

Strategies to Accelerate Adoption of Sustainable Construction in the Built Environment

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Abstract: Sustainable construction remains under-adopted due to first-cost premiums, uneven enforcement, capability gaps, and fragmented information. This article contributes a context-fit roadmap by identifying and prioritizing strategies across regulatory, market, informational, and capability levers. A mixed-methods, cross-sectional design combined a structured Likert-scale questionnaire with semi-structured interviews of purposively sampled industry actors; descriptive statistics ranked strategies and narratives clarified complementarities. All strategies were rated effective (aggregate mean ≈ 4.21 ; SD ≈ 0.96). Highest support emerged for client/end-user education via case studies and county-level demonstration centres, followed by curriculum integration, building-code revision, stakeholder empowerment, approval-stage sustainability checklists, and targeted financial incentives. Findings corroborate diffusion and international evidence, adding nuance on the outsized role of visible exemplars and client-facing education. Recommended actions include updating codes, embedding approval checklists, deploying time-bound incentives, expanding labeling and cost-benefit data, integrating sustainability in curricula/CPD, establishing demonstration centres, and instituting adaptive monitoring.

Keywords: Sustainable Construction, Adoption Strategies, Policy Instruments, Financial Incentives, Diffusion of Innovations, Capacity Building.

I. INTRODUCTION

A. Background Information

The construction industry is one of the most resource-intensive sectors globally, and its environmental footprint has raised critical concerns regarding climate change, resource depletion, and public health. According to the International Energy Agency, the construction sector consumes more than 40% of global energy and contributes an equivalent proportion of greenhouse gas (GHG) emissions, while also using 40% of raw materials, 16% of water, and 25% of timber resources annually [1]. Building-related activities generate significant volumes of waste; in the United Kingdom alone, construction accounts for over 50% of landfill volume, with 70 million tons of waste produced annually, while in the United States the figure exceeds 100 million tons [2].

These statistics emphasize the urgency of transforming the built environment through sustainable materials and practices that can curb unsustainable resource consumption and emissions. Sustainable construction, particularly through green building technologies (GBTs) and energy-efficient innovations, has emerged as a promising pathway toward reducing the environmental burden of the sector. GBTs, which include technologies such as passive solar design, green roofs, energy-efficient HVAC systems, and sustainable insulation, have been shown to reduce building energy use by 30–80% [1]. For example, the application of high-performance wall technologies can save up to 24.8% of operational energy in residential

buildings [3]. Beyond environmental benefits, sustainable construction practices improve competitiveness in the industry by enhancing corporate reputation, expanding market opportunities, and improving occupants' health and productivity [4]. Nonetheless, the diffusion of sustainable construction technologies remains uneven across regions, with developed countries advancing faster while developing economies struggle with slower adoption [1].

Several interrelated barriers impede the widespread uptake of sustainable materials and practices. Cost is one of the most persistent barriers, with sustainable technologies often requiring higher upfront investment despite long-term savings [3]. Lack of awareness and technical expertise among stakeholders, ranging from policymakers to contractors and end-users, further hinders adoption [2]. Moreover, fragmented regulatory frameworks, insufficient incentives, and resistance to change within the construction industry exacerbate the problem [1]. For instance, empirical studies in Ghana found that despite awareness of sustainability challenges, strategies such as media publicity, stakeholder training, and institutional frameworks for green building implementation were either underdeveloped or inconsistently applied [1]. Similarly, in Pakistan, promotional strategies such as tax incentives, international conferences, and policy enforcement were identified as critical levers but were inadequately institutionalized [4]. These challenges illustrate the pressing need for coherent, context-sensitive strategies that can drive adoption of sustainable practices globally. At the same time, international evidence highlights effective strategies that can accelerate the uptake of sustainable construction. Financial incentives, including subsidies, tax breaks, and low-interest loans, have consistently emerged as powerful drivers [3].

