



Influence of User Awareness on Green Building Adoption in Project Management: The Case of Institution of Engineers Rwanda

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Abstract: *This study examined the influence of user awareness on green building adoption in project management within the Institution of Engineers Rwanda (IER). Employing a mixed-methods approach, data were collected from 210 IER professionals through structured questionnaires, semi structured interviews, document reviews, and observations. Quantitative analysis utilized descriptive and inferential statistics, while qualitative data underwent thematic analysis. Results revealed a statistically significant positive relationship between user awareness and green building adoption ($R^2 = 0.523$, $\beta = 0.723$, $p < 0.001$), with awareness explaining 52.3% of adoption variance. While 76.2% of respondents recognized green building benefits, only 67.6% demonstrated comprehensive understanding of principles, revealing a critical awareness-implementation gap. Barriers included limited exposure to green building concepts (16.2% reported unawareness), hierarchical decision-making favouring traditional methods, and supply chain constraints. The study advocates for perception-centric strategies including localized awareness campaigns, experiential learning modules, and culturally resonant certification frameworks aligned with Rwanda's Vision 2050 sustainability targets. Findings position IER as both a technical guide and behavioural catalyst in bridging policy-practice divides through targeted capacity-building interventions.*

Keywords: *User awareness; Green building adoption; Project management; Sustainable construction; Environmental sustainability; Rwanda*

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1. Introduction

Green building has become central to global sustainability efforts, offering solutions to challenges of environmental degradation and resource inefficiency (Jones, 2019). In Rwanda, despite progressive initiatives such as the Green Building Minimum Compliance System (GBMCS) established in 2019 and alignment with Vision 2050

sustainability goals (Government of Rwanda, 2020), implementation remains limited. Recent studies show that while 90.2% of construction professionals in Kigali are aware of green building practices, only 17.9% integrate them into projects (Minani et al., 2024). This awareness practice gap threatens Rwanda's target to make green buildings standard by 2035, with the UNFCCC (2022), projecting that building-related CO₂ emissions could rise by 574% by 2050 without effective adoption.

User awareness defined as stakeholders' comprehension of green building concepts, principles, and benefits is a critical determinant of adoption behaviour (Tanaka & Nakamura, 2017). Empirical research consistently identifies lack of awareness as the leading barrier to green building implementation globally (Darko et al., 2019) and regionally in Sub-Saharan Africa, where 60% of construction professionals cite insufficient technical knowledge as a major constraint (Kihila et al., 2021). In Rwanda, the Institution of Engineers Rwanda (IER), established by official gazette in 2017, plays a central role in advancing professional standards and promoting sustainable engineering (IER, 2021). However, the effectiveness of IER's awareness programs in driving actual adoption has yet to be empirically evaluated.

This study therefore investigates the influence of user awareness on green building adoption within Rwanda's project management context. Unlike prior research focusing broadly on barriers (Mugisha & Murekezi, 2019) or general stakeholder attitudes (Kayitesi, 2020), it isolates awareness as a key predictive factor of adoption among IER members. The findings are expected to contribute to evidence-based policymaking, strengthen IER's capacity-building initiatives, and support Rwanda's transition toward climate-resilient infrastructure consistent with national development priorities and global sustainability frameworks (World Bank, 2023).

1.1 Problem statement

Rwanda is making strides in green building awareness, with over 90% of engineers and project managers familiar with sustainable construction principles. However, actual implementation lags significantly, with only 17.9% applying these practices (Minani, Hategekimana & Niyonzima, 2024). This gap persists despite national commitments including Vision 2050's target for green buildings to become standard by 2035 and mounting environmental pressures. Key barriers to adoption include high upfront costs, insufficient local technical capacity, and entrenched perception barriers among construction professionals.

This study examines how user perceptions, analysed through the Innovation-Expectation-Resistance (IER) framework, influence green building adoption in project management. It proposes targeted strategies across three critical areas: cost management, capacity building, and awareness enhancement. These interventions aim to accelerate green building uptake and advance Rwanda's sustainable development and climate mitigation objectives.

1.2 Research Objective

The main purpose of this study is to examine the Influence of user awareness on green building adoption in project management.

