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Identifying factors affecting green real estate investment development project management in Vietnam from the developer's perspective through the extended TOE+F framework

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ABSTRACT

This study extends the Technology-Organization-Environment (TOE) framework into a TOE+F model comprising six factor groups to identify and rank the determinants of green real estate investment project management in Vietnam from the developer's perspective. The proposed framework isolates finance (F) as an independent analytical dimension, distinguishes strategic governance capacity (O1) from operational implementation capacity (O2), and separates the external environment into institutional (E1) and market (E2) contexts. The factor system was developed through a systematic literature review covering the period 2005-2025, reducing 42 initial factors to 22 preliminary candidates. These were validated through a two-round Delphi survey involving 18 experts from seven stakeholder groups, followed by the Analytic Hierarchy Process (AHP) to derive priority weights. The final model confirms 20 factors. The AHP results indicate that Finance-Cost (27.27%) and the Institutional Environment (24.06%) are the two most influential groups. The five highest-ranked factors account for 44% of the total weight and are concentrated in the conceptualization and project formulation stages. Three Vietnam-specific factors-integrated design process (IDP), green taxonomy, and measurement-reporting-verification (MRV)-also achieved strong consensus. These findings provide an empirical basis for policymakers, developers, and financial institutions to prioritize the core drivers of green real estate development in Vietnam.

1. Introduction

The building and construction sector accounts for approximately 34 % of total global CO_2 emissions [1]. At COP26 in 2021, Vietnam committed to achieving net-zero emissions by 2050, imposing an urgent transformation requirement on this sector. Developing green real estate (GRE) through energy-efficient design, low-emission materials, and optimized building operation represents a direct solution, given that every new building will remain in operation for roughly 50 to 70 years. However, by the end of 2025, the country had only approximately 780 green-certified buildings with a total floor area of about 18.69 million m^2 [2]-a negligible figure compared with the annual volume of new construction. The gap between macro-level commitments and on-the-ground implementation suggests the presence of systemic barriers that warrant identification and analysis.

This research adopts a life-cycle perspective on green real estate project management, from concept inception to end-of-life. For a commercial green office project, for instance, the lifecycle encompasses concept formation and investment opportunity study, project formulation and investment decision, design and green certification application, construction and supervision, commissioning and handover, leasing operation and facility management, renovation and upgrading, and ultimately demolition or redevelopment. Many commercial real estate developers retain ownership or management responsibilities throughout this lifecycle and therefore confront influencing factors at every stage. This characteristic means that a developer's decision to integrate green standards is not merely a one-off design decision but a strategic management decision affecting long-term operating costs, asset value, and competitiveness.

The factors influencing green real estate and green building project management are multidimensional and complex. High initial investment costs constitute the most significant barrier inhibiting the growth of green construction globally [3-5]. In addition, the shortage of specialized human resources and inadequate capacity among contractors and consultants directly contribute to schedule delays, cost overruns, and reluctance to adopt green technologies [3, 5, 6]. The influence of the legal and institutional framework-including cumbersome procedures, lack of transparent financial incentives,

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overlapping regulations, and lax law enforcement-is also among the foremost risk factors and barriers to green real estate project management worldwide [7-9]. Nevertheless, the majority of existing studies stop at listing and ranking individual barriers without anchoring them within a clear theoretical framework.

In Vietnam, high upfront investment costs and an inconsistent legal framework are the most visible obstacles [10-13]. A study by Lam et al. (2025) indicated that the additional cost for EDGE certification ranges from 2 % to 3 %, and for LEED from 1.5 % to 8 %, increasing total investment by 5 % to 15 % compared with conventional buildings [10]. Meanwhile, limited market awareness, inadequate project management team capacity, and a lack of top-management commitment have been identified as the root bottlenecks [12, 13].

Several recent studies have classified barriers to innovation adoption in the construction industry along three dimensions: Technology (T), Organization (O), and Environment (E). Research by Tran et al. [14] and Wang et al. [15] demonstrates that the TOE framework is an extremely comprehensive analytical tool widely applied in the construction sector to evaluate the adoptability of new technologies. The TOE framework posits that for a firm to adopt a technology-whether green building or BIM-one must look not only at the nature of the technology itself but also at the firm's internal management capacity (Organization) and the external forces and barriers from the market, partners, and government (Environment). The original TOE framework by Tornatzky and Fleischer (1990) [16] provides a formal theoretical basis for this three-dimensional approach. However, the original TOE framework exhibits two limitations when applied to green real estate. First, financial factors are dispersed between the Organization and Environment groups, whereas the international literature consistently identifies finance as the single most prominent barrier. Second, the granularity of the original framework does not reflect the decision-making structure of developers-specifically, it fails to distinguish between strategic governance capacity and operational management capacity.

From the foregoing analysis, four research gaps are identified: (i) the absence of an analytical framework tailored to the specificities of green real estate; (ii) financial factors have not been isolated as an independent analytical dimension; (iii) the developer's perspective as the entity managing the entire project lifecycle has been insufficiently represented; and (iv) factor groups have not been linked to specific lifecycle stages of the investment project.

