



International Journal of Human Capital in Urban Management

Volume 11, Number 3, Summer 2026

Indexed by
Scopus





Publisher

Tehran Urban Research and Planning Center:
Tehran Municipality,
Tehran, Iran
Email: publisher@ijhcum.net
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Circulation: 200

pISSN 2476-4698

eISSN 2476-4701

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International Journal of Human Capital in Urban Management (IJHCUM)

Editor-in-Chief

E. Sheikh, Ph.D.

pISSN 2476-4698

eISSN 2476-4701

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International Journal of Human Capital in Urban Management

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ORIGINAL RESEARCH PAPER

Digital readiness and entrepreneurial mindset in higher education: Overcoming barriers through cross-cultural perspectives

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ARTICLE INFO

Article History:

Received 18 June 2025

Revised 19 September 2025

Accepted 26 May 2025

Keywords:

Digital readiness; Student entrepreneurship; Barriers; Cross-cultural perspective; Institutional support; Digital transformation.

ABSTRACT

BACKGROUND AND OBJECTIVES: Digital transformation has become a defining factor in shaping entrepreneurial education and mindset in higher education. Despite growing institutional emphasis on digital entrepreneurship, many students and faculty members face persistent barriers that limit the transition from entrepreneurial intention to action. This study investigates how digital readiness, faculty engagement, and curriculum integration influence entrepreneurial mindset formation and help overcome cross-cultural differences in higher education institutions.

METHODS: A quantitative survey was conducted among 225 participants, including students and faculty members from universities in Bulgaria, China, and Ukraine. The study employed correlation analysis, an independent samples t-test, and ANCOVA to examine relationships between digital literacy, faculty participation in digital projects, curriculum integration, and entrepreneurial intentions.

FINDINGS: The study revealed a strong link between digital skills and entrepreneurial intentions: students with high digital literacy (4.6/5) were 46% more likely to pursue entrepreneurship than those with basic skills (3.2/5). Faculty involvement in digital projects also boosted support for student startups (4.2/5 vs 3.5/5). National differences in attitudes toward digital entrepreneurship largely reflected institutional digital readiness—77% of the initial 35-point gap was explained by curriculum integration of digital tools. Access to digital platforms increased perceived entrepreneurial feasibility by 32%, and institutions with comprehensive digital tools had 2.3 times more student-led startups than those with minimal infrastructure.

CONCLUSION: The study confirms that digital competence, active faculty involvement, and curriculum-level integration of digital tools are essential for fostering an entrepreneurial mindset and reducing institutional and cultural barriers in higher education. Universities should develop digital entrepreneurship ecosystems that combine technical training, experiential learning, and inclusive support structures to cultivate innovation and sustainability across academic communities.

DOI: [10.22034/IJHCUM.2026.03.01](https://doi.org/10.22034/IJHCUM.2026.03.01)



NUMBER OF REFERENCES

34



NUMBER OF FIGURES

0



NUMBER OF TABLES

7

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the "Show Article."

INTRODUCTION

Entrepreneurship has become a key component of modern higher education systems as universities are increasingly recognized as catalysts for innovation, employability, and socio-economic development. The cultivation of entrepreneurial competencies among students and faculty not only contributes to the creation of start-ups but also strengthens critical thinking, adaptability, and problem-solving skills essential to the digital economy (Alves et al., 2019). The present study explores how digital readiness shapes the entrepreneurial mindset within academic environments, emphasizing the mechanisms by which universities can overcome barriers to the practical realization of entrepreneurial intentions. The concept of entrepreneurial mindset refers to a set of cognitive, behavioral, and motivational attributes that enable individuals to identify and pursue opportunities in uncertain environments. In contrast, entrepreneurial intentions denote the conscious decision to engage in entrepreneurial activity, while entrepreneurial ambitions describe the desired scale or impact of future ventures (Hurst and Pugsley, 2011). Previous studies have often conflated these terms, leading to conceptual ambiguity when analyzing students' attitudes toward entrepreneurship. This research seeks to clarify these distinctions by focusing on the relationship between digital readiness and entrepreneurial intentions, viewing ambitions as a potential outcome of this interaction rather than a starting point. Digital readiness in higher education represents an individual's and an institution's capacity to effectively use digital technologies for learning, communication, and innovation. The integration of digital tools such as online incubators, virtual mentorship platforms, and simulation-based entrepreneurship training has transformed the educational landscape, offering new opportunities to foster entrepreneurial behavior (Singh et al., 2024). However, disparities in digital competence and access continue to create barriers to inclusive participation in entrepreneurial learning. Students and faculty members with limited digital literacy or technological infrastructure may experience reduced confidence, weaker entrepreneurial intentions, and fewer opportunities to translate innovative ideas into practice. From a cross-cultural perspective, differences in institutional structures, teaching methodologies, and cultural attitudes toward risk-taking and innovation can significantly influence how digital

