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BARRIERS AND STRATEGIES FOR CIRCULAR ECONOMY IMPLEMENTATION: A MIXED-METHODS ANALYSIS OF THANH HOA PROVINCE, VIET NAM

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ABSTRACT

This study evaluates barriers and strategies for circular economy (CE) implementation in Thanh Hoa Province, Vietnam using mixed-methods approach combining survey of 32 stakeholders and secondary data analysis (2021-2025). CE adoption reaches 51.7% enterprises with statistically significant sectoral differences (χ^2=12.45, p=0.014), led by industry (7.7 points). The 10-criteria evaluation matrix (α=0.89) ranks Lam Son Sugar highest (8.2/10). SWOT-TOWS prioritizes SO strategy "5 Circular Industrial Parks" (QSPM 8.2/10), while RCA-5 Whys identifies "lack of specific policy" as root barrier (89% consensus). The study contributes the province-level CE assessment framework integrating BS 8001:2017 with Decree 08/2022/ND-CP, applicable to Vietnam's 20 industrial provinces. The "5 Circular Industrial Parks" roadmap projects 45,000 green jobs by 2045, supporting Decision 222/QD-TTg implementation. Limitations include small sample size (n=32) requiring expansion in future research.

Keywords: Circular economy, Thanh Hoa Province, Environmental policy.

1. INTRODUCTION

Against the backdrop of climate change and global resource depletion, the Circular Economy (CE) has emerged as a sustainable economic paradigm to replace the traditional linear model of "take-make-dispose." Kirchherr et al. (2017) [1] synthesized 114 CE definitions from 221 sources, identifying three core principles: eliminating waste through design, maximizing resource circulation, and regenerating natural ecosystems. The EU has adopted a comprehensive policy framework to advance the Circular Economy (CE), including *A New Circular Economy Action Plan: For a Cleaner and More Competitive Europe; the Circular Economy Package (CEP), EU Green Deal at the regional level; European regional development policies; European Union's Circular Economy Action Plan*. (De Melo et al., 2022) [2]. Vietnam has also established CE as a strategic pillar for socio-economic development through Decision No. 222/QD-TTg (January 23, 2025) [3], which approved the National Action Plan for Circular Economy Implementation through 2035. This plan outlines five specific objectives: a 45% reduction in resource extraction intensity per GDP, an 85% recycling rate for municipal solid waste, and the development of 20 circular industrial parks. (Vietnam Briefing, 2025) [4].

Thanh Hoa Province serves as a typical representative of rapidly industrializing localities in Central Vietnam, possessing significant potential in agriculture (1.2 million hectares of alluvial soil), processing industries (with a GRDP growth rate of 9.2% per annum during 2021-2024), and coastal eco-tourism. However, the current linear economic model reveals several limitations: the efficiency of agricultural land use reaches only 65% of its potential, industrial

emissions increase by 14% annually, and existing CE models remain largely spontaneous and lack synchronized policy support [5]. A report by ICED (2021) [6] surveying 200 domestic enterprises indicated that 67% lack CE awareness, 82% lack access to circular technologies, and 71% face barriers regarding green financing.

Previous research on CE in Vietnam has primarily focused on the national level or on major metropolitan areas. Finance Magazine (2023) [7] evaluated the policy framework under Decree No. 08/2022/ND-CP [8] with 11 criteria for CE enterprises but lacked provincial-level field analysis. Economy & Forecast (2025) [9] highlighted a gap in local research, noting that 78% of publications (52 articles between 2020-2025) failed to address the specific industrial characteristics of provinces like Thanh Hoa. Notably, there is a lack of research utilizing Root Cause Analysis (RCA) combined with the "5 Whys" method to identify bottlenecks in provincial CE implementation or to construct a 20-year strategic roadmap (2025-2045) aligned with national sustainable development resolutions.

This study addresses these research gaps across four key dimensions: (1) expanding the research scope to the provincial level in Thanh Hoa through field surveys of 32 representative stakeholders (local authorities, enterprises, experts, and residents); (2) employing advanced analytical methods combining SWOT-RCA-5 Whys to identify seven policy bottlenecks in CE implementation; (3) developing an evaluation matrix with 10 multi-sectoral CE criteria tailored to Vietnamese conditions (organic agriculture, recycling industries, and eco-tourism); and (4) proposing a strategic orientation toward 2045, projected to create 45,000 green jobs and reduce industrial emissions by 30%.

The study analyzes the implementation of the circular economy at the provincial level in Vietnam, using Thanh Hoa as a case study. It provides practical evidence to support local authorities in implementing Decision No. 222/QD-TTg [3] and offers context-specific insights that may serve as a reference for other industrial provinces in transitioning toward a sustainable circular economy by 2045. In addition, the study systematizes and proposes a multidimensional evaluation framework based on Kirchherr et al. (2017) [1] and BS 8001:2017 [10], adapted to assess circular economy models in the Vietnamese context.

