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Suggestions for High-Quality and Sustainable Development Pathways of Dalian Coastal Health and Wellness Scenic Areas Empowered by the Zero-Waste Concept

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Abstract: With the in-depth advancement of the "Zero-Waste City" construction and the high-quality development of the health and wellness industry, Dalian's coastal health and wellness scenic areas are at a critical window for green and low-carbon transformation. These scenic areas feature sensitive ecological environments and strong public service attributes. However, due to concentrated tourist consumption, there are significant fluctuations in waste generation with pronounced seasonal peaks. Coupled with incomplete resource utilization chains, solid waste management has been under considerable pressure. Based on the foundation of Dalian's zero-waste city construction and the resource endowments of coastal health and wellness, this paper constructs a quantitative evaluation model grounded in the circular economy. Taking Amber Bay Health and Wellness Scenic Area as an example, it analyzes the comprehensive benefits of the "zero-waste" transformation and proposes development pathways, including a "Blue Cycle" recycling system, integration of new consumption formats, carbon footprint accounting, and cross-departmental collaborative governance. This provides theoretical support and decision-making references for the high-quality and sustainable development of coastal health and wellness scenic areas in Dalian.

Keywords: Zero-waste concept; Coastal health and wellness; Circular economy; Sustainable development; Amber Bay, Dalian

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1. The foundation of Dalian's "Zero-Waste City" construction and the current status of coastal health and wellness resources

1.1. Achievements of Dalian's "Zero-Waste City" construction

Since being selected as one of the cities for the "Zero-Waste City" construction during the "14th Five-Year Plan" period in April 2022, Dalian has adopted a model of "comprehensive planning and multi-party co-

governance", achieving remarkable results in reducing, recycling, and safely disposing of solid waste [1]. In January 2026, Dalian was selected as one of the first batch of pilot areas for beautiful cities nationwide, with continuous enhancement capabilities in ecological environment governance. **Table 1** compares the key common indicators of Dalian's ecological environment quality before and after the implementation of the "Zero-Waste City" construction. Considering the impact of production halts due to the pandemic, data from the years 2020, 2021, and 2022 have been excluded.

Table 1. Comparative table of common indicators of ecological environment quality in Dalian

Indicator Category	Specific Indicator	2019	**2023**	**2024**
Air Quality	Number of Good Air Quality Days in Urban Area	302 days (good rate 82.7%)	319 days (good rate 87.4%)	333 days (good rate 91%)
Water Environment (Rivers)	Proportion of National Assessment River Sections with Good Water Quality	100% (7 sections)	100% (13 sections)	100% (13 sections)
Marine Environment	Proportion of Coastal Waters with Good Water Quality (Class I & II)	98.3%	99.1% (up 0.8 percentage points year-on-year)	98.3% (down 0.8 percentage points year-on-year)
Natural Ecology	Ecological Quality Index (EI/EQI)	67.2 (Good)	63.82 (Class II)	63.78 (Class II)
Urban Greening	Green Coverage Rate in Built-up Areas	44%	45.92%	45.94%

1.2. Distribution of coastal health and wellness resources in Dalian

Dalian boasts a coastline stretching 2,211 kilometers, endowing it with exceptional coastal tourism resources. After long-term development, it has gradually established a spatial layout for health and wellness tourism characterized by "one core and two wings" [4]. Specifically, the "one core" refers to the core coastal tourism area in southern Dalian, encompassing renowned attractions such as Bangchui Island, Laohutan, Fujiazhuang, and Xinghai Square. The "two wings" consist of two parts: the eastern Jinshitan-Changhai Archipelago health and wellness resort wing and the western Lushunkou historical and cultural health and wellness wing. From 2023 to 2025, the total number of tourists in the city increased from 35 million to 40 million, with the proportion of health and wellness tourists rising from 12% to 15%. The revenue related to health and wellness tourism approached 50 billion yuan [2]. Meanwhile, the proportion of the elderly population in the city continues to climb, with the number of people aged 60 and above surpassing 1.8 million. The public's demand for health and wellness is constantly upgrading, showing a more diversified and high-end development trend [3]. **Table 2** lists the names, geographical locations, and core resources of major coastal health and wellness scenic spots in Dalian. The primary coastal health and wellness scenic spots in the four urban districts are mainly concentrated along the Coastal Road.

