“Zero-Waste Campus” Construction in Western China under the Background of Low-Carbon Economy: Evidence from Universities in Gansu Province

Jiagen Zang*, Miao Zhang

Lanzhou University of Finance and Economics, Lanzhou, Gansu730020, China

*Corresponding author

Abstract

With the deep integration of the "Dual Carbon" strategy and ecological civilization construction, universities as the core platforms for ecological education and green practices have made "Zero-Waste Campus" initiatives a pivotal driver for advancing green transformation in higher education and supporting regional sustainable development. This study, based on a mixed-methods empirical investigation of 12 diverse universities in Gansu Province, incorporates 2,387 valid questionnaires, 156 semi-structured interviews, and field observations in five key areas. It systematically identifies three core challenges in Gansu's "zero-waste campus" development: structural deficiencies in waste sorting facilities and standardized signage systems, cognitive-behavioral gaps in student waste sorting, and systemic failures in resource recycling. By applying the Theory of Planned Behavior, Collaborative Governance Theory, and Circular Economy Theory, the research analyzes constraints across four dimensions-facility planning, educational incentives, technological policies, and behavioral culture-and proposes a four-dimensional governance model: "intelligent empowerment, educational immersion, collaborative linkage, and policy safeguards." Building on this foundation, the study offers regionally adaptive and practical strategies to provide replicable pathways for "Zero-Waste Campus" development in Gansu and ecologically fragile western regions, thereby enriching global theoretical and practical paradigms for green governance in non-developed areas.

Keywords

Zero-Waste Campus, Waste Classification, Low-Carbon Economy, Governance Model

1. Introduction

Under the dual backdrop of global "Carbon Neutrality" goals and China's "3060 dual carbon" strategy implementation, green, low-carbon, and circular development has shifted from policy advocacy to systematic practice. As comprehensive entities for talent cultivation, scientific innovation, and social services, universities' "zero-waste campus" construction not only meets the intrinsic requirements of ecological civilization education but also serves as a crucial demonstration for leading society's green transformation. The core of the "Zero-Waste" concept lies in achieving "near-zero landfill and maximized resource utilization" of waste through a full-chain governance approach of "source reduction-classification and recycling-resource utilization-end-of-pipe control," rather than absolute waste-free [1].

Gansu Province is located in the core area of China's western ecological security barrier, where ecological fragility coexists with lagging economic development. Universities face unique challenges in building "Zero-Waste Campuses," including weak infrastructure, limited funding, rigid environmental behaviors among faculty and students, and insufficient regional industrial collaboration. The 2018 Ministry of Education's "Notice on Promoting Waste Classification Management in Schools" and the 2019 "Green Campus Evaluation Standards" both set clear requirements for waste classification and resource recycling in higher education institutions. However, research shows that the progress of waste management in Gansu universities lags significantly behind that of developed eastern regions, and even fails to meet basic standards.

Most existing studies focus on universities in eastern China, emphasizing facility optimization and awareness enhancement [2], while paying insufficient attention to the regional particularities of universities in ecologically fragile western areas, lacking systematic research in the "theory-empirical-mechanism-countermeasures" framework. Therefore, this study clarifies the practical challenges and constraining mechanisms of "zero-waste campus" construction in Gansu universities through in-depth empirical research, and constructs a governance model suitable for western universities. This not only provides practical solutions for Gansu universities but also fills the theoretical gap in green governance research for western universities, offering China's experience to universities in similar regions worldwide.

2. Theoretical Foundations and Research Review

2.1 Theoretical Foundations

2.1.1 Zero Waste Theory and Circular Economy Theory

The "Zero Waste" theory emphasizes "full life cycle responsibility," viewing waste as "misplaced resources" and achieving resource closure through process optimization [3]. Circular economy theory, centered on "reduce, reuse, recycle," requires breaking the linear "resources-products-waste" model. Together, these theories form the theoretical foundation for building "zero-waste campuses," providing a theoretical basis for this study's comprehensive chain strategy of "source reduction-classified recycling-resource utilization."

2.1.2 Theory of Planned Behavior (TPB)

Ajzen [4] (1991)'s Theory of Planned Behavior posits that individual behavior is shaped by three key factors: attitude, perceived behavioral control, and subjective norms. This study applies the theory to explain the' knowledge-action gap 'among students: their positive attitudes toward waste sorting (cognitive level) fail to translate into sustained behavior, primarily due to' insufficient perceived behavioral control '(inconvenient facilities and cumbersome procedures) and' weak subjective norms' (lack of incentives and cultural support). These findings provide theoretical foundations for designing educational incentive mechanisms.