To address these gaps, this paper extends the TOE framework into a TOE+F framework comprising six factor groups. The initial factor system was constructed through a systematic literature review, extracting 42 raw factors and screening them down to 22 preliminary factors, which were then validated through a two-round Delphi survey with 18 experts from seven stakeholder groups. The results confirmed 20 final factors.

2. The extended TOE+F framework and research methodology

2.1. The extended TOE+F framework

The integration of green standards into real estate projects is essentially an organizational innovation adoption decision. The TOE framework [16] classifies influencing factors along three contexts: technology, organization, and external environment. Alternative frameworks each exhibit limitations: TAM (Technology Acceptance Model) operates at the individual level, which is unsuitable for developer-level organizational decisions; DOI (Diffusion of Innovations) focuses on systemic diffusion without categorizing the sources of barriers; PESTLE covers only exogenous factors, lacking an internal capacity dimension. The TOE framework encompasses both factors within the developer's control (organization) and those beyond it (technology, environment). Table 1 summarizes five representative studies that have applied the TOE framework in the construction industry and related fields.

Among these, the study by Tran et al. [14], which shares the developer's perspective in Vietnam and focuses on green building, analyzed the decision to adopt green building technologies in general rather than linking the analysis to green real estate investment project management across the lifecycle. Notably, none of these studies isolate finance as an independent analytical dimension: costs are placed within the T group as "disadvantages of green building technology" [14], financial resources are assigned to the O group [17, 18], or financial incentives fall under E [19]. Furthermore, the studies do not disaggregate the Organization group into strategic governance (O1) and operational implementation (O2), although Yuan et al. (2019) [17] and Tran et al. [14] both identified "top management leadership" as a distinct factor, suggesting the need for such disaggregation without having implemented it.

This paper extends the TOE framework through three steps. *First*, finance (F) is separated as an independent analytical dimension, since financial factors are both internal (capital allocation, lifecycle cost analysis) and external (green credit, green taxonomy) in nature, while also serving a mediating role. *Second*, the Organization dimension is split into O1 (governance capacity: strategy, leadership commitment, internal policies) and O2 (operational capacity: personnel, construction processes, multi-stakeholder coordination). *Third*, the Environment dimension is divided into E1 (institutional: legal framework, incentives, certification) and E2 (market: awareness, information transparency, competition). Stakeholder theory provides the theoretical basis for this disaggregation. Mitchell et al. (1997) [21] classify stakeholders according to three salience attributes: power, legitimacy, and urgency. Applying this logic to the Organization dimension, governance capacity (O1) relates to the power and legitimacy of top management in setting green objectives and allocating resources, whereas operational capacity (O2) concerns the urgency of day-to-day implementation by project teams, contractors, and technical staff. Similarly, for the Environment dimension, the institutional environment (E1) reflects coercive and normative pressures from government regulations and certification bodies, while the market environment (E2) captures mimetic pressures and demand-side signals from customers and competitors. The AHP results empirically support this disaggregation: O1 and O2 received markedly different weights (18.80 % vs. 9.41 %), and E1 and E2 similarly diverged (24.06 % vs. 10.27 %), confirming that they function as distinct dimensions rather than a single construct.

The TOE+F framework comprises six groups with a total of 22 preliminary factors, as presented in Figure 1. This figure also depicts the conceptual linkages among the six groups, derived from the literature review: the Institutional Environment shapes Governance Capacity; Governance Capacity guides Operational Capacity; Operational Capacity interacts with Finance; and the Market Environment forms a feedback loop with Finance. These linkages represent the theoretical logic underpinning the framework's structure; however, their empirical validation lies beyond the scope of this study, which focuses on identifying and ranking the factors. Structural relationship analysis methods such as SEM or DEMATEL may be employed in future research to test these linkages.

2.2. Process for developing the initial factor system

A systematic review of domestic and international scholarly works on factors affecting green building development during the period 2005-2025 yielded 42 raw factors. Screening according to three criteria (elimination of semantic duplicates, consolidation of overlapping content, and filtering by the developer's perspective) reduced the list to 22 preliminary factors classified into six TOE+F groups: O1 with 4 factors, O2 with 4 factors, T with 4 factors, F with 4 factors, E1 with 3 factors, and E2 with 3 factors.

2.3. Combined Delphi and AHP methodology

2.3.1. Overall design

The study employs a combined Delphi-AHP approach in two phases. Phase 1 consists of a two-round Delphi survey with 18 experts to screen and confirm the factor set. Phase 2 applies the AHP to determine weights and priority rankings for the factors achieving consensus. The two methods address complementary questions: Delphi identifies which factors are important (screening and retention), while AHP determines which factors are more important than others and by how much (precise weighting). Delphi provides the input for AHP; AHP produces the output that Delphi alone cannot deliver (consistent weights and rankings).

The Delphi method was selected for four reasons: the nascent market necessitates the exploitation of expert knowledge; the novel TOE+F framework requires convergent feedback; the anonymity mechanism permits the collection of diverse viewpoints; and open-ended questions facilitate the discovery of new factors.

