“Influence of consumer motivations and perception on the adoption of smart, green, and sustainable building materials”

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ARTICLE INFO	Rajendra P. and Mohanasundaram T. (2023). Influence of consumer motivations and perception on the adoption of smart, green, and sustainable building materials. *Innovative Marketing* , *19*(4), 66-80. doi:10.21511/im.19(4).2023.06
DOI	http://dx.doi.org/10.21511/im.19(4).2023.06
RELEASED ON	Wednesday, 25 October 2023
RECEIVED ON	Tuesday, 20 June 2023
ACCEPTED ON	Saturday, 23 September 2023

JOURNAL	"Innovative Marketing "
ISSN PRINT	1814-2427
ISSN ONLINE	1816-6326
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
45	2	5

BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine
www.businessperspectives.org

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INFLUENCE OF CONSUMER MOTIVATIONS AND PERCEPTION ON THE ADOPTION OF SMART, GREEN, AND SUSTAINABLE BUILDING MATERIALS

Abstract

The purpose of this study is to analyze the barriers to the widespread use of smart, green, and sustainable building materials in the construction industry by focusing on the perceptions, motivations, strategies, and challenges faced by consumers. The analysis employed an exploratory methodology and surveyed 385 respondents in Bangalore, India. The study result shows a significant positive partial correlation ($r = 0.629$, $p = 0.001$) between the challenges of adoption and the overall factors that influence adoption after controlling the annual income as a control variable. The higher mean score of personal values and ethics of 4.25 implies that moral values and ethics influence the decisions on the adoption of construction materials. The findings of multiple regression with robust standard error revealed perception of performance of smart, green and sustainable building materials is better compared to traditional building materials (p-value = 0.001), factors positively influencing adoption (p-value = 0.004), motivating factors of adoption (p-value = 0.001) and strategies that encourage adoption of smart, green, and sustainable building materials (p-value = 0.001). All of these have a substantial influence on how consumers evaluate the government's efforts to increase the adoption of such materials. However, challenges in adoption showed a negative coefficient ($B = –0.049$) and a robust standard error of 0.024 (p-value = 0.048), demonstrating a negative influence on consumers' perception. This research acts as a guiding beacon for green adoption policies by studying consumer motivations and perceptions toward adoption of eco-friendly building materials for the sustainable future.

Received on: 20th of June, 2023
Accepted on: 23rd of September, 2023
Published on: 25th of October, 2023

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Keywords sustainability, green materials, smart materials, challenges, consumer perception, adoption factors, consumer motivation

JEL Classification M00, M30, M31, L74, Q01

Conflict of interest statement:
Author(s) reported no conflict of interest

INTRODUCTION

Based on growing concern about natural resources and the need to address the adverse environmental impacts of the construction sector, it is crucial to understand consumer behavior, specifically motivations, perceptions and barriers to smart, green, and sustainable building materials. Smart, green, and sustainable building materials or eco-friendly building materials are essential to reduce pollution and attain sustainability. Incorporating these eco-friendly building components into construction could benefit the environment. Bamboo and stabilized mud brick are smart, green and sustainable building materials that might reduce energy usage and pollution. Unfortunately, few people use these building materials in structures, and consumer problems such as lack of interest, high running expenses, and others must be addressed. This requires intensive efforts to promote the knowledge about the benefits of utilizing certain construction materials. To encourage a greater understanding and acceptance of these contempo-

http://dx.doi.org/10.21511/im.19(4).2023.06

rary construction materials, manufacturers and builders must organize educational efforts, promotional campaigns, and cooperative alliances to make consumers aware of the benefits of smart, green and sustainable building materials.

The primary objective is to develop a roadmap for a sustainable future, focusing on consumer behavioral factors like motivation and perceptions affecting the successful adoption of these eco-friendly building materials. The main research questions for the study are: What are the primary motivations driving consumers to embrace smart, green, and sustainable building materials? What are the most significant hurdles that consumers face while adopting smart, green and sustainable construction materials? What are the relationships between hurdles in adoption and overall factors of adoption with annual income acting as a control variable? Although consumers are becoming more aware of the significance of environmentally conscious building materials, they still face a number of obstacles that influence their adoption decision. Understanding customer motivations and challenges is crucial in promoting eco-friendly materials for construction.

Limited research studies have been conducted in Bangalore, India, pertaining to consumer perceptions and use of smart, green, and sustainable construction materials in this cosmopolitan city. Thus, it is essential to acknowledge and cover this research gap, overcoming limitations, and strive towards achieving enduring sustainability objectives via the assessment of consumer motivations perceptions, barriers, and other determinants that impact the acceptance of such building materials.

1. LITERATURE REVIEW

The use of smart, green, and sustainable building materials is essential to mitigate the environmental effects of the construction industry. Promoting these materials requires a thorough understanding of consumer behavior, including adoption barriers, use-motivating factors, and advantages associated with using these products. The notion of smart, green, and sustainable materials is well described in the literature. Most of the existing studies focused on the technological characteristics of these materials and its adoption, leaving a gap in the understanding of the behavioral aspects of consumers. Building materials that fall under the categories of smart, green, and sustainable comprise a wide variety of products helping to reduce energy consumption and waste. This includes aerogel, self-healing concrete, bamboo, stabilized mud bricks, etc. Smart materials are a class of materials that possessed the ability to react to alterations in their environment or internal state in a practical and often cyclical fashion (Patel & Goyal, 2018). Green building materials are recyclable or decomposable (Zhao et al., 2018). Sustainability involves long-term resource preservation and minimizing negative impacts on the environment. Sustainable construction materials minimize their environmental effect and preserve resources (Song & Zhang, 2018).