2.1.3 Collaborative Governance Theory

The theory of collaborative governance emphasizes that multiple stakeholders (government, universities, enterprises, communities, and faculty/students) achieve governance objectives through resource sharing and shared responsibility. This study applies this theory to the design of a four-party linkage mechanism (university, enterprise, community, and government) to address the governance limitations of universities as single entities, echoing the University of Cambridge's practical experience in' multi-stakeholder collaboration to advance circular economy' [5].

2.2 Research Review

Foreign universities have established a mature "zero-waste" model featuring "legal safeguards-technological empowerment-educational integration": Japan implemented the "Basic Law for Promoting the Formation of a Recycling-Oriented Society" to create a refined classification responsibility system between universities and communities. Kyoto University categorized waste into 12 types with over 90% accuracy [6]. Germany's Technical University of Munich introduced AI-powered sorting equipment and kitchen waste composting systems, achieving a resource recovery rate of 75% [7]. The University of California, Berkeley incorporated waste sorting into its credit system, maintaining student participation rates above 80% for five consecutive years [8]. These models demonstrate "institutional rigidity + technological empowerment + educational normalization," offering valuable references for western universities while requiring adaptation to regional characteristics of economic underdevelopment and limited technological resources.

Domestic research primarily focuses on universities in eastern China, concentrating on three key areas: First, facility optimization and signage design. Tan Wei [9] proposed "zero-waste" standard colors and signage schemes. Second, behavioral influence factors. Chen Shaojun et al. [10] empirically demonstrated that improved facility accessibility could increase participation willingness by 30%. Third, governance model innovation. Chai Yuan [11] developed a "user needs-management optimization" service design framework. However, existing studies exhibit notable gaps: insufficient research on regional adaptability in ecologically fragile western universities; lack of in-depth analysis of multi-dimensional coupling mechanisms between "facilities, behavior, institutions, and technology"; and policy recommendations predominantly focusing on single dimensions rather than establishing systematic governance frameworks.

Based on the above analysis, this study constructs the following research framework based on the logical main line of "current situation diagnosis-constraint identification-path construction".

Figure 1. Research Framework

3. Research Design and Methods

This study adopts a mixed research method, using both quantitative questionnaires and qualitative interviews to ensure the breadth and depth of the study.

First, a questionnaire covering campus waste classification awareness, attitudes, behaviors, and facility utilization was designed. After pilot revisions, 2,600 questionnaires were distributed to 12 universities of different types in Gansu Province (including comprehensive, science and engineering, teacher-training, finance and economics, and medical institutions), with 2,387 valid responses collected, achieving a 91.8% response rate. Survey participants included undergraduates, graduate students, and faculty members. Next, semi-structured interviews were conducted with 156 relevant personnel (including university leaders, logistics managers, teachers, and student representatives) to assess policy implementation, management mechanisms, and educational campaigns. Finally, systematic observations were made in key areas such as teaching zones, dormitories, cafeterias, libraries, and laboratories, with video documentation of waste disposal, collection, and temporary storage processes.

Quantitative data were processed using SPSS 25.0 for descriptive statistics, correlation analysis, and binary logistic regression to examine factors influencing waste sorting behaviors (including facility accessibility, incentive mechanisms, and environmental awareness). Qualitative data were analyzed using NVivo 12 for coding to identify constraints and governance needs. Through comprehensive analysis of questionnaire and interview results, this study reveals the current status, experiences, and challenges in implementing 'zero-waste' campus initiatives at universities in Gansu Province.

4. Empirical Analysis: Current Status of Zero-Waste Campus Development in Gansu Universities

4.1 Unreasonable Configuration of Garbage Classification Facilities and Chaotic Signage System

The survey found that there are serious deficiencies and non-uniform standards in the garbage classification facilities of colleges and universities in Gansu.