The Analytic Hierarchy Process (AHP) was selected for three reasons. First, the hierarchical structure of AHP is congruent with the TOE+F framework (6 groups → 20 factors). Second, the pairwise comparison mechanism compels experts to clearly differentiate priority levels among factors-something that the Likert scale used in Delphi cannot accomplish. Third, the consistency ratio (CR) of AHP provides a quality-control mechanism for expert evaluations.

2.3.2. Phase 1: Delphi method

A survey was administered to 18 experts from seven stakeholder groups. Selection criteria required at least seven years of experience and participation in a minimum of one green real estate project. The expert panel had a mean experience of 17.1 years, with 89 % possessing ten or more years. The sample size is consistent with the recommended range of 10 to 18 experts for multi-disciplinary Delphi studies [22, 23].

The factor set was developed from a literature review on factors affecting green building development in emerging markets. Each factor is bidirectional: when absent or weak, the factor acts as a barrier; when improved or satisfied, it becomes an enabler. For example, "lack of strategy and top-management commitment to green development" (O1.1) is a barrier, but when leadership formulates a clear green strategy, it becomes the strongest enabler. This approach allows the ranking results to be interpreted in both directions: the highest-ranked factor is both the most pressing barrier to resolve and the most effective lever when addressed.Consensus criteria were established before the survey, based on three statistical indicators: mean value (Mean), coefficient of variation (CV), and consensus rate (percentage of experts rating 4 or above on a 5-point Likert scale). The retention and elimination rules were applied consistently across rounds as follows: factors with a Mean below 3.50 were eliminated after that round [3, 13]; factors with a Mean of 3.50 or above but a CV exceeding 15 % [23] or a consensus rate below 70 % [24] were deemed not yet having reached consensus and were re-evaluated in the subsequent round accompanied by aggregated statistical feedback; factors simultaneously meeting all three thresholds (Mean $\geq$ 3.50, CV $\leq$ 15 %, consensus rate $\geq$ 70 %) were retained.

After the final round, factors with a CV exceeding 20 % were eliminated due to non-convergence of expert opinion after two rounds of feedback. Factors with a Mean of 3.50 or above and a CV not exceeding 20 % were retained in the research model. The 20 % CV threshold was adopted based on Zhao et al. (2020) [25], in which this threshold was applied as the elimination criterion for multi-disciplinary Delphi studies. This threshold is higher than the 15 % inter-round screening threshold, consistent with the recommendation of von der Gracht (2012) [23] that the choice of consensus threshold should depend on the panel structure and research objectives, particularly when the expert panel comprises multiple stakeholder groups with different roles.

2.3.3. Phase 2: Analytic Hierarchy Process (AHP)

The factors achieving consensus from the Delphi process were entered into the AHP to determine weights and priority rankings. The hierarchical structure comprises three tiers: Tier 1 is the research objective (determining the priority of factors affecting green real estate investment project management in Vietnam); Tier 2 consists of the factor groups according to the TOE+F framework; and Tier 3 comprises the specific factors within each group. The same 18 experts who participated in the Delphi process performed pairwise comparisons on Saaty's 9-point scale (1 = equal importance, 9 = absolute importance) for both Tier 2 (among groups) and Tier 3 (among factors within each group) [26]. Individual pairwise comparison values were aggregated using the geometric mean across the full panel (n = 18). The composite weight of each factor equals the product of its Tier 2 and Tier 3 weights; the priority ranking was arranged in descending order of global weights. The consistency of each matrix was verified using the consistency ratio CR = CI/RI [26]; matrices with CR ≤ 0.10 were accepted; those exceeding the threshold were re-evaluated by the expert.

3. Results and discussion

3.1. Delphi Round 1 results

Round 1 evaluated 22 preliminary factors. The results were classified into three groups according to the pre-established criteria.

Two factors were eliminated due to a Mean below 3.50: O1.3 (lack of a dedicated organizational structure; Mean = 3.44, consensus rate = 38.9 %) and F.3 (difficulty in accessing green capital; Mean = 3.39, consensus rate = 44.4 %).

Six factors had a Mean of 3.50 or above but did not achieve consensus because their CV exceeded 15 % or their consensus rate fell below 75 %: T.3 (Mean = 4.00, CV = 17.15 %), T.4 (Mean = 4.33, CV = 15.83 %), F.2 (Mean = 4.39, CV = 15.90 %), E1.2 (Mean = 4.56, CV = 18.78 %), E2.2 (Mean = 3.89, CV = 17.39 %), and E2.3 (Mean = 4.17, CV = 20.58 %, consensus rate = 72.2 %). These factors were carried forward to Round 2 for re-evaluation accompanied by aggregated statistical feedback.

Fourteen remaining factors met all three consensus criteria and were retained.

