JOURNAL OF MATERIALS & CONSTRUCTION
Journal of Materials and Construction
ISSN 2734-9438
Website: www. jomc.vn

Developing a multi-tiered decision-making framework for screening FDI construction projects in Vietnam: Integrating lean, green, and circular approaches toward Net-Zero 2050

Nguyen Anh Duc[1*]

[1] Ha Noi University of Civil Engineering

KEYWORDS

Construction projects
Foreign Direct Investment (FDI)
Decision making
Lean construction
Green buildings
Circular economy
Screening
Government supports

ABSTRACT

Vietnam's pledge to attain net-zero emissions by 2050 requires effective strategies to assess the sustainability of foreign direct investment (FDI) construction projects. This study introduces a multi-tiered decision-making framework that integrates lean construction, green building, and circular economy ideas into a unified assessment tool. Eight pilot FDI projects, representing four primary FDI categories: Food & Beverage Processing Facilities, Electronics & Tech Manufacturing Plants, High-Rise Residential/Mixed-Use Buildings, and Commercial/Industrial Parks, are used to deduce weights in multiple linear regression. Three other projects were assessed to verify the framework's prediction precision. Results demonstrate that elevated index scores are associated with enhanced resource efficiency, reduced carbon footprints, and superior waste management techniques. A tier classification system (Platinum, Gold, Silver, Bronze) provides explicit benchmarks for politicians and investors, aiding in the allocation of incentives and promoting ongoing enhancement. This approach customizes lean, green, and circular tactics to local contexts, aligning foreign direct investment projects with Vietnam's decarbonization path and offering a pragmatic model for evaluating construction proposals in developing countries.

1. Introduction

Construction is pivotal in worldwide resource utilization and greenhouse gas (GHG) emissions, highlighting its essential significance in climate change mitigation. The swift industrial and urban expansion in Vietnam, driven by Foreign Direct Investment (FDI), amplifies the sector's impact on the country's energy landscape [1]. Although Vietnam has pledged net-zero emissions by 2050, existing mechanisms to screen FDI construction proposals often fail to adopt a holistic sustainability perspective [2]. Evaluations typically focus on short-term economics or basic environmental compliance, with insufficient attention to lean construction methods, green building standards, and circular economy principles promoting material reuse and minimized waste.

This study addresses these gaps by developing a comprehensive framework that unifies lean, green, and circular approaches into a single decision-making tool for FDI construction projects. Developed from empirical data from pilot case studies, surveys, and expert consultations, the framework organizes sustainability factors into sub-types-such as food and beverage processing, electronics manufacturing, high-rise residential, and commercial or industrial parks-each reflecting distinct operational priorities. These sub-types inform a multi-tiered scoring system that integrates coefficients derived from multiple linear regression (MLR) and expert review. The system both quantifies a project's life-cycle efficiency and environmental impact potential and enables policymakers to link incentives directly to performance tiers, thereby encouraging proposals better aligned with Vietnam's net-zero objectives.

The framework incorporates lean, green, and circular components, encompassing interconnected facets of operational efficiency, resource conservation, and material life cycles. It thus provides a unique and empirically based screening strategy tailored to the changing dynamics of Vietnam's building industry. This research underscores the potential of organized, evidence-based evaluation techniques to direct foreign direct investment towards more sustainable trajectories in emerging economies seeking substantial carbon reductions.

2. Literature Review

Decarbonizing the construction industry has emerged as a priority for countries striving to reduce GHG emissions, given that buildings and infrastructure account for a substantial portion of global energy consumption and carbon outputs [3]. Many advanced economies have introduced green certifications, stricter building codes, and financial incentives aimed at lowering the embodied and operational carbon in new developments [4], [5], [6], [7], [8]. However, in emerging contexts such as Vietnam, accelerating urban growth and industrialization can overwhelm nascent regulatory measures, making it difficult to implement comprehensive decarbonization strategies without systematic screening tools [1], [2].

Lean construction

Lean construction ideas, mostly sourced from lean manufacturing,

*Corresponding author: ducna@huce.edu.vn

Received 12/03/2025, explanation 20/04/2025, accepted 21/04/2025
Link DOI: https://doi.org/10.54772/jomc.v15i01.866

focus on the continuous eradication of waste and the enhancement of value throughout the project life cycle [9]. Prevalent topics in lean construction encompass process flow optimization, defect reduction, and just-in-time (JIT) deliveries, all aimed at enhancing efficiency and minimizing rework [9], [10]. In reality, lean techniques have proven effective in reducing material waste and cost overruns on building projects; yet, their general implementation in Vietnam remains inconsistent [1]. An expanding corpus of literature indicates that the implementation of lean approaches can markedly decrease resource utilization [4], although additional empirical evidence is required to validate these conclusions across diverse categories of foreign-invested projects.