There are a fair number of research on smart building materials that explain their advantages. One such smart material that has caught the interest of the scientific community is aerogel. Aerogel-based materials are used for highly efficient thermal insulation in the construction sector, as it has extremely low thermal conductivity and highest porosity (Günther et al., 2020; Shanmugam et al., 2020). Aerogel acts as an insulation, which can improve building's energy efficiency, reduce cost of heating and cooling, and also enhance comfort for its occupants. Traditional insulating materials could be replaced by aerogels, as they are manufactured from renewable and biodegradable elements (Cen et al., 2023). Marketing aerogel materials in construction will go a long way among the consumers who are pro-environmentalists. Self-healing concreate is another widely discussed smart building material in the literature. Numerous techniques, including autogenous, chemical, and bacterial self-healing, are used in self-healing concrete to repair the material's structural integrity (Manhanga et al., 2022). Cracks and other damage on the building can be self-healed, thus enhancing the building's lifespan and reducing the need for expensive repairs (Chen et al., 2023). Thus, this helps consumers to reduce their annual maintenance cost of building and also helps in achieving sustainability.

There are also numerous studies related to green and sustainable building materials. Among them bamboo and stabilized mud bricks are widely addressed in the literature. Bamboo building has the ability to contribute to sustainable development and reduce deforestation (Böck, 2014). They are used to make laminated boards, beams, columns, roofing, and interior treatments (Lianto et al., 2019). As bamboo can withstand earthquakes, it is elastic, and it is simple to work with (Ramatia et al., 2020). The environmental impact of bamboo is beneficial since it is a sustainable resource and it offers durability. Stabilized mud brick is another green and sustainable building material that has received ample attention from researchers. Stabilized mud bricks may be utilized as a cost-effective substitute for conventional burnt clay bricks (Mishra, 2015). Such bricks saved labor and increased speed of construction (Tekpe et al., 2022). They are an environmental friendly alternative to traditional clay brick in sustainable construction (Daniel et al., 2021). These bricks do not need to be burned, which makes them a green and healthy building material.

Many researches have thrown light on the barriers in adopting smart, green, and sustainable building materials. Some important outcomes of the studies that focused on the challenges in adoption of these materials are as follows. Innovation and information transmission to purchasers in the residential building market has been suboptimal, hindering the adoption of novel construction materials (Graham & Warren-Myers, 2019). Implementing sustainable building materials is challenging due to high upfront cost and protracted payback times (Simion et al., 2019). The survey of 187 individuals revealed that consumers were reluctant to adopt innovative construction materials (Anastasiou et al., 2022). In undeveloped nations, people were unaware of green building materials' advantages, making them hard to adopt (Akcay, 2023; Adeniyi & Mohamed, 2020). Insufficient information, excessive expenses, lack of incentives, little interest, and low demand were the most prominent hurdles (Darko & Chan, 2017). In Ghana, adoption was hindered by a lack of knowledge of current green buildings, incentives, Ghanaians' conservative attitude, active government participation, insufficient human resources, a lack of understanding of advantages, costs, and finance, and legal support (Agyekum et al., 2019). Project delays, lack of research and development, public disinterest, poor building code enforcement, long payback periods, unpredictable green material supply, inappropriate policy framework implementation, and green building technology performance plagued India and other developing countries (Saha et al., 2021). Three main hurdles are broken down from the study findings: (a) being green is too difficult (b) green is frowned upon, and (c) reservations for green are made (Johnstone & Tan, 2015).

Numerous research sought to identify the benefits and crucial factors that significantly influence consumers' decisions to purchase smart, green, and sustainable building materials. Due to intrinsic motivators like inherent enjoyment and personal values, consumers adopted ecologically friendly products or engaged in environmentally beneficial behaviors like recycling, waste reduction, and material repair (Kouhizadeh et al., 2019). The determinants that govern consumer behavior with respect to sustainable construction practices can be complicated and diverse, as the desire to buy a house, live in a more secure environment, and leave a legacy for future generations served as driving forces for consumers (Kirby et al., 2022). In order to foster the concept of sustainable construction in consumers, education played a vital role. Sustainable consumer behavior scores in the United States are higher among people who have taken building education and training courses that emphasize sustainable design and construction (Jung et al., 2019). Government authorities should impose sustainable consumer behavior training and education as an obligatory course across all areas of academics for better awareness and adoption of these building materials. Likewise, the green building movement was backed by the construction industry because it was ecologically beneficial and improved consumer perceptions of social values (Tam et al., 2012). The intention was modified by subjective norm, perceived behavior control, and other factors (Yang et al., 2019). These variables influence people's decisions to employ smart building materials in construction. A Lebanon based research found that using locally available sustainable building materials led to social advancement (Sonebi et al., 2022). Consumers who are aware of green buildings and have a strong environmental attitude and lifestyle are more likely to adopt green and sustainable building materials (Kirby et al., 2023).

http://dx.doi.org/10.21511/im.19(4).2023.06

Research mainly targeted some specific smart, green, and sustainable materials. Most studies have focused on the challenges, determinants, and benefits of those building materials. Moreover, almost all the studies emphasized one or a few aspects of consumer behavior toward smart, green, and sustainable building materials. The present study is holistic in nature as it captures different dimensions of consumer behavior related to the adoption of smart, green, and sustainable building materials. In addition, there are only a few studies carried out in India regarding consumer behavioral aspects of adopting smart, green, and sustainable building materials. Thus, there is a dire need for an exclusive and holistic study in this domain. Finally, this study seeks to fill the knowledge gap by identifying the key factors that explain specific barriers to adoption of smart, green, and sustainable building materials in multicultural settings and also offering solutions to these barriers.