In addition to the quantitative evaluation, Round 1 included an open-ended question inviting experts to propose supplementary factors. Three new factors emerged. Factor O1.5 (lack of integrated lifecycle project management processes and an integrated design process, abbreviated IDP): experts emphasized that the traditional siloed design process increases green costs by 5 %-8 % instead of 1 %-3 % when integration is adopted from the outset. This factor subsumes O1.4, which was therefore merged into O1.5. Factor F.5 (lack of a unified green taxonomy in Vietnam): financial experts argued that the absence of a common classification framework deprives credit institutions of an appraisal basis. Factor E2.4 (lack of a measurement-reporting-verification system, abbreviated MRV): experts contended that without MRV, the risk of greenwashing would erode market confidence.

A total of 22 factors were carried into Delphi Round 2.

3.2. Delphi Round 2 results and consensus verification

Round 2 evaluated 22 factors. Two factors were eliminated due to their CV exceeding the 20 % threshold after two rounds of feedback: T.3 (difficulty in applying BIM and energy simulation technologies; CV = 21.4 %) and T.4 (lack of standardized performance data for green buildings in Vietnam; CV = 24.8 %). The remaining 20 factors, all with a Mean of 3.50 or above and a CV not exceeding 20 %, were retained in the research model, of which 10 factors achieved ideal consensus (CV below 15 %) and 10 factors had a CV between 15 % and 20 %.

Several factors that had achieved consensus in Round 1 exhibited a slight increase in CV in Round 2 [25]. This pattern is consistent with multi-disciplinary Delphi panels [23]: after receiving aggregated statistical feedback, experts evaluate based on substantive expertise rather than superficial agreement from Round 1. The dispersion is not random but systematic: groups directly involved in projects rated factors related to construction practice and costs higher, while indirectly involved groups evaluated more cautiously. Von der Gracht (2012) [23] noted that differences in perspective among stakeholder groups are a structural feature of multi-disciplinary panels and do not necessarily imply a lack of consensus.

The final results confirmed 20 official factors: O1 with 3, O2 with 4, T with 2, F with 4, E1 with 3, and E2 with 4 factors (Table 4). The Rank column is based on descending Mean values.

3.3. Analysis by TOE+F group

Organizational Governance Capacity (O1) achieved the highest group-level Mean of 4.54 and a CV of 10.06 %. The Institutional Environment (E1) and Operational Management Capacity (O2) both attained a Mean of 4.35, ranking second and third, respectively. Finance and Cost (F) ranked fourth with a Mean of 4.25. The Market Environment (E2) ranked fifth and Technology (T) ranked sixth.

Figure 2 visually depicts the evaluation differentiation among the three stakeholder groups. The most pronounced difference lies in the Finance and Cost group (F): developers rated it at 4.44, notably higher than direct stakeholders (4.19) and indirect stakeholders (4.20). Conversely, for the Organizational Governance Capacity group (O1), indirect stakeholders rated it markedly lower (4.13) compared with developers (4.67) and direct stakeholders (4.70). This differentiation is consistent with stakeholder theory [21, 27]: each group prioritizes factors that they directly confront in their respective roles.

3.4. AHP results

The 20 factors achieving consensus from the Delphi process were entered into the AHP to determine weights and priority rankings. The same 18 experts performed pairwise comparisons on Saaty's 9-point scale for both the group tier and the factor tier [26]. The consistency ratio (CR) of all matrices was below 0.10.

Table 6 presents the consolidated AHP results. At the group tier, Finance-Cost (F) has the highest weight (27.27 %), followed by the Institutional Environment (E1, 24.06 %) and Organizational Governance Capacity (O1, 18.80 %); these three groups account for over 70 % of the total weight. Operational Management Capacity (O2) has the lowest weight (9.41 %)-not because it is unimportant, but because experts consider it a downstream implementation group that becomes actionable once institutional and financial conditions are secured. Within each group, the leading factors are O1.1 (47.57 %), O2.2 (30.33 %), T.2 (58.02 %), F.5 (34.25 %), E1.1 (45.26 %), and E2.4 (35.80 %).

The five highest-priority factors by global weight are: E1.1-legal framework (10.89 %), F.5-green taxonomy (9.34 %), O1.1-leadership strategy (8.94 %), F.4-cost-benefit sharing (7.72 %), and E1.2-government incentives (7.05 %), accounting for 44 % of the total weight and concentrated in the legal framework and financial mechanisms rather than technical capacity [7, 28].

3.5. Discussion

The AHP priority ranking differs markedly from the Mean-based ranking in the Delphi results (Table 7). At the group level, Finance-Cost (F) rose from rank 4 in the Delphi to rank 1 in the AHP, while Operational Management Capacity (O2) fell from rank 3 to rank 6. These results are not contradictory but rather reflect two different aspects: the Delphi shows that all 20 factors are important (all Mean values $\geq$ 3.50), while the AHP discriminates priority levels when resources are limited.

The five highest-ranked factors by AHP (E1.1, F.5, O1.1, F.4, E1.2) account for 44 % of the total weight, indicating that the top-priority factors concentrate on the legal framework and financial mechanisms rather than on technical capacity. This finding is consistent with the majority of the international literature [7, 28] and demonstrates that the characteristics of a nascent market in Vietnam do not create an exception in priority order but rather produce differences in the degree of consensus among stakeholder groups.