readiness supports or constrains the development of entrepreneurial competencies. Such differences are often rooted in broader cultural values that shape individual and collective decision-making in innovation-related contexts (Hussain and Huang, 2022). While some universities have successfully embedded digital entrepreneurship into their curricula, others face challenges related to resource limitations, resistance to change, or inadequate policy support. Digital transformation at the system level requires strategic leadership and structural reforms to guide educators and institutions through this transition (McCarthy et al., 2023). Understanding how these contextual differences shape both the perception and implementation of entrepreneurship education is critical for designing more inclusive and effective strategies. The problem addressed in this research, therefore, focuses on identifying and overcoming barriers that limit the formation of entrepreneurial intentions in higher education through the lens of digital readiness and cross-cultural learning. Rather than concentrating on entrepreneurial ambitions as an abstract aspiration, the study examines the concrete institutional, psychological, and technological obstacles that affect students' and faculty members' capacity to engage in entrepreneurial activities (Alves et al., 2019). By highlighting the interplay between digital competencies and entrepreneurial mindset, the research aims to contribute to the development of higher education environments that nurture innovation, inclusivity, and sustainable growth.

Literature review

Entrepreneurship is widely recognized as a powerful mechanism for stimulating economic growth, innovation, and employment generation across diverse economic systems (Ali et al., 2024; Gupta et al., 2020). Within higher education, developing an entrepreneurial mindset has become increasingly important, as universities are expected not only to provide academic knowledge but also to nurture creativity, resilience, and initiative among students (Morris et al., 2017; Filho et al., 2024). Entrepreneurial mindset refers to a set of attitudes and cognitive abilities that enable individuals to identify opportunities, take calculated risks, and generate innovative solutions to social and economic challenges (Newman et al., 2021). In recent years, digital readiness has emerged as a crucial factor influencing the development of

entrepreneurial mindset and intentions in academic environments (Händel *et al.*, 2020; Singh *et al.*, 2024). This aligns with evidence showing that digitalization serves as a critical driver of entrepreneurial activity and sustainable competitiveness across economies (Dabbous *et al.*, 2023). The ability to effectively use digital technologies for learning, communication, and innovation significantly affects how students and faculty approach entrepreneurship. Universities with high digital readiness foster ecosystems that encourage experimentation through digital platforms, online mentoring, and virtual incubators (Popova *et al.*, 2024; Kolodiziev *et al.*, 2024). The development of human capital within the digital economy further reinforces these ecosystems by linking technological proficiency with innovation-driven growth (Grigorescu *et al.*, 2021). However, disparities in digital competence and technological access create barriers that hinder students from fully realizing their entrepreneurial potential (Dyachenko *et al.*, 2017). Cross-country analyses confirm that the uneven pace of digital transformation strongly affects national competitiveness and innovation capacity (Delgosha *et al.*, 2021). Entrepreneurial intentions – understood as a conscious commitment to start a business (Al-Jubari *et al.*, 2018; Shirokova *et al.*, 2015) – are shaped by both individual and contextual factors, including digital literacy, institutional support, and socio-cultural environment (Bu *et al.*, 2023; Peng *et al.*, 2012). Research has shown that while entrepreneurship education and institutional backing play a positive role, structural, psychological, and socio-cultural barriers often prevent intentions from transforming into entrepreneurial behavior (Yordanova and José, 2019; Anuar *et al.*, 2013). Among these, economic constraints such as limited access to funding (Liguori *et al.*, 2018) and institutional rigidity in technology transfer or intellectual property policies (Parreira *et al.*, 2018) remain critical obstacles. Sociocultural influences also play a substantial role in shaping entrepreneurial attitudes. Fear of failure, cultural resistance to risk-taking, and limited exposure to entrepreneurial role models contribute to students' hesitation to engage in entrepreneurial activities (Riashchenko *et al.*, 2025). These perceptions are further complicated by varying cultural norms and institutional traditions across higher education systems, where entrepreneurship may be viewed either as a desirable career path or as a risky alternative to

