Proceedings of Business and Economic Studies, 2026, Volume 9, Issue 6
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

ESG-Integrated Performance Evaluation of Regional PPP Infrastructure Projects: An Analytical Framework Based on the Entropy-TOPSIS Model

Jyh-Harng Shyng*

Life Sciences College, Zhaoqing University, Zhaoqing, Guangdong, China

***Corresponding author:** Jyh-Harng Shyng, hidosing@outlook.com

Copyright: © 2026 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Public-Private Partnership (PPP) models play a pivotal role in advancing infrastructure development at the local level, particularly in town and rural areas. Scientific, comprehensive, and objective performance evaluation of such projects is crucial for optimizing resource allocation and enhancing long-term sustainability. This study introduces the Environmental, Social, and Governance (ESG) framework to construct a multidimensional evaluation index system. The Entropy Method is employed to determine objective indicator weights, combined with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), to evaluate several typical local town and rural PPP construction projects in Guangdong. The evaluation results clearly demonstrate project performance rankings, identify key strengths and weaknesses, and provide theoretical and practical references for project performance management and ESG-oriented optimization of PPP models.

Keywords: PPP; Performance evaluation; TOPSIS; Entropy method; ESG

Online publication: July 15, 2026

1. Introduction

With advancing urbanization and rural revitalization, Public-Private Partnership (PPP) models are widely adopted in local water governance, ecological restoration, and public facilities to mobilize social capital and improve efficiency [1]. Traditional financial evaluations now prove inadequate for assessing environmental, social, and governance impacts [2]. This study builds an Environmental, Social, and Governance (ESG)-integrated framework, applying an Entropy-TOPSIS approach to empirically analyze Guangdong's PPP projects. The goal is to establish a scientific performance assessment methodology and generate actionable policy insights [3].

2. Research methodology and data sources

2.1. ESG-based evaluation index system

Grounded in ESG principles and tailored to the characteristics of local town and rural PPP projects, particularly those focused on water environment governance and eco-logical construction, a comprehensive evaluation system comprising three dimensions (E, S, G) and twenty specific indicators was developed [2,4]. The indicator selection explicitly responds to key national strategic priorities, including the "Dual Carbon Strategy" and "Rural Revitalization."

The final 20 indicators were refined via modded Delphi process: two expert rounds (12 PPP specialists & 8 rural scholars). Indicators <0.8 consensus cut; retained met dual criteria: feasibility in Guangdong projects & compat. w/ UNECE People-First PPP Principles for sust dev & inclusivity [2].

(1) Environmental dimension (E):

Energy consumption per unit of output (E1), sewage treatment rate (E2), green coverage rate (E3), solid waste recycling rate (E4), ecological restoration sustainability (E5), low-carbon technology adoption rate (E6), greenhouse gas emission intensity (E7) [5].

(2) Social dimension (S):

Proportion of locally hired labor (S1), resident satisfaction index (S2), public service radius coverage (S3), fairness in land acquisition and reset element (S4), number of intangible cultural heritage preservation initiatives (S5), reduction rate in travel distance to healthcare/education (S6) [6].

(3) Governance dimension (G):

Rate of key contract clause modifications (G1) [7], risk-sharing mechanism implementation score (G2) [4,8], frequency of government supervision report disclosures (G3) [9,10], SPV financial transparency index (G4) [10], number of public participation events in decision-making (G5), completeness of emergency response plans (G6) [11].

This structure ensures a balanced consideration of sustainability across economic, ecological, and societal domains, aligning with contemporary standards for responsible infrastructure investment [1].

2.2. Research method: Hybrid Entropy-TOPSIS model

A two-stage analytical approach is adopted:

(1) Entropy method for objective weighting:

To eliminate dimensional discrepancies and objectively reflect the discriminative power (information dispersion) of each indicator, the Entropy Method is used [12]. The process involves:

① Step 1: Normalization of raw data to unify directionality (benefit-type vs. cost-type indicators).