Table 1. Sampling Statistics of Waste Sorting Facilities in Gansu Universities (N=12)

University	Configure categories in the same bucket	Label clarity	Kitchen waste disposal method	Special Waste Disposal
Lanzhou University of Finance and Economics	Only two types of bins: Recyclables and Other Waste	Unclear and lacks a unified standard	Mix other junk	Branches are scattered
Northwest Normal University	Four types of barrels, 30% of the facilities are old	Color distortion and error	Direct out of category	Information about hazardous waste sites is not transparent
Lanzhou University	There is no special delivery bucket in the dormitory	Some parts are blurry and faded	Yuzhong campus composting pilot	Donations of old clothes are unevenly distributed
Gansu University of Chinese Medicine	Special bucket for hazardous waste in the laboratory	Text faded and illegible	Mixed waste	No standardized transfer of chemical waste
Lanzhou University of Technology	The teaching building has regular trash cans	Use the old national standard pattern	Unsorted for external transport	Branches pile up in the corner of the campus

- The signage system remains disorganized. 9 universities (75% of surveyed institutions) face issues with inconsistent signage, outdated patterns, or faded designs. For instance, Lanzhou University of Technology still uses obsolete classification labels. At 41.7% (5/12) of institutions, classification bin labels show faded text and blurry patterns. The laboratory trash bin signage at Gansu University of Traditional Chinese Medicine has deteriorated beyond recognition due to prolonged neglect. Only 16.7% (2/12) of universities provide sorting guides (QR codes or pictorial instructions) near bins, while the remaining institutions offer no auxiliary guidance whatsoever.

- Lack of high-frequency waste management. Only 41.7% (5/12) of universities have implemented full-category bins in teaching areas, dormitories, and cafeterias, while others only provide sorting bins in dormitory areas, with teaching buildings and libraries generally lacking such facilities. Specialized collection devices are missing for takeaway food containers (41.7% of universities generating over 2,000 daily servings) and express packaging (58.3% of universities producing over 1 ton daily). At Lanzhou University's Yuzhong Campus, 89% of takeaway containers are improperly disposed of.

- Special waste management remains inadequate. None of the 12 universities have established standardized collection channels for garden waste (branches and fallen leaves), with 8 institutions (66.7%) still engaging in random disposal. Only 3 universities (25%) have set up temporary storage points for laboratory hazardous waste, and none have implemented standardized transportation procedures.

4.2 The Phenomenon of "Disconnection Between Knowledge and Practice" in Students' Garbage Classification is Significant

Survey data shows a widespread 'cognitive-behavioral gap' among students, where environmental awareness fails to translate into concrete actions. See Table 2 for details.

Table 2. Statistical Analysis of Factors in Student Classification Behavior Disorders (N=2387)

Hindrings	Selected Portion	Main Feedback
Distance is too far / inconvenient	42.1%	It takes 5 minutes to walk from the dormitory to the sorting bin.
The classification process is cumbersome	31.5%	"I don't know what kind of foam to put in the delivery package"
Lack of incentive mechanism	15.3%	"Classification is not helpful and unnecessary"
Insufficient publicity and education	11.1%	Never taken a classified training course, just guess

As shown in Table 2, there exists a significant disconnect between environmental awareness and actual behavior. While 72.3% of students recognize the "four-category" classification system and 58.6% acknowledge the environmental value of waste sorting, only 29.6% consistently sort waste correctly, 13% actively dismantle packaging materials for proper disposal, and 9.7% know designated hazardous waste disposal points. The binary logistic regression analysis reveals that "insufficient perceived behavioral control" (OR=0.32, $p<0.01$) and "lack of incentive mechanisms" (OR=0.45, $p<0.01$) are key factors contributing to this disconnect, whereas environmental attitudes (OR=1.21, $p>0.05$) show no significant impact on behavior. This confirms the "attitude = behavior" theoretical hypothesis. A multidimensional analysis of behavioral barriers through regression reveals detailed results in Table 3.

Table 3. Regression Analysis of Behavioral Barriers to Student Waste Sorting (N=2387)

Obstacles	Selected portion	Regression Coefficient (β)	Significance (p)	Impact Direction
Far distance / inconvenient	42.1%	-0.89	<0.001	-
The classification process is cumbersome	31.5%	-0.67	<0.001	-
Lack of incentive mechanism	15.3%	-0.42	<0.001	-
Insufficient publicity and education	11.1%	-0.28	<0.001	-

As shown in Table 3, the convenience of facilities is the primary factor affecting behavior, followed by classification complexity and incentive mechanism, while the influence of publicity and education is relatively weak, which is different from the conclusion that "publicity and education are the main driving force" in eastern universities, reflecting the reality of "insufficient basic guarantee" in western universities.

4.3 Lack of Systematic Planning for the Recycling of Campus Resources

The recycling of resources in Gansu universities has not yet formed a closed loop, showing the characteristics of "dispersion, low efficiency and no coordination".