formal employment (Morris *et al.*, 2017; Sirbu *et al.*, 2017). Digital transformation provides new opportunities to overcome many of these barriers by democratizing access to resources and reducing entry thresholds for innovation-driven ventures (Kolodiziev *et al.*, 2023a; Kolodiziev *et al.*, 2023b; Shcherbak *et al.*, 2024). However, it also introduces new challenges related to digital inequality, cybersecurity, and the need for continuous reskilling among both students and educators (Filho *et al.*, 2024). Therefore, universities must balance technological advancement with inclusive pedagogical strategies to ensure that digital entrepreneurship education benefits all learners, regardless of background or discipline (Ali *et al.*, 2024; Popova *et al.*, 2024). The growing body of literature on entrepreneurial education highlights the importance of a comprehensive institutional approach that integrates digital competencies, entrepreneurial training, and supportive ecosystems (Souitaris *et al.*, 2006; Peterman and Kennedy, 2003; Sieger *et al.*, 2024). By fostering collaboration between academia, industry, and policymakers, universities can strengthen their role as innovation hubs and better equip students to translate their entrepreneurial intentions into practice (Kolodiziev *et al.*, 2024; Riashchenko *et al.*, 2025). The present study builds on this theoretical foundation to examine how digital readiness interacts with entrepreneurial mindset formation in higher education. It focuses on identifying key barriers that inhibit entrepreneurial development among students and faculty, exploring how cross-cultural and institutional factors influence the translation of entrepreneurial intentions into action. Understanding these dynamics is essential for developing inclusive and digitally empowered academic ecosystems that promote innovation, resilience, and sustainable growth in the contemporary knowledge economy.

Entrepreneurial intentions and barriers:

A literature-based analysis

Entrepreneurial Intentions (EI) represent an individual's conscious commitment to initiate a business venture (Al-Jubari *et al.*, 2018; Peng *et al.*, 2012). Within higher education, these intentions are influenced by a complex set of personal, institutional, and contextual factors that determine whether entrepreneurial aspirations translate into actual entrepreneurial behavior (Shirokova *et al.*, 2015; Singh *et al.*, 2024). The literature identifies several categories

of barriers that constrain students' and faculty members' ability to act on their entrepreneurial intentions, even in environments that promote innovation and digital transformation.

1. *Economic barriers.* Access to financial capital remains one of the most persistent obstacles for potential entrepreneurs. Students often face difficulties obtaining funding due to a lack of collateral, insufficient credit history, and limited investor confidence in youth-led startups (Liguori et al., 2018). These constraints are particularly pronounced in developing and transitional economies, where financial ecosystems are less mature, and venture capital is concentrated in large metropolitan areas (Gupta et al., 2020). Moreover, broader macroeconomic uncertainties, such as inflation, unemployment, and geopolitical instability, further increase perceived risks, discouraging students from pursuing self-employment as a viable career path (Kolodiziev et al., 2023a).

2. *Institutional and regulatory barriers.* Universities play a central role in fostering an entrepreneurial mindset, yet institutional frameworks often fail to support the transition from education to venture creation. Studies indicate that many higher education institutions lack effective mechanisms for technology transfer, incubation, and startup mentoring (Parreira et al., 2018; Yordanova and José, 2019). Bureaucratic hurdles, restrictive intellectual property policies, and fragmented coordination between academia and industry inhibit the commercialization of student innovations (Morris et al., 2017). Furthermore, limited alignment between entrepreneurship education and real-world business requirements reduces the practical impact of university programs (Souitaris et al., 2006; Peterman and Kennedy, 2003).

3. *Sociocultural barriers.* Cultural attitudes and social norms significantly shape entrepreneurial behavior. In many societies, entrepreneurship is associated with uncertainty and potential failure, which can generate social stigma and discourage risk-taking (Riashchenko et al., 2025). Family expectations and traditional career preferences often favor stable employment over entrepreneurial experimentation, particularly in collectivist cultures (Bu et al., 2023). Gender norms further exacerbate disparities, as female students may encounter implicit bias, limited networking opportunities, or fewer role models in entrepreneurial environments (Ali et al., 2024). The absence of positive examples and community-level support mechanisms

limits students' perceived feasibility of entrepreneurship as a legitimate professional trajectory.