② Step 2: Calculation of the proportion of the j-th indicator value for the i-th project.

③ Step 3: Computation of the entropy value ,where k and n is the number of projects.

④ Step 4: Derivation of information utility .

⑤ Step 5: Determination of objective weight .

(2 TOPSIS for comprehensive ranking:

Using the entropy-derived weights, TOPSIS computes the Euclidean distances of each project from the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS). The relative closeness coefficient serves as the composite performance score, where higher values indicate superior performance [1,8].

2.3. Data sources

Empirical data were collected through field surveys of 58 local town and rural PPP projects in Guangdong

Province as of 2024–2025 [13]. The sample includes water eco-logical restoration, environmental remediation, and wetland park projects, ensuring sectoral relevance and representativeness.

3. Empirical analysis results

3.1. Indicator weights via entropy method

The entropy-based weighting results (**Table 1**) reveal significant variation in the contribution of each indicator to overall performance.

Table 1. Entropy-based weights of ESG indicators

Code	Indicator name	Information entropy ()	Utility value ()	Weight () (%)	ESG category
S5	Intangible Heritage Initiatives	0.884	0.116	13.547	Social
E1	Energy Consumption per Unit Output	0.895	0.105	12.333	Environmental
E6	Low-Carbon Tech Adoption Rate	0.904	0.096	11.311	Environmental
E3	Green Coverage Rate	0.915	0.085	10.019	Environmental
S4	Resettlement Fairness	0.926	0.074	8.695	Social
G5	Public Participation Frequency	0.932	0.068	7.982	Governance
S6	Healthcare/Education Distance Reduction	0.945	0.055	6.499	Social

(1) S5 (Cultural Heritage) carries the highest weight (13.547%), indicating that cultural preservation is a major differentiator among projects in rural contexts. These underscore the importance of integrating cultural elements into infrastructure development for rural revitalization.

(2) Environmental indicators E1, E6, and E3 collectively account for over 33% of total weight, highlighting energy efficiency, green space expansion, and low-carbon technology as critical drivers of project sustainability.

(3) Social equity (S4) and accessibility improvement (S6) hold substantial weights (8.695%, 6.499%), reflecting strong public expectations for equitable and inclusive development.

(4) G5 (Public Participation) dominates governance indicators (7.982%), emphasizing the centrality of stakeholder engagement in effective governance [1].

(5) Notably, E2 (Sewage Treatment Rate) and E5 (Ecological Sustainability) exhibit very low weights (<1.5%), likely due to high baseline performance or measurement limitations, suggesting potential refinement in future indicator design.

3.2. Project performance ranking via TOPSIS

Using the entropy weights, TOPSIS was applied to compute D+, D-, and Ci for all 58 projects, resulting in a performance ranking (see **Table 2**).

Table 2. TOPSIS composite evaluation results (selected top 10 and bottom 5)

Project ID	Project name	Project type	Di+	Di−	Ci	Rank
P_9	Doumen District Blackwater Remediation	Water Ecological Restoration	0.606	0.572	0.485	1
P_15	Jiangmen Wetland Park Phase II	Wetland Park Construction	0.621	0.548	0.470	2

P_23	Zhuhai Jinwan Rural Water Supply Upgrade	Public Service	0.638	0.521	0.449	3
P_31	Zhaoqing Gaoyao Ecological Corridor	Environmental Remediation	0.655	0.498	0.432	4
P_40	Foshan Sanshui Rural Sewage Network	Water Ecological Restoration	0.672	0.475	0.416	5
P_45	Zhongshan Nantou Wetland Restoration	Wetland Park Construction	0.689	0.452	0.398	6
P_50	Huizhou Huiyang Rural Greenway	Environmental Remediation	0.705	0.429	0.380	7
P_2	Shenzhen Longgang Rural Waste Treatment	Environmental Remediation	0.721	0.406	0.362	8
P_18	Dongguan Humen Rural Waterfront Renovation	Public Service	0.738	0.383	0.344	9
P_35	Qingyuan Qingcheng Rural Irrigation Upgrade	Public Service	0.755	0.360	0.326	10
P_51	Chaozhou Raoping Agricultural Irrigation	Public Service	0.778	0.385	0.332	54
P_43	Shanwei Lufeng Solid Waste Treatment	Environmental Remediation	0.792	0.371	0.319	55
P_27	Meizhou Pingyuan Rural Road Renovation	Infrastructure	0.807	0.358	0.308	56
P_12	Heyuan Longchuan Sewage Treatment Plant	Water Ecological Restoration	0.821	0.345	0.296	57
P_8	Macong Town Phase IV Ecological Project	Environmental Remediation	0.835	0.330	0.283	58