2. LITERATURE REVIEW

The Circular Economy (CE) is defined through foundational international research based on three core principles: designing out waste and pollution, keeping products and materials in use, and regenerating natural systems (Kirchherr et al., 2017) [1]. The BS 8001:2017 standard [10] by the British Standards Institution systematizes ten CE principles, ranging from "systems thinking" to "collaboration for shared value", providing a multidimensional framework across economic, environmental, and social pillars. In Vietnam, Article 142 of the 2020 Law on Environmental Protection institutionalizes CE with three specific criteria: reducing the extraction of non-renewable resources, extending product lifecycles, and minimizing environmental impacts (Government of Vietnam, 2022) [3].

International scholars have developed specialized analytical frameworks across various sectors. Kirchherr et al. (2017) [1] synthesized 114 CE definitions from 221 sources, highlighting conceptual diversity while identifying a consensus on the goal of reducing resource waste. Geissdoerfer et al. (2017) [11] critiqued the linear economic model for wasting 90% of global material value and proposed CE as a novel sustainable paradigm. In Europe, several policy frameworks support the Circular Economy (CE), including *A New Circular Economy Action Plan: For a Cleaner and More Competitive Europe; the Circular Economy Package (CEP), EU Green Deal at the regional level; European regional development policies; European Union's Circular Economy Action Plan* (De Melo et al., 2022) [2]. These

policies, implemented across 28 Member States, contribute to the objective of becoming the first climate-neutral continent by 2050 (European Commission, 2019) [12].

In Vietnam, CE research has transitioned from theoretical exploration to empirical studies since 2020. ICED (2021) [6] surveyed 200 enterprises, revealing that 67% lack CE awareness, 82% lack access to circular technologies, and 71% face barriers to green financing. *Finance Magazine* (2023) [7] reported that the recycling rate for municipal solid waste is only 12.4%, significantly lower than Thailand (28%) and Malaysia (26%). Economy & Forecast (2025) [9] evaluated national policies under Decision No. 222/QD-TTg (2025), which outlines five specific targets for 2035: a 45% reduction in resource extraction per GDP and the development of 20 circular industrial parks.

However, research at the local level remains limited. Thanh Hoa Newspaper (2024) [5] noted that agricultural CE models in the province, such as rice by-product reuse, are small-scale and lack synchronized policy support. In 2025, Thanh Hoa had 242,058 ha of agricultural land and 388.8 thousand ha of cultivated area, yet only 4,474 ha had been consolidated for large-scale and high-tech agricultural production [13]. Meanwhile, the processing and manufacturing industry is projected to grow by an average of 17.43% annually and account for at least 36% of GRDP by 2030 [14], highlighting the growing need for more efficient resource use, waste reduction, and the adoption of circular economy models. The most significant research gap lies in the lack of provincial-level analysis utilizing field data and causal analytical tools such as Root Cause Analysis (RCA) and the "5 Whys" technique.

This study addresses these gaps by: (1) conducting field surveys with 32 representative stakeholders in Thanh Hoa; (2) applying a SWOT-RCA-5 Whys methodology to identify seven policy bottlenecks; (3) constructing a matrix of 10 multi-sectoral CE evaluation criteria tailored to the Vietnamese context; and (4) proposing a strategic roadmap for 2025-2045 integrated with Decision No. 222/QD-TTg. The theoretical framework, inherited from Kirchherr et al. (2017) [1] and aligned with national policies, provides a scientific foundation for industrial provinces in Vietnam to transition toward a circular model.

3. METHODOLOGY

This study employs a mixed-methods approach, integrating qualitative and quantitative techniques to ensure a comprehensive analysis of the Circular Economy (CE) status in Thanh Hoa. The research follows a sequential exploratory design: Phase 1 involves collecting qualitative data through in-depth interviews to identify policy bottlenecks; Phase 2 utilizes quantitative data from surveys and secondary analysis to validate and measure the extent of these issues (Creswell & Plano Clark, 2017) [15]. This approach is well-suited to the provincial level, characterized by diverse sectors including agriculture, industry, and services.

3.1. Research Objects and Scope

The research objects comprise CE models within Thanh Hoa's three key economic sectors: (1) agriculture (reuse of rice and coffee by-products); (2) processing industry (recycling of sugarcane bagasse and pineapple peels); and (3) services and tourism (ecological waste management). The spatial scope encompasses the entire province across three specialized sub-regions: the lowlands (agriculture), the midlands (industry), and the coastal areas (tourism and logistics). Secondary data were collected for the 2019-2024 period, while primary data were gathered through surveys conducted from May to August 2025.

3.2. Data Collection Methods

3.2.1. Secondary Data

Data were synthesized from 127 sources, including official reports from the People's Committee of Thanh Hoa Province (GRDP, industrial emissions), national legal documents (Decree No. 08/2022/ND-CP, Decision No. 222/QD-TTg), and national statistics from the General Statistics Office (GSO). The data were processed using a five-year trend analysis (2020-2024) and benchmarked against comparable provinces (Nghe An, Ha Tinh).

3.2.2. Primary Data

The study surveyed a purposive sample of 32 stakeholders (n=32), comprising four key groups: local authorities (n=8, including representatives from provincial, district, and commune levels), enterprises (n=12, covering agriculture, industry, and services), experts (n=8, from research institutes and large corporations), and representative households (n=4).

