

Impact of Public Awareness and Participation on Sustainable Waste Management for Tadong Ward under Gangtok Municipal Corporation.

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Abstract:

This research explores the crucial interaction between public awareness, community involvement, and sustainable waste management in Tadong Ward, under the Gangtok Municipal Corporation. Utilizing a mixed-methods approach, it assesses current awareness levels, examines community engagement, and analyses the relationship between awareness, participation, and waste management results. Through surveys, interviews, and observations, the study reveals a complex waste management landscape in Tadong Ward. Despite moderate awareness, varying community participation levels highlight grassroots initiatives' significance. Key findings stress the need for targeted strategies to enhance awareness and involvement. Educational campaigns, community workshops, and incentive programs are effective in promoting behavioural change and fostering sustainability. By elucidating public engagement dynamics and their impact on waste management, this study provides valuable insights for policy formulation and strategic interventions. Future research should consider longitudinal studies to monitor the long-term effects of awareness campaigns and community initiatives. Ultimately, informed engagement is vital for sustainable waste management, enabling cleaner, healthier urban environments.

Introduction

Solid Waste Management (SWM) is essential for urban planning and public health, covering the entire process from waste generation to disposal. It involves collection, transportation, treatment, and disposal, alongside regulatory, monitoring, and legal frameworks. SWM aims to mitigate negative impacts on health and the environment, enhance resource recovery, and promote sustainable development (Guerrero et al., 2013). In urban areas, rapid population growth and industrialization increase waste generation, leading to pollution and health hazards if not managed properly. Effective SWM prevents disease spread, minimizes environmental impacts through recycling and composting, and offers economic benefits like job creation and resource conservation (Wilson et al., 2015).

Tadong Ward, a key administrative area in Gangtok, Sikkim, reflects the challenges and opportunities of urban SWM. As the capital city's hub, Gangtok's growth has heightened the need for robust waste strategies. Tadong Ward's diverse demographics—residential, commercial, and institutional—generate various waste types, necessitating tailored management approaches. The Gangtok Municipal Corporation (GMC) oversees waste

management, facing challenges like infrastructure limitations and varying public participation. Tadong Ward's active community groups and schools provide fertile ground for community-based waste initiatives and sustainability education (GMC, 2022).

Commercial establishments in Tadong Ward significantly contribute to waste, emphasizing the need for business engagement in reduction and recycling efforts. Existing infrastructure, including roads and waste collection points, plays a critical role in waste management effectiveness. Healthcare facilities in the ward also generate biomedical waste, requiring special handling to prevent health hazards. Recent initiatives in Tadong Ward focus on waste segregation, recycling, composting, and public awareness campaigns. Success here can model SWM practices for other wards in Gangtok and similar urban areas, providing valuable insights for policymakers, urban planners, and environmentalists. Continuous research, innovation, and community engagement are crucial for achieving sustainable waste management and improving urban environments (Guerrero et al., 2013).