- The resource utilization rate remains alarmingly low, with massive waste occurring. At Lanzhou University alone (1 pilot facility processing 60kg daily), the remaining 11 institutions all employ the "mixed disposal-external transportation" model, achieving less than 1% resource recovery. This results in approximately 500 tons of kitchen waste being wasted annually. Recycling coverage for items like old clothing and waste paper stands at merely 35%, with most collection points being temporary setups. Shockingly, 72% of students remain unaware of recycling channels, leading to an estimated 80 tons of recyclable materials being discarded yearly. Notably, none of the 12 universities have achieved resource utilization. They annually generate around 120 tons of branches and fallen leaves, with only 2 institutions outsourcing waste removal to third parties. The rest dump the waste indiscriminately.

- The lack of coordinated mechanisms leads to isolated efforts. None of the 12 universities have established any waste management cooperation mechanisms, resulting in the inability to share resources, technologies, and expertise. Only one university (Lanzhou University) collaborates with recycling enterprises, while the others have no corporate involvement, lacking both technological support for resource utilization and financial backing. Furthermore, universities and communities have not established a waste recycling coordination network, leaving campus recyclables disconnected from the broader social recycling system.

5. Analysis of Limiting Factors and Mechanisms

Based on empirical data and theoretical support, the restrictive mechanism is deeply analyzed from the four dimensions of "facilities, education, technology and policy".

5.1 Facility Planning and Management Mechanism: Lack of System and Coordination

Higher education institutions have failed to implement routine monitoring of waste generation and composition, with facility configurations mismatching actual waste scenarios (e.g., cafeterias lacking food waste bins, dormitories without takeout containers), resulting in "supply-demand mismatch". The logistics department, student management, and

environmental clubs operate in silos without establishing a unified "zero-waste campus" leadership group, lacking comprehensive coordination across the entire chain. Western universities face limited educational funding, with less than 0.1% allocated for waste sorting infrastructure construction and maintenance – significantly lower than their eastern counterparts' 1.2% – leading to outdated facilities and delayed upgrades.

5.2 Educational Incentives and Cultural Mechanisms: Insufficient Immersion and Weak Drive

Environmental education primarily relies on "one-off campaigns" (such as Environmental Awareness Week). Only 8.3% (1/12) of universities offer environmental-related electives, which are not integrated into the talent development system, resulting in short-lived educational effects. The lack of "material + spiritual" multi-dimensional incentives is evident, as only two universities conduct "Green Dormitory" evaluations without long-term incentives like credit linkage or point redemption, leading to insufficient student motivation. The campus environmental atmosphere remains weak, with environmental clubs averaging fewer than three annual activities and participation rates below 2%, failing to establish a cultural consensus of "everyone's participation."

5.3 Technology Policy and Coordination Mechanism: Insufficient Empowerment and Weak Support

The absence of modern technologies like AI-powered waste sorting systems and IoT-based traceability mechanisms has forced reliance on manual sorting, resulting in low efficiency and poor accuracy. At the provincial level, no specific policies have been introduced for "zero-waste campuses" in universities, leaving the implementation dependent solely on national guidelines without region-specific adaptation indicators or evaluation mechanisms. Furthermore, the lack of collaborative frameworks between government agencies, universities, enterprises, and communities, coupled with environmental authorities 'failure to provide hazardous waste treatment support and enterprises' absence from resource recovery initiatives, has created a fragmented "fighting alone" scenario.

5.4 Behavioral Habits and Perceptual Mechanisms: Path Dependence and Lack of Control

The persistent habit of "mixed investment" creates path dependence, with students perceiving the "psychological cost" of sorting as high and lacking motivation to change. Inconvenient facilities and cumbersome procedures reduce students '"perception of behavioral feasibility," as seen in situations like "sorting bins being too far away" or "not knowing how to sort," leading to "wanting to sort but being unable to." The absence of positive role models and supervision from peers and teachers fails to establish "social pressure" for sorting behaviors, making students prone to develop a "if others don't sort, I won't either" herd mentality.

In conclusion, the construction of "zero-waste campus" in Gansu universities is constrained by multiple factors such as internal cognition, mechanisms, facilities and external policy resources, and requires comprehensive measures to improve. The complex waste management in universities requires multi-party collaboration, which provides a direction for breaking the constraints.

6. Countermeasures and Suggestions

To address the constraints and mechanisms, a four-dimensional governance model of "intelligent empowerment, education immersion, collaborative linkage and policy guarantee" is constructed, and refined countermeasures are proposed.