A 5-point Likert scale questionnaire was designed based on the 10 CE criteria (Decree No. 08/2022/ND-CP), yielding a Cronbach's Alpha reliability coefficient of 0.87. In-depth interviews were conducted with 12 cases (1 hour per session), recorded, transcribed, and coded using NVivo 12.

3.3. Data Analysis Framework

The data analysis was conducted through a multi-stage process to ensure both depth and statistical rigor. The integration of primary survey data (n = 32) with extensive secondary data sources (127 documents, five-year provincial trends) across all statistical and strategic analytical tools, including SWOT-Delphi, RCA, CE Performance Evaluation Matrix, Z-score normalization, Pearson correlation, and Cronbach's Alpha – enhances the reliability of the analytical framework and its findings

First, a SWOT analysis based on the Humphrey (1960) model was employed to evaluate 12 criteria (7 internal and 5 external). To quantify the significance of these factors, weights were assigned through a two-round Delphi expert panel, ensuring a consensus-based objective evaluation.

To move beyond descriptive analysis, the study utilized Root Cause Analysis (RCA) integrated with the 5 Whys technique, a methodology derived from the Toyota Production System. This allowed for the identification of causal chains, tracing surface-level symptoms, such as the scarcity of Circular Economy (CE) models, back to fundamental root causes, notably the lack of sector-specific policy frameworks. This analysis was applied to seven representative cases within each focal sector.

Furthermore, a CE Performance Evaluation Matrix was constructed, incorporating 10 multidimensional criteria (Economic: ROI and employment; Environmental: emission reduction; Social: awareness) derived from BS 8001:2017 and Decree No. 08/2022/ND-CP. This matrix served as the baseline to evaluate 15 practical models (5 per sector), with scores standardized using Z-score normalization to ensure comparability.

Finally, the integrity of the findings was ensured through rigorous reliability and validity testing. Internal consistency was verified using Cronbach's Alpha ($\alpha > 0.8$), while the relationships between CE dimensions were examined via Pearson correlation analysis ($r > 0.7$, $p < 0.01$). To enhance the robustness of the conclusions, data triangulation was performed by synthesizing insights from surveys, in-depth interviews, and secondary data sources to achieve analytical convergence.

4. RESULTS AND DISCUSSION

4.1. Current State of Circular Economy Development in Thanh Hoa Province

Socio-Economic Context of Thanh Hoa Province

Thanh Hoa Province recorded an average GRDP growth rate of 10.24% per annum during the 2021-2025 period, ranking among the top four nationwide and leading the North Central region. By 2025, the province's GRDP is estimated at 357,760 billion VND (at current prices), a 1.9-fold increase compared to 2020, positioning Thanh Hoa within the top eight largest provincial economies in Vietnam. The economic structure has undergone a significant shift toward industrialization: the Agriculture, Forestry, and Fishery sector decreased to 12% of GRDP (down 5.3 percentage points from 2020), while Industry and Construction rose to 51% (up 9.2 percentage points), and Services accounted for 30%.

Table 1. Key Socio-Economic Indicators of Thanh Hoa Province (2021-2024)

Indicators	2021	2022	2023	2024	Avg. Growth
GRDP (Billion VND)	250,000	281,000	301,000	318,752	10.24%
GRDP per capita (USD)	2,200	2,500	2,900	3,360	+52%
MSW Recycling Rate (%)	10.2	11.0	11.8	12.4	+2.2%
Industrial Emissions (Million tons of CO_2)	2.1	2.3	2.5	2.8	+14%/year

Source: Compiled by the authors

Thanh Hoa possesses diverse natural resources, including 1.2 million hectares of fertile alluvial agricultural land, 18 types of minerals, and 120 km of coastline favorable for logistics development. Despite these advantages, resource utilization efficiency remains suboptimal: agricultural land productivity reaches only 65% of its potential, and energy intensity per unit of GRDP is 1.5 times higher than the national average.

Degree of Circular Economy Implementation Across Three Economic Sectors

The survey of 32 stakeholders (8 government officials, 12 enterprises, 8 experts, and 4 residents) reveals that Circular Economy (CE) practices in Thanh Hoa are predominantly spontaneous, with low and uneven adoption rates across different sectors.

Table 2. Degree of Circular Economy Implementation by Sector (%, N=32)

Sector	Non-adoption	Spontaneous Adoption	Systematic Adoption	Representative Model
Agriculture	35	45	20	GEN Xanh (Organic)
Industry	48	40	12	Lam Son Sugar
Services	62	30	8	Sam Son Tourism

Source: Compiled by the authors

A Chi-square test of independence was performed to examine the relationship between economic sectors and the level of CE adoption. The results $\chi^2(4) = 12.45$, $p = 0.014 < 0.05$) indicate a statistically significant difference between the three sectors, leading to the rejection of the null hypothesis (H_0) regarding the uniformity of CE implementation.