2. AIMS AND HYPOTHESES

This paper aims to discover the motivating factors, barriers, and adoption strategies related to smart, green, and sustainable building materials in Bangalore, India. The study also investigates the differences in motivation across various occupation levels and measures the influence of income as a control variable on adoption hurdles and overall factors.

The following hypotheses have been formulated and mapped on to the conceptual model/research framework in Figure 1:

H_1: *The dependent variable (perception of the overall performance of smart, green, and sustainable building materials compared to traditional building materials) cannot be significantly explained by at least one of the independent variables (factors positively influencing adoption, motivating factors of adoption, challenges/hurdles in adoption and strategies encouraging adoption among smart, green, and sustainable building materials).*

H_2: *There is no significant difference in motivation to embrace smart, green, and sustainable building material across different occupation levels.*

H_3: *There is no significant relationship between challenges/hurdles in adoption and overall factors affecting adoption, controlling for the effect of annual income.*

3. METHODOLOGY

The study follows exploratory research method to conduct research by identifying and categorized variables influencing consumer adoption. This study employs both judgment sampling and snowball sampling in an effort to capture a wide variety of consumer perspectives on building material adoption. Participants are selected based on their knowledge and expertise in these building materials across different nature of occupations. Snowball sampling was used to gather a diverse range of perspectives by asking participants to recommend others who met the criteria. This method of selection ensures that participants have insightful and pertinent perspectives to share. This study seeks to comprehend the propelling forces, motivations, and barriers that consumers encounter during the adoption phase of smart, green, and sustainable building materials.

The population size of Bangalore is estimated to be approximately 13,608,000 (Macrotrends, n.d.). Using the formula for the sample size calculation with a desired confidence level of 95% (Z = 1.96) and a margin of error (E) of 5% (0.05), the sample size is determined as follows:

$$n = \frac{N \cdot Z^2 \cdot p \cdot q}{\left(N \cdot Z^2 \cdot p \cdot q\right) + \left(E^2 \cdot (N-1)\right)}, \quad (1)$$

where N = 13,608,000 (population size of Bangalore); Z = 1.96 (Z-score for 95% confidence level); p = 0.5 (estimated proportion); q = 1–p = 0.5; E = 0.05 (margin of error). Evaluation of this equation yields a sample size (n) estimate of 385.

$$n = \frac{13.608.000 \cdot 1.96^2 \cdot 0.5 \cdot 0.5}{\left[\left(13.608.000 \cdot 1.96^2 \cdot 0.5 \cdot 0.5\right) + \left(0.05^2 \cdot (13.608.000 - 1)\right)\right]} = 385. \quad (2)$$

