Proceedings of the 9th International Scientific and Practical Conference «Science in the Environment of Rapid Changes»
(July 26-28, 2026).
Brussels, Belgium

No
303

INTERCONF
SCIENTIFIC PUBLISHING CENTER

Mobile–WebGIS Applications for Community-based Urban Solid Waste Management: a Mini Review

Tu Thanh Tri[1], Duong Thi Thuy Nga[2]

[1] *Ho Chi Minh City University of Natural Resources and Environment;* Vietnam

[2] *Ho Chi Minh City University of Natural Resources and Environment;* Vietnam

Abstract. The rapid growth of urban populations has significantly increased municipal solid waste (MSW) generation, posing substantial challenges to environmental sustainability and public health. Conventional waste management systems often rely on manual reporting and fragmented information, limiting the efficiency of waste monitoring, collection, and decision-making processes. In recent years, the integration of Mobile Geographic Information Systems (Mobile GIS) and Web Geographic Information Systems (WebGIS) has emerged as a promising digital solution for enhancing community-based urban solid waste management. These technologies enable real-time spatial data collection, interactive visualization, citizen participation, and efficient communication between residents and municipal authorities. This mini-review summarizes recent advances in Mobile-WebGIS applications for community-based urban solid waste management, with particular emphasis on citizen reporting, spatial monitoring, waste collection optimization, and decision support. Furthermore, the advantages, current challenges, and future development trends of Mobile-WebGIS technologies are critically discussed, including system interoperability, data quality, user engagement, and the integration of emerging technologies such as the Internet of Things (IoT), artificial intelligence (AI), and cloud computing. Finally, a conceptual framework is proposed to illustrate the role of Mobile-WebGIS in supporting sustainable, participatory, and data-driven urban waste management. This review provides useful insights for researchers, software developers, and policymakers interested in developing next-generation smart waste management systems.
Keywords: *Mobile GIS, WebGIS, Urban solid waste management, Community participation, Smart city, Geographic information systems.*

1. Introduction

Municipal solid waste (MSW) generation has increased rapidly due to urbanization, population growth, and changing consumption patterns, creating significant environmental and public health challenges worldwide. In many cities, conventional waste management systems still rely on manual inspection, periodic surveys, and fragmented databases, resulting in delayed information updates, inefficient waste collection, and limited communication between citizens and municipal authorities. Therefore, adopting digital technologies has become an essential strategy for improving the efficiency and sustainability of urban solid waste management [1].

Geographic Information Systems (GIS) have been widely employed to support spatial analysis, environmental monitoring, and decision-making in waste management. With the rapid development of mobile devices, cloud computing, and wireless communication, GIS has evolved into Mobile Geographic Information Systems (Mobile GIS) and Web Geographic Information Systems (WebGIS) [2]. Mobile GIS enables users to collect georeferenced information directly in the field using smartphones equipped with Global Positioning System (GPS), cameras, and internet connectivity, whereas WebGIS facilitates real-time visualization, management, and sharing of spatial information through web-based platforms. The integration of these technologies provides an efficient framework for monitoring waste generation, optimizing collection routes, and supporting data-driven decision-making.

In recent years, community participation has become an increasingly important component of sustainable waste management. Mobile applications integrated with Mobile-WebGIS allow citizens to report illegal dumping, overflowing waste bins, and other environmental issues by submitting location-based information and photographs in real time. Such community-based approaches improve environmental awareness, enhance communication between residents and local authorities, and enable more responsive waste management services [3]. Consequently, Mobile-WebGIS has become one of the keys enabling technologies for developing smart and sustainable cities. Although numerous studies have reported the application of Mobile GIS, WebGIS, and smart technologies in urban waste management, most focus on specific case studies or individual technological components. A concise review emphasizing the integration of Mobile-WebGIS with community participation for sustainable urban solid waste management remains limited. Therefore, this mini-review summarizes recent advances in Mobile-WebGIS applications for community-based urban solid waste management. It discusses the evolution of Mobile-WebGIS technologies, their major applications, current challenges, and future research directions. In addition, a conceptual framework is proposed to illustrate the role of Mobile-WebGIS in supporting sustainable, participatory, and intelligent urban waste management.