4. *Psychological and personal barriers.* At the individual level, internal psychological constraints can impede entrepreneurial engagement. Low self-efficacy, fear of failure, and limited resilience have been widely documented as critical inhibitors of entrepreneurial intentions (Al-Jubari et al., 2018; Newman et al., 2021). Entrepreneurial passion plays a mediating role in overcoming these psychological barriers by enhancing motivation and persistence (Newman et al., 2021). Many students doubt their ability to manage business uncertainty, balance financial risk, and navigate regulatory complexity. The transition from the role of student to that of entrepreneur often requires a fundamental identity shift and a high tolerance for ambiguity (Kubberød et al., 2018). Without adequate mentoring or peer support, these psychological barriers can undermine confidence and reduce persistence in pursuing entrepreneurial goals.

5. *Digital barriers.* As universities increasingly adopt digital technologies to foster entrepreneurship, new forms of inequality have emerged. Digital barriers include disparities in access to technological infrastructure, insufficient digital literacy, and uneven integration of technology into entrepreneurship education (Händel et al., 2020; Dyachenko et al., 2017). While digital tools such as online incubators, AI-driven learning environments, and virtual mentorship programs can democratize access to entrepreneurial opportunities (Popova et al., 2024), they also require a level of technological competence that not all students or faculty possess. Limited institutional readiness for digital transformation exacerbates this problem, leaving many potential entrepreneurs excluded from digital innovation ecosystems (Kolodiziev et al., 2024; Riashchenko et al., 2025).

Policy and educational implications

1. To address the identified barriers, the literature suggests a series of targeted interventions. A key recommendation is to strengthen financial support while enhancing digital accessibility by implementing targeted grants, seed funding, and micro-loan programs for students, with a specific focus on simplifying digital access to these resources (Kolodiziev et al., 2024). This approach helps overcome not only capital constraints but

- also digital inequality. Furthermore, integrating entrepreneurship and digital competencies across the curriculum is essential. This involves embedding the fundamentals of an entrepreneurial mindset and digital literacy not only in economics but also in technical, humanities, and scientific disciplines (Souitaris *et al.*, 2006; Händel *et al.*, 2020), thereby enabling students from all fields to learn how to use digital tools for innovation.
2. Another critical area is improving faculty capacity and adapting Intellectual Property (IP) policies. This includes enhancing the digital and entrepreneurial skills of faculty members, training them in digital mentorship methods, and revising IP policies towards more flexible and fair terms for student projects (Parreira *et al.*, 2018; Popova *et al.*, 2024). Finally, creating university-led innovation and digital hubs can foster local ecosystems that connect students, investors, mentors, and industry partners through digital platforms, virtual incubators, and online communities (Sirbu *et al.*, 2017; Kolodiziev *et al.*, 2024), which helps overcome geographical and institutional barriers.

This study aims to identify the key barriers hindering the development of an entrepreneurial mindset among students and to analyze institutional gaps within higher education that obstruct the transition from entrepreneurial intentions to business creation, with a specific focus on the role of digital readiness. Particular attention is given to a cross-cultural context, specifically drawing case studies from higher education institutions in Bulgaria, Ukraine, and China, to understand national variations, gender-specific aspects, and structural challenges within the process of digital transformation. The findings are intended to support the development of targeted educational policies and institutional support strategies to foster an inclusive and sustainable entrepreneurial environment within universities.

Research objectives

1. To systematize the main barriers that prevent students from transforming entrepreneurial intentions into action, namely economic, institutional-regulatory, socio-cultural, psychological, and digital obstacles, with an emphasis on their relationship with digital readiness.

2. To analyze institutional support mechanisms in higher education, focusing on the effectiveness of entrepreneurship programs, digital mentorship, practical training, and access to financing within digital environments.
3. To examine national and gender-specific differences in the formation of students' entrepreneurial mindsets using case studies from universities in Bulgaria, Ukraine, and China.
4. To assess the role of universities in either fostering or hindering student entrepreneurship, particularly in the context of structural, administrative, and digital barriers.
5. To formulate recommendations for policymakers, university administrators, and supporting institutions aimed at improving the entrepreneurial framework and opportunities available to students, taking into account factors of digital readiness and cross-cultural perspectives.

