Optimizing Smart Waste Management for Sustainable Real Estate Value and Community Well-Being

Joshus Stubbs and Mentor Dr. Changhyon (Lyon) Nam

ABSTRACT

Sustainable urban development increasingly depends on technology-driven systems that enhance environmental performance, operational efficiency, and community well-being. As waste generation continues to rise in campus and urban environments, traditional collection methods often struggle to meet growing sustainability and infrastructure demands. This study aimed to investigate the role of smart waste management systems in improving sustainability outcomes, user behavior, and community value within campus and urban settings. A qualitative approach was employed. Following a literature review and three pilot tests, a survey instrument was developed comprising demographic items, open-ended questions, and multiple-choice items. In-depth interviews were also conducted with participants (n = 26 females, n = 11 males), lasting approximately 13 minutes each. Survey responses were analyzed using Qualtrics, and qualitative data were examined using content analysis. Findings will offer practical insights for campus planners, community stakeholders, and real estate professionals seeking to integrate smart waste systems into their sustainability and operational strategies.

INTRODUCTION

- Smart waste management systems use Internet of Things (IoT) sensors, AI analytics, and optimized routing to improve efficiency and reduce environmental impacts (Ahmad et al., 2025).
- Research shows these systems enhance collection accuracy, reduce contamination, and support circular economy goals (Kannan et al., 2024; Olawade et al., 2024).
- Environmental design, especially bin placement, also significantly shapes user behavior (Kannan et al., 2024).
- Despite expanding adoption, limited research examines how bin placement influences user behavior in campus settings or how these behaviors relate to sustainability performance and real estate value.
- Addressing this gap is essential for optimizing infrastructure investments.
- This study investigates smart waste implementation across Florida State University facilities and Tallahassee community centers, focusing on behavioral outcomes, sustainability alignment, and community well-being (Huang et al., 2025).
- Smart waste technologies complement traditional strategies such as recycling and upcycling (World Design Organization, 2021; U.S. Environmental Protection Agency, 2025), particularly where institutions face processing costs and infrastructure limitations (University of Maryland, 2011).
- By improving waste diversion, reducing operational costs, and enhancing shared spaces, smart waste systems can increase user satisfaction, strengthen LEED/ESG performance, and support higher property values (Kannan et al., 2024; Olawade et al., 2024).
- Because bin placement strongly affects sorting accuracy and accessibility, understanding spatial design is key to optimizing system performance and engagement. This study examines these factors to inform sustainable urban development and community-focused infrastructure planning.

RESEARCH QUESTIONS & PURPOSE

RQ1: How does the placement of smart waste bins influence user behavior and system efficiency?
RQ2: What benefits do smart waste systems provide for campus and community buildings?
RQ3: How can smart waste systems help campuses and communities meet sustainability standards such as LEED and ESG?
RQ4: What implications do smart waste systems have for real estate value and community well-being?

This study aimed to investigate the role of smart waste management systems in improving sustainability outcomes, user behavior, and community value within campus and urban settings.

METHODS

- Participants included 37 individuals, consisting of Florida State University undergraduates and community center users.
- Participation was voluntary and anonymous.
- Data were collected through an online structured survey containing Likert-scale items, multiple-choice questions, and open-ended responses assessing waste-disposal behaviors and perceptions of system effectiveness.
- The study used a cross-sectional survey design with no experimental manipulation. Measures included proper disposal frequency, bin visibility and proximity, signage and design clarity, perceived system effectiveness, and self-reported improper disposal behaviors.
- Data were analyzed using descriptive statistics and cross-tabulations to examine relationships between bin placement and disposal behaviors.
- Open-ended responses were coded thematically to identify recurring patterns.