2. Mobile-WebGIS Technologies for Urban Solid Waste Management

The rapid advancement of digital technologies has transformed conventional GIS into more flexible and intelligent platforms for environmental management. In recent years, Mobile GIS and WebGIS have become increasingly important in municipal solid waste management by enabling real-time acquisition, visualization, and sharing of spatial information. A recent systematic review covering 473 studies published between 2000 and 2024 identified GIS as one of the core technologies supporting landfill site selection, waste collection optimization, transfer station planning, and integrated waste management (**Fig. 1**). The review also highlighted a growing trend toward combining GIS with real-time data, AI, and cloud-based platforms to improve decision-making and operational efficiency [4].

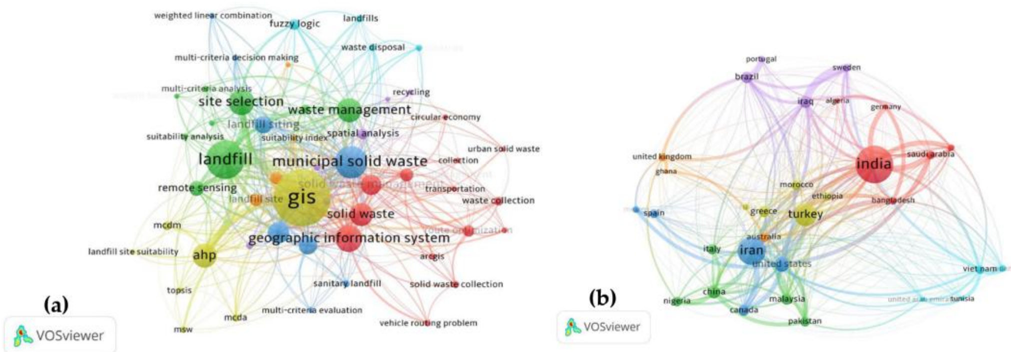

Figure 1
Global research landscape of GIS-based municipal solid waste management, showing the most frequently occurring keywords and the geographical distribution of published studies [4]

Unlike conventional desktop GIS, Mobile GIS enables field personnel to collect and update georeferenced information directly using smartphones equipped with GPS, cameras, and wireless communication. These capabilities allow waste collection activities, illegal dumping sites, overflowing waste bins, and other environmental incidents to be recorded immediately in the field with high spatial accuracy. Meanwhile, WebGIS provides a centralized platform for storing, managing, analyzing, and visualizing these data through interactive digital maps and web dashboards [5]. By integrating spatial databases, web services, and cloud infrastructure, WebGIS allows municipal authorities to monitor waste management activities in real time and supports evidence-based planning through spatial analysis and decision-support tools. Recent studies have demonstrated that WebGIS platforms have evolved beyond simple map visualization tools into integrated decision-support systems for municipal solid waste management. By consolidating spatial information on waste collection vehicles, recycling infrastructure, commercial waste generators, and other environmental assets within a unified web-based environment, these platforms enable authorities to monitor field operations, evaluate infrastructure distribution, and support evidence-based planning. Furthermore, WebGIS facilitates collaborative data sharing among multiple stakeholders, thereby improving operational transparency and management efficiency (**Fig. 2**).

Figure 2

WebGIS applications for visualizing waste collection infrastructure and recycling facilities in the Kadikoy case study (adapted from Karademir and Acımert [5])

The integration of Mobile GIS and WebGIS has further expanded the capabilities of urban waste management by connecting field operations with centralized administrative systems. Information collected through mobile devices can be synchronized instantly with WebGIS servers, allowing managers to track collection progress, identify waste accumulation hotspots, evaluate service performance, and optimize collection routes using up-to-date spatial information. Compared with conventional reporting approaches, this integrated framework substantially reduces reporting delays, minimizes manual data entry errors, and improves operational transparency. Recent studies have demonstrated that integrating GIS with agent-based simulation and route optimization models can substantially improve municipal solid waste management. In Hung Yen City, the optimized collection

Proceedings of the 9th International Scientific and Practical Conference «Science in the Environment of Rapid Changes»
(July 26-28, 2026).
Brussels, Belgium

No
303

system reduced waste residue by 59% and achieved a collection rate exceeding 80%, highlighting the effectiveness of GIS-based decision-support systems [6] (**Fig.3**).