6.1 Intelligent Empowerment: Building a Standardized and Intelligent Facility System

- Standardized facility configuration. The cafeteria has introduced dual-compartment bins for "food waste and disposable tableware", while dormitory areas are equipped with four-category sorting bins for "takeout containers, express packaging, recyclables, and other waste". Laboratories have installed hazardous waste cabinets with transparent transfer procedures. Color-coded waste classification (recyclables blue, food waste green, hazardous waste red, and other waste gray) is implemented alongside clear pictorial signage. QR codes near bins provide sorting guides and point redemption functions. A closed-loop system for garden waste management ("collection-crushing-composting") has been established, integrated with campus landscaping. In collaboration with environmental authorities, a hazardous waste management mechanism featuring "temporary storage-scheduled collection-public disclosure" has been implemented.

- Empowerment through smart technology. Intelligent AI-powered trash bins with image recognition provide real-time voice alerts for improper disposal, achieving an accuracy rate of ≥85%. Through IoT technology, students and dormitories gain 'eco-accounts' where correct waste sorting earns points redeemable for campus services (e.g., laundry vouchers, book loan extensions) or cultural products. The system continuously monitors waste generation, sorting accuracy, and resource recovery rates, providing data-driven insights for facility optimization.

6.2 Education Immersion: Establishing a Regular and Diversified Education Incentive Mechanism

- Education integrated into talent development. The university will offer elective courses such as "Ecological Circular Economy" and "Zero-Waste Campus Practice" (1-2 credits for all majors). It will establish "Upcycling Workshops" and "Composting Practice Bases", encouraging students to participate in campus waste sorting volunteer services, with their practical achievements incorporated into comprehensive quality evaluations. Additionally, specialized waste sorting training will be provided to logistics managers and counselors to enhance their guidance capabilities.

- Building a multi-dimensional incentive system. The 'Green Points' system is implemented, where points can be exchanged for material rewards or certificates of honor. 'Green Dormitory' and 'Green Class' evaluations are conducted, with results linked to scholarships and awards. A performance-based bonus system is established for cleaning staff, with payments based on classification accuracy, thereby boosting frontline staff motivation.

- Green culture cultivation. The institution regularly promotes waste sorting knowledge through campus radio, official WeChat accounts, and bulletin boards, while organizing monthly events like the 'Sorting Challenge' and 'Eco-Lecture'. It also supports environmental clubs in hosting distinctive activities such as 'Book-for-Green' exchanges and 'Eco-Innovation Competitions', providing financial and venue support to amplify their impact.

6.3 Collaborative Linkage: Building a Four-Sided Network of Universities, Enterprises, Communities, and Government

- University-enterprise collaboration: Connecting resource chains. Collaborate with recycling companies to establish campus sorting centers for packaging materials and used clothing, with profits supporting eco-friendly campus initiatives. Partner with waste-to-resource firms to install composting systems in cafeterias, using processed organic fertilizer for campus landscaping. Introduce branch shredders to transform garden waste into resources. Jointly develop internship programs with environmental agencies, providing students with hands-on experience in green technology.

- School-community collaboration: social outreach. Establish a collaborative waste recycling network with neighboring communities, open the campus sorting center to the public, and share resources and technologies. Through the 'Students Lead Families' initiative, distribute household waste sorting guides and encourage students to promote sorting knowledge to their families, thereby amplifying the demonstration effect.

- School policy coordination: Strengthening policy support. Actively contact environmental protection departments to seek policy support for the collection and transportation of hazardous waste and the procurement of intelligent equipment; provide campus waste classification data to government departments to provide reference for regional environmental governance.

6.4 Policy Guarantee: Building a Long-Term and Institutionalized Support System

- Provincial policy guidance. The Department of Education is advised to spearhead the formulation of the "Implementation Guidelines for Zero-Waste Campus Development in Gansu Higher Education Institutions", establishing quantifiable benchmarks including facility configuration, resource recovery rates, and educational integration (e.g., achieving ≥60% accurate waste classification by 2027 and ≥30% resource recovery rate). Provincial-level "Zero-Waste Campus Innovation Pilot" programs should be launched, providing equipment procurement subsidies (50% coverage) and research funding support to participating universities. Furthermore, the "Zero-Waste Campus" initiative must be incorporated into the ecological civilization assessment system for higher education institutions, with its implementation directly linked to funding allocations and excellence evaluations.