Sustainable architecture

Green building has emerged as a central theme in sustainable construction research [5], with rating systems such as LEED [11], EDGE [12], and regionally tailored frameworks (for instance, LOTUS in Vietnam [13]) shaping design criteria. Fundamental attributes of green buildings encompass improved energy efficiency, water conservation, utilization of low-impact materials, and the promotion of healthier indoor environments [13]. Research indicates that green-certified buildings frequently achieve operational savings in energy and water use, along with enhanced occupant well-being [14]. Nonetheless, expenses associated with certification processes and the notion of prolonged payback periods persist in obstructing widespread adoption in Vietnam. Current legislative measures seek to enhance the use of green building methods; however, a unified framework for integrating green criteria with other sustainability aspects is yet inadequately developed [6].

Circular economy in the construction sector

Circular economy strategies in construction aim to maintain material value through reuse, recycling, and regeneration processes, as opposed to linear models that culminate in disposal [15]. Global literature has recognized techniques like planning for disassembly, enhancing high-value material recovery networks, and establishing closed-loop supply chains that reintegrate building and demolition waste into manufacturing [3]. Although circular concepts have gained prominence in several industrial parks in Vietnam, the inadequate availability of dependable recycling infrastructure and stakeholder knowledge continues to be a substantial obstacle [1]. Integrating circular concepts into initial project evaluations may facilitate wider adoption by recognizing and incentivizing ideas that exhibit closed-loop potential [16].

Table 1 provides a comprehensive compilation of sub-factors extracted from the literature. These considerations influence the indices and weighting methodologies of the succeeding framework.

Foreign direct investment has been crucial in developing Vietnam’s construction and industrial industries, with substantial multinational projects providing both finance and technological proficiency [2]. However, not all foreign direct investment initiatives prioritize sustainability, and local authorities lack a unified framework to evaluate bids based on criteria that exceed basic regulatory compliance [1]. Current research highlights the importance of integrating sustainability criteria into foreign direct investment approvals; nevertheless, it seldom examines the potential for amalgamating lean, green, and circular elements into a singular evaluative framework. This disparity is especially pronounced in Vietnam, which contends with escalating construction activity amidst constrained resources and rapidly changing environmental restrictions.

An examination of pertinent literature on lean construction, green building, circular economy, and foreign investment reveals that a cohesive strategy may more efficiently achieve decarbonization objectives [3]. Although current research has demonstrated limited successes of each feature alone, few studies have comprehensively integrated these principles into a cohesive screening framework for FDI-driven development. The disparity between the swift expansion of Vietnam's building output and the lack of comprehensive sustainability evaluations constitutes a significant challenge. This study seeks to fill the existing gap by creating and validating a decision-making framework that systematically evaluates lean, green, and circular elements in foreign direct investment construction projects, thereby providing a pathway for regulators, investors, and other essential players.

Table 1. Consolidated Lean, Green, and Circular Sub-Factors from Literature.

Principle	Sub-Factors	Key References
Lean construction	Process Flow Efficiency; JIT Delivery; Defect Reduction; Construction Timeline Adherence; On-Site Waste Recycling; Modular Methods; Resource Planning & Mapping	[4], [5], [9], [10], [17]
Green buildings	Energy Efficiency; Water Consumption & Recycling; Insulation & Cooling Systems; Indoor Environmental Quality; Renewable Energy Integration; Stormwater Management	[5], [6], [11], [12], [13], [14]
Circular economy	Design for Disassembly; Material Recovery; E-Waste Take-Back; Organic Waste Valorization; Packaging Circularity; Post-Occupancy Recycling; Shared Resource Looping	[3], [7], [8], [15], [16], [18], [19]

3. Methodology

This study employs a mixed-methods approach to develop and test a decision-making framework for assessing FDI construction projects in Vietnam through a lean, green, and circular lens. The technique consists of three fundamental stages: selecting representative pilot projects, performing quantitative and qualitative data gathering, and employing MLR to ascertain sub-factor weights for each project sub-type.

A total of eight pilot FDI projects were selected to represent the diversity of Vietnam’s construction sector, specifically focusing on four subcategories: (1) Food & Beverage (F&B) Processing Facilities, (2) Electronics & Technology Manufacturing Plants, (3) High-Rise Residential Buildings, and (4) Commercial or Industrial Parks (IP). Two specimens were selected for each sub-type, guaranteeing an equilibrium of geographic distribution and operational maturity. Table 2 encapsulates these eight pilot projects, detailing their locations, operational years, and significant sustainable attributes. Documentation for each pilot project-including feasibility studies, pro forma designs, and environmental impact assessments-was compiled, along with available operating metrics such as energy usage, waste management records, and resource recovery data.

Simultaneously with the selection of the pilot project, a methodical data collection initiative was conducted. A systematic survey was conducted with a sample of 95 participants, including FDI developers and managers, government officials, local contractors, and academic specialists. Each participant evaluated a set of sub-factors associated with lean construction, green building, and circular economy principles using a five-point importance scale. The survey solicited feedback on perceived obstacles, policy assistance, and expected financial repercussions. Semi-structured interviews were performed with a subset of stakeholders to complement these quantitative insights, providing deeper perspectives on context-specific implementation issues and accomplishments.