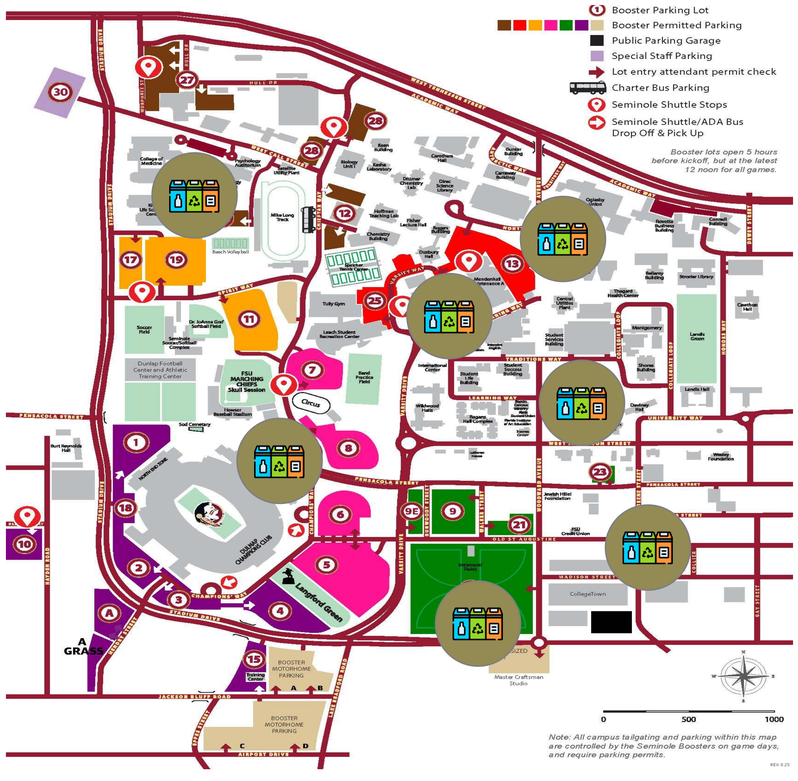

Figure 1. Optimal locations of the smart waste bins within FSU campus.

ACKNOWLEDGMENTS

I would like to thank Professor Lyon Nam for allowing me to participate in this research project and learn more about it, as well as for helping me along the way. I would also like to thank my UROP leaders Barbora Melichova and Miles Rosoff, along with UROP Senior Associate Director Alicia Batailles, for providing guidance and support throughout this process.

RESULTS

- The results (n = 37) showed that bin placement plays a central role in shaping waste-disposal behavior.
- A total of 73% of respondents agreed that bins are generally located where waste is generated, and 86% indicated that bin placement influences their willingness to recycle at least moderately.
- Convenience and visibility emerged as the most common drivers of proper disposal, and many participants noted that bins placed near high-waste areas improve system effectiveness.
- Participants most frequently reported disposing of food waste (40.5%), followed by beverage containers (16.2%) and paper products (16.2%): *Campus waste-management strategies should prioritize placing appropriate bins in high-traffic zones.*
- Participants consistently were more likely to sort waste correctly when bins were easy to locate and clearly visible.
- More than half of respondents reported strong behavioral influence from bin placement (38.9% “a lot,” 19.4% “a great deal”), while another 30.6% reported a moderate influence: *Accessible bin placement increases recycling participation and operational efficiency.*
- Label clarity also affected behavior
- A majority (88.9%) reported that bin location improves their disposal behavior, suggesting that well-positioned bins contribute to cleaner, more comfortable shared spaces in both campus and community buildings: *Potential alignment with sustainability frameworks such as LEED and ESG*.
- By encouraging proper disposal and increasing participation in recycling, strategically placed smart waste bins may support LEED Materials and Resources waste-diversion credits and strengthen ESG environmental performance.

DISCUSSION & CONCLUSION

- Although this study did not directly assess LEED or ESG outcomes, the results indicated that strategic bin placement and clearer labeling can improve waste-management efficiency and support broader sustainability goals.
- Convenience and visibility emerged as key factors influencing disposal behavior, underscoring the importance of user-centered design in smart waste systems.
- The study’s strength lies in its integration of behavioral insights with sustainability and built-environment considerations.
- However, the small sample size and reliance on self-reported data limit generalizability, and findings should be viewed as preliminary.
- Overall, the results suggested that thoughtful spatial design, particularly bin placement and clear signage, can meaningfully enhance waste-sorting behavior and operational performance.
- Continued data collection will help clarify how spatial design contributes to sustainability outcomes and inform future infrastructure and real-estate planning.

REFERENCES

Ahmad, G., Aleem, F. M., Alyas, T., Abbas, Q., Nawaz, W., Ghazal, T. M., Aziz, A., Aleem, S., Tabassum, N., & Ibrahim, A. M. (2025). Intelligent waste sorting for urban sustainability using deep learning. *Scientific Reports, 15*(1), 27078.

Huang, J., Bibri, S. E., & Keel, P. (2025). Generative spatial artificial intelligence for sustainable smart cities: A pioneering large flow model for urban digital twin. *Environmental Science and Ecotechnology, 24*, 100526.

Kannan, D., Khademolqorani, S., Janatyan, N., & Alavi, S. (2024). Smart waste management 4.0: The transition from a systematic review to an integrated framework. *Journal of Cleaner Production, 174*, 1–14.

Olawade, D. B., Fapohunda, O., Wada, O. Z., Usman, S. O., Ige, A. O., Ajisafe, O., & Oladapoh, B. I. (2024). Smart waste management: A paradigm shift enabled by artificial intelligence. *Science of the Total Environment, 2*(2), 244–263.

U.S. Environmental Protection Agency. (2025, September 2). *Recycling basics and benefits*. https://www.epa.gov/recycle/recycling-basics-and-benefits

University of Maryland. (2011). *Cost-benefit analysis of recycling programs. Interpolations Journal*. https://english.umd.edu/research-innovation/journals/interpolations/interpolations-spring-2011/cost-benefit-analysis

WDO. (2021, September 30). *Bringing recycling to remote communities around the world. World Design Organization*. https://wdo.org/bringing-recycling-to-remote-communities-around-the-world/