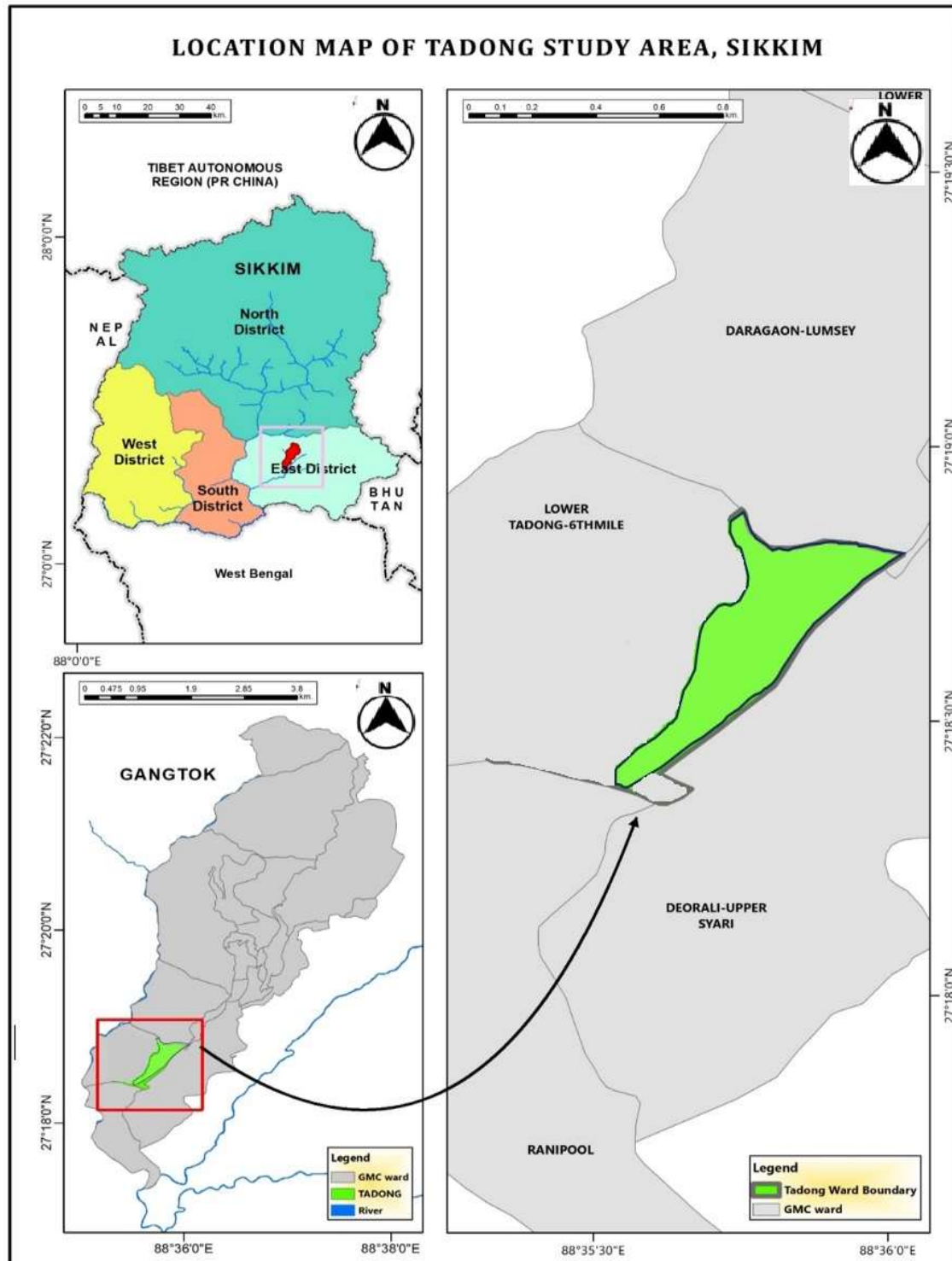
Study Region

1.1. Location

Its latitudinal and longitudinal extents are 27° 18' 21.01" N to 27° 18' 53.06" N, 88° 35' 17.65" E to 88° 36' 1.58" E respectively. Area looks like a distorted rectangle shaped a Hans back on the western side. Toward its north Daragaon Lumsey, on the southern side lies its west lies Tadong 6th mile and on its southeast lies Deorali upper Syari region. The area gained its importance ever since the trade was started with Tibet via its silk route, which touched the region and became a very important resting place for the traders from the beginning. Due to opening of the trade many houses of this region started lending their vacant room for one- or two-days halt, they used to provide food and stay and trader used to give them pay them in cash and kind both, from that time only, a kind of business set up was there though not in a large scale.

Tadong falls under ward number 13 of municipality of Gangtok, the area got its name from Bhutia language meaning a walk ways or the resting place for horses, made up of stones and gravels, this road used to be very narrow little bigger than foot path called 'gora sadak' in nepali language. When traders used to reach these place some of them used to rest there in the locals' house where they used to have food and water, and then after they used to move to Tibet for trading.

The current state of waste management in Tadong Ward presents significant challenges necessitating urgent intervention. Despite efforts by the Gangtok Municipal Corporation (GMC), the ward struggles with inefficient waste collection, segregation, and disposal practices. A major portion of the waste—household, commercial, and biomedical—often ends up in open dumpsites, causing environmental degradation and public health risks.