Governmental interventions in the form of mandatory regulations, building codes, and green certification schemes such as Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment Method (BREEAM) have proven essential in mainstreaming sustainability into construction practices [5]. Education, training, and information dissemination, through seminars, workshops, and public awareness campaigns, are equally important in shifting stakeholder perceptions and consumer demand [1]. Furthermore, collaboration between government, academia, and industry in research and development can foster innovation and lower costs of emerging sustainable technologies [4]. Collectively, these strategies point toward the importance of multi-level interventions that address financial, regulatory, informational, and cultural barriers. Despite these insights, there remains a gap in translating global knowledge into localized, actionable frameworks that can accelerate adoption in different contexts of the built environment. Many existing studies are country-specific and cannot be directly generalized across regions, given differences in economic structures, cultural values, and policy regimes [2,3]. Additionally, the interaction between strategies, such as how financial incentives complement public education or how regulations interact with market-based mechanisms, remains underexplored in the literature. These gaps limit the formulation of comprehensive policies that can drive systemic change.

By examining strategies to accelerate adoption of sustainable construction materials and practices, the research will identify effective measures that can overcome the persistent barriers to uptake. The study will analyze both global best practices and local challenges, providing evidence-based insights for policymakers, industry practitioners, and researchers. Ultimately, it will contribute to the sustainable transformation of the built environment by offering a coherent framework of strategies tailored to promote adoption, reduce environmental impacts, and align construction practices with global sustainability goals.

B. Contribution

The environmental and resource-related impacts of the construction industry are well documented, with buildings consuming over 40% of global energy and generating up to 30% of greenhouse gas emissions [1]. Research has shown that sustainable construction technologies and practices can significantly mitigate these impacts, delivering both environmental and socio-economic benefits [3,4]. However, despite the proven potential of such innovations, their adoption remains limited, particularly in developing regions, due to high initial costs, insufficient regulatory enforcement, lack of awareness, and inadequate stakeholder training [1,2]. While existing studies have identified barriers and suggested strategies, many remain fragmented, country-specific, or lacking empirical validation, leaving knowledge gaps in understanding how strategies can be effectively combined and scaled. Therefore, it is essential to investigate context-relevant and integrative strategies to accelerate the uptake of sustainable construction in the built environment. This research seeks to address this gap by identifying and evaluating effective strategies that can overcome existing barriers and drive widespread adoption.

II. RELATED WORKS

A. Theoretical Formulation

This study is grounded in Diffusion of Innovations (DOI), complementary lenses that explain how and why sustainable construction practices diffuse and what levers accelerate their uptake. Diffusion of Innovations follows Rogers' diffusion logic, widely applied in construction technology research, the uptake of new practices proceeds through knowledge, persuasion, decision, implementation and confirmation stages and follows an S-curve across adopter segments (innovators, early adopters, early or late majority, laggards) [2,6]. In construction, diffusion is slowed by perceived risk, lack of information, training burdens, and path-dependence on "tried and tested" methods; diffusion improves when benefits are clear (cost, quality, productivity), risks are low, and trialability is possible [2]. This theoretical lens positions the study objective, to identify strategies that accelerate adoption, as an exercise in altering perceived innovation attributes such as increasing relative advantage through incentives, reducing complexity via training, increasing observability via labeling/certification) and in targeting interventions to specific adopter segments along the diffusion pathway [2].

B. Current Thinking and Approaches

Cross-national surveys by [3] identify incentives, regulation, labeling, and better information as the top strategies globally developing-country studies stress media publicity, training, and institutional frameworks (Ghana) [1] and prioritize tax incentives/regulation plus knowledge exchange using ISM to map interdependencies (Pakistan) [4]. Comparative work on guideline systems such as LEED, BREEAM or Comprehensive Assessment System for Built Environment Efficiency (CASBEE) highlights certification and third-party verification as central informational and normative devices [5]. Broader construction-innovation literature explains variable success through information flows, risk perception, training demands, and policy [2].

The related study's findings are fragmented and context-specific; second, interrelationships among strategies are under-specified except where ISM is used; third, few studies bridge policy instruments with organizational capability and DOI staging in one coherent model [1,2,3,4]. This motivates a study that integrates these strands to surface a context-fit, sequenced portfolio of strategies.