Descriptive statistics for the sub-factors, as shown in Table 3, reveal the relative importance participants assigned to concepts such as process flow efficiency, energy efficiency, and design for disassembly. The mean relevance ratings often varied from the mid-3s to upper 4s, reflecting a broad recognition of these principles as vital to sustainable construction, but also demonstrating heterogeneity in their perceived significance in practical applications. The standard deviation and coefficient of variation indicated a notably high variability in organic waste valorization and design for disassembly, aligning with interview findings that these measures are less standardized in Vietnam compared to JIT delivery or energy efficiency benchmarks.

Table 2. Overview of Eight Pilot FDI Projects.

Project Code	Sub-Type	Location	Operational Status	Key Sustainability Features
P1	F&B Facility	Hung Yen IP	Operating 3+ years	Water reuse system, moderate waste reduction
P2	F&B Facility	Hanoi IP	Operating 2 years	Lightweight packaging, by-product valorization
P3	Electronics Manufacturing	Bac Ninh IP	Operating 1 year	E-waste aggregator, advanced HVAC controls
P4	Electronics Manufacturing	Ho Chi Minh city IP	Operating 2+ years	JIT deliveries, rooftop solar integration
P5	High-Rise Residential	Ho Chi Minh city	Near full occupancy	Prefab slabs, partial green facade
P6	High-Rise Residential	Ho Chi Minh city	80% occupancy	Rainwater harvesting, insulation upgrades
P7	Commercial/Industrial Park	Binh Duong IP	Operating 3 years	Central recycling facility, shared resource loop
P8	Commercial/Industrial Park	Hai Phong IP	Operating 1+ years	Modular construction, stormwater management

Table 3. Descriptive statistics for key Lean, Green, and Circular sub-factors ($n = 95$).

Sub-Factor	Mean	SD	CV
Process Flow Efficiency (Lean)	4.3	0.8	0.19
JIT Delivery (Lean)	4.2	0.7	0.17
Defect Reduction (Lean)	3.9	1.0	0.26
Energy Efficiency (Green)	4.5	0.6	0.13
Water Consumption & Recycling (Green)	4.3	0.8	0.19
Indoor Environmental Quality (Green)	4.0	1.0	0.25
Renewable Energy Integration (Green)	4.2	0.7	0.17
Design for Disassembly (Circular)	3.8	0.9	0.24
E-Waste Take-Back (Circular)	4.2	0.7	0.17
Organic Waste Valorization (Circular)	3.7	1.1	0.30

The subsequent methodological phase was the application of MLR to the operational performance data of the eight pilot projects, which was normalized into a 0–1 "sustainability outcome" variable. The average survey importance of each sub-factor, verified against project documentation and expert validation, functioned as an independent variable. The resulting model produced standardized regression coefficients (β) that identified the sub-factors with the most significant impact on real-world resource efficiency or carbon reduction. Factors with negligible or insignificant effects were eliminated to prevent model overfitting. After two iterations, each sub-type exhibited an adjusted R^2

ranging from 0.70 to 0.82, indicating that the lean, green, and circular factors jointly accounted for a significant share of variance in project-level results.

A final refinement was conducted by a Delphi-style panel of 10 experts-policy planners, FDI project managers, and academic researchers-who evaluated the regression results and made slight modifications to align with Vietnam-specific conditions. The weighting of water use and recycling in food and beverage establishments was adjusted upward compared to the raw regression, reflecting regional apprehensions of water scarcity in specific regions. The expert-informed modifications guaranteed that the final weighting structure accurately represented empirical relationships while also conforming to practical priorities within Vietnam's policy context. Figure 1 deliniates the research steps in its entirety.

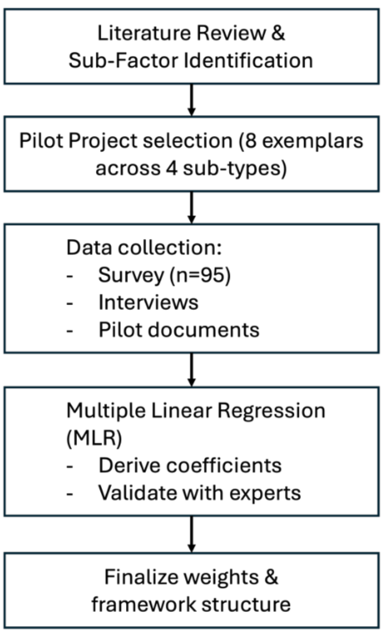

Figure 1. Methodology of the study.