Table 2. Distribution and characteristics of resources in major coastal health and wellness scenic spots in Dalian

Scenic Spot Name	Location	Core Resources	Annual Visitor Volume (10,000 person-times)	Health & Wellness Features
Jinshitan National Tourist Resort	Jinpu New District	Sea erosion landforms, hot springs	985.64	Geological wellness, hot spring therapy
Bangchuidao Scenic Area	Zhongshan District	Island forest, sandy beaches	300+	Forest bathing, seaside therapy
Haiyun Park	Zhongshan District	Mountain-sea landscape	30	Mountain climbing with sea view, forest wellness
Fujiazhuang Park	Xigang District	Beach bath	approx. 150	Seawater bathing, sunbathing
Amber Bay (Shicao)	Zhongshan District	Bay reefs, fishing village	approx. 50-80	Coastal leisure, homestay wellness
Changhai Archipelago	Changhai County	Island ecology	approx. 100	Island vacation, fisherman's wellness
Lüshunkou Scenic Area	Lüshunkou District	Historical relics, seaside	approx. 180	Historical and cultural wellness

From the perspective of resource distribution, the coastal health and wellness resources in Dalian exhibit characteristics of "core agglomeration and radial extension": Zhongshan District centers around Laohutan and Amber Bay, focusing on "high-end ecological health and wellness"; Xigang District centers around Fujiazhuang and the Coastal Road, emphasizing "leisure convalescence + hiking health and wellness"; Jinzhou District centers around Jinshitan, highlighting "beach health and wellness + family-friendly health and wellness"; and Lushunkou District centers around the Lushun Convalescence Base, specializing in "medical health and wellness + elderly care services." These resources are highly complementary, fostering an integrated development trend of "sightseeing + health and wellness + convalescence."

1.3. Current status of solid waste management in coastal health and wellness scenic spots

To comprehensively understand the current status of solid waste management in coastal health and wellness scenic spots in Dalian, this study selected four typical scenic spots: Amber Bay Health and Wellness Area, Jinshitan Golden Coast, Fujiazhuang Scenic Spot, and the Laohutan-Bangchui Island coastal section. Through field research, questionnaire surveys, interview surveys, and data statistics, the authors have outlined the current status of solid waste management in these areas. **Table 3** presents the statistical results of the four typical scenic spots in terms of annual tourist volume, solid waste composition ratio, economic indicators, and governance effectiveness evaluation.

Table 3. Survey data on the current status of solid waste management in typical coastal health and wellness scenic spots in Dalian

Survey Dimension / Indicator Unit	Hupo Bay	Jinshitan	Fujiazhuang	Laohutan - Bangchuidao
Annual tourist volume (10,000 person-times)	120	550	320	185
Waste generation intensity (kg/person/day)	1.65	1.42	1.25	1.58
2. Solid Waste Composition Ratio				
Kitchen & organic waste (%)	48%	45%	35%	32%
Packaging waste (%)	22%	25%	42%	18%

Survey Dimension / Indicator Unit	Hupo Bay	Jinshitan	Fujiazhuang	Laohutan - Bangchuidao
Health care consumables (%)	18%	2%	1%	12%
Landscaping & green waste (%)	8%	10%	15%	35%
Marine debris (%)	4%	18%	7%	3%
3. Economic Indicators				
Waste treatment cost (yuan/ton)	485	420	390	510
Waste transportation distance (km)	18	45	12	22
Facility coverage rate (%)	15%	8%	5%	20%
4. Governance Efficiency Assessment				
Waste sorting accuracy rate (%)	42%	35%	28%	55%
Resource utilization rate (%)	2%	5%	0%	8%

(1) The total amount of waste generated in scenic spots is relatively high and exhibits significant seasonal fluctuations. Field research results indicate that the per capita waste generation intensity in the four major monitored scenic spots is at a high level. Among them, Amber Bay generates 1.65 kilograms of waste per person per day, while Jinshitan Golden Coast produces up to 85 tons of waste in a single day during peak tourist seasons. These seasonal peaks in waste generation place significant pressure on the instantaneous processing capacity of sanitation facilities in the scenic spots, substantially increasing the waste transfer load during peak seasons and easily leading to environmental issues such as waste accumulation.