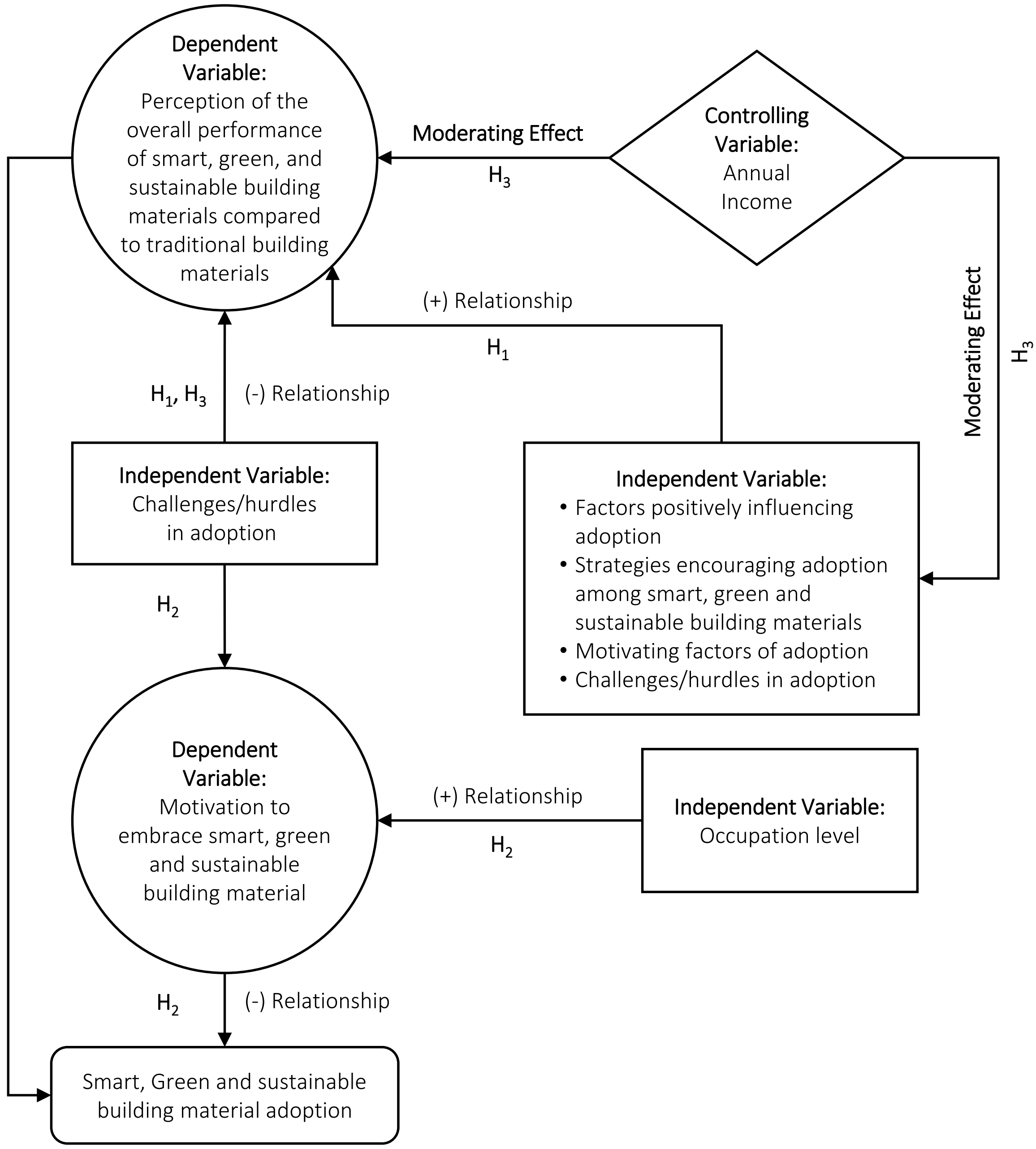

Figure 1. Research framework for H_1, H_2 and H_3

The questionnaire's items are tested for reliability using Cronbach's alpha. The questions were created based on research articles. Participants are surveyed to collect primary data. Based on the research's goals and questions, the questionnaire has gathered customer motivations and obstacles to adopt smart, green, and sustainable building materials.

The data collected are evaluated using applicable statistical techniques like Robust multiple regression analysis, multivariate analysis (MANOVA) with post hoc Dunnet T3 and Partial correlation. The key motives and obstacles found by the survey results are evaluated, and any noteworthy differences across demographic perceptions, specifically as occupation, are studied. The study is intended to find common barriers restricting the adoption of smart, green, and sustainable building materials among customers in Bangalore. The paper has secured informed consent from all participants in the survey, ensuring that their data would be used for research purposes while maintaining confidentiality and anonymity. The analysis is done in compliance with applicable ethical norms and legislation.

http://dx.doi.org/10.21511/im.19(4).2023.06

4. RESULTS

Diverse statistical measures and tools were used to derive and interpret the resulting inferential analysis. Given the varying number of items within each scale, only the mean score and standard deviation value were reported in Figure 2. The final transformed weighted score reported here is obtained by aggregating the scores of all sub-factors/items (questions grouped under a single concept or heading) for each respective factor. The main factors/constructs acting as motivation, perception and hurdles in adoption are factors positively influencing adoption (FPIA), motivating factors in adoption (MFA), challenges in adoption (CIA) and strategies encouraging adoption of smart, green and sustainable building material (SEASGSBM). These factors are first summed using the compute variable option on IBM SPSS and then transformed from ordinal type to ratio scale type variable by summing row-wise variables of each ordinal variables. Under each construct, 5 sub-factors are designed to meet the purposes of the study.

The sub-factors for the factors positively influencing adoption construct include (i). Sustainable building certifications, (ii). Desire to support sustainable practices in the construction industry, (iii). Aesthetics and design options, (iv). Recommendations from industry experts or professionals, and (v). Natural heating ventilation and air conditioning.

The sub-factors for the motivating factors in adoption construct involve (i). Personal values and ethics, (ii). Environmental impact reduction, (iii). Cost savings in the long run, (iv). Government incentives, and (v). Influence of peers, friends and family. The challenges in adoption construct consists of (i). Perceived higher upfront costs compared to traditional building materials, (ii). Lack of awareness about smart, green and sustainable building material options, (iii). Limited access to reliable and credible sources of information about smart, green and sustainable materials, (iv). Influence of local cultural factors and preferences that prioritize durability over sustainability, (v). Influence of societal norms and perceptions.

The sub-factors for the strategies encouraging adoption of smart, green and sustainable building material construct include (i). Government subsidies on these smart, green and sustainable building materials, (ii). Better education programs on these building materials, (iii). Showcase successful case studies and live examples, (iv). Collaboration and knowledge sharing among industry stakeholders, and (v). Increased availability and variety of smart, green and sustainable materials.

The assessment of the reliability of the research constructs is based on their ability to maintain internal consistency. The Cronbach's alpha method has been employed to assess the validity of the construct. In the domain of scientific research, the alpha threshold of 0.70 remains sufficient to evaluate the dependability or internal coherence of the instruments, as per Taber (2018).

Table 1. Reliability analysis for measuring internal consistency

Constructs	No. of Items	Cronbach's Alpha (α)
FPIA	5	0.820
MFA	5	0.782
CIA	5	0.745
SEASGSBM	5	0.938

Note: FPIA = factors positively influencing adoption; MFA = motivating factors in adoption; CIA = challenges in adoption; SEASGSBM = strategies encouraging adoption of smart, green and sustainable building material.