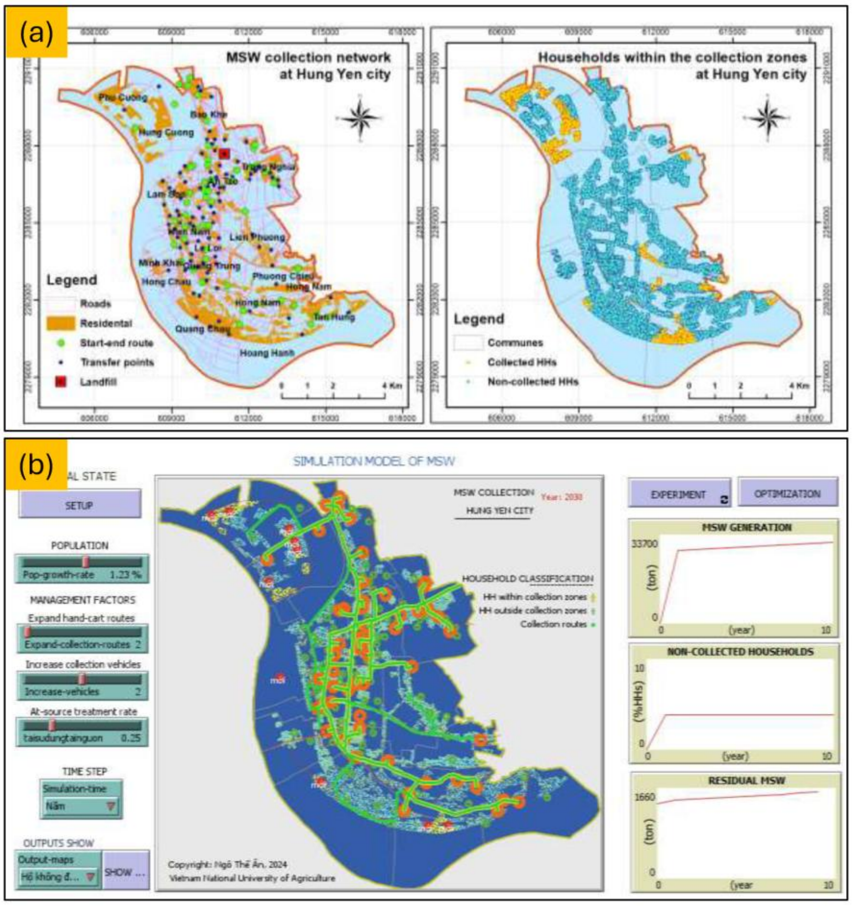

Figure 3

GIS-based municipal solid waste collection network and its optimization using an integrated agent-based simulation framework. (a) Existing waste collection network showing the current service coverage and collection routes. (b) Optimized collection network generated through GIS-integrated agent-based modeling, illustrating improved routing and expanded service coverage under the proposed management scenario. Adapted from An et al. [6]

An equally important development is the growing emphasis on community participation in smart waste management. Rather than relying exclusively on municipal staff, many recent Mobile-WebGIS platforms allow citizens to actively contribute to environmental monitoring by reporting illegal dumping, overflowing bins, or uncollected waste using geotagged photographs and GPS-enabled mobile applications. These reports are automatically integrated into WebGIS platforms, where responsible agencies can verify incidents, prioritize responses, and provide feedback to users. A Web-GIS framework proposed for sustainable waste governance further demonstrates that participatory platforms improve communication between stakeholders and promote transparency by allowing both authorities and communities to contribute to and access spatial information [5]. Such participatory approaches are increasingly recognized as essential components of sustainable waste governance and smart city development.