One critical issue exacerbating this situation is the lack of public awareness and participation in sustainable waste management practices. Many residents and businesses in Tadong Ward are either unaware of or indifferent to the importance of segregating waste at the source, leading to low rates of recycling and composting. Additionally, the absence of consistent educational campaigns and community engagement initiatives leaves a gap in residents' understanding of

their role in waste management. The current system relies heavily on municipal services, without fostering a sense of responsibility among citizens.

This lack of public involvement is compounded by insufficient infrastructure, such as an inadequate number of waste bins and improper waste collection schedules, further hindering effective waste management. The community's passive attitude towards waste disposal, driven by a lack of awareness and motivation, poses a significant barrier to achieving sustainable waste management goals. Consequently, this results in overflowing bins, littering, and the proliferation of illegal dumping sites, defacing the aesthetic appeal of Tadong Ward and contributing to environmental pollution and health hazards.

Addressing these issues requires a multifaceted approach that combines enhancing public awareness, improving participation through community-based programs, and upgrading waste management infrastructure. By fostering a more sustainable and effective waste management system in Tadong Ward, these efforts can mitigate environmental and public health risks, leading to a cleaner and healthier community.

Objectives of the study

1. To evaluate the impact of conversant and conscious community participation on waste segregation and recycling.
2. To assess the level of public awareness regarding SWM in Tadong Ward and to recommend strategies for enhancing public awareness and participation.

Database and Methodology

This study employs a mixed-methods research design, integrating both qualitative and quantitative approaches to provide a comprehensive analysis of solid waste management in Tadong Ward. The quantitative aspect involves surveys and statistical analysis to quantify public awareness and participation levels, while the qualitative component includes interviews and focus groups to explore residents' perceptions and attitudes towards waste management.

The database for this study on solid waste management in Tadong Ward is structured to capture comprehensive data through various methods. Surveys and questionnaires will gather respondent demographics, knowledge of waste management practices, attitudes towards recycling, participation levels, and barriers to participation. Interviews and focus groups will provide qualitative data on community perceptions, motivations, barriers, and suggestions for improvement in waste management practices. Observation techniques will document waste collection processes, segregation practices, disposal methods, and assess the condition of waste management infrastructure. Quantitative data will be analysed using descriptive and inferential statistics, employing software like SPSS, while qualitative data from interviews and focus groups will undergo thematic analysis and visual representation using QGIS.

The study will utilize a stratified random sampling method to ensure representation from various demographic groups within Tadong Ward, considering residential areas, commercial zones, and institutional clusters. The sample size will be determined based on statistical principles to achieve a representative sample of the population. The sample size calculation will consider factors such as the desired level of confidence, margin of error, and population size of Tadong Ward. A larger sample size will be allocated to strata with higher population density to ensure adequate representation. This comprehensive database will facilitate a thorough analysis of the current state of waste management in Tadong Ward, providing valuable insights for future improvements.

1.1. Results and Discussion

A survey in Tadong Ward revealed a moderate level of public awareness about solid waste management (SWM). While residents understood basic concepts like segregation and recycling, a significant knowledge gap persisted regarding the broader environmental and health impacts of improper waste disposal. This gap disproportionately affected residents with limited access to education. The study found a correlation between educational background, socioeconomic status, and engagement with SWM initiatives. Individuals with higher education and access to information channels demonstrated a deeper understanding. This highlights the need for targeted education and comprehensive information dissemination. To bridge the knowledge gap, understanding the factors influencing resident awareness is crucial. Socioeconomic factors, language barriers, and cultural norms can influence how residents perceive and engage with waste management. Recognizing these disparities is essential for developing targeted educational programs. Utilizing multiple communication channels like radio, television, posters, and community workshops is vital to reach all residents. Collaborating with schools and NGOs can foster environmental awareness in younger generations.