The literature converges on a pragmatic core: adoption of sustainable construction is accelerated when regulatory baselines (codes, mandatory standards) are paired with market instruments (tax credits, subsidies, concessional finance) and reinforced by informational mechanisms (ratings, labels, transparent cost-benefit data). In developing contexts, capability-building (training, awareness, professional accreditation) and institutional scaffolding (dedicated agencies, implementation frameworks) are repeatedly shown to be decisive. Yet evidence remains fragmented, often perception-based, and rarely models how these levers complement or sequence across diffusion stages; causal and longitudinal assessments are scarce, and local tailoring is uneven. The way forward is an integrated, context-specific portfolio that (i) establishes minimum compliance through regulation and procurement, (ii) de-risks first-costs via targeted finance, (iii) reduces uncertainty through credible labeling and open data, and (iv) sustains momentum with workforce development and R&D partnerships. Interdependencies should be explicitly validated (e.g., ISM/MICMAC), sequenced to adopter segments, and embedded in adaptive monitoring and evaluation. Priorities include aligning incentives with enforcement capacity, localizing certification to materials and climate, leveraging public projects as lead markets, and employing mixed-methods and quasi-experimental designs to generate actionable, comparative evidence. This portfolio offers a disciplined path from scattered initiatives to scalable, enduring uptake.

C. Empirical Review

An international survey by [3] examined which strategies most effectively promote green building technologies worldwide, combining a literature review with a questionnaire of 104 experts to rank relative importance; the study consistently elevated financial and market incentives, robust cost-benefit information, mandatory policies, and green rating/labeling, concluding that a common core can guide practitioners and policymakers, but its cross-sectional perceptions offered no causal validation or modeling of inter-strategy dependencies.

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[1] study localized this agenda by deriving 15 strategies through interviews and surveying 43 experienced professionals, then using factor analysis to show the primacy of media publicity, stakeholder education and training, institutional frameworks, strengthened R&D, and financial incentives, organized into coherent clusters; the work underscored context-specific priorities but was limited by a small sample and the absence of outcome tracking or sequencing analysis. [4] addressed energy-efficient technologies in Pakistan using a mixed method, literature extraction, fuzzy Delphi, and ISM/MICMAC, to prioritize levers such as tax/financial schemes, conferences and workshops, policy learning from developed countries, and regulations/standards, demonstrating structural dependencies essential for implementation roadmaps, though generalizability beyond EETs and longitudinal policy execution remained untested.

[5] compared LEED, BREEAM, and CASBEE and, informed by field insights, proposed an implementation strategy emphasizing institutional frameworks, incentives, awareness, and professional accreditation; while conceptually compelling, it lacked empirical impact testing.

[2] synthesized innovation-diffusion theory with construction studies to explain under-diffusion: adoption improves when business cases are clear, training burdens low, networks supportive, and policies aligned, reinforcing that organizational design and policy levers must be jointly managed; they emphasized on integrative models linking diffusion theory, policy instruments, and organizational capabilities with empirical testing.

Recent research converges that regulatory baselines and market incentives, reinforced by credible labeling and transparent cost-benefit information [7,8], are the principal drivers of sustainable construction uptake, while in developing contexts capacity-building, sustained publicity, and robust institutional frameworks are especially decisive. Yet the evidence remains fragmented and largely perception-based, with little modeling of how levers complement one another or how they should be sequenced across diffusion stages [9,10,11]. This points to research that integrates policy instruments with organizational capabilities and diffusion-of-innovations staging to craft context-fit strategy portfolios. The way forward is to map complementarities, prioritize foundational drivers (regulation and finance), embed rating/labeling and information services, and invest in ongoing education and institutional scaffolding to move adopters along the diffusion curve.

III. METHODOLOGY

A. Research Design

The study adopts a mixed-methods, cross-sectional design to capture both the breadth and depth of factors that accelerate sustainable construction adoption. Quantitative and qualitative strands run in tandem to triangulate perceptions of strategy effectiveness with rich, context-specific explanations. The unit of analysis is individuals and organizations in the built environment, with a target population comprising consultants, developers, contractors, and end users. A purposive sampling strategy selects information-rich participants (e.g., project managers, architects, engineers) who shape, implement, or experience sustainability decisions, ensuring that insights are grounded in practice. The design is theory-informed, drawing on diffusion, and operationalized through constructs derived from the literature (barriers, drivers, incentives, regulation, labeling, information, and training). Internal validity is strengthened by methodological triangulation (questionnaires plus interviews), while reliability is supported through pilot testing and refinement of instruments prior to the main study. Ethical procedures include institutional introduction letters, organizational permissions, research licensing, informed participation, and confidentiality protocols. The cross-sectional snapshot is appropriate for establishing a ranked portfolio of strategies and for identifying associations that warrant deeper longitudinal work, while the mixed approach mitigates the limitations of perception-based surveys by embedding stakeholder narratives and use-case examples.