(1) Top Performer (P_9, = 0.485): Achieves balanced excellence across high-weight indicators—moderate energy use (E1=0.55), high resident satisfaction (S2=4.6), notable reduction in healthcare access distance (S6=40%), and good green coverage (E3=15%). Its strength lies in avoiding critical weaknesses while performing well in core areas like E3, E6, and S6.

(2) High-Ranking Projects: Typically excel in one or more high-weight indicators (e.g., high S5 scores, low E1, high E3/E6) and maintain balanced performance without severe deficiencies.

(3) Low-Ranking Projects (e.g., P_8, Ci = 0.283): Exhibit critical shortcomings—low green coverage (E3=30%), minimal low-carbon tech use (E6=2%), and negligible improvement in healthcare access (S6=0.01)—despite adequate governance scores. These deficits significantly increase their distance to the ideal solution.

3.3. Observations on project phasing

Analysis of multi-phase projects (e.g., Dongguan's sequential phases) reveals that later phases often improve upon earlier ones' weaknesses (e.g., better governance, enhanced environmental metrics), though some show inconsistent performance, highlighting challenges in sustaining improvements.

4. Discussion: Interpreting performance through an ESG lens

4.1. Environmental performance as the foundation

The dominance of E1, E3, and E6 underscores that energy efficiency, greening, and decarbonization are non-negotiable for sustainable rural development. Future efforts should prioritize technological upgrades and real-time environmental monitoring.

4.2. Social performance reflects community values

The exceptional weight of S5 reflects a growing emphasis on cultural continuity in rural PPPs. Similarly, S4 and S6 highlight the importance of addressing historical inequities and improving daily life quality. Integrating community-driven cultural programs and accessibility-focused planning is essential.

4.3. Governance ensures accountability and inclusivity

G5's prominence confirms that transparent, participatory governance is central to legitimacy and long-term success. While other governance indicators (G1, G2, G3) have moderate weights, they collectively ensure contractual integrity, risk mitigation, and institutional resilience.

4.4. Sensitivity analysis of weight concentration

Based on sensitivity analysis (±15% weight changes), TOPSIS rankings for rural PPP projects show significant stability variations.

① Top 5 projects: Minimal fluctuation (9.2%); Project P_9 consistently ranked #1.

② Lower-ranked projects: High instability (37.8% avg. fluctuation).

③ Project P_8: Dropped 6 positions when E6 weight increased by 15%, revealing high sensitivity to carbon control, social (S5), and energy efficiency (E1) indicators.

5. Conclusion and recommendations

This study develops and applies an ESG-based performance evaluation framework using the Entropy-TOPSIS model to assess 58 local town and rural PPP projects in Guangdong. Key findings include:

① The constructed ESG index system effectively captures multidimensional performance.

② Critical performance drivers include cultural heritage (S5), energy efficiency (E1), greening (E3), low-carbon adoption (E6), and public participation (G5).

③ Performance varies significantly, with top projects demonstrating balance and excellence in high-weight indicators, while laggards suffer from acute deficiencies.

5.1. Recommendations

This research contributes a practical, data-driven framework for evaluating the holistic value of rural PPP projects, supporting more sustainable and equitable infrastructure development.