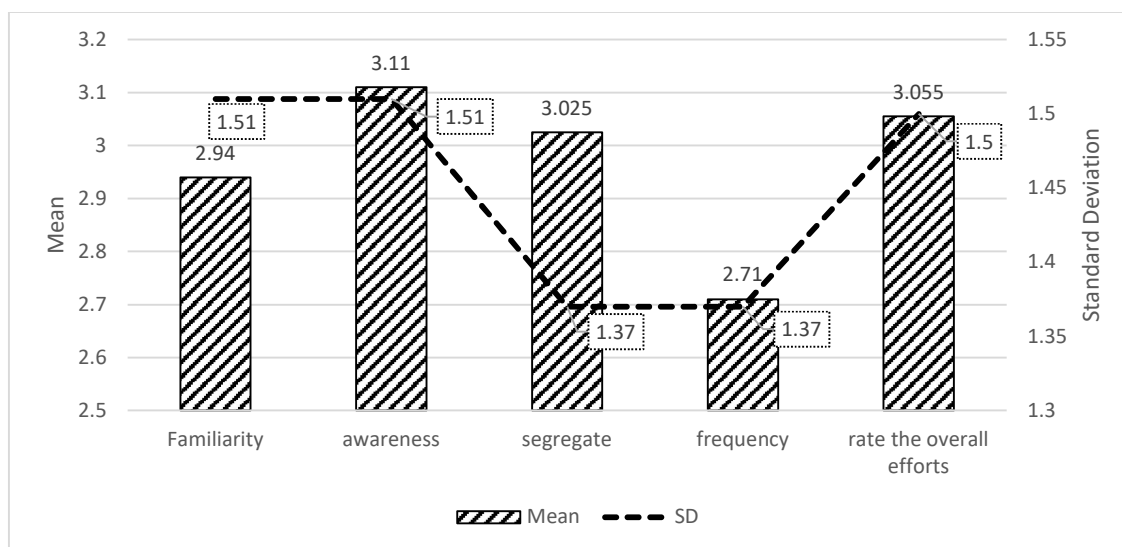
The study also revealed an uneven distribution of community participation in SWM efforts. Some areas showcased exemplary engagement due to strong local leadership, organized community groups, and effective collaboration with authorities. However, other areas demonstrated passivity or resistance to change. To overcome these challenges, building trust, providing targeted education, and demonstrating the tangible benefits of proper waste disposal are crucial. Collaborative efforts involving community leaders, residents, and local government authorities are essential to promote a culture of sustainability and shared responsibility. A multifaceted approach to SWM in Tadong Ward is necessary. By addressing the knowledge gap, fostering community ownership, and implementing effective waste management systems, the ward can achieve a sustainable future. Following is the detailed statistical analysis and interpretation of the collected field data.

Table 1: *Public Awareness Levels and Community Participation*

Research Questions	Total	Mean	Median	Mode	SD
How familiar are you with the concept of Solid Waste Management (SWM)?	588	2.94	3.0	1	1.51
How aware are you of the current waste management practices implemented in Tadong Ward?	622	3.11	2.7	5	1.51
How often do you segregate your household waste before disposal?	605	3.025	3.0	3	1.37
How frequently do you attend SWM awareness programs or workshops?	542	2.71	2.9	2	1.37
How would you rate the overall cleanliness and waste management efforts in Tadong Ward?	611	3.055	3.0	5	1.5

Source: Field Survey Tadong Ward

Figure 1: *Public Awareness Levels and Community Participation*



Source: Field Survey Tadong Ward

The table 1 presents data from a survey assessing public awareness and behaviours related to solid waste management (SWM) in Tadong Ward, covering five research questions on familiarity, awareness, segregation practices, and perceptions of cleanliness and management efforts with like hood scale of 1 to 5. The first question, “How familiar are you with the concept of Solid Waste Management (SWM)?” shows a moderate familiarity among respondents, with a mean of 2.94, a median of 3.0, and a mode of 1, indicating that while some residents are knowledgeable, a significant portion lacks familiarity. The second question, “How aware are you of the current waste management practices implemented in Tadong Ward?” reveals a mean of 3.11, a median of 2.7, and a mode of 5, suggesting a broad distribution of awareness levels, with a notable number of highly aware individuals but an overall moderate awareness. Regarding the question “How often do you segregate your household waste before disposal?” the mean score of 3.025, a median of 3.0, and a mode of 3 indicate a moderate frequency of waste segregation among residents. The fourth question, “How frequently do you attend SWM awareness programs or workshops?” shows a lower engagement with a mean of 2.71, a median of 2.9, and a mode of 2, reflecting infrequent attendance at such programs. Finally, the question “How would you rate the overall cleanliness and waste management efforts in Tadong Ward?” shows a generally positive perception with a mean of 3.055, a median of 3.0, and a mode of 5, indicating that many residents rate the efforts highly, though the overall view remains mixed. In summary, while there is a reasonable baseline familiarity and some positive perceptions of SWM efforts among Tadong Ward residents, there is significant room for improvement in awareness and active participation, particularly in attending awareness programs and workshops.