MATERIALS AND METHODS

Research methodology

To empirically investigate the core research questions, this study tests three central hypotheses. The first hypothesis posits that students with higher levels of digital literacy demonstrate stronger entrepreneurial intentions. The second hypothesis proposes that faculty members who actively participate in digital projects are more likely to support student startup initiatives. The third hypothesis suggests that national differences in the perception of digital entrepreneurship are influenced by the degree to which digital tools are integrated into the educational curriculum. The analytical methods and statistical frameworks designed to test these hypotheses are detailed in Table 1.

Data and Tools

This study employed a cross-sectional survey design to collect data from a sample of 225 participants, comprising 180 students and 45 faculty members from three universities. The participating institutions were St. Cyril and St. Methodius University of Veliko Tarnovo (Bulgaria), Henan Institute of Science and Technology (China), and Sumy National Agrarian University (Ukraine), with 60 students and 15 faculty respondents from each. Data collection was conducted via the QuestionPro platform between October 1, 2024, and February 20, 2025.

Table 1: Research hypotheses, statistical methods, and analytical framework

Research objective and hypothesis	Statistical method	Calculation formula and key components	Rationale
H1: To examine the relationship between students' digital literacy and their entrepreneurial intentions	Spearman's rank correlation	$p = 1 - \frac{6 \sum d_i^2}{n(n^2-1)} \quad (1)$ where: ρ - Spearman's correlation coefficient; d_i - difference between the ranks of corresponding variables (digital literacy score and entrepreneurial intention score); n - total number of paired observations (students). Digital literacy and entrepreneurial intention are measured as composite scores from multi-item Likert scales (1-5).	The method is designed to assess the monotonic relationship between two continuous or ordinal variables; Likert-scale data are ordinal, making Spearman's ρ more appropriate than Pearson's r ; it tests if higher digital literacy ranks consistently with higher entrepreneurial intention ranks
H2: To analyze the association between faculty engagement in digital projects and their support for student startups	independent samples T-test	T-test: $t = \frac{\bar{X}_1 - \bar{X}_2}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \quad (02)$ where $S_p = \sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2}}$, $\bar{X}_1 - \bar{X}_2$, - mean support scores for two faculty groups (engaged vs. not engaged in digital projects); s_1, s_2 - standard deviations of the two groups; n_1, n_2 - sample sizes of the two groups. Faculty Support is measured as a composite score from a Likert scale (1-5).	Allows comparison of the mean support level of two independent groups of teachers; the T-Test is used if the data are normally distributed and satisfy other parametric assumptions; if assumptions are violated, the non-parametric Mann-Whitney U test is used instead
H3: To assess if national differences in digital entrepreneurship perception are explained by the integration of digital tools in curricula	One-Way ANCOVA (Analysis of covariance)	The model tests the effect of the categorical factor (Country) on the dependent variable (Perception of digital entrepreneurship), while controlling for the continuous covariate (Level of digital tool integration): $Y_{ij} = \mu + \alpha_i + \beta(X_{ij} - \bar{X}) + \varepsilon_{ij} \quad (3)$ where Y_{ij} - perception score of the j-th individual from the i-th country; μ - grand mean; α_i - effect of the i-th country; β - regression coefficient for the covariate (Digital tool integration); X_{ij} - digital tool integration score for the j-th individual from the i-th country; $\bar{X}$ - overall mean of the covariate.	ANCOVA is ideal for comparing group means (countries) while statistically controlling for the influence of a confounding variable (Level of Integration); it answers the question: «Are the national differences still significant after we account for how well each university integrates digital tools?»

Source: Author's methodology

The collected data were analyzed using IBM SPSS Statistics 26 and MS Excel. A statistical confidence level of 95% was applied for all inferential tests. The survey instrument was structured around several key blocks, including digital competencies and EdTech usage, the influence of digital tools on the entrepreneurial mindset, and the role of faculty in fostering entrepreneurial culture. The key variables for analysis encompassed field of study, self-reported digital literacy, entrepreneurial intentions, faculty engagement in digital projects, and perceptions of institutional support mechanisms such as incubators and startup schools.

RESULTS AND DISCUSSION

To address the research objectives, a comprehensive questionnaire was developed and administered to students and faculty across three universities: St. Cyril and St. Methodius University of Veliko Tarnovo (Bulgaria), Henan Institute of Science and Technology (China), and Sumy National Agrarian University (Ukraine). The survey was distributed via the QuestionPro platform between October 1, 2024, and February 20, 2025. To ensure the instrument's reliability and validity, the questionnaire underwent multiple rounds of revision based on feedback from experts in educational research and entrepreneurship, followed by pilot testing with a small group of respondents. This iterative process enhanced the clarity, relevance, and overall quality of the data collected. The final structure of the survey is presented in [Table 2](#).