Overall, recent research indicates that Mobile-WebGIS has evolved beyond a conventional mapping technology into an integrated decision-support platform that combines real-time spatial information, collaborative communication, and intelligent management. With the continued incorporation of emerging technologies such as IoT, cloud computing, artificial intelligence, and geospatial big data, Mobile-WebGIS is expected to become a key technological foundation for developing more efficient, transparent, and citizen-centered urban solid waste management systems.

3. Applications of Mobile-WebGIS in Community-Based Waste Management

Recent advances in Mobile-WebGIS technologies have significantly expanded their applications in community-based urban solid waste management. Beyond serving as mapping and visualization tools, modern Mobile-WebGIS platforms have evolved into integrated management systems that support citizen participation, operational monitoring, route optimization, and evidence-based decision-making. Table 1 summarizes the major application domains of Mobile-WebGIS reported in recent studies.

One of the most widely adopted applications is citizen-based environmental reporting. Mobile applications equipped with GPS and cameras enable residents to report illegal dumping, overflowing waste bins, litter accumulation, and other environmental problems by submitting geotagged photographs directly to municipal authorities. Compared with conventional complaint mechanisms such as telephone hotlines or paper-based reporting, Mobile-WebGIS provides faster information exchange and substantially improves the spatial accuracy of reported incidents. Studies conducted in Türkiye, Indonesia, and India demonstrated that integrating community-generated reports into WebGIS platforms enables authorities to identify waste hotspots more efficiently while promoting greater public engagement in environmental governance. The availability of real-time location information also reduces the time required for field verification and accelerates response to environmental incidents. These findings indicate that Mobile-WebGIS has shifted community participation from passive feedback to active environmental monitoring, making citizens important contributors to urban waste governance.

Another important application is real-time monitoring of waste collection activities. Mobile GIS allows field workers to record collection progress, update waste quantities, and document operational conditions directly through smartphones. The collected information is automatically synchronized with WebGIS dashboards, allowing managers to supervise collection activities without relying on delayed manual reports. Several studies have shown that integrating Mobile GIS with cloud-based WebGIS platforms improves operational transparency by providing continuous updates on vehicle locations, collection status, and infrastructure conditions. This capability enables municipal authorities to monitor workforce performance, evaluate service quality, and rapidly identify operational bottlenecks, thereby improving the overall efficiency of waste management systems.

Table 1

Representative studies highlighting recent applications of Mobile-WebGIS in community-based urban solid waste management

Reference	Country	Application	Major Findings	Limitation
Ghose et al. (2006) [7]	India	GIS-based waste collection routing	Reduced collection cost through optimized routing.	Static road network.
Malakahmad et al. (2014) [8]	Malaysia	GIS route optimization	Improved collection efficiency and reduced travel distance.	No real-time traffic data.
Düzgün et al. (2016) [9]	Türkiye	GIS + Hybrid Genetic Algorithm	Optimized vehicle routing under road constraints.	High computational complexity.

INFORMATION AND WEB TECHNOLOGIES

Table continuation 1

Nguyen-Trong et al. (2017) [10]	Vietnam	GIS + Agent-based modeling	Reduced transportation cost by **11.3%**.	Limited to one case study.
Hallaq & Mosabeh (2019) [11]	Palestine	GIS for bin management	Optimized waste bin locations and collection routes.	Static waste generation.
Hina et al. (2020) [12]	Pakistan	GIS transportation optimization	Reduced travel distance and collection time.	No dynamic traffic integration.
Mai et al. (2022) [13]	Vietnam	GIS route optimization	Improved collection route planning in Hue City.	No real-time monitoring.
Karademir & Özbakır Acımert (2024) [5]	Türkiye	WebGIS for waste governance	Enhanced spatial visualization and decision support.	Single-city implementation.
Ngo The An et al. (2024)[6]	Vietnam	GIS + Agent-based simulation	Improved MSW collection planning using spatial simulation.	Simulation-based validation only.
Das et al. (2024) [14]	Global	GIS-based route optimization	Improved routing efficiency and reduced operational costs.	Focused mainly on routing algorithms.
Devi et al. (2026) [4]	Global	Systematic review of GIS in MSWM	Identified route optimization and landfill siting as dominant GIS applications.	Community-based Mobile-WebGIS remains underexplored.
Suresh et al. (2026)[15]	India	Participatory GIS route optimization	Reduced travel distance by **32%** and fuel use by **35%**.	Single municipality.
GIS-based route optimization for MSW collection (2026)[16]	India	GIS network analysis	Reduced route length by **18%** and improved household coverage.	Medium-sized city case only.