Impact on Waste Management Practices & Barriers to Effective Public Participation

The impact of public awareness and community participation on waste management practices in Tadong Ward is evident, with higher awareness and active involvement leading to better segregation, recycling, and overall waste management outcomes. Increased awareness has driven behavioural changes among residents, resulting in reduced waste generation, higher recycling rates, and cleaner neighbourhoods. Community-led initiatives have been pivotal in promoting sustainable practices and instilling a sense of responsibility towards waste management. However, several barriers hinder effective public participation in solid waste

management (SWM) in Tadong Ward. Socio-economic factors, such as poverty and lack of infrastructure, significantly challenge marginalized communities. These barriers are compounded by cultural attitudes towards waste and traditional practices, which influence residents' willingness to adopt new behaviours. Additionally, institutional barriers, including inadequate support from local authorities and limited access to recycling facilities, further impede community participation. Addressing these barriers requires a comprehensive approach. Targeted education is essential to raise awareness and change cultural attitudes. Infrastructure development is crucial to provide the necessary facilities and resources for effective waste management. Moreover, policy support is needed to create an enabling environment that encourages sustainable practices. By implementing a multi-faceted strategy that combines education, infrastructure, and policy interventions, Tadong Ward can overcome these challenges and enhance public participation in SWM. This approach will not only improve waste management outcomes but also foster a culture of sustainability and responsibility among residents, ensuring long-term success in managing waste and maintaining clean, healthy neighbourhoods.

Table 2: *Impact on Waste Management Practices & Barriers to Effective Public Participation*

Research Questions	Total	Mean	Median:	Mode	SD	Correlation analysis between 1 & 2	Correlation analysis between 3 & 4
1. How regularly do you segregate your waste into different categories (e.g., biodegradable, recyclable, non-recyclable) at home?	581	2.905	3	1	1.49	0.02649	
2. How motivated are you to participate in waste segregation and recycling?	609	3.045	3	2	1.38		
3. How much improvement have you noticed in waste management due to community participation in Tadong Ward?	611	3.055	3	4	1.43		0.135336
4. How difficult is it for you to participate in waste segregation and recycling efforts?	641	3.205	3.5	5	1.47		

Source: Field Survey Tadong Ward

The table 2 presents summary statistics for four research questions related to waste management and recycling behaviour, motivation, perceived community improvement, and participation difficulty. Additionally, it includes correlation analyses between specific pairs of questions.