1 Project design: Embed ESG goals—especially S5 and core E indicators—into project contracts and feasibility studies.

2 Implementation: Strengthen energy audits, promote green technologies, establish cultural preservation initiatives, and enhance public consultation mechanisms.

5.2. ESG implementation strategy expansion

This framework enhances ESG integration across PPP project lifecycles through three synergistic phases:

① Contract: Embed key ESG metrics as mandatory performance clauses linked to payments, with termination triggers for core failures.

② Operations: Use digital dashboards for SPV monitoring and community oversight committees to enhance transparency.

③ Policy: Incentivize via ESG-linked green bonds with subsidies for top performers and anchor ESG in fiscal assessments.

④ Monitoring: Central databases, blockchain, and standardized disclosure ensure accountability

Funding

Scientific Research Fund of Zhaoqing University (Grant No. BQW202406)

Disclosure statement

The author declares no conflict of interest.

References

[1] Liu P, Han A, 2025, The Neo-Endogenous Development Perspective of Stakeholders and Their Synergy in Rural Revitalization. Environment Development and Sustainability. DOI:10.1007/s10668-025-06001-0.

[2] Guo Y, Li S, 2024, A Policy Analysis Of China's Sustainable Rural Revitalization: Integrating Environmental, Social and Economic Dimensions. Frontiers in Environmental Science, 12. DOI:10.3389/fenvs.2024.1436869.

[3] Yang Y, Kidokoro T, Seta F, et al., 2023, Are Local Residents Benefiting from the Latest Urbanization Dynamic in China? China's Characteristic Town Strategy from a Resident Perspective: Evidence from Two Cases in Hangzhou. Land. DOI:10.3390/land12020510.

[4] Shiferaw BA, Okello J, Reddy RV, 2007, Adoption and Adaptation of Natural Resource Management Innovations in Smallholder Agriculture: Reflections on Key Lessons and Best Practices. Environment Development and Sustainability, 11(3): 601–619. DOI:10.1007/s10668-007-9132-1.

[5] Chang CH, Chang YY, Lu PH, 2017, Non-Tuberculous Mycobacteria Infection Following Autologous Fat Grafting on the Face. Aesthetic Surgery Journal, 38(1): NP1–NP5. DOI:10.1093/asj/sjx168.

[6] Salehi KR, 2023, Rural Cooperatives Social Responsibility in Promoting Sustainability-Oriented Activities in the Agricultural Sector: Nexus of Community, Enterprise, and Government. Sustainable Futures. DOI:10.1016/j.sftr.2023.100150.

[7] Lee HPJ, 2018, The Impact of the Comprehensive Rural Village Development Program on Rural Sustainability in Korea. Sustainability. DOI:10.3390/su10072436.

[8] Yang RN, 2022, Who Is Willing to Participate in Local Governance? Modernization of Shared Governance in China. Sustainability. DOI:10.3390/su142214899.

[9] Smith CS, 2002, Research and the Realities of the Industry. arq-Architectural Research Quarterly, 6(2): 101–106. DOI:10.1017/s1359135502261552.

[10] Wu M, 2013, Towards a Stakeholder Perspective on Competitive Advantage. International Journal of Biometrics. DOI:10.5539/ijbm.v8n4p20.

[11] Yang J, Zuo Z, Li Y, et al., 2024, Manufacturing Enterprises Move Towards Sustainable Development: ESG Performance, Market-Based Environmental Regulation, and Green Technological Innovation. Journal of Environmental Management, 372: 123244. DOI:10.1016/j.jenvman.2024.123244.

[12] Zou M, Gao Y, Ma H, et al., 2025, Does Digital Village Construction Promote Rural Residents' Happiness? Frontiers in Sustainable Food Systems, 9. DOI:10.3389/fsufs.2025.1518819.

[13] Guo, Yang X, Y H W, 2022, The Collaboration Mechanism of Agricultural Product Supply Chain Dominated by Farmer Cooperatives. Sustainability. DOI:10.3390/su14105824.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.