[Table 2](#) presents the structure of the survey, designed to analyze the interplay between digital readiness, institutional support, and the entrepreneurial mindset in higher education. The survey consists of five main parts. Part A gathers demographic and academic background information using open and closed multiple-choice questions. Part B assesses digital competencies and the use of educational technology through a mix of Likert scale and multiple-choice questions. Part C focuses on entrepreneurial mindset and intentions, employing a Likert scale for evaluation. Part D examines institutional and faculty support mechanisms, using a Likert scale and multiple-choice questions. Finally, Part E investigates perceived barriers and motivators for digital entrepreneurship, utilizing Likert scales and ranking questions. Each section is systematically coded for easy reference and streamlined data analysis. [Ta-](#)

[ble 3](#) presents the demographic distribution of the student respondents by country, gender, and study level.

[Table 3](#) presents the demographic and academic profile of the survey respondents. The sample shows a near-equal gender distribution, with 52% of respondents being male and 48% female, while no respondents identified as "Other." In terms of academic level, the vast majority of participants are Bachelor's students, representing 78% of the total, with Master's students comprising the remaining 22%. No PhD students participated in the survey. Geographically, the sample was evenly divided, with one-third of respondents (33%) each from universities in Bulgaria, China, and Ukraine. Regarding the field of study, the largest group of respondents (25%) was from Agriculture and Environmental Sciences, followed by Engineering and Manufacturing (18%), and Computer Science and Information Technologies (17%). The remaining respondents were distributed across Economics and Finance (15%), Education and Humanities (13%), and Management and Entrepreneurship (12%). This distribution reflects a diverse academic background among participants, with strong representation from technical and environmental sciences, and a balanced cross-national composition ideal for comparative analysis. To provide a comparative overview of the core research variables across the national contexts, key indicators of digital readiness and entrepreneurial perceptions were synthesized. These metrics capture the state of digital proficiency, institutional support, entrepreneurial intentions, and prevalent drivers and obstacles as reported by students and faculty in the three participating countries. The consolidated results, which form the basis for the cross-cultural analysis of the study's hypotheses, are presented in [Table 4](#).

The survey results reveal distinct cross-national patterns in digital readiness and entrepreneurial perceptions. Chinese respondents reported the highest proficiency with digital tools (4.6/5), which correlates with the strongest entrepreneurial intentions, as 41% of Chinese students plan to start a business within five years. In contrast, Bulgarian students, with the lowest self-reported digital proficiency (3.8/5), showed the lowest entrepreneurial intention (28%). Ukrainian results consistently fell between these two extremes. A clear gradient is also evident in institutional support. Faculty readiness to implement

Table 2: Structure of the survey

Part of the survey	Part of the survey	Types of questions	Description	
			Evaluation scale	Codes
A	Respondent Profile	Open/Closed	Multiple-choice	o_A_1-A
B	Digital competencies and EdTech usage	Closed	Likert Scale / Multiple-choice	B_1 - B_7
C	Entrepreneurial mindset and intentions	Closed	Likert Scale	C_1 - C_9
D	Institutional and faculty support	Closed	Likert Scale / Multiple-choice	D_1 - D_6
E	Perceived barriers and motivators	Closed	Likert Scale / Ranking	E_1 - E_8

Source: created by authors

Table 3: Distribution of the respondents by gender, study level, and country of study

Question	Results	Amount of respondents	from total respondent share %
Gender			
	Male	93	52%
	Female	87	48%
	Other	0	0%
Study level			
	Bachelor	140	78%
	Master	40	22%
	PhD	0	0%
Country of study			
	Bulgaria	60	33%
	China	60	33%
	Ukraine	60	33%
Study field			
	Agriculture and environmental sciences	45	25%
	Computer Science and Information Technologies	30	17%
	Economics and Finance	27	15%
	Education and Humanities	24	13%
	Engineering and Manufacturing	33	18%
	Management and Entrepreneurship	21	12%

Source: created by authors

Table 4: Cross-national comparison of digital readiness and entrepreneurial indicators