Mobile-WebGIS has also been extensively applied to route optimization and collection planning, one of the most economically important components of municipal solid waste management. By integrating spatial information with road networks, traffic conditions, waste generation data, and collection schedules, WebGIS supports the optimization of collection routes using geographic analysis and intelligent algorithms. Previous studies have reported that GIS-based route optimization can reduce travel distance, fuel consumption, operational costs, and greenhouse gas emissions while improving collection efficiency. Recent developments further integrate optimization algorithms with IoT sensors and real-time monitoring, allowing collection routes to be dynamically adjusted according to the fill levels of waste bins and traffic conditions. Such intelligent routing strategies contribute to more sustainable and resource-efficient waste collection services. Beyond operational management, Mobile-WebGIS increasingly functions as a decision-support platform for municipal authorities. By integrating spatial information from multiple sources, including citizen reports, waste collection records, recycling facilities, and demographic data, WebGIS enables comprehensive spatial analysis for planning and policy development. Decision-makers can identify underserved areas, evaluate the accessibility of waste collection infrastructure, estimate future service demands, and prioritize investments based on spatial evidence. Furthermore, interactive dashboards facilitate communication among government agencies, service providers, and the public by presenting complex geographic information in an intuitive and accessible manner. The integration of Mobile-WebGIS with cloud computing and geospatial databases has therefore transformed urban waste management from reactive operation into proactive planning. Although the applications of Mobile-WebGIS have expanded considerably, recent studies also highlight several challenges that limit large-scale implementation. Most existing systems have been developed as case-specific platforms, resulting in limited interoperability and difficulties in transferring solutions between cities. Moreover, the effectiveness of community-based reporting depends heavily on citizen participation, internet accessibility, and data quality. These issues indicate that future Mobile-WebGIS platforms should move beyond standalone applications toward integrated smart city ecosystems capable of combining real-time geospatial information with artificial intelligence, IoT technologies, and advanced decision-support models.

4. Conclusion

Mobile-WebGIS has become an effective technology for enhancing community-based urban solid waste management by enabling real-time spatial data collection, efficient information sharing, and evidence-based decision-making. The reviewed studies demonstrate its broad applications in waste collection monitoring, route optimization, infrastructure management, and citizen participation. Despite these advantages, challenges such as data interoperability, internet dependence, and limited integration with intelligent technologies remain. Future research should focus on combining Mobile-WebGIS with emerging technologies, including AI, IoT, and cloud computing, to develop smarter, more sustainable, and citizen-centered waste management systems.

References:

[1] Y.-C. Chen, Effects of urbanization on municipal solid waste composition, Waste Manag. 79 (2018) 828–836. https://doi.org/10.1016/j.wasman.2018.04.017.
[2] X. Li, J. Yue, S. Wang, Y. Luo, C. Su, J. Zhou, D. Xu, H. Lu, Development of Geographic Information System Architecture Feature Analysis and Evolution Trend Research, Sustainability. 16 (2023) 137. https://doi.org/10.3390/su16010137.
[3] M.E. Bautista-Vargas, S. Gómez-Carpizo, H.G. Reyes-Anastacio, Location and Monitoring Unofficial Trash Places via Mobile Application, OALib. 12 (2025) 1–13. https://doi.org/10.4236/oalib.1113852.
[4] R.J. Devi, A. Kalamdhad, N. Ngullie, Geographic information systems for sustainable municipal solid waste management: A systematic review and bibliometric analysis, Waste Manag. Res. J. a Sustain. Circ. Econ. 44 (2026) 888–904. https://doi.org/10.1177/0734242X251415331.
[5] M. Karademir, B.A. Özbakır Acımert, Sustainable Waste Governance Framework via Web-GIS: Kadikoy Case, Sustainability. 16 (2024) 7171. https://doi.org/10.3390/su16167171.
[6] N.T. An, T.N. Bang, N.T. Lan, N.Q. Viet, N.D. Trung, Optimizing Municipal Solid Waste (MSW) Collection and Transportation Network Using GIS and Agent-based Modeling Approach: A Case Study in Hung Yen City, Vietnam, VNU J. Sci. Earth Environ. Sci. (2024). https://doi.org/10.25073/2588-1094/vnuees.5049.
[7] M.K. Ghose, A.K. Dikshit, S.K. Sharma, A GIS based transportation model for solid waste disposal – A case study on Asansol municipality, Waste Manag. 26 (2006) 1287–1293. https://doi.org/10.1016/j.wasman.2005.09.022.
[8] A. Malakahmad, P.M. Bakri, M.R.M. Mokhtar, N. Khalil, Solid Waste Collection Routes Optimization via GIS Techniques in Ipoh City,

Malaysia, Procedia Eng. 77 (2014) 20-27. https://doi.org/10.1016/j.proeng.2014.07.023.
[9] H.Ş. Düzgün, S.O. Uşkay, A. Aksoy, Parallel Hybrid Genetic Algorithm and GIS-Based Optimization for Municipal Solid Waste Collection Routing, J. Comput. Civ. Eng. 30 (2016). https://doi.org/10.1061/(ASCE)CP.1943-5487.0000502.
[10] K. Nguyen-Trong, A. Nguyen-Thi-Ngoc, D. Nguyen-Ngoc, V. Dinh-Thi-Hai, Optimization of municipal solid waste transportation by integrating GIS analysis, equation-based, and agent-based model, Waste Manag. 59 (2017) 14-22. https://doi.org/10.1016/j.wasman.2016.10.048.
[11] M.A. El-Hallaq, R. Mosabeh, Optimization of Municipal Solid Waste Management of Bins Using GIS. A Case Study: Nuseirat City, J. Geogr. Inf. Syst. 11 (2019) 32-43. https://doi.org/10.4236/jgis.2019.111003.
[12] S.M. Hina, J. Szmerekovsky, E. Lee, M. Amin, S. Arooj, Effective municipal solid waste collection using geospatial information systems for transportation: A case study of two metropolitan cities in Pakistan, Res. Transp. Econ. 84 (2020) 100950. https://doi.org/10.1016/j.retrec.2020.100950.
[13] C. Van Mai, S.H. Nguyen, C.D. Dao, T. Van Le, H.A. Phan, A GIS Application in Optimizing the Collection and Transportation Route of Domestic Solid Waste in Hue City, Vietnam, in: Glob. Chang. Sustain. Dev. Asian Emerg. Mark. Econ. Vol. 2, Springer International Publishing, Cham, 2022: pp. 599-609. https://doi.org/10.1007/978-3-030-81443-4_38.
[14] S. Das, A. Baral, I.M. Rafizul, S. Berner, Efficiency enhancement in waste management through GIS-based route optimization, Clean. Eng. Technol. 21 (2024) 100775. https://doi.org/10.1016/j.clet.2024.100775.
[15] R. Suresh, A.G.Z. Vadakkan, A. P. R., N.C. Narayanan, A participatory geographic information system-based route optimisation for decentralised municipal solid waste management system: A case study from a flood-prone town in Kerala, India, Waste Manag. Res. J. a Sustain. Circ. Econ. (2026). https://doi.org/10.1177/0734242X261437538.
[16] C. Prathyusha, C. Anshu, S.G. Singh, S. Srikanth, S. Dey, GIS-based route optimization for sustainable municipal solid waste collection: A case study of Kadapa, India, Cities Smart Futur. (2026) 100001. https://doi.org/10.1016/j.csf.2026.100001.