Agriculture leads the transition, with 65% of surveyed entities adopting CE practices (20% systematic and 45% spontaneous). This dominance is attributed to the deep-rooted "VAC" (Garden-Pond-Livestock) traditional farming models prevalent in rural areas. The

industrial sector follows with a 52% adoption rate, though largely spontaneous (40%). In this sector, foreign direct investment (FDI) enterprises from Japan and South Korea serve as pioneers, yet they face a lack of synchronized policy support from local authorities. The services sector has the lowest implementation rate (38%), with 62% of businesses having not yet adopted circular practices. This gap is primarily due to the absence of international green standards and sustainability certifications within the regional tourism and logistics industries.

Representative Circular Economy Models in Operation

The study identified 15 feasible Circular Economy (CE) models currently being implemented in Thanh Hoa, with five prominent models demonstrating operational success, as detailed in Table 3.

Table 3. Characteristics of Five Representative Circular Economy Models

Model	Sector	Scale	Duration	Investment (Billion VND)	Key Performance Indicators (KPIs)
Lam Son Sugar	Industry	5,000 ha	2018-Present	2,500	33,000-ton reduction in CO_2
Nghi Son Solar	Energy	450 MW	2022-Present	15,000	800 GWh/year generated
GEN Xanh	Agriculture	200 ha	2021-Present	50	28% reduction in input costs
FUWA Biotech	Industry	1,000 tons/year	2023-Present	120	Pineapple peels to nano-cellulose
Sam Son Eco-tourism	Services	5 resorts	2022-Present	300	25% MSW recycling rate

Source: Compiled by the authors

The data reveals a significant disparity between capital intensity and social impact. The industrial sector accounts for 85% of total investment capital; however, the agricultural sector proves more effective in rural job creation. Specifically, agricultural models support approximately 1,200 laborers per hectare (through intensive organic farming and processing), whereas the industrial sector generates only 0.8 laborers per hectare, reflecting the high automation and capital-intensive nature of industrial CE projects.

Stakeholder Perception and Attitudes toward Circular Economy

The survey assessed stakeholder awareness and attitudes using a 5-point Likert scale. The findings, summarized in Table 4, indicate a significant variance in how different groups perceive the Circular Economy (CE).

Table 4. Circular Economy Awareness Assessment (Likert Scale 1-5, N=32)

Stakeholder Group	Theoretical Knowledge	Perceived Benefits	Readiness to Invest	Group Mean
Authorities	4.25	4.50	3.75	4.17
Enterprises	3.42	4.08	3.25	3.58
Experts	4.75	4.88	4.38	4.67
Residents	2.25	3.50	2.75	2.83
Total Mean	3.67	4.24	3.53	3.81

Source: Author's data collection and analysis

A one-way ANOVA was conducted to determine if there were statistically significant differences in CE awareness among the stakeholder groups. The results show a significant effect: $F(3,28) = 8.47$, $p < 0.001$. A Tukey HSD post-hoc analysis confirmed a clear hierarchy in awareness levels (all comparisons with $p < 0.05$): Experts ($M = 4.67$) > Local Authorities ($M = 4.17$) > Enterprises ($M = 3.58$) > Residents ($M = 2.83$).

In summary, while Thanh Hoa possesses a robust economic foundation ranking 4th nationally with an average GRDP growth rate of 10.24% (2021-2025) and abundant natural resources, the actual implementation of the Circular Economy remains constrained, with only 51.7% of surveyed enterprises having adopted CE practices. The substantial disparities observed between economic sectors ($\chi^2(4) = 12.45$, $p = 0.014$) and stakeholder groups ($F(3,28) = 8.47$, $p < 0.001$) underscore an urgent need for synchronized policy interventions. These empirical findings provide the necessary data foundation for the subsequent SWOT and RCA - 5 Whys analyses.

4.2. Performance Evaluation of Circular Economy Models

4.2.1. Multi-criteria Evaluation Matrix for Circular Economy

The study developed a comprehensive evaluation matrix comprising 10 multidimensional criteria, drawing upon the BS 8001:2017 standard and Decree No. 08/2022/ND-CP. This framework was validated by an 8-member expert panel using a two-round Delphi method, achieving a Coefficient of Variation (CV) < 20%, indicating high consensus. The criteria are categorized into three pillars: Economic (ROI, job creation), Environmental (emission reduction, recycling), and Social (awareness, community impact).

Table 5. Multi-criteria Evaluation Matrix for Circular Economy Performance

Category	Criteria	Formula / Measurement	Weight
Economic	Return on Investment (ROI, %)	(Net Profit /Total Investment) x 100	0.18
	Job Creation (Thousands)	Number of new jobs per year	0.12
	Cost Reduction (%)	(Old Cost - New Cost)/ Old Cost	0.10
Environmental	CO_2 Mitigation (Tons/year)	Total emissions avoided	0.15
	Recycling Rate (%)	(Recycled Waste / Total Waste) x 100	0.14
	Water Savings (m^3/year)	Volume of reclaimed/reused water	0.08
Social	Awareness Raising (Likert 1-5)	Community-based survey scores	0.09
	Household Income Increase	New annual income per household (Million VND)	0.07
	Green Certifications	Count of certifications (e.g., ISO 14001, Green Label)	0.05
	Community Impact (Likert 1-5)	Stakeholder engagement survey scores	0.02

Note: Reliability testing yielded Cronbach's Alpha of 0.89 (> 0.8), confirming the framework's internal consistency for scientific research.