4. Framework Development

The results from the pilot projects, surveys, and expert consultations were amalgamated into a cohesive decision-making framework. The system includes separate indices for Lean, Green, and Circular dimensions, each assigned coefficients (β) obtained and optimized by MLR. Following the delineation of the sub-type classification for FDI building projects, the subsequent steps clarify the development of the MLR models to empirically derive weights for each sub-factor. Sub-Type Classification Foreign Direct Investment construction projects in Vietnam frequently exhibit significant variation in scope and operating requirements. A preliminary scoping examination of domestic and international literature, supplemented by expert panel insights, revealed four primary groups with unique sustainability drivers:

1. Food and Beverage Processing Facilities
2. Electronics and Technology Manufacturing Facilities
3. High-Rise Residential Structures
4. Commercial or Industrial Parks

Each category emphasizes distinct lean, green, and circular sub-factors. For example, a food and beverage facility may have organic waste valorization as a fundamental element, while electronics manufacturing plants are more inclined to emphasize e-waste take-back programs or JIT inventory systems. By categorizing each FDI building proposal according to the sub-type that most accurately represents its functional essence, the framework guarantees that the assessment encompasses the most pertinent design and operational criteria. Identification and Evaluation of Sub-Factors.

Prior to the MLR modeling, the study assembled a comprehensive list of sub-factors derived from literature on lean construction, green building, and circular economy and validated their local significance through surveys (n = 95) and interviews. The sub-factors encompassed themes such as Process Flow Efficiency, Energy Efficiency, Indoor Environmental Quality, and Material Recovery. Each component was evaluated for significance on a five-point scale, and these evaluations informed the first scoring rubrics.

When utilizing the framework for particular projects, evaluators provide a score ranging from 1 to 5 to each pertinent sub-factor (e.g., 1 for minimal or no adoption, 5 for substantial or exemplary adoption). In the initial assessment, these sub-factor ratings generally originate from feasibility studies, Environmental Impact Assessment documents, and pledges made during the design process. Partial or complete operational data (e.g., actual waste logs, energy bills) are utilized to enhance the sub-factor scores whenever feasible. By formalizing this method, the framework attains traceability: each sub-factor score may be linked to evidence from project documentation or site observations.

- Calculation of β Coefficients using Multiple Linear Regression

A fundamental component of this approach is the quantitative assessment of each sub-factor within the Lean, Green, and Circular dimensions. The study employed MLR on data from eight experimental FDI initiatives instead of depending exclusively on expert judgment. The dependent variable for each project was a "Sustainability Outcome" measure, normalized to a range of 0.0–1.0, reflecting its actual operational success in energy savings, waste reduction, or carbon intensity in relation to scale.

The author allocated sub-factor scores for each pilot project based on paperwork and operational evidence. The sub-factor scores functioned as the independent variables in the MLR. The general structure of the regression can be represented as:

$$Sustainability\ Outcome = \beta_0 + \sum_{i=1}^{n} \beta_i \times X_i + \varepsilon \qquad (1)$$

where:

• X_i are the sub-factor scores for Lean, Green, or Circular practices,

• β_i $(for\ i = 1 \dots n)$ are the regression coefficients indicating the relative importance of each factor,

• β_0 is the intercept, and

• ε is the error term.

For each sub-type (F&B, Electronics, High-Rise, Commercial/Industrial Park), a separate regression was performed, using pilot projects that closely aligned with that sub-type's operational characteristics. Factors that were not statistically significant ($p > 0.05$) or yielded negligible standardized coefficients (< 0.10) were excluded in a backward-elimination process to maintain a parsimonious model. The final adjusted $\boldsymbol{R^2}$ values ranged from 0.70 to 0.82 across the four sub-types, indicating that the retained sub-factors collectively explained the majority of variance in the pilot projects' sustainability outcomes.

- Refining Coefficients for Local Context

The MLR results provided a foundational set of coefficients (β) for each sub-factor, while an expert panel significantly contributed to contextual refinement. Certain sub-factors-such as Water Consumption & Recycling in Food and Beverage or Indoor Environmental Quality in High-Rise Structures-experienced minor upward or downward modifications in accordance with local policy goals and practical practicality. If regression analysis revealed that water conservation strategies had a lower coefficient than the panel considered suitable for Vietnam's drought-affected areas, the final weighting was slightly elevated. The panel generally employed consensus-driven dialogue, guaranteeing that the final coefficients corresponded with both empirical data and intricate local factors.

- Composite Score Calculation

The final weighting system for each sub-type converts the sub-factor coefficients into dimension-level weights (Lean, Green, Circular) that exhibit minor variations per sub-type. For example, Food & Beverage facilities may exhibit a {Lean:Green:Circular} ratio of {0.30:0.40:0.30}, whereas an Electronics facility would implement a ratio of {0.35:0.35:0.30}, indicating variances identified in the regression analysis and expert calibrations.

When assessing a particular FDI initiative:

1. Sub-Factor Rating: Each Lean, Green, or Circular sub-factor is assigned a score from 1 to 5 based on the project's design commitments or preliminary operational data.

2. Dimensional Summation: Scores within each dimension (e.g., Lean) are multiplied by their corresponding coefficients and aggregated to create a raw dimension score.