- Institutional safeguards. Establish a "Zero-Waste Campus" initiative steering committee led by university administrators, with participation from logistics, student affairs, academic affairs, and research departments to coordinate implementation. Universities should develop customized implementation guidelines based on their specific conditions, clearly defining departmental responsibilities, timelines, and evaluation criteria. Conduct quarterly assessments of waste sorting accuracy, facility utilization rates, and student engagement levels to optimize strategies in a timely manner.

7. Conclusions and Prospects

This study, through empirical research at 12 universities in Gansu Province, reveals the core challenges in implementing "zero-waste campus" initiatives in ecologically fragile western regions: structural deficiencies in facility allocation, cognitive-behavioral disconnection among students, and systemic failures in resource recycling. The underlying constraints stem from "unscientific planning, superficial education, inadequate technological empowerment, and insufficient coordination." Building on this, we propose a four-dimensional governance model integrating "intelligent empowerment, educational immersion, collaborative linkage, and policy support." The recommended strategies demonstrate both regional adaptability and practical feasibility, effectively addressing practical challenges such as limited funding, technological constraints, and insufficient awareness in western universities. The research validates the applicability of the planned behavior theory in western higher education, demonstrating that "perceived behavioral control" (facility accessibility) is the primary factor influencing categorized behaviors rather than environmental attitudes. It also confirms the effectiveness of collaborative governance theory in overcoming governance dilemmas caused by single-subject approaches, with the "quadruple linkage" mechanism proving effective in compensating for resource shortages in western universities.

However, the survey sample only covered 12 universities in Gansu Province, excluding other western provinces. The lack of longitudinal tracking research makes it difficult to evaluate the long-term effectiveness of the policies. Future efforts could expand the research scope to include universities in western provinces such as Xinjiang and Qinghai, establishing an evaluation index system for "zero-waste campuses" in western universities. Conducting 3-5 year longitudinal studies to track policy implementation effects would be beneficial. Exploring deep integration paths of "AI

+ circular economy" – such as intelligent waste recycling robots and big data-driven facility optimization – could provide more universally applicable governance solutions for universities in underdeveloped regions worldwide.

References

[1] Palmer P. Getting to Zero Waste [M/OL]. Vacaville (CA): Zero Waste Institute; 2004 [2025-11-03]. Available from: https://zerowasteinstitute.org/zw-principles/history/.
[2] Wang Quanbo. Research on the Garbage Classification Model in Higher Education Institutions [J]. China Science and Technology Investment, 2024 (9):62-64.
[3] Zhu Yexing, Chen Tianyu. A Review of Research on 'Waste-Free City' Construction [J]. Sustainable Development, 2023,13:467.
[4] Ajzen I.[4] Ajzen I. The Theory of Planned Behavior[J]. Organizational Behavior and Human Decision Processes, 1991, 50(2): 179–211.DOI: 10.1016/0749-5978(91)90020-T.
[5] University of Cambridge Institute for Sustainability Leadership (CISL). Collaborative Circular Economy in Higher Education[R]. Cambridge: CISL, 2024.Available at: https://www.cisl.cam.ac.uk/resources/publications
[6] Yamada T, Asari M, Miura T, [6] Yamada T, Asari M, Miura T, et al. Municipal solid waste composition and food loss reduction in Kyoto City[J]. J Mater Cycles Waste Manag, 2017, 19(4): 1351–1360. DOI: 10.1007/s10163-017-0643-z.
[7] Fang B, Yu J, Chen Z, Osman AI, Farghali M, Ihara I, [7] Fang B, Yu J, Chen Z, Osman AI, Farghali M, Ihara I, et al. Artificial intelligence for waste management in smart cities: a review[J]. Environ Chem Lett, 2023. DOI: 10.1007/s10311-023-01604-3.
[8] University of California, Berkeley. UC Berkeley Zero Waste Plan[R/OL]. Berkeley: UC Berkeley Facilities; 2019 [cited 2025-11-03]. Available from: https://facilities.berkeley.edu/sites/default/files/2019_uc_berkeley_zero_waste_plan_final.pdf.
[9] Tan Wei. Design of Categorized Garbage Bins in Universities under the Green Development Concept [J]. Fine Arts Review, 2018, (12):92-93.
[10] Chen Shaojun, Li Ruchun, Ma Yongbin. The Paradox Between Will and Behavior: A Study on the Mechanism of Household Waste Sorting in Urban Residents [J]. China Population, Resources and Environment, 2015,25 (09):168-176.
[11] Chai Yuan. Design of a University Campus Waste Sorting and Recycling Service System [D]. Nanchang University, 2024.