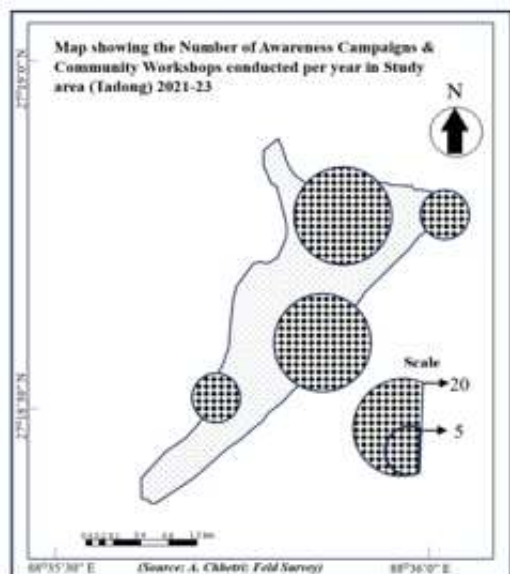
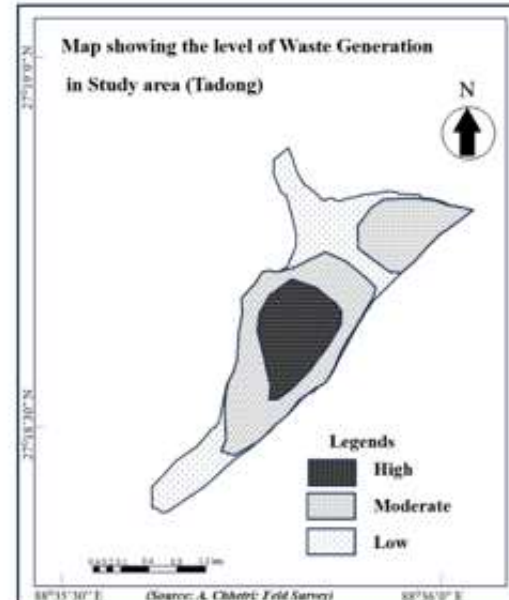
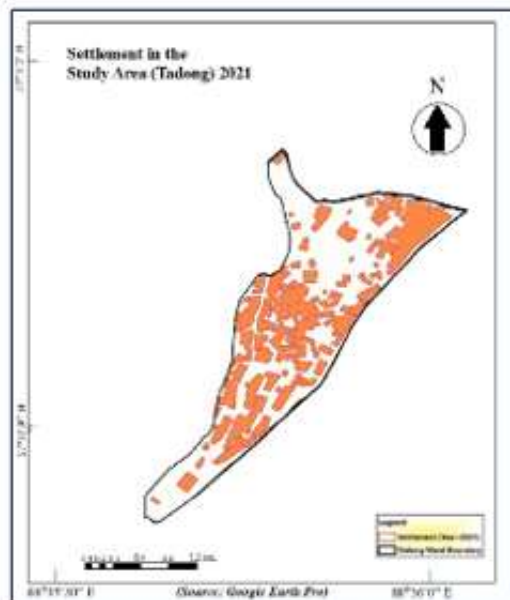
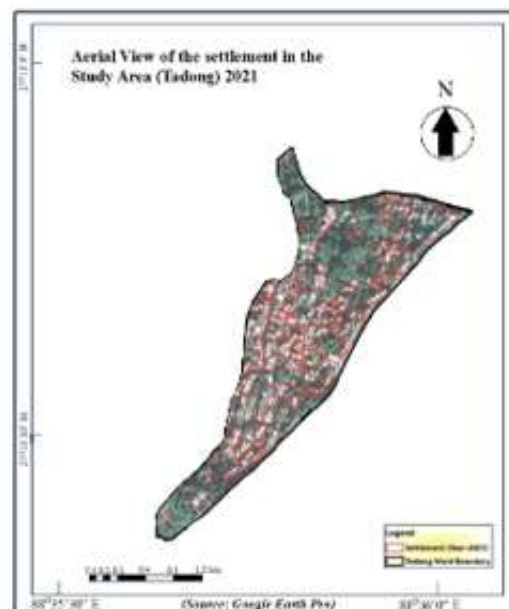
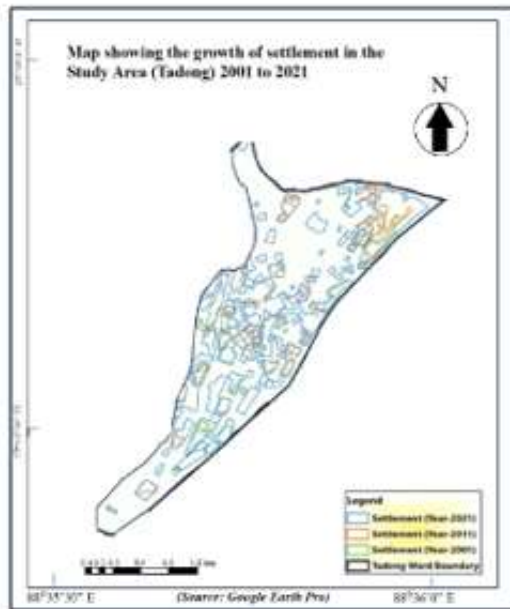
The research question on how regularly participants segregate their waste into different categories at home shows a total of 581 responses, with a mean of 2.905, a median of 3, a mode of 1, and a standard deviation (SD) of 1.49. The correlation between this regularity and motivation to participate in waste segregation and recycling is 0.02649, indicating a very weak positive correlation. This suggests that there is almost no relationship between how regularly participants segregate waste and their motivation to do so. The question on how motivated participants are to engage in waste segregation and recycling received 609 responses, with a mean of 3.045, a median of 3, a mode of 2, and an SD of 1.38.