(2) Kitchen waste and organic waste account for a relatively high proportion of solid waste in scenic spots, but their resource utilization rates are generally low. Monitoring data shows that organic waste constitutes the main component of household waste in each scenic spot, with Amber Bay accounting for 48% and Jinshitan accounting for 45%. In contrast, the overall resource utilization rate of such waste is low, with Amber Bay at only 2%, Jinshitan at 5%, and Fujiazhuang not implementing any resource utilization treatment. A significant amount of organic material with recycling potential fails to achieve resource utilization, such as composting and power generation, instead entering municipal disposal processes in a mixed manner, resulting in notable resource loss and waste.

(3) The economic efficiency of solid waste governance is low. Due to the coastal locations of health and wellness scenic spots, waste transfer distances are long, leading to high per-ton waste processing costs. The combination of high logistics costs and extremely low on-site disposal rates has trapped the current governance model in a dilemma of “high investment, low output”, lacking the cost-offsetting effects brought by a circular economy.

(4) There are significant shortcomings in waste classification management and overall governance capabilities across scenic spots, with notable variations in implementation effectiveness across different regions. Taking Fujiazhuang Scenic Spot as an example, the accuracy rate of on-site waste classification is only 28%, indicating weak overall implementation. In terms of hardware configuration, the coverage of intelligent classification and recycling facilities is limited, and there is a lack of intelligent, real-time waste monitoring and scheduling methods.

2. Construction of a quantitative evaluation model for waste-free coastal health and wellness scenic spots

2.1. Theoretical basis and system framework for evaluation model design

In response to the aforementioned situation, this study takes the "3R principles" (reduce, reuse, recycle) of the circular economy as its core and combines the Material Flow Analysis (MFA) method to construct a three-level evaluation system ("objective layer—criterion layer—indicator layer") tailored to the characteristics of "dense tourist populations, marine sensitivity, and prominent health and wellness service attributes" in Dalian's coastal health and wellness scenic spots. This system comprehensively measures the waste-free transformation level and overall benefits of the scenic spots [5].

In terms of the indicator system framework, this study uses the Analytic Hierarchy Process (AHP) to determine indicator weights by inviting experts in the fields of ecological environment, cultural tourism, health and wellness, and scenic spot management to score the indicators. **Table 4** presents the final indicator system after consistency testing (CR < 0.1) [6]. Among them, higher values for positive indicators are better, lower values for negative indicators are better, and stable values for neutral indicators are acceptable. The target values are set with reference to national "waste-free city" construction standards, advanced levels of similar coastal health and wellness scenic spots in China, and Dalian's waste-free city construction goals.

Table 4. Evaluation indicator system for waste-free health and wellness scenic spots

Objective Level	Criterion Level (Weight)	Indicator Level	Unit	Indicator Nature	Weight	Current Value of Amber Bay	Target Value
Waste-Free Coastal Wellness Tourism Comprehensive Evaluation Index	Source Reduction of Solid Waste (0.30)	Annual tourist volume	10,000 person-times	Neutral	0.05	120	120
		Waste generation intensity	kg/person/day	Negative	0.25	1.65	1
		Proportion of kitchen and organic waste	%	Positive	0.08	48	40
		Proportion of packaging waste	%	Negative	0.07	22	10
	Optimization of Solid Waste Structure (0.25)	Proportion of wellness care consumables	%	Negative	0.05	18	5
		Proportion of landscaping green waste	%	Positive	0.03	8	15
		Proportion of marine floating waste	%	Negative	0.02	4	1
	Resource Utilization Level (0.25)	Resource utilization rate	%	Positive	0.15	2	40
		Waste sorting accuracy rate	%	Positive	0.1	42	85
	Operation and Governance Efficiency (0.20)	Waste treatment cost per ton	yuan/ton	Negative	0.08	485	300
		Waste transfer distance	km	Negative	0.04	18	10
		Facility coverage rate	%	Positive	0.04	15	90
		Comprehensive governance efficiency score	—	Positive	0.04	—	90

2.2. Theoretical model and evaluation method

This study employs a weighted comprehensive scoring method to calculate the comprehensive evaluation index for waste-free scenic spots, with the formula as follows:

$$I = \sum_{i=1}^{n} Wi \times Xi$$

where: I represents the comprehensive evaluation index for waste-free coastal health and wellness scenic spots; Wi denotes the weight of the i-th indicator; Xi signifies the standardized value of the i-th indicator; and *n* indicates the number of indicators (in this system, *n*=13).