3. Dimension Weighting: The unadjusted dimension score is multiplied by its corresponding dimension-level weight (e.g., 0.30 for Lean in Food and Beverage).

The Composite Index is derived by summing the weighted values of Lean, Green, and Circular metrics to provide a score ranging from 0 to 5, which is subsequently scaled to a range of 0 to 100 by multiplying by 20. The conclusive index establishes the project's tier categorization (Platinum, Gold, Silver, Bronze).

To enhance clarity in policymaking decisions, the study used tier thresholds as outlined below: Platinum: 80–100; Gold: 60–79; Silver: 50–59; Bronze: 30–49. Projects with scores below 30 may necessitate substantial revisions to fulfill basic sustainability criteria. Government entities can incorporate these tiers into incentive frameworks: high-scoring proposals may obtain expedited permits, tax incentives, or technical support, while lower-tier projects are required to amend their design-phase commitments or implement supplementary lean, green, and circular strategies to progress towards a net-zero trajectory. This tiered methodology encourages ongoing enhancement, providing project developers with a clear framework for evaluating their initiatives and striving for elevated sustainability levels.

5. Empirical Testing and Validation

In this step of the study, the empirical testing and validation of the multi-tiered decision-making framework are conducted. Three new FDI construction projects-denoted as V1, V2, and V3-were evaluated using the sub-type–specific indices developed through regression modeling and expert panel input. Each project corresponds to a different sub-type in order to illustrate how lean, green, and circular sub-factors manifest under varied operational contexts.

5.1. Overview of the Three Validation Projects

The first project (V1) is a Food & Beverage (F&B) facility in an industrial zone in Binh Duong. Its feasibility studies proposed fruit pulp reuse and modular piping to minimize resource wastage, with partial operational data supporting the viability of these circular strategies. The second project (V2), located in an industrial zone near Da Nang, focuses on Electronics and Tech Manufacturing and emphasizes JIT supply chains alongside real-time energy management software. The third project (V3) is a High-Rise Residential development on the outskirts of Ho Chi Minh City; although near completion, it has yet to finalize certain occupant-oriented circular measures, such as on-site material recovery options. Table 4 summarizes these key attributes of the validating projects.

5.2. Sub-Factor Ratings and Index Calculations

Following the standardized process introduced previously, each project's lean, green, and circular practices were assessed using nine sub-factors (three per dimension) with regression-derived coefficients. Table 5 and Table 6 detail these sub-factor ratings (on a 1–5 scale), the resulting dimension-level sums, and the final 0–100 composite index. The lean dimension was weighted at 0.30 for V1, 0.35 for V2, and 0.25 for V3, reflecting sub-type–specific outcomes from the MLR on eight pilot projects. The green and circular dimensions similarly varied, with the total dimension score scaled to ensure accurate representation of each sub-type's sustainability priorities.

Similarly, the other two validating projects' scores are presented in shown in Table 6.

Table 4. Summary of the Three New Validation Projects.

Project	Sub-Type	Location	Construction Status	Major Sustainability Commitments
V1	Food & Beverage (F&B)	Binh Duong IZ	~70% Operational	Organic waste valorization, modular piping, water reuse
V2	Electronics & Tech Manufacturing	Near Da Nang city	Partially operational	JIT logistics, energy monitoring software, e-waste aggregator
V3	High-Rise Residential	Thu Duc (HCMC)	~90% completion	LOTUS certification target, occupant recycling, green facade

Table 5. Detailed calculation of project V1's score.

Sub-Factor	Rating	Coefficient	Product (Rating × Coeff.)
Lean Dimension *(Weight = 0.30)*			
1) Process Flow Efficiency	4.2	0.30	4.2 × 0.30 = 1.26
2) JIT Delivery	3.8	0.30	3.8 × 0.30 = 1.14
3) Defect Reduction	3.6	0.40	3.6 × 0.40 = 1.44
Sum of Lean Sub-Factors	-	-	1.26 + 1.14 + 1.44 = 3.84
Weighted Lean = (Sum) × (0.30)	-	-	3.84 × 0.30 = 1.15
Green Dimension *(Weight = 0.40)*			
4) Energy Efficiency	4.2	0.40	4.2 × 0.40 = 1.68
5) Water Consumption & Recycling	4.0	0.30	4.0 × 0.30 = 1.20
6) Indoor Environmental Quality	3.7	0.30	3.7 × 0.30 = 1.11
Sum of Green Sub-Factors	-	-	1.68 + 1.20 + 1.11 = 3.99
Weighted Green = (Sum) × (0.40)	-	-	3.99 × 0.40 = 1.60
Circular Dimension *(Weight = 0.30)*			
7) Organic Waste Valorization (F&B)	4.4	0.30	4.4 × 0.30 = 1.32
8) Packaging / Material Recovery	3.7	0.30	3.7 × 0.30 = 1.11
9) Additional Circular Factor (Post-Occupancy Reuse)	4.1	0.30	4.1 × 0.30 = 1.23
Sum of Circular Sub-Factors	-	-	1.32 + 1.11 + 1.23 = 3.66
Weighted Circular = (Sum) × (0.30)	-	-	3.66 × 0.30 = 1.10
Composite Score (0–5)	-	-	1.15 + 1.60 + 1.10 = 3.85
Final Index (0–100) = (Composite ÷ 5) × 100	-	-	(3.85 ÷ 5) × 100 = 77
Tier Classification	-	-	Gold (60–79)

Table 6. Projects V2 and V3's scores.