Table 1 has four constructs measured in the study viz., FPIA, MFA, CIA, and SEASGSBM. The study found that all four constructs had high internal consistency, as shown by Cronbach's Alpha values that were all more than 0.70. SEASGSBM has the highest internal consistency (0.938), followed by FPIA (0.820), MFA (0.782), and CIA (0.745).

The variables measured in Figure 2 are all based out of a 5-point Likert scale. Among the variables, cost savings in long run (CSILR) has the highest mean score of 4.54 and lowest standard deviation of 0.79. This indicates that most respondents have given high importance to this variable and more consistent in their response. The sustainability building certificates (SBC) has lowest mean score of 3.59 and highest

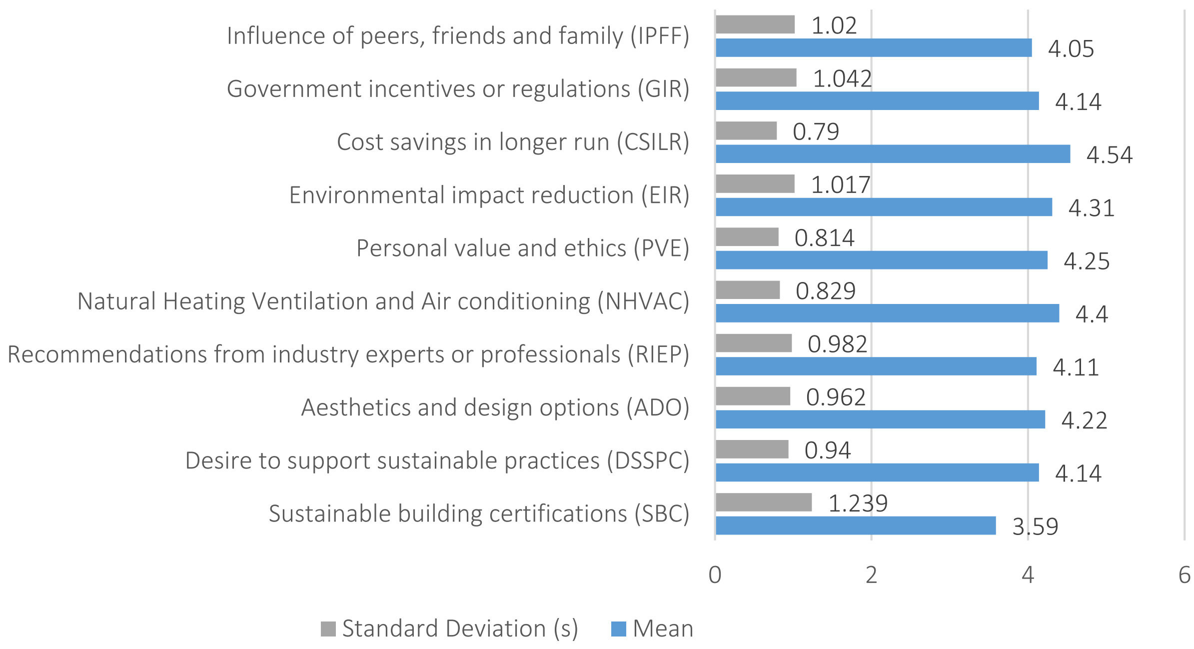

Figure 2. Mean and standard deviation scores of factors positively influencing adoption

standard deviation of 1.239. This represents that most respondents have considered this factor as a least important and also comparatively inconsistent in their views.

4.1. Testing H_1

Effects ranging from moderate to strong were linked to R-squared values equal to or exceeding 0.4 in subjects such as psychology, education, and sociology (Cohen et al., 2013). The R^2 score of 0.400, or 40%, shows a modest amount of explained variation of the robust regression model. Robust standard errors offer a means of estimating the standard errors of regression coefficients that is relatively insensitive to violations of assumptions such as normality (Knief & Forstmeier, 2021). Robust standard errors will help resolve heteroscedasticity. The White test for Heteroscedasticity indicates test is significant ($p = 0.001$) by showing that error variance may vary across independent variable levels. However, the modified Breusch-Pagan tests in the study ($p = 0.576$) indicates the opposite i.e., presence of non-linear relationship and presence of heteroscedasticity. Even if the normality requirements and non-linear relationship are not satisfied, robust standard errors enable statistical inference and hypothesis testing for regression coefficients. Multiple regression analyses with robust standard error parameter estimates and tests for heteroscedasticity were performed since the data did not have a normal distribution. The test results in Table 2 show PPSGSBMCTBM with $p = 0.001$, FPIA with $p = 0.004$, MFA with $p = 0.001$, and SEASGSBM with $p = 0.001$. All of these factors showed a significant influence on how people evaluate the government's efforts to increase the usage of smart, green and sustainable building materials. But, challenges in adoption (CIA) have a negative coefficient of –0.049 and a robust standard error of 0.024 with (t-value = –1.985, p-value = 0.048), demonstrating an adverse influence on perception of the respondents. The SEASGSBM variable has a coefficient of 0.035 and a standard error of 0.007, which positively affects the perception of smart, green, and sustainable building material performance (t-value = 4.807, p-value = 0.001). The corrected model shows a substantial influence ($p = 0.001$), meaning the independent variables explain 40% of the dependent variable's variance, hence the study rejects the null hypothesis and accept the alternative hypothesis. Henceforth, the dependent variable (perception about government role in promotion of these contemporary building materials) significantly explained by at least one of the independent variables (PPSGSBMCTBM, FPIA, MFA, CIA and SEASGSBM).