(1) I≥0.85: Excellent, indicating full compliance with waste-free scenic spot standards and optimal synergy among ecological, economic, and social benefits.

(2) 0.70≤I<0.85: Good, suggesting a relatively well-established waste-free system with core indicators meeting standards and room for continuous optimization.

(3) 0.50≤I<0.70: Moderate, reflecting initial progress in waste-free transformation with some indicators not meeting standards and requiring focused rectification.

(4) I<0.50: Poor, indicating a lack of implementation of waste-free concepts, prominent solid waste management issues, and the need for comprehensive rectification.

3. Economic benefit analysis of waste-free transformation in the Amber Bay Health and Wellness Scenic Spot

3.1. Current status and post-compliance evaluation index calculation

Based on the current status data of Amber Bay Health and Wellness Scenic Spot, and by applying the standardized formula and comprehensive evaluation model, the authors calculate:

$$I_{current} = 0.10$$

The evaluation grade is “poor”, reflecting weak solid waste management foundations, extremely low levels of waste reduction and resource utilization, and insufficient waste-free governance effectiveness in Amber Bay Scenic Spot.

Now, assuming that Amber Bay Scenic Spot fully implements the waste-free evaluation system and all indicators reach the excellent-grade target values, the authors calculate:

$$I_{target} = 0.92$$

The evaluation grade is “excellent”, representing an improvement of 0.82 from the current status. This indicates that waste-free transformation can comprehensively enhance solid waste management levels in Amber Bay Scenic Spot, achieving a leap from “poor” to “excellent.”

3.2. Economic benefit analysis of waste-free transformation in Amber Bay Health and Wellness Scenic Spot

Economic benefits primarily stem from cost savings and resource utilization revenues. Cost savings refer to

the reduction in waste generation intensity → decrease in total solid waste volume → lower processing and transfer costs. Resource utilization revenues involve the resource utilization of kitchen waste, landscaping waste, and recyclables → generating sales revenues.

Based on the basic data, the authors can calculate:

(1) Annual total solid waste generation:

Current status: 1.2 million person-times×1.65 kg/person-day×365 days/1000=72,270 tons/year

Post-compliance: 1.2 million person-times×1.00 kg/person-day×365 days/1000=43,800 tons/year

Reduction: 28,470 tons/year

(2) Resource utilization structure:

Current status: 2% resource utilization rate, no classification revenue

Post-compliance: 40% resource utilization rate, including composting revenue of 80 yuan/ton for kitchen and organic waste (40%), crushing and covering revenue of 50 yuan/ton for landscaping waste (15%), and sales revenue of 200 yuan/ton for recyclables (45%)

(3) Direct economic benefit calculation:

Solid waste processing cost savings: 21,910,950 yuan/year

Waste transfer cost savings: 1,294,260 yuan/year

Total resource utilization revenue: 2,268,840 yuan/year

Comprehensive direct economic benefit: approximately 25.4741 million yuan/year

4. Suggestions for high-quality and sustainable development pathways for Dalian coastal health and wellness scenic spots

4.1. Establish a “blue cycle” recycling system for coastal health and wellness scenic spots

Leveraging Dalian’s coastal characteristics, construct a land-sea integrated “blue cycle” solid waste recycling system centered around four core aspects: solid waste source reduction, structural optimization, resource utilization, and operational governance effectiveness [7]. For source reduction, increase the density of intelligent classification facilities in beach, reef, and health and wellness station areas, clearly mark classification standards, and guide tourists to dispose of waste properly to reduce increments caused by mixed disposal. For structural optimization, add dedicated collection containers for marine waste, classify and store floating marine debris and discarded fishing gear, and reduce the proportion of hazardous waste. For resource utilization, introduce third-party professional recycling enterprises to establish a closed loop for the “collection-storage-transportation-utilization” of recyclables. For operational governance, establish a linkage mechanism of “coastline inspection + offshore salvage + fixed-point clearance” to improve waste clearance efficiency, address coastal waste governance challenges, and promote quality and efficiency improvements in solid waste governance.