Among the three Vietnam-specific factors proposed by experts, F.5 (lack of a green taxonomy) rose from rank 6 to rank 2 in the AHP, indicating that this is the most urgent factor. The absence of a green finance taxonomy deprives credit institutions of an appraisal basis, creating a vicious cycle in accessing green capital. Conversely, O1.5 (IDP) fell from rank 1 (Mean = 4.78) to rank 13 in the AHP (global weight = 3.54 %). This reversal is explained by the two-tier allocation mechanism of the AHP: within the O1 group, when directly compared with leadership strategy (O1.1) and internal policies (O1.2), IDP obtained the lowest Tier 3 weight (18.81 %); simultaneously, the O1 group accounts for only 18.80 % of the Tier 2 weight, so the global weight of O1.5 = 18.80 % × 18.81 % = 3.54 %. This does not mean that IDP is unimportant-the Delphi confirms a very high level of consensus-but reflects a priority logic: when resources are limited, experts judge IDP as a technical solution that can be deployed after institutional and financial conditions are secured.Table 8 allocates the 20 factors to six lifecycle stages of a green real estate investment project, combined with AHP rankings, to provide a reference tool for project managers in identifying factors requiring priority attention at each stage.

Factors are arranged by TOE + F group; within each group, factors are listed in descending order of AHP rank. The five highest-priority factors by AHP (E1.1, F.5, O1.1, F.4, E1.2) all concentrate in the Conceptualization and Project Formulation stages-the point at which the decision to integrate green objectives is either formed or abandoned. This finding suggests that policy interventions should be prioritized during the early stages of the project lifecycle, where the effectiveness of intervention is greatest.

Table 1. Summary of studies applying the TOE framework in the construction industry and related fields.

No.	Authors	Technology adopted	Technology context (T)	Organization context (O)	External environment (E)
1	Wang, Tao, Gong, Qiao, Zhang & Zhang (2025) [15]	BIM	Compatibility, complexity, relative advantage, trialability	Organizational culture, organizational support and top management support	Coercive pressure, normative pressure
2	Yuan, Yang & Xue (2019) [17]	BIM (developer's perspective)	BIM technical characteristics → positive effect on perceived usefulness	Organizational support not statistically significant; Social influence not significant	Government BIM policies → positive effect on perceived usefulness
3	Nguyen, Nguyen & Dang (2022) [18]	AI in accounting	Compatibility (+); Relative advantage (+); Technical complexity (-)	Technical capacity; Managerial capacity;	Government participation (+); Market uncertainty; Supplier partnership

No.	Authors	Technology adopted	Technology context (T)	Organization context (O)	External environment (E)
				Organizational readiness (strongest effect)	
4	Nguyen (2025) [19]	AI in auditing	Compatibility (β = 0.200); Technical complexity (β = -0.208); Perceived benefit (β = 0.127, weakest)	Top management support (β = 0.192); Organizational readiness (β = 0.267, strongest)	Government participation (β = 0.138); Competitive pressure (β = 0.201)
5	Tran, Nazir, Nguyen, Ho, Dinh, Nguyen, Nguyen, Phan & Kieu (2020) [14]	Green building technology (GBT) (developer's perspective)	Green building technology advantages (+, β = 0.213); Green building technology disadvantages (-, β = -0.105)	Organizational resources (not significant); Top management leadership (+, β = 0.156)	Government support (+, β = 0.156); Project participant readiness (+, β = 0.150); Market readiness (not significant); Social demand (+, β = 0.254, strongest)

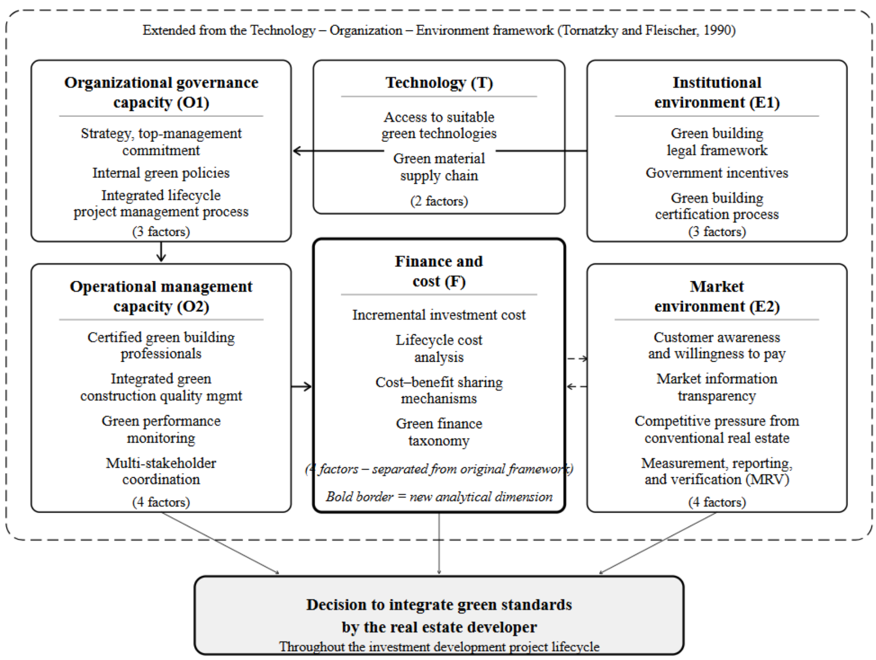

Figure 1. The TOE + F analytical framework.