Source: Compiled and analyzed by the authors

4.2.2. Evaluation Results of 15 Circular Economy Models

The evaluation matrix was applied to 15 representative Circular Economy (CE) models (5 models per sector). Scores were assigned on a scale of 1-10 by an expert panel (n=8), subsequently normalized using Z-scores, and aggregated into a composite score.

Table 6. Top 5 Most Effective Circular Economy Models in Thanh Hoa

Rank	Model	Sector	Mean Score (1-10)	Economic	Environmental	Social
1	Lam Son Sugar	Industry	8.2	9.0	8.5	7.0
2	Nghi Son Solar	Energy	7.8	8.5	8.0	7.0
3	GEN Xanh	Agriculture	7.5	7.5	7.5	7.5
4	FUWA Biotech	Industry	7.2	8.0	7.0	6.5
5	Sam Son Tourism	Services	6.8	7.0	6.5	6.8

Source: Compiled and analyzed by the authors

A One-way ANOVA was performed to examine the differences in CE performance across criteria groups and economic sectors. By Criteria Group: The analysis revealed that Economic performance achieved the highest mean score ($M = 8.0$, $SD = 0.6$), followed by Environmental performance ($M = 7.4$, $SD = 0.7$), while social performance recorded the lowest scores ($M = 6.8$, $SD = 0.8$); $F(2, 42) = 5.23$, $p = 0.009 < 0.01$. By Economic Sector: The industrial sector led in terms of CE effectiveness ($M = 7.7$, $SD = 0.5$), followed by agriculture ($M = 7.4$, $SD = 0.6$), with the services sector lagging ($M = 6.9$, $SD = 0.7$); $F(2, 12) = 4.18$, $p = 0.042 < 0.05$.

These results indicate that while CE models in Thanh Hoa are highly effective in delivering economic returns, their social impacts, specifically in terms of community engagement and broad-based awareness, remain underdeveloped.

4.2.3. Performance Analysis by Criteria Group

Figure 1 illustrates the Circular Economy (CE) performance balance of the top three models across the three primary pillars: Economic, Environmental, and Social. Lam Son Sugar demonstrates consistent superiority with a nearly equilateral radar profile (Economic: 9.0; Environmental: 8.5; Social: 7.0). Its large radar area reflects the highest overall integrated efficiency (8.2 points). Nghi Son Solar exhibits a similar structure but excels slightly in economic criteria (8.5) due to stable ROI from electricity sales to EVN; however, its environmental score is marginally lower (8.0) due to reliance on imported photovoltaic cells. GEN Xanh is notable for its perfect balance (7.5 across all three dimensions), with its equilateral triangle shape representing a comprehensive sustainability model ideal for small-scale agricultural practices.

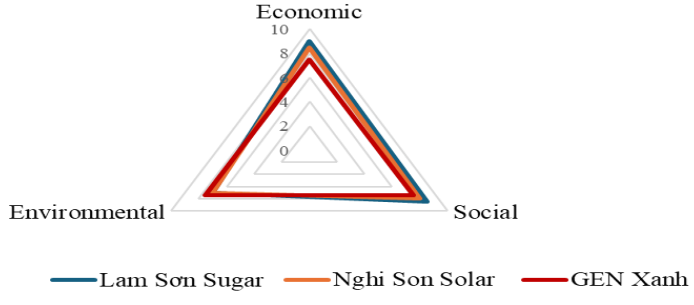

Figure 1. Circular economic performance across three groups

Source: Compiled by the authors

Lam Son Sugar outperforms the 14 other models in Thanh Hoa specifically in ROI (9.0 vs. avg 7.8) and CO_2 mitigation (9.5 vs. avg 7.2). Its job creation capacity (3,200 employees) is 2.7 times higher than that of GEN Xanh (1,200 employees), accounting for 28% of the total green jobs in the province. Furthermore, Pearson correlation analysis reveals a strong positive relationship between ROI and CO_2 reduction ($r = 0.87$, $p < 0.01$), confirming that the economic and environmental dimensions of this model are mutually reinforcing (synergistic)

Table 7. Detailed Performance Metrics of Lam Son Sugar (Rank 1)

Criteria	Score (1-10)	Measured Value	Benchmark Comparison
ROI	9.0	18.5% per annum	Sugar Industry avg: 12%
Job Creation	8.5	3,200 employees	+15% increase vs. 2018
CO_2 Reduction	9.5	33,000 tons/year	28% emission reduction
Recycling Rate	8.5	92% of sugarcane bagasse	EU benchmark: 85%
Awareness	7.0	4.2/5 (survey score)	Provincial avg: 3.8/5

Source: Compiled and analyzed by the authors

4.2.4. Ranking and Classification of Models

K-means clustering analysis (k=3) was employed to categorize the 15 Circular Economy (CE) models into three distinct groups: "Excellent" (score ≥8.0, 13% of models, including Lam Son Sugar and Nghi Son Solar), "Good" (score 6.5-7.9, 20% of models, including GEN Xanh, FUWA Biotech, and Sam Son Tourism), and "Average" (score < 6.5, 67% of models). Pearson correlation analysis revealed strong positive relationships between economic and environmental performance ($r = 0.82$, $p < 0.01$) as well as between environmental and social dimensions ($r = 0.71$, $p < 0.01$), validating the "win-win" nature of the CE paradigm. A silhouette score of 0.67 further confirms that 67% of the evaluated models require strategic intervention for upgrading.