4.2. Cultivate new consumption formats integrating “health and wellness + waste-free”

Guided by four core dimensions, promote the deep integration of waste-free concepts and health and wellness consumption to cultivate green and low-carbon new business formats. For source reduction, scenic spots should comprehensively implement “waste-free guest rooms” and “waste-free catering” models, cease providing disposable items, actively promote reusable health and wellness equipment, and reduce the generation of various types of waste from the consumption source. For structural optimization of solid

waste, strengthen guidance for scenic spot merchants, urge them to reduce the use of packaging waste and disposable consumables, and simultaneously increase the proportion of standardized collection of organic waste to gradually optimize the solid waste composition [8]. In the resource utilization link, perform harmless treatment on kitchen waste and green waste to convert them into fertilizers required for health and wellness landscapes. Meanwhile, rely on these recyclable resources to develop an environmentally friendly health and wellness culture, creative products, and achieve resource reuse. At the operational governance level, create characteristic projects such as beach cleaning, health and wellness, and environmental protection handicraft experiences, strengthen the promotion of waste-free concepts to tourists, and establish a sound consumption incentive mechanism to fully mobilize the participation enthusiasm of tourists and merchants, ultimately achieving a win-win goal of ecological environment protection and enhanced health and wellness experiences [9].

4.3. Establish a carbon footprint accounting and information disclosure system for coastal health and wellness scenic spots

Relying on four core dimensions, construct a scientific and comprehensive carbon footprint accounting and information disclosure system to promote low-carbon operations in scenic spots. Through carbon footprint accounting, accurately locate the key carbon emission points in the solid waste generation process and formulate targeted reduction measures. For structural optimization of solid waste, optimize the solid waste disposal structure through accounting data to reduce the proportion of high-carbon-emission solid waste. In terms of resource utilization, quantify the carbon reduction effects of resource utilization, promote the on-site resource utilization of organic waste such as kitchen and green waste, and enhance carbon reduction benefits. At the operational governance level, establish standardized accounting ledgers, regularly disclose carbon footprint data and governance effects, incorporate carbon reduction into scenic spot assessments, strengthen supervision and management, and assist in the coordinated promotion of “waste-free city” and “dual carbon” goals [10].

4.4. Improve a cross-departmental collaborative governance mechanism

Centered around four core dimensions, improve a cross-departmental collaborative governance mechanism to enhance the standardization level of solid waste governance. For source reduction, multiple departments should jointly issue control policies to regulate the use of disposable items by scenic spot merchants and strengthen classification guidance for tourists. For structural optimization of solid waste, the cultural tourism and ecological environment departments should collaborate to conduct solid waste composition monitoring and optimize classification plans in a targeted manner. In terms of resource utilization, collaborate with renewable resource enterprises and research institutions to research and promote solid waste resource utilization technologies and improve utilization efficiency. At the operational governance level, clarify the responsibilities of cultural tourism, marine, urban management, and other departments, establish joint inspection, law enforcement, and reward and punishment mechanisms, improve the merchant assessment system, guide community and volunteer participation in governance, and construct a governance pattern of “multi-party collaboration and whole-process control” to comprehensively enhance solid waste governance effectiveness.

5. Conclusion

Driven by the dual strategies of “waste-free city” construction and high-quality development of the health and wellness industry, the green transformation of Dalian’s coastal health and wellness scenic spots is both

a development opportunity and a practical requirement. Based on Dalian's "waste-free city" construction foundations and coastal health and wellness resource endowments, this paper addresses issues such as large solid waste generation volumes, significant seasonal fluctuations, high proportions of organic waste, low resource utilization levels, and insufficient governance effectiveness in scenic spots. It constructs a quantitative evaluation model for solid waste management based on the circular economy's "3R principles" and Material Flow Analysis (MFA) and systematically calculates the comprehensive benefits of waste-free transformation using Amber Bay Health and Wellness Scenic Spot as an empirical object. The study proposes four development pathways: establishing a "blue cycle" recycling system, cultivating new consumption formats integrating "health and wellness + waste-free", establishing a carbon footprint accounting and information disclosure system, and improving a cross-departmental collaborative governance mechanism. These pathways comprehensively cover the four core dimensions of solid waste source reduction, structural optimization, resource utilization, and operational governance effectiveness enhancement. The aforementioned pathways not only align with Dalian's coastal ecological characteristics and health and wellness industry positioning but also conform to waste-free city construction and sustainable development goals. They can effectively address solid waste governance pain points, enhance ecological, economic, and social benefits, provide theoretical support and decision-making references for the high-quality and sustainable development of Dalian's coastal health and wellness scenic spots, and offer a replicable practical paradigm for the green transformation of similar coastal health and wellness scenic spots across the country.

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Disclosure statement

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