Note: → Hypothesized relationships between groups
- - - → Hypothesized feedback loop

Table 2. Structure of the expert panel.

No.	Stakeholder group	Count	Specific criteria
1	Developers	4	Have implemented ≥ 1 green-certified real estate project
2	Project management consultants	3	Have managed at least 1 green building project
3	Design and green building certification consultants	3	Have provided green building design consultancy; hold an international certification

No.	Stakeholder group	Count	Specific criteria
4	Construction contractors	3	Have constructed at least 1 green-standard building
5	Government authorities	2	Have participated in developing green building policies/standards
6	Financial institutions	2	Have appraised/financed a green project
7	International green building certification bodies	1	Directly issue green building certifications in Vietnam

Table 3. Characteristics of the expert panel (n = 18).

Characteristic	Count	Percentage (%)
Experience: 7-10 years	3	16.7
Experience: 11-20 years	13	72.2
Experience: over 20 years	2	11.1
Doctoral degree	3	16.7
Master's degree	3	16.7
Bachelor's degree / Engineer / Architect	12	66.7
Participated in 1 green building project	8	44.4
Participated in 2-3 green building projects	5	27.8
Participated in 4 or more green building projects	5	27.8

Table 4. Influencing factors after Delphi Round 2.

Code	Factor	Mean	SD	CV (%)	%CR	Med	Mode	Rank
O1.1	Lack of strategy and top-management commitment	4.72	0.46	9.8	100	5	5	2
O1.2	Lack of internal policies integrating green objectives	4.11	0.47	11.5	94.4	4	4	13
O1.5	Lack of integrated project management processes (IDP)	4.78	0.43	9.0	100	5	5	1
O2.1	Shortage of certified green building professionals	4.50	0.51	11.4	100	4.5	4	5
O2.2	Lack of integrated green construction quality management	4.22	0.65	15.3	88.9	4	4	10
O2.3	Insufficient green performance monitoring capacity	4.11	0.58	14.2	88.9	4	4	14
O2.4	Difficulty in multi-stakeholder coordination	4.56	0.62	13.5	94.4	5	5	4
T.1	Limited access to suitable green technologies	3.78	0.65	17.1	66.7	4	4	20
T.2	Unstable green material supply chain	4.22	0.73	17.3	83.3	4	4	11
F.1	Incremental investment cost	4.39	0.70	15.9	88.9	4.5	5	9
F.2	Lack of lifecycle cost analysis methods	4.00	0.69	17.2	77.8	4	4	16
F.4	Lack of cost-benefit sharing mechanisms	4.11	0.58	14.2	88.9	4	4	15
F.5	Lack of a unified green taxonomy	4.50	0.79	17.5	83.3	5	5	6

Code	Factor	Mean	SD	CV (%)	%CR	Med	Mode	Rank
E1.1	Incomplete green building legal framework	4.50	0.51	11.4	100	4.5	4	7
E1.2	Lack of government incentive mechanisms	4.67	0.59	12.7	94.4	5	5	3
E1.3	Complex green building certification process	3.89	0.68	17.4	72.2	4	4	19
E2.1	Limited customer awareness and willingness to pay	4.22	0.73	17.3	83.3	4	4	12
E2.2	Lack of green real estate market information transparency	3.94	0.64	16.2	77.8	4	4	18
E2.3	Competitive pressure from conventional real estate	4.00	0.77	19.2	72.2	4	4	17
E2.4	Lack of an MRV system	4.50	0.51	11.4	100	4.5	4	8

Note: Mean: mean value; SD: standard deviation; CV: coefficient of variation; %CR: consensus rate (score ≥ 4); Med: median; Mode: most frequent value; n = 18.

Table 5. Summary of Delphi results by TOE + F group and stakeholder perspective.

Group	Group name	No. of factors	Group Mean	Group CV (%)	Developer (n = 4)	Direct stakeholder (n = 9)	Indirect stakeholder (n = 5)	Rank
O1	Organizational governance capacity	3	4.54	10.06	4.67	4.70	4.13	1
E1	Institutional environment	3	4.35	13.85	4.42	4.37	4.27	2
O2	Operational management capacity	4	4.35	13.61	4.19	4.50	4.20	3
F	Finance and cost	4	4.25	16.17	4.44	4.19	4.20	4
E2	Market environment	4	4.14	16.59	4.12	4.08	4.25	5
T	Technology	2	4.00	17.23	4.00	4.17	3.70	6

Note: Direct stakeholders include project management consultants, design and green building certification consultants, and construction contractors (n = 9). Indirect stakeholders include government authorities, financial institutions, and international green building certification bodies (n = 5). The axis starts at 3.50; higher values indicate higher ratings.