V2 (Electronics)		V3 (High-rise)	
Lean Dimension *(Weight = 0.35)*	$Rating \times Coef = Sub - score$	Lean Dimension *(Weight = 0.25)*	
1) Process Flow Efficiency	4.3 × 0.35 = 1.51	1) Process Flow Efficiency	3.8 × 0.25 = 0.95
2) JIT Delivery	4.5 × 0.30 = 1.35	2) JIT Delivery	3.5 × 0.20 = 0.70
3) Defect Reduction	4.0 × 0.35 = 1.40	3) Defect Reduction	3.7 × 0.25 = 0.93
Weighted Lean = (Sum) × (0.35)	4.26 × 0.35 = 1.49	Weighted Lean = (Sum) × (0.25)	2.58 × 0.25 = 0.65
Green Dimension *(Weight = 0.35)*		Green Dimension *(Weight = 0.45)*	
4) Energy Efficiency	4.3 × 0.40 = 1.72	4) Energy Efficiency	4.1 × 0.35 = 1.44
5) Water Consumption & Recycling	3.8 × 0.30 = 1.14	5) Water Consumption & Recycling	3.6 × 0.30 = 1.08
6) Indoor Environmental Quality	3.9 × 0.25 = 0.98	6) Indoor Environmental Quality	3.8 × 0.30 = 1.14
Weighted Green = (Sum) × (0.35)	3.84 × 0.35 = 1.34	Weighted Green = (Sum) × (0.45)	3.66 × 0.45 = 1.65
Circular Dimension *(Weight = 0.30)*		Circular Dimension *(Weight = 0.30)*	

V2 (Electronics)		V3 (High-rise)	
7) E-Waste / Advanced Circular Strategy	4.5 × 0.30 = 1.35	7) Design for Disassembly / Circular Strategy	3.9 × 0.30 = 1.17
8) Packaging / Material Recovery	3.6 × 0.25 = 0.90	8) Packaging / Material Recovery	3.5 × 0.20 = 0.70
9) Additional Circular Factor (e.g., Eco-Industrial Link)	4.2 × 0.30 = 1.26	9) Post-Occupancy Recycling / Reuse	3.8 × 0.25 = 0.95
Weighted Circular = (Sum) × (0.30)	3.51 × 0.30 = 1.05	Weighted Circular = (Sum) × (0.30)	2.82 × 0.30 = 0.85
Composite Score (0–5)	1.49 + 1.34 + 1.05 = 3.88	Composite Score (0–5)	0.65 + 1.65 + 0.85 = 3.15
Final Index (0–100) = (Composite ÷ 5) × 100	(3.88 ÷ 5) × 100 = 78	Final Index (0–100) = (Composite ÷ 5) × 100	(3.15 ÷ 5) × 100 = 63
Tier Classification	Gold (60–79)		Gold (60–79)

5.3. Validation of Results

The final index scores demonstrate the general efficacy of the framework for evaluating FDI projects, with V1 (77) and V2 (78) categorized as Gold, while V3, scoring 63, also falls within the Gold range but at the lower end. A senior official at the Ministry of Planning and Investment stated that these findings underscore the practical significance of lean, green, and circular sub-factors: elevated sub-factor ratings for design-phase commitments often result in substantial resource savings throughout operation. Discussions with local sustainability consultants highlighted that Projects V1 and V2 notably excelled in lean logistics and focused energy management, which significantly enhanced their final results. Simultaneously, V3's limited efficacy in on-site waste optimization and design for disassembly led to a weaker overall ranking, albeit notable environmental initiatives including enhanced indoor air quality. Nonetheless, experts agree that a 63-point Gold tier signifies significant advancement toward net-zero goals, and more enhancements-particularly in the circular aspect-could improve V3's score in future evaluations.

6. Discussion and Policy Implications

The results underscore the potential of the lean–green–circular (LGC) framework to influence policy decisions, stimulate FDI in sustainable building, and steer future research endeavors. The validation results indicate that Projects V1, V2, and V3 attained Gold-tier scores at varying levels, hence reinforcing the notion that commitments made during the design phase and partial operational data are consistently correlated with superior environmental performance.

The framework, which can be adopted by the government, is deliniated in Figure 2.