2.Literature Review

User awareness has been identified as a key driver for the uptake of green buildings in several theoretical frameworks. Davis' (1989) technology acceptance model shows that perceived utility and ease of use determine the behaviour of acceptance, as does Alwalwan et al. (2022) confirming that the long-term environmental and economic benefits are prioritised by informed stakeholders, despite the initial costs. Similarly, Ajzen's (1991) theory of planned behaviour suggests that awareness shapes attitudes that, combined with social norms and perceived control, predict behaviour intentions, a relationship confirmed by Yadav and Pathak (2022), who found that attitudes based on awareness explain 41 percent of the variation in adoption rates. Rogers (1962) the diffusion of innovation theory places awareness as a catalyst for the movement from early adopter to majority acceptance, particularly relevant in contexts such as Rwanda, where the penetration of green buildings remains at 17.9 percent. However, research distinguishes between passive awareness (surface-level knowledge) and active awareness (perceived knowledge), which has a greater predictive power in terms of actual implementation (Darko et al., 2019; Oduho et al., 2022).

Global and regional evidence confirms that awareness is a strong predictor of acceptance, while also revealing persistent obstacles to implementation. In a developed context, Weber and colleagues (2019) found that German users value health benefits but require clearer operational guidelines, while mandatory sustainability education in Singapore correlated with a 40 percent increase in green certification (Building and Building Authority, 2024). However, studies in sub-Saharan Africa reveal a critical gap in awareness-raising: despite high awareness levels, uptake is still limited by technical skills gaps, accessibility problems and cost barriers (Anzagira et al., 2021; Ombati, 2023). In Rwanda, Minani (2018) and Niyonzima & Uwizeza (2020) found that limited policy enforcement and technical capacity prevent the implementation of awareness, as illustrated by the fact that 80 percent of new buildings in Kigali are assessed for their environmental performance.

The present study addresses three critical gaps in the existing literature on the uptake of green buildings in Rwanda. First, previous research in Rwanda (Minani,

2018; Kayitesi, 2020) used mainly descriptive methods without statistically quantifying the relationship between the level of awareness and the uptake rate, leaving the extent of the impact of awareness empirically unproven. Second, no study has explored the specific role of the Institute of Engineers of Rwanda (IER) as a central professional body in creating awareness through training, certification standards and political advocacy, despite its central role in the construction sector. Thirdly, while studies acknowledge the gap between awareness and implementation (Mugisha and Murekezi, 2019), none has empirically investigated the mechanisms by which awareness translates or does not translate into real behavioural change in project management practices. By quantifying these relationships and isolating the institutional impact of IER, this research provides actionable insights to bridge the persistent gap between knowledge of green building and implementation in Rwanda.

3. Methodology

This study examined the relationship between user awareness and green building adoption among 600 IER members using a mixed-methods approach. 240 participants were chosen using stratified random sampling with a 5 percent margin of error, divided into five groups: engineers (n = 80), project managers (n = 20), contractors (n = 20), employees (n = 80), and beneficiaries (n = 40). Four awareness dimensions knowledge, benefit understanding, information seeking, and recognition were measured using structured, pre-tested questionnaires with an 87.5 percent response rate (n=210). Site observations, GBMCS policy and IER curriculum reviews, and twenty-four semi-structured interviews comprised the qualitative data. Reliability tests revealed Cronbach's $\alpha=0.85$ and test-retest $r = 0.81$ ($p<0.001$), guaranteeing consistency and stability. Content (I-CVI ≥ 0.78 , S-CVI ≥ 0.9), construct (EFA loadings ≥ 0.5 ; CFA CFI=0.97, RMSEA=0.04), and criterion validity ($r>0.70$) were used to confirm validity (DeVellis, 2016).

Data analysis used methodological triangulation, combining SPSS version 28 for quantitative analysis and

thematic coding for qualitative interpretation (Creswell & Creswell, 2018).

Descriptive statistics summarized awareness levels and adoption patterns, while Pearson correlation and simple linear regression examined relationships between awareness and adoption (operationalized as belief in adoption essentiality). Qualitative thematic analysis of interviews, policy documents, and field observations revealed implementation gaps and sociocultural dynamics. Integrating quantitative and qualitative findings provided comprehensive insights into awareness mechanisms and the IER framework's institutional influence on Rwanda's construction practices.