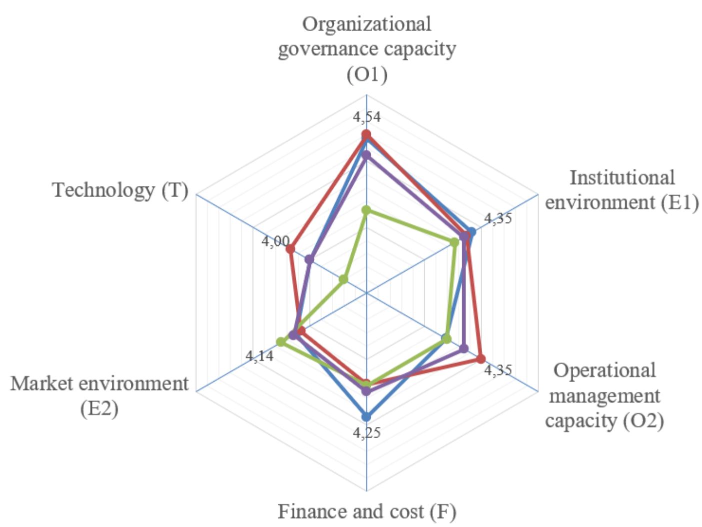

Figure 2. Radar chart comparing Mean by stakeholder group and TOE + F group.

Table 6. Consolidated AHP weights and ranking of 20 factors.

Rank	Code	Factor	w(T2)	w(T3)	Global W	CR	Group
1	E1.1	Incomplete green building legal framework	0.2406	0.4526	0.1089	0.001	E1
2	F.5	Lack of a unified green taxonomy	0.2727	0.3425	0.0934	0.009	F
3	O1.1	Lack of strategy and top-management commitment	0.1880	0.4757	0.0894	0.001	O1
4	F.4	Lack of cost-benefit sharing mechanisms	0.2727	0.2831	0.0772	-	F
5	E1.2	Lack of government incentive mechanisms	0.2406	0.2931	0.0705	-	E1
6	O1.2	Lack of internal policies integrating green objectives	0.1880	0.3362	0.0632	-	O1
7	E1.3	Complex green building certification process	0.2406	0.2544	0.0612	-	E1
8	T.2	Unstable green material supply chain	0.1018	0.5802	0.0591	N/A	T
9	F.2	Lack of lifecycle cost analysis methods	0.2727	0.2063	0.0563	-	F
10	F.1	Incremental investment cost	0.2727	0.1680	0.0458	-	F
11	T.1	Limited access to suitable green technologies	0.1018	0.4198	0.0428	-	T
12	E2.4	Lack of an MRV system	0.1027	0.3580	0.0368	0.002	E2
13	O1.5	Lack of integrated project management processes (IDP)	0.1880	0.1881	0.0354	-	O1
14	O2.2	Lack of integrated green construction quality management	0.0941	0.3033	0.0285	0.002	O2
15	O2.3	Insufficient green performance monitoring capacity	0.0941	0.3027	0.0285	-	O2
16	E2.1	Limited customer awareness and willingness to pay	0.1027	0.2563	0.0263	-	E2
17	O2.1	Shortage of certified green building professionals	0.0941	0.2275	0.0214	-	O2
18	E2.3	Competitive pressure from conventional real estate	0.1027	0.1971	0.0202	-	E2
19	E2.2	Lack of green real estate market information transparency	0.1027	0.1886	0.0194	-	E2
20	O2.4	Difficulty in multi-stakeholder coordination	0.0941	0.1664	0.0157	-	O2
		TOTAL			1.0000		

Note: w(T2) = Tier 2 weight (among 6 groups; Tier 2 CR = 0.005); w(T3) = Tier 3 weight (within each group); Global W = w(T2) × w(T3). CR: consistency ratio of the Tier 3 matrix, reported only for the first factor in each group; "-" = same group CR already reported; N/A = Group T has only 2 factors and is therefore always consistent. All CR ≤ 0.10 [26].

Table 7. Comparison of group rankings between Delphi and AHP.

Group	Group name	Delphi rank	AHP rank	Change
O1	Organizational governance capacity	1	3	↓ 2
E1	Institutional environment	2	2	-
O2	Operational management capacity	3	6	↓ 3
F	Finance - Cost	4	1	↑ 3
E2	Market environment	5	4	↑ 1
T	Technology	6	5	↑ 1

Table 8. Allocation of 20 factors to six lifecycle stages of a green real estate investment project.