http://dx.doi.org/10.21511/im.19(4).2023.06

Table 2. Multiple regression with robust standard errors

Tests for Heteroscedasticity		
White Test for Heteroscedasticity		
χ^2	df	Sig.
267.122	20	0.001
Breusch–Pagan Test for Heteroscedasticity		
χ^2	df	Sig.
0.313	1	0.576
Modified Breusch–Pagan Test for Heteroscedasticity		
χ^2	df	Sig.
0.333	1	0.564

Tests of Between–Subjects Effects					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	171.034	5	34.207	42.524	0.001
Intercept	0.279	1	0.279	0.347	0.556
Perception of performance of smart, green and sustainable building material is better compared to traditional building material (PPSGSBMCTBM)	44.193	1	44.193	54.938	0.001
Factors positively influencing adoption (FPIA)	10.279	1	10.279	12.778	0.001
Motivating factors of adoption (MFA)	5.293	1	5.293	6.580	0.011
Challenges in adoption (CIA)	4.515	1	4.515	5.613	0.018
Strategies that encourage adoption of smart, green and sustainable building material (SEASGSBM)	44.104	1	44.104	54.827	0.001
Error	304.873	379	0.804		
Total	4593	385			
Corrected Total	475.906	384			
R^2	0.400				
Adj. R^2	0.392				

Parameter Estimates with Robust Standard Errors						
Parameter	**B**	**Robust Std. Error[a]**	**t**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Intercept	–0.230	0.443	–0.508	0.612	–1.095	0.645
(PPSGSBMCTBM)	0.392	0.061	6.459	0.001	0.273	0.511
(FPIA)	0.051	0.018	2.863	0.004	0.016	0.086
(MFA)	0.050	0.015	3.210	0.001	0.019	0.078
(CIA)	–0.049	0.024	–1.985	0.048	–0.094	0.001
(SEASGSBM)	0.058	0.008	6.971	0.001	0.042	0.074

Note: “a” HC3 method.

4.2. Testing H_2

It has been observed that the reliability of MANOVA increases once the overall sample size reaches a specific threshold (Thomas & Heath, 2022). The sample of size of this study is 385, which is sufficient to reach the reliability threshold. MANOVA is considered to be resistant against violations of normality assumptions. Due to MANOVA’s robustness against breaches of normality assumptions, valid and statistically significant outcomes might still be obtained even when the research data may not have exactly followed a normal distribution. The Pillai’s trace statistic is known for its robustness against assumption violations of normality (Kovanović et al., 2015). The p-values associated with the variables factors positively influencing adoption, motivating factors in adoption, and SEASGSBM are all below the threshold ($p < 0.05$), indicating a statistically significant difference in motivation across different occupation levels for these variables. Regarding Box’s Test, with a 0.001 p-value, the box M statistic was 376.283. This suggests that there is a difference in the covariance matrices. It implies large covariance differences between groups.

Table 3. Multivariate analysis (MANOVA)

Occupation				
Motivation to embrace smart, green and sustainable building material	**F-value**	**p-value**	**Partial Eta Squared**	**R^2**
Factors positively influencing adoption (FPIA)	3.214	0.023	0.130	0.045
Motivating factors for adoption (MFA)	10.057	0.001	0.138	0.073
Strategies encouraging adoption (SEASGSBM)	47.948	0.001	0.274	0.274
Multivariate tests results				
Hotelling's Trace	**Pillai's Trace**	**Wilks' Lambda**	**Roy's Largest Root**	
0.516	0.389	0.640	0.410	
Sig. (p-value) of Multivariate tests (Box's Test)				
0.001	0.001	0.001	0.001	

Levene's test shows that the error variances of the three dependent variables vary between groups ($p = 0.001$). Thus, equal variances are violated. The corrected model analysis shows substantial impacts of the profession on all three dependent variables: factors that positively impact adoption ($p = 0.023$), motivating factors for adoption ($p < 0.001$), and strategies to promote adoption. The Partial Eta Squared values of 0.130, 0.138, and 0.274 in this case imply that the occupation levels have a moderate to significant influence in explaining the differences in desire to use smart, green, and sustainable building materials. Based on Wilks' Lambda significance value of 0.640, the study null hypothesis and reject alternate hypothesis.

Table 4 shows MANOVA with Dunnett T3 post hoc analysis findings, which examined occupation-level differences in desire to use smart, green, and sustainable construction materials. Regarding factors positively influencing adoption, there is a significant difference in motivation levels be-