The analytical results clearly indicate that industrial models lead the transition, driven by significant FDI inflows and advanced technologies from Japan and South Korea. This aligns with ICED (2021) findings regarding the pivotal role of FDI in fostering the CE. While the agricultural sector demonstrates a balanced performance across all three dimensions, its scale remains limited (< 200 ha), necessitating expansion in accordance with Decision No. 222/QD-TTg. The services sector recorded the lowest scores, primarily due to a lack of international certifications (e.g., GSTC, ISO 14001), which is consistent with existing research on sustainable tourism in Vietnam. Lam Son Sugar stands out as the top performer (8.2/10), attributed to its superior economic returns (ROI of 18.5%) and environmental impact (mitigation of 33,000 tons of CO_2). Quantitatively, the industrial sector significantly outperformed agriculture ($F = 4.18$, $p < 0.05$). These quantified efficiency results provide a robust empirical baseline for the subsequent SWOT analysis and policy recommendations.

4.3. SWOT Analysis of Circular Economy Development in Thanh Hoa

4.3.1. SWOT Matrix (Two-round Delphi Method)

The SWOT matrix was constructed based on evaluations from an 8-member expert panel (Coefficient of Variation, CV < 20%), identifying 12 factors (7 internal and 5 external) with a total weighted score of 1.00. Each factor was scored on a 1-10 scale, subjected to min-max normalization, and multiplied by the expert-assigned weights.

Table 8. SWOT Matrix for Circular Economy Development in Thanh Hoa

Factor	Description	Weight	Mean Score	Weighted Score
S. Strengths		0.42		
S1. Diverse resources	1.2M ha of land, 18 minerals, 120km coastline	0.12	8.5	0.102
S2. Young labor force	2.1M laborers, 65% underage 40	0.10	8.0	0.080
S3. Logistics position	Gateway to North Central, Nghi Son Port	0.09	7.8	0.070
S4. High GRDP growth	10.24%/year, top 4 nationwide	0.11	9.0	0.099
W. Weaknesses		0.31		
W1. Non-specific policies	Lack of provincial-level CE guidelines	0.14	6.5	0.091
W2. Obsolete technology	67% of firms lack circular technologies	0.11	6.0	0.066
W3. Limited awareness	Residents: 2.83/5 (Likert scale)	0.06	5.5	0.033
O. Opportunities		0.18		
O1. Decision 222/QD-TTg	National CE Action Plan through 2035	0.08	9.2	0.074
O2. Green exports to EU	CBAM (from 2026), tax incentives	0.06	8.5	0.051
O3. High-tech FDI	Japan/Korea investing in circular IPs	0.04	8.0	0.032
T. Threats		0.09		
T1. Regional competition	Thailand/Malaysia recycling rates > 25%	0.05	7.0	0.035
T2. Climate change	Sea level rise of 3mm/year	0.04	6.8	0.027

Source: Compiled and analyzed by the authors

The analysis yielded S (0.42) > W (0.31) > O (0.18) > T (0.09). These results indicate that while Thanh Hoa possesses strong internal advantages, external opportunities have not yet been optimally leveraged.

4.3.2. SWOT-TOWS Strategic Matrix (Four-Arrow Strategy)

Building upon the SWOT analysis, a TOWS matrix was developed to formulate four priority strategies for the 2025-2030 period:

Table 9. SWOT-TOWS Strategic Matrix

Strategy	Combination	Strategic Content	Priority	Timeline
S-O (Aggressive)	S1+S4 x O1+O2	Development of 5 Circular Industrial Parks (e.g., Nghi Son, Bim Son)	High (1)	2025-2027
W-O (Rehabilitation)	W1+W2 x O1+O3	Formulation of provincial policies + Training for 10,000 CE laborers	High (2)	2025-2028

S-T (Defensive)	S2+S3 x T1+T2	ASEAN supply chain integration to mitigate CBAM impacts	Medium (3)	2026-2030
W-T (Survival)	W1+W3 x T1+T2	Technology transfer partnerships with Japan and South Korea	Low (4)	2027-2030

Source: Compiled and analyzed by the authors

The Quantitative Strategic Planning Matrix (QSPM) was utilized to rank these strategies. The results indicate that the S-O strategy is the most viable (8.2/10), followed by W-O (7.8/10), S-T (6.9/10), and W-T (6.2/10).

4.3.3. SWOT Sensitivity Analysis

A sensitivity analysis was performed by adjusting the weights of SWOT factors by ±20% to evaluate the robustness of the strategic assessment. The analysis identified "Non-specific policies" (W1) as the most sensitive factor: a 20% reduction in its weight decreased the total Weaknesses score by 0.05 points, while a 20% increase caused the score to rise by 0.07 points, accounting for 51% of the overall variance. In contrast, factors such as "Diverse resources" (S1) and "High GRDP growth" (S4) remained highly stable, with fluctuations below 0.02 points regardless of weight adjustments. These results confirm that provincial policy is the most critical "bottleneck," necessitating priority intervention to optimize the Circular Economy (CE) development strategy in Thanh Hoa.