AHP Rank	Group	Code	Factor	Concept-ualization	Project formul-ation	Design	Constr-uction	Commis-sioning	Operation & mgmt
1	E1	E1.1	Incomplete green building legal framework	●	●				
2	F	F.5	Lack of a unified green finance taxonomy	●	●				
3	O1	O1.1	Lack of strategy and top-management commitment to green development	●	●				
4	F	F.4	Lack of cost–benefit sharing mechanisms among stakeholders		●				●
5	E1	E1.2	Lack of government incentive mechanisms for green buildings	●	●				
6	O1	O1.2	Lack of internal policies integrating green objectives into management processes		●	●			
7	E1	E1.3	Complex green building certification process			●		●	
8	T	T.2	Unstable green material supply chain			○	●		
9	F	F.2	Lack of building lifecycle cost analysis methods		●	●			●
10	F	F.1	Incremental investment cost compared with conventional buildings		●	●	●		
11	T	T.1	Limited access to suitable green technologies			●	●		
12	E2	E2.4	Lack of an MRV system for green performance					●	●
13	O1	O1.5	Lack of integrated lifecycle project management processes and IDP			●	○		
14	O2	O2.2	Lack of integrated green construction quality management capacity				●	○	
15	O2	O2.3	Insufficient green performance monitoring capacity in operation					●	●
16	E2	E2.1	Limited customer awareness and willingness to pay	●					●
17	O2	O2.1	Shortage of certified and experienced green building professionals			○	●		
18	E2	E2.3	Competitive pressure from conventional real estate	●	●				●
19	E2	E2.2	Lack of green real estate market information transparency	●					●
20	O2	O2.4	Difficulty in multi-stakeholder coordination			●	●		

Note: ● primary impact at stage; ○ secondary impact at stage.

4. Conclusions

This paper extends the TOE analytical framework into a TOE+F framework comprising six factor groups to identify and rank the factors affecting green real estate investment project management in Vietnam. An integrated Delphi-AHP methodology was applied with 18 experts from seven stakeholder groups: a two-round Delphi process screened 22 preliminary factors down to 20 official factors, and the AHP determined weights and priority rankings. The consistency ratio (CR) of all AHP matrices was below 0.10, ensuring the reliability of the ranking results.

The main contributions of this paper directly address the four identified research gaps. Regarding gap (i), the paper develops a TOE+F framework comprising six factor groups, extending the original TOE framework to suit the specificities of green real estate investment project management. Regarding gap (ii), the isolation of finance (F) as an independent analytical dimension is confirmed by the AHP results: the F group attains the highest weight (27.27 %), demonstrating the necessity of this separation. Regarding gap (iii), the disaggregation of Organization into Governance (O1) and Operations (O2) reflects the decision-making structure of the developer throughout the project lifecycle; the AHP results show a significant weight differential between these two groups (O1 = 18.80 %, O2 = 9.41 %), confirming that strategic governance capacity and operational implementation capacity are two distinct dimensions requiring independent analysis. Regarding gap (iv), Table 8 allocates the 20 factors to six project lifecycle stages, revealing that the five highest-priority factors all concentrate in the Conceptualization and Project Formulation stages. Furthermore, the combination of Delphi and AHP exploits two complementary information dimensions: Delphi confirms that all 20 factors are important (Mean ≥ 3.50), while AHP clearly differentiates priority levels when resources are limited. The AHP results show that Finance-Cost (F, 27.27 %) and the Institutional Environment (E1, 24.06 %) are the two highest-priority groups, accounting for over 50 % of the total weight. These results are consistent with the international literature [7, 28] and supplement the nascent market perspective: in the Delphi, experts agreed that governance is important (O1 ranked first by Mean), but when the AHP forces direct comparison, finance and institutional factors are prioritized, indicating that these are root causes requiring resolution first.

The five highest-priority factors by AHP are: E1.1 (incomplete legal framework, 10.89 %), F.5 (lack of a green finance taxonomy, 9.34 %), O1.1 (lack of strategy and leadership commitment, 8.94 %), F.4 (lack of cost-benefit sharing mechanisms, 7.72 %), and E1.2 (lack of government incentives, 7.05 %), accounting for 44 % of the total weight and all concentrated at the Conceptualization and Project Formulation stages. Among the three Vietnam-specific factors, F.5 (green taxonomy) ranks second in the AHP, reflecting the pressing need for a national green finance taxonomy. E2.4 (MRV) ranks twelfth, reflecting the risk of greenwashing in the absence of a verification mechanism. O1.5 (IDP) ranks thirteenth in the AHP despite having the highest Mean in the Delphi (4.78), indicating that it is an important technical solution that nevertheless requires institutional and financial preconditions.

The research findings provide a basis for three target groups. For government authorities: prioritize the completion of a mandatory green building legal framework, establish a national green finance taxonomy, and develop specific incentive mechanisms-these are the three factors ranked first, second, and fifth by AHP. For developers: proactively formulate a green development strategy and internal policies integrating green criteria into project management processes, rather than waiting for institutional improvements before taking action. For financial institutions: develop green credit appraisal criteria and cost-benefit sharing mechanisms among stakeholders.

Despite its contributions, the study has several limitations. The panel of 18 experts is consistent with recommendations for multi-disciplinary Delphi studies but limits generalizability. The Delphi process terminated after two rounds based on Mean stability criteria. The study focuses on identifying and ranking factors without analyzing the causal relationships among them. The scope is limited to the Vietnamese market. Future research directions include: combining structural relationship analysis methods to elucidate the interaction mechanisms among factor groups; expanding the survey sample and validating the results with large-scale data; and comparing the results across green real estate segments (residential, commercial, industrial).

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