Table 4. MANOVA with Dunnet T3 post hoc analysis

Dependent Variable (DV)	Occupation (i)	Occupation (j)	(i) – (j)	P-value	95% confidence Interval	
					Lower Bound	Upper Bound
Factors positively influencing adoption	Professional	Government official	–2.17	0.002	–3.75	-0.59
	Government official	Private sector employee	1.87	0.006	0.39	3.34
		Non–profit organization or advocacy group	2.83	0.001	1.40	4.25
	Private sector employee	Government official	–1.87	0.006	–3.34	-0.39
	Non–profit organization or advocacy group	Government official	–2.83	0.001	–4.25	-1.40
Motivating factors for adoption	Professional	Government official	–2.30	0.001	–3.71	-0.88
		Private sector employee	–1.63	0.002	–2.81	-0.45
		Non–profit organization or advocacy group	–2.84	0.001	–4.28	-1.41
	Government official	Professional	2.30	0.001	0.88	3.71
	Private sector employee	Professional	1.63	0.002	0.45	2.81
		Non–profit organization or advocacy group	–1.21	0.019	–2.28	-0.14
	Non–profit organization or advocacy group	Professional	2.84	0.001	1.41	4.28
		Private sector employee	1.21	0.019	0.14	2.28
Strategies encouraging adoption among smart, green and sustainable building material	Professional	Government official	8.78	0.001	7.15	10.40
		Non–profit organization or advocacy group	7.07	0.001	3.37	10.76
	Government official	Professional	–8.78	0.001	–10.40	-7.15
		Private sector employee	–10.11	0.001	–11.51	-8.71
	Private sector employee	Government official	10.11	0.001	8.71	11.51
		Non–profit organization or advocacy group	8.40	0.001	4.78	12.01
	Non–profit organization or advocacy group	Professional	–7.07	0.001	–10.76	-3.37
		Private sector employee	–8.40	0.001	–12.01	-4.78

http://dx.doi.org/10.21511/im.19(4).2023.06

tween professional and government official (p = 0.002, confidence interval: –3.75 to –0.59). The difference between government official and private sector employee is also statistically significant (p = 0.006), with a confidence interval of 0.39 to 3.34. Similar to this, there is a significant difference between government official and non-profit organization and advocacy group (p = 0.001) with a confidence range of 1.40 to 4.25.

Regarding motivating factors for adoption, there is a significant difference in the levels of motivation between professional and government official (p = 0.001), with a confidence range of 3.71 to –0.88. The difference between government official and private sector employee is also significant (p = 0.002), with a confidence interval of –2.81 to –0.45. The difference between non-profit organization or advocacy group and government official is also statistically significant (p = 0.001) with a confidence range of –4.28 to –1.41.

Regarding strategies encouraging adoption, there is a very significant difference in the motivation levels between professional and government official (p = 0.001), with a confidence range of 7.15 to 10.40. The difference between non-profit organization or advocacy group and professional is also highly significant (p = 0.001), with a confidence interval of –10.76 to –3.37. Similar to this, there is a very significant difference between non-profit organization or advocacy group and private sector employee (p = 0.001), with a confidence range of 4.78 to 12.01. The significant p values from the post hoc analysis indicate that occupation has an important influence on consumer motivations to adopt smart, green, and sustainable building materials. Therefore, alternative hypotheses are accepted.

4.3. Testing H_3

The partial correlation technique may still be employed even if the normality assumption is violated (Vignali et al., 2003). In contrast to alternative correlation measures, partial correlation exhibits a reduced vulnerability to the influence of extreme data points or outliers (Alexander-Bloch et al., 2013). By conducting partial correlation analysis, studies enhance the internal validity of the research results as it helps to minimize the influence of confounding variables and potential biases. In Table 5, partial correlation is used to look at the relationship between the overall factors that affect adoption (OFAA), which include constructs like (i) FIPA, (ii) MFA, and (iii) SEASGSBM, while taking into account the annual income as a control variable. Controlling for annual income, the study found a moderate positive partial correlation between CIA and OFAA (r = 0.629 and p = 0.001). Higher levels of CIA were significantly related to an increase in OFAA while controlling for annu-

Table 5. Partial correlation investigating relationship between challenges/hurdles in adoption (CIA) and overall factors affecting adoption (OFAA)

Control Variables			Challenges/Hurdles in adoption	Overall factors affecting adoption	Annual Income
–none–[a]	Challenges/Hurdles in adoption (CIA)	Correlation	1.000	0.632	0.231
		Significance (2–tailed)	–	0.001	0.001
		df	0	383	383
	Overall factors affecting adoption (OFAA)	Correlation	0.632	1.000	0.097
		Significance (2–tailed)	0.001	–	0.058
		df	383	0	383
	Annual Income	Correlation	0.231	0.097	1.000
		Significance (2–tailed)	0.001	0.058	–
		df	383	383	0
Annual Income	Challenges/Hurdles in adoption (CIA)	Correlation	1.000	0.629	
		Significance (2–tailed)	–	0.001	
		df	0	382	
	Overall factors affecting adoption (OFAA)	Correlation	0.629	1.000	
		Significance (2–tailed)	0.001	–	
		df	382	0	

Note: ‘a’ Cells contain zero-order correlations (Pearson).

al income. This indicates that respondents with higher annual income tend to adopt smart, green, and sustainable building materials with relatively fewer challenges or obstacles. The zero-order correlation analysis (r = 0.632 and p = 0.001) revealed that controlling for annual income strengthened the relationship between these two variables. Finally, based on significance 2 tailed p value of 0.001, the study rejects null hypothesis and accept alternate hypothesis, that there is significant relationship between CIA and OFFA with annual income as a control or moderating variable.

5. DISCUSSION

The paper sheds light on smart, green, and sustainable building material adoption in Bangalore region from a cosmopolitan perspective. The survey data were statistically analyzed to draw conclusions among factors of motivation and perception to adopting these smart, green, and sustainable building materials. SPSS's "compute variable" function summed and translated them from ordinal to ratio scale variables. Cronbach's alpha reliability showed good internal consistency for all constructs, ranging from 0.745 to 0.938. Figure 2 shows the mean and standard deviation for motivational and perception variables that positively influence adoption; specifically, cost savings in long run had mean value of 4.54, indicating higher importance that consumers displayed while adopting smart, green and sustainable building materials. However, sustainable building certification had a moderate mean score of 3.59, showing consumers reasonable relevance when choosing construction materials. Sustainable certifications and labels play a crucial role in helping consumers recognize sustainable goods and encourage the embrace of more environmentally friendly consumption practices (Sogari et al., 2016). It is crucial to communicate the value of and steps involved in obtaining environmental certifications clearly and openly in order to increase customer understanding and trust (Furuya et al., 2018).