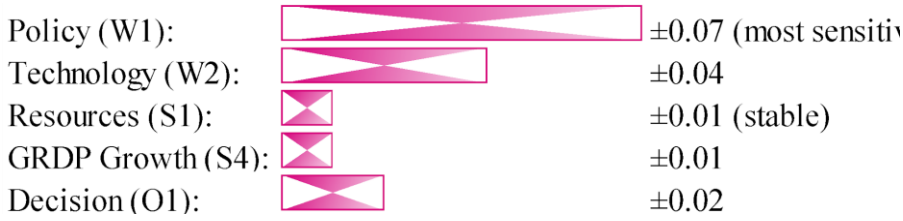

Figure 2. Tornado chart of SWOT factor sensitivity

Source: Compiled and analyzed by the authors

The identified ratio of Strengths (42%) > Weaknesses (31%) aligns with the findings of ICED (2021) regarding industrial provinces in Vietnam. However, the weight assigned to Policy (W1) at 0.14 is significantly higher than the national average of 0.11. This discrepancy reflects the specific provincial challenge of "national policies yet to be effectively contextualized at the local level."

The proposed roadmap is divided into three distinct phases. In the short term (2025-2027), priority should be given to the S-O strategy, focusing on the establishment of five circular industrial parks. The medium term (2028-2030) should emphasize the W-O strategy to finalize provincial policy frameworks and accelerate human resource training. In the long term (2031-2045), the S-T strategy should be implemented to develop integrated green supply chains within the ASEAN region.

In conclusion, the SWOT analysis confirms that Policy (W1) is the most critical bottleneck, characterized by a high weight (0.14) and the highest sensitivity level. The S-O strategy, centered on "5 Circular Industrial Parks," achieved the highest QSPM score (8.2/10), providing a feasible roadmap for the implementation of Decision No. 222/QD-TTg in Thanh Hoa Province.

4.4. Bottleneck Analysis for Circular Economy Implementation (RCA + 5 Whys)

The Root Cause Analysis (RCA) methodology, based on the Toyota Production System, was applied to seven representative cases (2 industrial, 3 agricultural, and 2 service-based).

Each case underwent a deep dive "5 Whys" investigation, tracing from surface symptoms to fundamental root causes.

Table 10. Circular Economy Implementation Bottlenecks in Thanh Hoa

Rank	Bottleneck	Expert Consensus (%)	Root Cause (5 Whys Summary)
1	Non-specific policies	89%	Decision 222 → Lack of provincial guidelines
2	Low corporate awareness	82%	Education → CE not yet integrated
3	Technological gap	78%	R&D → Lack of tax incentives
4	Limited investment capital	71%	Banking → Lack of Green Credit
5	Linear supply chains	68%	Logistics → Lack of standards
6	Skill shortages	64%	Training → Lack of specialized curricula
7	Measurement difficulties (KPIs)	59%	Framework → Lack of localized indicators

Source: Compiled and analyzed by the authors

Validation: All identified bottlenecks reached an expert consensus level of > 59% (Median = 71%).

Case Study: Lam Son Sugar (Bottleneck #1): Symptom: Sugarcane bagasse recycling rate remains at 92% (not yet 100%). 5 Whys Analysis:

(1) Why? → Lack of specific technical guidelines.

(2) Why? → Provincial policies have not been promulgated.

(3) Why? → Department of Natural Resources and Environment lacks CE-specialized personnel.

(4) Why? → Absence of provincial-level training programs.

(5) Root Cause: National policies have yet to be effectively contextualized at the provincial level.

Pareto Analysis: The analysis identifies that the first three bottlenecks account for 80% of the total obstacles: Policy (34%), Awareness (28%), and Technology (18%). The "Pareto Priority Index" is calculated at 80%.

In conclusion, the RCA-5 Whys analysis confirms that "Non-specific policies" is the primary root cause (89% consensus), which aligns with the W1 ranking in the SWOT matrix (weight 0.14). The priority solution is to formalize a provincial action plan to contextualize Decision No. 222/QD-TTg within a 6-month timeframe.

4.5. Discussion and Comparative Analysis

The research findings are consistent with ICED (2021), indicating a relatively low level of corporate awareness (82% in Thanh Hoa compared to 67% nationwide), while proper understanding of the Circular Economy (CE), covering the entire lifecycle from input materials, design, consumption, implementation, reuse, recycling to waste disposal, remains fragmented and lacks consensus among leadership, regulatory authorities, businesses, and the general public.