B. Data Collection

Data are drawn from primary and secondary sources. Primary data consist of (i) a structured questionnaire and (ii) semi-structured interviews. The questionnaire has two sections: respondent profile and study constructs. The questionnaire had two sections: respondent background (role, experience, organization) and core study variables on sustainable-construction adoption. Items combined multiple-choice, short-answer, and strategy-focused prompts translated from the literature into measurable indicators and rated on a 5-point Likert scale. Constructs covered perceived barriers, enablers/strategies (e.g.,

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incentives, regulation, labeling, information), and impacts of sustainable practices to allow prioritization and inference. Instrument development was preceded by a literature review and a pilot to refine wording and flow; internal consistency was later checked using Cronbach's alpha. This structure enabled both descriptive profiling and comparative ranking of adoption strategies. The sampling frame targets knowledgeable practitioners across the project lifecycle; purposive selection ensures coverage of design, procurement, delivery, and operation perspectives. Pilot administration tests clarity, flow, and timing; feedback informs minor revisions. To assure validity, the study employs triangulation across methods and sources; to assure reliability, it uses a pilot study and computes Cronbach's alpha for internal consistency of Likert scales before full analysis. Fieldwork proceeds under ethical approvals: institutional letters, organizational consent, and a research permit, with all data handled solely for academic purposes under confidentiality.

C. Data Analysis

Quantitative data are cleaned, coded, and analyzed using descriptive statistics (means, standard deviations, and percentages) to profile respondents and to rank strategies by perceived importance. Processing starts in spreadsheet form and proceeds in R (v4.5.1) with tidyverse workflows for reproducibility (standardizing variable names, handling missing values, converting categorical responses to numeric scores). Frequency tables and visual summaries (e.g., bar and pie charts) are generated for Likert-type items; outputs are programmatically exported for direct integration into reports. Inferential analysis tests hypotheses on the association between sustainability dimensions (economic, environmental, social) and adoption outcomes using t-tests ($\alpha = 0.05$) and multiple linear regression where appropriate. When responses are provided as category frequencies, individual-level vectors are reconstructed (by replicating Likert scores by frequency) to fit regression models; vectors are aligned for model compatibility.

IV. RESULTS AND DISCUSSION**A. Respondents Information**

The 100% response rate was achieved through purposive sampling of accessible, information-rich stakeholders and active follow-up using structured in-person or digital tools. Respondents covered core roles in Kenya's construction ecosystem, project managers, end users, quantity surveyors, engineers, architects, contractors, and developers, with most affiliated to private firms, followed by government and NGOs. Experience levels skewed toward early-career professionals (<5 years) with a substantial mid-career segment (6–10 years) and minimal novices, offering both fresh and practice-grounded perspectives.

The core instrument translated literature-derived levers into a 5-point Likert scale (1 = Not at all to 5 = Very great extent) to prioritize strategies that could accelerate the uptake of sustainable materials and practices. Items included: introducing local-government sustainability checklists during approvals; revising building codes to embed sustainability; empowering stakeholders on benefits; providing government financial incentives; establishing county-level green demonstration centers; integrating sustainability content in educational curricula; and educating clients/end users through case studies for public sensitization. This structure enables ranking of high-leverage interventions and comparison across stakeholder groups. The instrument yields a defensible mapping of who respondents are, where they work, and how strongly they rate specific policy, market, informational, and capability-building strategies for accelerating sustainable construction adoption.

B. Results

This section addresses the research question: Which strategies can accelerate the uptake of sustainable construction materials and practices in the built environment? Respondents rated each proposed measure on a 5-point Likert scale (1 = not at all, 2 = little extent, 3 = moderate extent, 4 = great extent, 5 = very great extent). The portfolio of measures spans four intervention families commonly cited in sustainability transitions: policy/regulatory, market/financial, educational/capability-building, and technological/knowledge levers. Responses were analysed using frequency distributions, mean scores, and standard deviations to rank strategies and gauge the degree of consensus and the results are presented in TABLE I.