This study maintains strict ethical standards with Mount Kigali University approval. Participants provided informed consent after receiving complete study information, ensuring voluntary participation. Confidentiality is protected through secure data storage and post-analysis deletion, with no external sharing. Anonymity is ensured through aggregated-only reporting without personally identifiable details, aligning with established ethical guidelines.

4. Results and Discussion

The study achieved a response rate of 87.5 percent (210 respondents) which strengthens the credibility and minimises bias in non-response. Table 1 shows the demographic profile of the participants, showing that the sample is predominantly male (70.5), age-oriented (25-44 years) and highly educated, with 88.1 percent having a university degree or higher. Engineers accounted for 40.9 percent of the respondents, followed by workers (30.5), suppliers (11.9), grant holders (10.5) and project officers (6.2). As regards the categories of IER members, graduate members made up 43.8 percent, professional members 37.1 percent and non-professionals 14.8 percent. It is noteworthy that while 61 percent of them reported to be involved in green building projects, 39 percent remained uninvolved, despite being members of the IER, which highlights the untapped potential of awareness-raising interventions. Experience in managing projects was broken down as follows: less than 2 years (37.1), 2-5 years (39.5), 6-10 years (19.5) and more than 10 years (3.9).

Table 1: Demographic Profile of Respondents (N=210)

Characteristic	Category	Frequency	Percentage
Gender	Male	148	70.5%
	Female	62	29.5%
Age Group	Below 25	9	4.3%
	25-34	134	63.8%
	35-44	61	29.0%
	45-54	5	2.4%
	55-64	1	0.5%
Education Level	Primary/Secondary	22	10.5%
	University	150	71.4%
	Master's	35	16.7%
	Higher Education	3	1.4%
Occupation	Engineer	86	40.9%
	Project Manager	13	6.2%
	Contractor	25	11.9%
	Worker	64	30.5%
	Beneficiary	22	10.5%
IER Membership	Graduate Member	92	43.8%
	Professional Member	78	37.1%
	Fellow Member	31	14.8%
	Other	9	4.3%
Green Building Involvement	Involved	128	61.0%
	Not Involved	82	39.0%
PM Experience	<2 years	78	37.1%
	2-5 years	83	39.5%
	6-10 years	41	19.5%
	>10 years	8	3.9%

Table 2 presents descriptive statistics for user awareness across four dimensions: knowledge of green building principles, understanding of environmental and economic benefits, information-seeking behaviour, and recognition capability. Across all dimensions, approximately 67-72% of respondents agreed or strongly agreed with awareness indicators, demonstrating generally positive perceptions. Knowledge of principles recorded a mean of 3.62 (SD=1.23), with 43.8% agreeing and 23.8% strongly agreeing. Understanding of benefits achieved the highest mean of 3.72 (SD=1.28), with 41.4% agreeing and 30.5%

strongly agreeing. Information-seeking behaviour yielded a mean of 3.63 (SD=1.26), while recognition capability also scored 3.72 (SD=1.17). Overall awareness influence on adoption recorded a mean of 3.79 (SD=1.31), with 71.4% expressing agreement. However, 17-19% of respondents disagreed across dimensions, revealing a significant awareness deficit among nearly one-fifth of professionals. Neutral responses ranging from 9-16% suggest ambivalence or limited exposure, particularly regarding benefits understanding and information-seeking behaviour.

Table 2: User Awareness Descriptive Statistics (N=210)

Awareness Dimension	SD	D	N	A	SA	Mean	SD
Knowledge of Principles	11.4%	6.2%	14.8%	43.8%	23.8%	3.62	1.23
Understanding of Benefits	10.5%	8.6%	9.0%	41.4%	30.5%	3.72	1.28
Information-Seeking Behavior	10.5%	8.1%	16.2%	38.6%	26.7%	3.63	1.26
Recognition Capability	7.1%	9.0%	14.3%	43.8%	25.7%	3.72	1.17
Overall Awareness Influence	11.0%	6.7%	11.0%	34.3%	37.1%	3.79	1.31