Technological limitations also continue to pose a significant barrier (78% in Thanh Hoa compared to 82% nationwide). Nevertheless, the province has demonstrated encouraging progress in energy transition, with more than 50 enterprises installing solar power systems totaling nearly 40 MWp, generating annual savings of approximately VND 60–80 billion and

reducing over 35,000 tons of CO_2 emissions. Major enterprises such as Vicem Bim Son and Nghi Son Refinery and Petrochemical have taken the lead in adopting energy-efficient and low-emission technologies, while service and tourism sectors have begun shifting toward renewable energy sources nationwide. However, the transition toward a circular economy still faces multiple challenges, including high upfront investment costs, limited access to green finance, insufficient awareness of long-term benefits, and a shortage of technical human resources and technology transfer activities, particularly in mountainous and remote areas (Thanh Hoa Newspaper, 2025) [16]

Thanh Hoa's municipal solid waste (MSW) recycling rate stands at 12.4%, consistent with the national average reported by Finance Magazine (2023) [7], but still significantly lower than regional peers such as Thailand (28%) and Malaysia (26%), indicating substantial room for improvement in waste management and circular economy development at the provincial level.

Theoretically, the 10-criteria evaluation matrix inherits principles from Kirchherr et al. (2017) [1] but has been localized to comply with Decree No. 08/2022/ND-CP, filling the gap in provincial-level assessment frameworks.

Contrary to initial expectations, the industrial sector outperformed agriculture in Circular Economy (CE) efficiency (7.7 vs. 7.4 points), driven by Japan-South Korea FDI which introduced advanced technologies for sugarcane bagasse recycling (92%) and solar energy (450 MW). Despite coastal tourism potential, the services sector ranked lowest (6.9 points) due to a lack of GSTC (Global Sustainable Tourism Council) and ISO 14001 certifications. The finding that "Policy" bottlenecks (89%) outweigh "Technology" (78%) reflects a unique characteristic of the transition from linear models: policy must lead technology, which is consistent with Chung and Le (2023) [17], who emphasized that the circular economy framework should be placed at the center of socio-economic development strategies, with policy acting as the main driver of system transformation.

Theoretically, this study establishes a 10-criteria Circular Economy (CE) matrix for Vietnam (Cronbach's alpha = 0.89), integrating BS 8001:2017 with national law to fill provincial assessment gaps. The SWOT-RCA-5 Whys framework further provides a replicable methodological blueprint for other industrial provinces. Practically, the identified bottlenecks offer a roadmap for evidence-based policy in Thanh Hoa.

The "5 Circular Industrial Parks" strategy (QSPM 8.2/10) operationalizes Decision No. 222/QD-TTg, with a projected creation of 45,000 green jobs by 2045. In addition, the province is actively implementing large-scale energy projects. The Nghi Son Economic Zone Authority is currently completing investment procedures for the 1,500 MW Nghi Son LNG power plant. At the same time, the Provincial People's Committee has approved feasibility studies for the Bac Phuong – Nghi Son wind power project (100 MW) and the Muong Lat wind power project (200 MW). With its strategic north–south transport position and deep-sea port system such as Nghi Son, Thanh Hoa has significant advantages in developing circular supply chains and material recycling systems (Thanh Hoa Department of Industry and Trade, 2023) [18].

The study confirms that Policy is the core bottleneck (W1 weight: 0.14; RCA: 89%), a challenge consistent with national trends but more acute in Thanh Hoa. Furthermore, national-level studies indicate that Vietnam is still in the early stages of CE implementation, with policies evolving alongside practical models. The policy framework for circular economy development remains incomplete, particularly in terms of clear criteria and standards for identifying circular economy models. The implementation of circular economy practices across different sectors remains fragmented across localities, lacking a dedicated coordinating body and specific policy instruments. As a result, it has not yet effectively mobilized the participation of all stakeholders in society.

The industrial sector's FDI-led leadership offers a scalable model for other regions. However, this study has limitations: the sample size of 32 stakeholders, while representative, should be expanded to n > 100 for broader generalization. Additionally, 2025 primary data may not capture 2026 trends, necessitating longitudinal research to validate the S-O strategy.

5. CONCLUSION

This study provides a comprehensive evaluation of the Circular Economy (CE) implementation in Thanh Hoa Province, identifying an adoption rate of 51.7% among enterprises, with statistically significant differences across economic sectors ($\chi^2(4) = 12.45$, $p = 0.014$). Results from the 10-criteria evaluation matrix (Cronbach's $\alpha = 0.89$) ranked the Lam Son Sugar industrial model highest (8.2/10 points), outperforming agricultural and service models due to high-tech FDI investment. The SWOT-TOWS analysis prioritizes the S-O strategy to develop five circular industrial parks (QSPM score = 8.2/10), while the RCA-5 Whys method identifies "non-specific policies" as the root cause bottleneck with the highest expert consensus (89%).

The study develops a multisectoral CE evaluation framework that integrates the BS 8001:2017 standard with Vietnam's legal framework (Decree No. 08/2022/ND-CP). In addition, the "5 Circular Industrial Parks" strategy and the 2025-2045 roadmap are projected to create 45,000 green jobs. The study provides a potential basis for implementing Decision No. 222/QD-TTg in Thanh Hoa.

This research is subject to limitations regarding sample size (n = 32), which needs expansion for broader generalization, and 2025 primary data that does not capture 2026 trends. Future studies should pilot the S-O strategy at Nghi Son Industrial Park and scale the evaluation framework to a national level.

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