TABLE I: STRATEGIES THAT NEED TO BE PUT IN PLACE TO INCREASE THE UPTAKE OF SUSTAINABLE CONSTRUCTION MATERIALS AND PRACTICES IN THE BUILT ENVIRONMENT

STRATEGIES	Not at all (1)	Little extent (2)	Moderate extent (3)	Great extent (4)	Very great extent (5)	Mean	SD
Development of building sustainability checklist by local governments during approval process	9 (2.75%)	10 (3.06%)	50 (15.29%)	110 (33.64%)	148 (45.26%)	4.16	0.98
Revision of building code to spearhead uptake of sustainable construction materials and practices	6 (1.83%)	7 (2.14%)	57 (17.43%)	108 (33.03%)	149 (45.57%)	4.18	0.92
Stakeholder empowerment on the positive impact of uptake of sustainable construction materials and practices	7 (2.14%)	17 (5.2%)	44 (13.46%)	100 (30.58%)	159 (48.62%)	4.18	0.99
Financial incentives by government	6 (1.83%)	30 (9.17%)	50 (15.29%)	94 (28.75%)	147 (44.95%)	4.06	1.06
Establishment of green built demonstration centres at county government level as a way of dissemination at grass roots level	5 (1.53%)	6 (1.83%)	50 (15.29%)	98 (29.97%)	168 (51.38%)	4.28	0.89
Curriculum in learning institutions should include wide coverage of sustainable construction materials and practices	3 (0.92%)	12 (3.67%)	52 (15.9%)	90 (27.52%)	170 (51.99%)	4.26	0.92
Educating clients /end users using case studies as a way of creating awareness and public sensitization	0 (0%)	6 (6.82%)	12 (13.64%)	17 (19.32%)	53 (60.23%)	4.33	0.95
Aggregate						4.21	0.96

TABLE I noted that respondents rated each strategy on a five-point Likert scale (1 = not at all to 5 = very great extent). For the development of a building-sustainability checklist used during local-government approvals, 2.75% selected “not at all,” 3.06% “little extent,” 15.29% “moderate extent,” 33.64% “great extent,” and 45.26% “very great extent.” The mean score was 4.16 (SD = 0.98), indicating broad acceptance and moderately consistent views. Revising the building code to spearhead uptake showed a similarly strong pattern: 1.83% “not at all,” 2.14% “little,” 17.43% “moderate,” 33.03% “great,” and 45.57% “very great,” yielding a mean of 4.18 (SD = 0.92) and reflecting high consensus on the regulatory role of codes. For stakeholder empowerment on the benefits of sustainable materials and practices, 2.14% chose “not at all,” 5.20% “little,” 13.46% “moderate,” 30.58% “great,” and 48.62% “very great,” producing a mean of 4.18 (SD = 0.99) and underscoring the importance of awareness and empowerment. Government financial incentives drew broader dispersion, 1.83% “not at all,” 9.17% “little,” 15.29% “moderate,” 28.75% “great,” and 44.95% “very great”, for a mean of 4.06 (SD = 1.06), suggesting strong support with slightly greater variation in perceived feasibility. Establishing county-level green-build demonstration centres attracted minimal rejection (1.53% “not at all,” 1.83% “little”), with 15.29% “moderate,” 29.97% “great,” and 51.38% “very great,” and achieved a high mean of 4.28 alongside the lowest SD (0.89), highlighting the influence of live demonstrations. Embedding sustainability comprehensively in learning-institution curricula also received strong approval, 0.92% “not at all,” 3.67% “little,” 15.90% “moderate,” 27.52% “great,” and 51.99% “very great”, with a mean of 4.26 (SD = 0.92), signalling consensus on preparing a future-ready workforce. Educating clients and end

users through case studies registered the highest mean (4.33; SD = 0.95), with no “not at all” responses and a clear majority indicating “very great extent,” underscoring the persuasive power of practical evidence. Overall, an aggregate mean of 4.21 (“great extent”) and aggregate SD of 0.96 indicate that the proposed strategies are widely regarded as effective, with relatively low variability across respondents.

C. Discussion

The survey findings align closely with established scholarship on accelerating sustainable construction adoption. High support for regulatory instruments, evidenced by strong ratings for revising building codes and introducing approval-stage sustainability checklists, echoes international and developing-country evidence that mandatory policies and standards are among the most powerful levers for uptake [1,3]. Codes reduce ambiguity, set minimum performance, and signal long-term policy commitment, a mechanism repeatedly highlighted in cross-national reviews and country cases alike [1,3,11]. The similarly strong endorsement of stakeholder empowerment and curriculum integration reinforces the central role of capability building. Ghana-focused work prioritizes training, public awareness, and institutional frameworks as near-term necessities for markets at an early adoption stage [1]; diffusion-oriented syntheses likewise emphasize that lower complexity, clearer guidance, and credible knowledge pathways speed movement from persuasion to implementation in Rogers’ framework [2,6].