Note: SD=Strongly Disagree, D=Disagree, N=Neutral, A=Agree, SA=Strongly Agree

Qualitative data from semi-structured interviews corroborated these quantitative findings, with interviewees emphasizing that awareness directly encourages adoption, particularly regarding environmental impact, cost savings, and regulatory compliance. One project manager articulated: "When engineers understand the long-term Return on Investment (ROI) and environmental benefits, they naturally advocate for green solutions. The problem is that awareness campaigns haven't reached everyone equally." Document reviews of IER's GBMCS and Climate Resilient Settlements Guidelines revealed mandated engineer proficiency in green standards, creating regulatory necessity that forces awareness development for compliance and permit eligibility. However, field observations at certified construction sites exposed implementation gaps: hierarchical decision-making patterns led junior engineers to defer to seniors favoring conventional methods, while supply chain bottlenecks undermined even informed professionals' adoption efforts. These findings reveal a critical distinction between passive awareness—superficial familiarity with green building concepts—and active awareness—operational competency to implement sustainable practices. Respondents differentiated these levels explicitly, with one engineer explaining: "We know green buildings exist and are beneficial but translating that knowledge into technical specifications requires training we haven't received." This echoes Oduho et al.'s (2022) Kenyan finding that 63.6% possessed passive awareness insufficient for adoption decisions.

Pearson correlation analysis examined relationships between awareness dimensions and overall green building adoption perception, operationalized as belief that adoption is essential for Rwanda's project management future. Table 3 presents the correlation matrix, demonstrating that all awareness dimensions exhibited statistically significant positive correlations with adoption at the $p < .01$ level. Knowledge of principles showed the strongest correlation ($r = .723$, $p < .01$), followed by understanding of benefits ($r = .698$, $p < .01$), information-seeking behaviour ($r = .665$, $p < .01$), and recognition capability ($r = .641$, $p < .01$). Inter-dimensional correlations ranged from $r = .598$ to $r = .701$, confirming awareness as a coherent construct and validating the scale's reliability. These strong positive correlations substantiate that as stakeholder awareness increases across all dimensions; the likelihood of adoption perception intensifies correspondingly. The findings validate theoretical propositions from Davis's (1989) Technology Acceptance Model and Rogers's (1962) Diffusion of Innovations Theory that awareness precedes and influences adoption decisions. Qualitative data reinforced this pattern: stakeholders with comprehensive awareness actively advocated for green practices during interviews, while those with limited awareness exhibited passive resistance or deference to traditional construction methods.

Table 3: Correlation Matrix

Variable	1	2	3	4	5
1. Knowledge of Principles	1.000				
2. Understanding of Benefits	.682**	1.000			
3. Information-Seeking	.645**	.701**	1.000		
4. Recognition Capability	.598**	.663**	.612**	1.000	
5. Green Building Adoption	.723**	.698**	.665**	.641**	1.000

*Note: *p < 0.01 (2-tailed)

Simple linear regression analysis assessed the predictive relationship between user awareness (independent variable: perceived influence of increased stakeholder awareness) and green building adoption (dependent variable: belief that adoption is essential). The model summary in Table 4 yielded R=.723, indicating a strong positive correlation, with R²=.523 revealing that 52.3% of variance in green building adoption perceptions is explained by user awareness. The adjusted R²=.521 confirmed model reliability after accounting for sample size, while the standard error of estimate (.851) reflected

moderate variability in predictions. This finding positions awareness as the strongest predictor among perceptual factors examined in the broader study, surpassing attitude (R²=.438), cultural norms (R²=.540), and personal experience (R²=.466). The magnitude of explained variance aligns with Tanaka and Nakamura's (2017) Japanese study identifying awareness-long-term benefit perception correlations, and supports Darko et al.'s (2019) global meta-analysis positioning lack of awareness as the primary adoption barrier across contexts.

Table 4: Model Summary

Model	R	R ²	Adjusted R ²	Std. Error of Estimate
1	.723	.523	.521	.851

Predictors: (Constant), Increased awareness among stakeholders
 Dependent Variable: Belief in green building adoption essentiality

The Analysis of Variance (ANOVA) results in Table 5 show that the regression model reached statistical significance at F=228.459 (p<.001), which supports the notion that awareness is a meaningful predictor of adoption and not a relationship attributable to accidental events. The squares regression sum (165.508) was significantly greater than the residual squares regression sum (150.687), suggesting that the model explains more of the variance than is unaccounted for. Table 6 shows the regression coefficients, and the non-standardised coefficient (B =.682, p<.001) indicates that the increase in awareness is consistent with an increase in acceptance of the adoption.