DSSPC got a mean score of 4.14, signifying a higher consumer willingness to promote sustainable construction techniques. People have a stronger predisposition to act sustainably when they are in an environment that supports sustainable construction practices (Wu et al., 2013). Aesthetics and design options scored 4.22, indicating aesthetics significantly influenced the selection of building material. People often show a stronger tendency to choose sustainable materials over conventional building materials when they are both conveniently available and affordable (Mouzaneh et al., 2022). The mean score of 4.11 for RIEP representing expert advice may be helpful in overcoming any concerns, ambiguity or challenges about the use of smart, green and sustainable building materials. Natural heating ventilation air conditioning systems mean score of 4.4 demonstrates high importance of this factor in construction. Consumers who understand sustainable building materials and their effects on HVAC systems are more likely to prioritize their adoption (Blanco et al., 2021). Personal value and ethics scored 4.25 on average, signifying high personal and ethical values practiced during adoption. Environmental impact reduction was crucial factor scoring 4.31 mean value. It is crucial to underline that, while selecting sustainable construction materials, the environment should take precedence over social and economic reasons (Gounder et al., 2023). Long-term cost savings recorded a 4.54 mean score, demonstrating its greater importance. Peers, friends, and family influence had a 4.05 mean score, indicating social influence had a larger bearing on decision-making in the adoption of smart, green, and sustainable building materials.

Multiple regression analysis with robust standard errors explored the association between the government's role in promoting and the independent variables. The perception of performance of smart, green and sustainable building material is better compared to traditional building material, factors positively influencing adoption, motivating factors in adoption, and strategies encouraging adoption of smart, green and sustainable building material all positively affected perception of consumers about the government's role in promotion of these building materials. However, challenges in adoption negatively affected perception of consumers about government role in promotion of these contemporary and eco-friendly building materials. Governments assume a pivotal role in the promotion and facilitation of sustainable construction practices by employing diverse instruments and policies (Djokoto et al., 2014). Occupation strong-

http://dx.doi.org/10.21511/im.19(4).2023.06

ly influences customer adoption of smart, green, and sustainable building materials, according to MANOVA analysis.

However, as per Wilks' Lambda value of 0.640 it was hypothesized that there was no significant difference in motivation to embrace smart, green, and sustainable building materials across different occupation levels. The partial correlations significant p value indicated that annual income played a moderating role in affecting the level of adoption of smart, green, and sustainable building materials. Thus, a person's annual income heavily influences purchasing choices, particularly when it comes to major purchases like homes. This decision might be one-time or recurring depending on the person's annual income and savings. Support for sustainable activities, aesthetics and design, industry expert advice, and natural HVAC systems drove acceptance from consumer end. Government incentives and rules, personal ethics, environmental impact reduction, and economic savings promote sustainable activities. These reasons emphasize the significance of specialized advertising techniques that meet individual customers' demand. The study found adoption barriers such as perceived greater upfront costs, lack of knowledge, limited access to credible information, cultural aversion to change, and the difficulty of integrating new technology. To increase adoption rates, these issues must be addressed via education, awareness, and communication. This paper helps policymakers, industry experts, and academics create strategies and initiatives to promote these materials in construction, promoting sustainable and ecologically friendly practices.

CONCLUSION

The goal of this study was to analyze the motivations, methods, and barriers that consumers face while adopting smart, green, and sustainable building materials. The outcomes revealed that sustainability certifications, desire to support sustainable practices, and strategic initiatives have positively influenced consumers' perception toward government's efforts in promoting the adoption of these materials. However, lack of knowledge and perception of larger initial costs have hindered consumer acceptance of these building materials. The annual income of individuals plays a significant role in influencing adoption rates, serving as an indirect factor that necessitates the implementation of strategies like consumer segmentation based on income levels. This approach enables the customization of promotional and marketing campaigns to effectively promote widespread adoption.

All the sub factors in the construct factors positively influencing adoption and few sub factors under the construct motivating factors of adoption are contributing to consumers' positive inclination in adoption of smart, green, and sustainable building material. The result shows a positive inclination of consumers toward factors like sustainability building certificates, desire to support sustainable practices, aesthetics and design options, recommendations from industry experts, natural heating ventilation and air conditioning, personal value and ethics, environmental impact reduction, cost savings in the longer run, and peers, friends, and family and governmental incentives. Therefore, it is imperative to take into account these factors when determining the segmentation, targeting, and positioning strategies for marketing promotions aimed at consumers, with a particular focus on cost of the material location. Occupation had a major influence, stressing the necessity for targeted marketing.

This paper adds to the long-term goal of sustainability and also aids in decreased environmental pollution by learning more about consumer behavioral aspects like motives, perceptions and tackling adoption barriers using innovative marketing strategies. The results of the study may be used by policymakers to create policies and state-of-the-art marketing strategies that promote wider consumer adoption of smart, green, and sustainable building materials.

AUTHOR CONTRIBUTIONS

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