Regarding the perceived improvement in waste management due to community participation in Tadong Ward, there were 611 responses, with a mean of 3.055, a median of 3, a mode of 4, and an SD of 1.43. The correlation between this perceived improvement and the difficulty in participating in waste segregation and recycling efforts is 0.135336, indicating a weak positive correlation. This implies a slight tendency for those who notice more improvement in community waste management to find it somewhat more difficult to participate in segregation efforts. The question on the difficulty of participating in waste segregation and recycling efforts had 641 responses, with a mean of 3.205, a median of 3.5, a mode of 5, and an SD of 1.47.

Overall, the mean values for the four questions range from approximately 2.9 to 3.2, indicating moderate levels of regularity, motivation, perceived improvement, and difficulty. The median values are close to 3 for all questions, suggesting a central tendency around the moderate response category. The modes vary more, with modes of 1, 2, 4, and 5 for different questions, indicating varied common responses among participants. The SD values, around 1.4 to 1.5 for all questions, indicate a moderate level of variability in the responses.

The extremely weak correlation between waste segregation regularity and motivation suggests that other factors might be more influential in determining the regularity of waste segregation rather than motivation alone.

To gain a deeper understanding, further research could investigate other factors that may influence regularity in waste segregation, such as access to resources, educational initiatives, and infrastructure. Exploring reasons behind the perceived difficulty despite noticing community improvements, such as possible complexities in the segregation process or lack of adequate support, would also be beneficial. Conducting qualitative research to complement these quantitative findings could provide deeper insights into participant experiences and attitudes.



1.1. Recommendations

To improve public awareness of solid waste management (SWM) in Tadong Ward, which can foster greater community participation in waste management activities, and to support sustainable solid waste management practices in Tadong Ward, the following policy recommendations are proposed:

- **Awareness Campaigns:** Conduct regular awareness campaigns using various media channels, including posters, pamphlets, and social media, to reach a wider audience and reinforce key messages.
- **Community Workshops:** Organize workshops and seminars that engage residents in hands-on activities, such as waste segregation demonstrations and composting workshops, to promote practical skills and knowledge.
- **Incentive Programs:** Introduce incentive programs, such as rewards for neighbourhoods with high recycling rates or discounts for eco-friendly products, to motivate residents to actively participate in waste reduction and recycling efforts.
- **Role of Local Leaders:** Empower local leaders, including community organizers, religious leaders, and elected representatives, to serve as champions for SWM initiatives and mobilize support within their communities.
- **Waste Management Regulations:** Strengthen existing waste management regulations and enforce penalties for violations, including illegal dumping and littering, to deter irresponsible behaviour and promote compliance.
- **Infrastructure Development:** Invest in infrastructure upgrades, such as waste collection systems, recycling facilities, and composting centres, to improve the efficiency and effectiveness of waste management operations.

Conclusion

This study on Tadong Ward's SWM practices highlights the critical link between public awareness and community engagement for achieving sustainable solutions. While current awareness levels are moderate and participation varies, areas with higher engagement demonstrate significant improvements. Educational background, socio-economic status, and awareness campaigns all influence resident knowledge, and successful initiatives showcase the power of grassroots collaboration.

Public awareness and participation are foundational for effective waste management. Increased awareness leads to behavioural changes, reducing waste generation, boosting recycling, and creating cleaner neighbourhoods. Active community involvement fosters ownership and responsibility, driving sustainable practices. Targeted educational programs, well-designed awareness campaigns, and strategic community engagement activities are crucial for promoting behavioural change and a culture of sustainability in waste management.

Future research should focus on longitudinal studies to assess the long-term impact of current initiatives. Additionally, exploring policy interventions and institutional support at municipal and state levels, along with comparative studies across diverse contexts, can provide valuable insights. By addressing these research gaps, future studies can contribute significantly to developing evidence-based policies and strategies for achieving sustainable waste management in Tadong Ward and beyond.

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