The top rating for client/end-user education via case studies and the consensus around county-level demonstration centres are consistent with diffusion theory’s trialability and observability attributes, which reduce perceived risk and accelerate adoption decisions [6]. Demonstrators and lived exemplars also answer calls for practical, context-specific evidence noted in construction adoption research, where clear business cases and visible performance outcomes are critical [2]. These preferences dovetail with implementation strategies that leverage certification and guidance tools (e.g., labeling, checklists) to translate principles into project-level specifics, as argued in the guideline-adoption literature drawing on LEED/BREEAM/CASBEE experience [5].

Financial incentives were rated highly but with slightly greater dispersion, a pattern that mirrors mixed feasibility in the literature: while incentives and concessional finance are repeatedly identified as core drivers globally [3], their design and fiscal sustainability vary by context, especially in emerging markets where budget constraints and administrative capacity can limit reach [8,9,10]. Structural analyses using ISM/MICMAC further suggest that regulation and finance often function as foundational drivers that enable downstream measures such as training, awareness campaigns, and technology promotion—an interdependency reflected in the current results, where strongly rated education and demonstration levers sit alongside calls for regulatory and financial scaffolding [4].

Taken together, the pattern of means, highest for case-based client education and demonstration centres, and consistently strong for curriculum reform, code revision, and stakeholder empowerment, maps onto a consolidated theory-informed portfolio: establish regulatory baselines to set direction, deploy targeted financial instruments to de-risk first costs, and build informational and capability infrastructures (labels, checklists, curricula, demonstrations) to reduce uncertainty and normalize practice [1,3,4,5]. This integrated pathway also resonates with ecosystem perspectives that emphasize multi-actor collaboration to unlock circular and sustainable innovations in construction [7]. Overall, the empirical ratings corroborate the literature’s current thinking while underscoring a context-fit way forward: pair enforceable codes and well-designed incentives with visible exemplars and sustained human-capital investments to move firms and clients along the diffusion curve from early trials to mainstream adoption [2,3,6,11].

V. CONCLUSION

This study examines practical, high-leverage strategies to accelerate the uptake of sustainable construction materials and practices in the built environment. Although environmental and socio-economic benefits are well documented, adoption remains constrained by first-cost premiums, uneven regulatory enforcement, capability gaps, and fragmented information flows. The study contributes a context-fit, sequenced roadmap that integrates regulatory, market, informational, and capability-building levers and quantifies stakeholder support for each.

A mixed-methods, cross-sectional design combined a structured Likert-scale questionnaire with semi-structured interviews of purposively sampled industry actors spanning design, procurement, delivery, and operations. Descriptive statistics (frequencies, means, standard deviations) ranked strategies and gauged consensus, while interview narratives clarified

complementarities and implementation realities. All proposed strategies were rated effective on average (aggregate mean \approx 4.21; SD \approx 0.96). Highest support emerged for client/end-user education using case studies (mean \approx 4.33; SD \approx 0.95) and for county-level demonstration centres (\approx 4.28; SD \approx 0.89), highlighting the importance of trialability and observability. Curriculum integration (\approx 4.26; SD \approx 0.92) and building-code revision (\approx 4.18; SD \approx 0.92) received strong, consistent endorsement, underscoring the twin roles of workforce preparation and regulatory clarity. Stakeholder empowerment (\approx 4.18; SD \approx 0.99) and approval-stage sustainability checklists (\approx 4.16; SD \approx 0.98) reinforced demand for capability and process integration, while targeted financial incentives (\approx 4.06; SD \approx 1.06) drew broad support with slightly greater dispersion reflecting feasibility concerns.

The findings align with diffusion-of-innovations theory: visibility, credible information, and enforceable baselines move adopters along the uptake curve, while education and exemplars normalize practice. Future studies needs to consider updating codes and institutionalizing approval-stage checklists; deployment of time-bound, well-targeted incentives where fiscal space are allowed; expanding labeling and transparent cost–benefit data; embedding sustainability in curricula and continuing professional development; establish demonstration centres to showcase performance and business cases; and institute adaptive monitoring and quasi-experimental evaluation to refine the strategy portfolio over time. Collectively, this pathway offers a disciplined shift from isolated initiatives to scalable, enduring adoption.

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