The multi-tiered structure illustrated in Figure 2 provides a clear framework for government entities, including the Ministry of Planning and Investment and local People's Committees, to evaluate FDI construction bids. High-scoring projects (e.g., V2 with a final score of 78) may obtain preferential treatment such as accelerated permission, tax incentives, or access to specialist technical support, thereby encouraging developers to implement more stringent lean, green, and circular strategies. By directly associating incentives with sub-factor indicators, regulators can stimulate specific enhancements-for instance, motivating electronics manufacturers to adopt comprehensive e-waste take-back programs or persuading high-rise developers to improve on-site trash recycling practices.

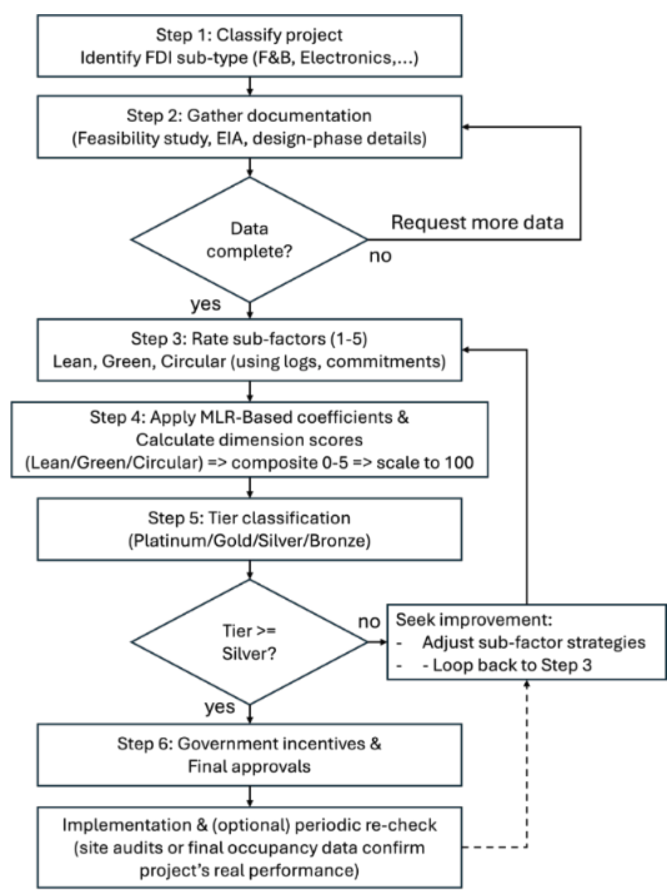

Figure 2. The assessment framework for screening sustainable FDI projects.

Feedback from industry interviews with senior officials and sustainability consultants indicates that the empirical basis of the LGC framework in MLR appeals to private investors desiring objective criteria. Nevertheless, comprehensive policy success may include capacity-building initiatives to assist smaller or less experienced foreign direct investment participants in mastering modern resource management and digital energy technologies. Moreover, local contractors observed that specific circular solutions, such as design for disassembly, are hindered by supply chain constraints and fluctuating market demand for reused components.

The framework's modular nature facilitates ongoing enhancement. Additional data-especially from fully operating projects-would enhance the regression models, potentially recalibrating sub-factor coefficients to reflect technical advancements or changing priorities (e.g., carbon pricing). The tier classifications are sufficiently adaptable to incorporate policy revisions, allowing the FDI construction industry to evolve gradually while achieving measurable advancements toward Vietnam's net-zero objectives. The LGC framework provides systematic, evidence-based screening processes that serve as a valuable tool for aligning foreign investment with the nation's overarching sustainability goals.

7. Conclusion

This study introduced a multi-tiered decision-making methodology for evaluating FDI building projects in Vietnam, integrating lean, green, and circular principles. The framework, established through a comprehensive analysis of sub-factors and corroborated by eight pilot projects, employs a MLR–based weighting system that associates greater commitments during the design phase with enhanced environmental performance in practice. The study proved that testing three new projects-V1 (Food & Beverage), V2 (Electronics), and V3 (High-Rise)-with meticulously calibrated lean, green, and circular indicators results in final index scores that correspond with actual efficiency and sustainability outcomes.

This research not only validates the framework's predictive capacities but also highlights the practicality of incorporating lean, green, and circular needs into Vietnam's comprehensive net-zero strategy. It emphasizes how a tiered classification system (Platinum, Gold, Silver, Bronze) might assist government agencies and investors in prioritizing eco-innovative initiatives. High-scoring projects may receive faster permissions and tax incentives, establishing a market-driven incentive framework to implement lean supply chains, low-carbon materials, efficient waste management, and design for disassembly. The capacity for ongoing enhancement is a key advantage: as additional FDI projects are evaluated and new data emerge, the framework's coefficients can be revised to align with evolving technologies or changing governmental goals.

The findings indicate that a systematic, evidence-based scoring instrument can expedite Vietnam's shift to net-zero construction, motivating both domestic and international stakeholders to embrace best practices and develop creative solutions. Future research may concentrate on including sophisticated lifecycle carbon assessments, broadening the dataset to capture regional variability, and investigating supplementary social and economic factors that influence sustainable development in foreign direct investment building.

