While Benaulim village may face challenges associated with managing a large volume of waste, Varca village demonstrates a relatively lower level of waste production.

CHAPTER 5

Conclusion

The analysis of waste generation trends in Salcete Taluka from 2020 to 2023, alongside the evaluation of the door-to-door waste collection program, has yielded several noteworthy insights. Firstly, it was found that both population size and per capita waste generated significantly contribute to waste generation, indicating the importance of addressing demographic factors and promoting sustainable consumption practices. While there were marginal differences between urban and rural villages in waste production, the distinction did not have a strong direct impact on waste generation in the models. The analysis revealed that tourist villages tended to have higher levels of waste generation compared to non-tourist villages, emphasizing the need for tailored waste management strategies in regions experiencing significant tourist influx. Overall, while the door-to-door waste collection program showed promise in managing household waste, ongoing efforts are necessary to tackle the challenges posed by population growth, shifting consumption patterns, and the influence of tourism on waste generation. By implementing targeted interventions and promoting sustainable waste management practices, Salcete Taluka can work towards minimizing waste generation and fostering a cleaner, healthier environment for its residents and visitors.

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