A standardised beta coefficient ($\beta = .723$, p<.001) confirmed a strong positive effect, t = 15.115 indicating high statistical significance. Based on these results, a null hypothesis (H₀: no significant correlation between user awareness and green building adoption) is definitively rejected. Data provide compelling evidence that user awareness significantly and positively predicts the uptake of green buildings in the context of project management in Rwanda, and this empirical validation has important policy implications: awareness-raising interventions promise to accelerate adoption to the maximum for the resources invested.

Table 5: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	165.508	1	165.508	228.459	.000
Residual	150.687	208	.724		
Total	316.195	209			

Table 6: Regression Coefficients

Model	B	Std. Error	β	t	Sig.
(Constant)	1.469	.181		8.105	.000
User Awareness	.682	.045	.723	15.115	.000

Although 67.6% of respondents reported strong awareness, only 17.9% of Kigali professionals actively use green practices (Minani et al., 2024), revealing a significant awareness-implementation gap. Qualitative findings illuminate this disconnect's underlying causes. Field observations showed that junior engineers with strong awareness often deferred to senior decision-makers preferring conventional methods, creating knowledge-practice gaps rooted in hierarchical structures. This aligns with Mukamana's (2019) finding that 80% of Rwandan construction projects face delays due to hierarchical deference, suggesting awareness interventions must target decision-makers to achieve behavioural change. Additionally, document reviews and site observations identified limited availability of GBMCS-compliant materials in rural areas, undermining adoption even among well-informed engineers. One contractor explained: "We understand rainwater harvesting benefits, but procurement lead times make conventional systems more viable for project timelines." These supply chain barriers indicate that awareness alone is insufficient it must be complemented by infrastructure development and improved material supply networks to translate knowledge into practice.

The Institution of Engineers Rwanda (IER) serves as the primary mechanism for cultivating green building awareness through training workshops, GBMCS enforcement, and certification programs, with 74.3% of respondents acknowledging the importance of compliance following professional development modules. Demonstration projects and certification-linked incentives effectively reinforced learning, though urban-rural disparities limit reach, leaving 16.2% of members unaware and highlighting the need for mobile, hands-on training in remote districts (Minani, 2018). Rwanda's collectivist culture enhances awareness when framed as community collaboration (Ubudehe) and aligned with national

development goals (Mutangana et al., 2019), though traditional construction practices sometimes conflict with modern green technologies, necessitating "bi-cultural competency" to integrate international standards with vernacular knowledge (Alemu & Teshome, 2020).

Comparative analysis situates Rwanda's findings within broader regional and global contexts: awareness explains 52.3% of adoption variance, similar to China's 48% (Li et al., 2021), but lags behind Singapore's regulatory-driven 40% certification increase (BCA, 2024) and Kenya's vocational curriculum integration. Addressing the 16–19% awareness deficit, particularly among rural workers and uninvolved members, could employ mobile microlearning, peer mentorship, and experiential apprenticeship models (Moyo, 2020) targeting ambivalent yet persuadable stakeholders. The integration of quantitative ($\beta=.723$) and qualitative evidence demonstrates that while awareness is necessary, sustainable adoption also requires attention to hierarchical structures, material supply chains, cultural alignment, and supportive regulatory frameworks to achieve Rwanda's green building objectives.

5. Conclusion and Recommendations

The study shows that user awareness is the main driver of uptake of green buildings among Rwandan engineers, accounting for over half of the variation in uptake ($R^2 = .523$). Despite the high awareness (over 67), practical implementation remains low (61%), suggesting that awareness alone is not enough without the support of institutional and resources. Awareness functions as a multi-dimensional construct, a combination of knowledge, motivation and application, which is reinforced by IER training, and certification programmes, which have significantly increased compliance (87 percent compared

to 34 percent). Hierarchical constraints, material constraints and cultural resistance are the main obstacles. The study recommends the extension of contextualised training, rural information and enforcement mechanisms, stressing that awareness must be combined with structural and institutional support to achieve meaningful implementation.

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