References

[1]. T. X. P. Nguyen, "Green Economic Development: International Lessons for Vietnam," *International Journal of Advanced Research in Economics and Finance*, vol. 5, no. 2, pp. 201–212, 2023, doi: 10.55057/ijaref.2023.5.2.19.

[2]. D. T. Pham, H. Van Pham, and T. Q. Dang, "Renewable Energy Consumption, Energy Efficiency, Trade, Economic Development and FDI on Climate Change in Vietnam," *International Journal of Energy Economics and Policy*, vol. 13, no. 6, 2023, doi: 10.32479/ijeep.14571.

[3]. C. C. Müller, P. Pradhananga, and M. ElZomor, "Pathways to Decarbonization, Circular Construction, and Sustainability in the Built Environment," *International Journal of Sustainability in Higher Education*, 2024, doi: 10.1108/ijshe-09-2023-0400.

[4]. X. Meng, "Lean Management in the Context of Construction Supply Chains," *Int J Prod Res*, 2019, doi: 10.1080/00207543.2019.1566659.

[5]. A. Banawi and M. M. Bilec, "A Framework to Improve Construction Processes: Integrating Lean, Green and Six Sigma," *International Journal of Construction Management*, 2014, doi: 10.1080/15623599.2013.875266.

[6]. G. Sun, M. Li, J. Dong, S. Wan, and J. Feng, "Evaluation of Key Factors for Promoting Green Construction Practices Based on a Hybrid Decision-Making Framework: A Case Study on the Renovation of Old Residential Communities in China," *Axioms*, 2023, doi: 10.3390/axioms12100971.

[7]. P. Santos *et al.*, "Circular Material Usage Strategies and Principles in Buildings: A Review," *Buildings*, 2024, doi: 10.3390/buildings14010281.

[8]. R. Charef, J. Morel, and K. Rakhshan, "Barriers to Implementing the Circular Economy in the Construction Industry: A Critical Review," *Sustainability*, 2021, doi: 10.3390/su132312989.

[9]. M. Fahmy, "Lean Principles Implementation in Construction Management: A One Team Approach," 2020, doi: 10.29117/cic.2020.0034.

[10]. S. Yang, "Application of Bim During Lean Construction of High-Rise Buildings," *Stavební Obzor - Civil Engineering Journal*, 2019, doi: 10.14311/cej.2019.03.0027.

[11]. K. Madson, B. Franz, R. Leicht, and J. Nelson, "Evaluating the Sustainability of New Construction Projects over Time by Examining the Evolution of the LEED Rating System," *Sustainability (Switzerland)*, vol. 14, no. 22, 2022, doi: 10.3390/su142215422.

[12]. O. A. Marzouk, "Zero Carbon Ready Metrics for a Single-Family Home in the Sultanate of Oman Based on EDGE Certification System for Green Buildings," *Sustainability (Switzerland)*, vol. 15, no. 18, 2023, doi: 10.3390/su151813856.

[13]. D. T. Doan, H. Van Tran, I. E. Aigwi, N. Naismith, A. Ghaffarianhoseini, and A. Ghaffarianhoseini, "Green building rating systems: A critical comparison between LOTUS, LEED, and Green Mark," *Environ Res Commun*, vol. 5, no. 7, 2023, doi: 10.1088/2515-7620/ace613.

[14]. S. Altomonte and S. Schiavon, "Occupant satisfaction in LEED and non-LEED certified buildings," *Build Environ*, vol. 68, 2013, doi: 10.1016/j.buildenv.2013.06.008.

[15]. C. Gillott, W. Mihkelson, M. Lanau, D. Cheshire, and D. D. Tingley, "Developing Regenerate: A Circular Economy Engagement Tool for the Assessment of New and Existing Buildings," *J Ind Ecol*, 2023, doi: 10.1111/jiec.13377.

[16]. X. Meng, S. Das, and J. Meng, “Integration of Digital Twin and Circular Economy in the Construction Industry,” *Sustainability*, 2023, doi: 10.3390/su151713186.

[17]. J. G. I Sarhan, B. Xia, S. Fawzia, A. Karim, A. O. Olanipekun, and V. Coffey, “Framework for the Implementation of Lean Construction Strategies Using the Interpretive Structural Modelling (ISM) Technique,” *Engineering Construction & Architectural Management*, 2019, doi: 10.1108/ecam-03-2018-0136.

[18]. M. Behún and A. Behúnová, “Advanced Innovation Technology of BIM in a Circular Economy,” *Applied Sciences*, 2023, doi: 10.3390/app13137989.

[19]. R. Minunno, T. O’Grady, G. M. Morrison, and R. L. Gruner, “Exploring environmental benefits of reuse and recycle practices: A circular economy case study of a modular building,” *Resour Conserv Recycl*, vol. 160, 2020, doi: 10.1016/j.resconrec.2020.104855.