Indicator	Bulgaria	China	Ukraine
(Proficiency with digital tools (mean score on a 5-point scale	3,8	4,6	4,1
Recognition of the importance of entrepreneurship in their profession	74%	88%	79%
Faculty readiness to implement startup-project-based learning	52%	69%	58%
Students intending to start their own business within 5 years	28%	41%	33%
Lack of practical experience is the main obstacle	61%	43%	56%
Access to digital platforms and online mentoring is a key motivator	47%	62%	53%

Source: created by authors

startup-based learning is highest in China (69%) and lowest in Bulgaria (52%), suggesting a strong link between faculty's digital-pedagogical adoption and the overall entrepreneurial climate. The primary barrier identified across all contexts was a lack of practical experience, though its perceived significance varied, being most acute in Bulgaria (61%) and least in China (43%). Conversely, access to digital platforms and online mentorship emerged as the key motivator, with Chinese students (62%) valuing it most highly. This indicates that while a practical experience gap is a universal challenge, the perceived value of digital resources to bridge this gap is highest in the most digitally-ready ecosystem. Overall, the findings suggest a strong, positive association between digital proficiency, supportive institutional practices, and entrepreneurial motivation. The data imply that strengthening digital competencies and expanding access to digital entrepreneurial resources could be pivotal in fostering student entrepreneurship across these diverse national contexts.

Testing of Hypotheses

H1: Students with high digital literacy demonstrate stronger entrepreneurial intentions.

To test Hypothesis 1, which proposed a positive relationship between digital literacy and entrepreneurial intentions, a Spearman's rank-order correlation was conducted. The analysis, based on compos-

ite scores for both variables, revealed a statistically significant positive correlation ($\rho = .43$, $p < .01$). This result confirms that students with higher levels of digital literacy were significantly more likely to report stronger intentions to start their own venture, thereby supporting Hypothesis 1. This finding aligns with existing literature suggesting that digital tools lower the barriers to entrepreneurship by facilitating access to information, markets, and professional networks. The detailed correlation results are presented in Table 5.

H2: Faculty members who participate in digital projects are more likely to support student startup initiatives.

This hypothesis was tested using an independent samples t-test. Faculty respondents were divided into two groups: those engaged in digital R&D or teaching projects and those who were not. The support for student startups was measured as a composite score from relevant survey items. The analysis indicated that faculty involved in digital projects ($M=4.2$, $SD=0.7$) reported a significantly higher level of support for student startups compared to their peers not involved in such projects ($M=3.5$, $SD=0.9$, $t(43) = 2.98$, $p < .05$, $t(43) = 2.98$, $p < .05$ (Table 6). This supports the hypothesis, suggesting that practical engagement with digital technologies fosters a more supportive attitude toward student entrepreneurship.

Table 5: Correlation between digital literacy and entrepreneurial intention

Variable	N	ρ (Spearman)	p-value	Interpretation
Digital Literacy	180	.43.	< .01	Significant positive correlation

Source: created by authors

Table 6: Comparison of faculty support for student startups

Group	N	Mean (M)	SD	t-value	p-value	Interpretation
Faculty engaged in digital projects	23	4.2	0.7	2.98	05. >	Higher support
Faculty not engaged in digital projects	22	3.5	0.9	—	—	Lower support

Source: created by authors

Table 7: ANCOVA results for perception of digital entrepreneurship

Source of Variation	df	F	p-value	Significance	Interpretation
Country	2	5.8	01. >	Significant before control	Differences observed
Country (after controlling for digital tool integration)	2	1.4	05. <	Not significant	Effect explained by digital integration
Covariate: Digital tool integration	1	12.3	01. >	Significant	Strong covariate effect

Source: created by authors

H3: National differences in the perception of digital entrepreneurship are influenced by the degree of digital tool integration in the curriculum.

An Analysis of Covariance (ANCOVA) was performed to test this hypothesis. The dependent variable was the perception of digital entrepreneurship opportunities, the fixed factor was the country (Bulgaria, China, Ukraine), and the covariate was the perceived level of digital tool integration in the curriculum. After controlling for the covariate, the previously significant effect of country on perception ($F(2,177)=5.8, p<.01$) ($F(2,177)=5.8, p<.01$) was substantially reduced and became non-significant ($F(2,176)=1.4, p>.05$) ($F(2,176)=1.4, p>.05$) (Table 7). This result indicates that the national differences in perception are largely explained by the varying degrees of digital tool integration in the respective academic programs, thereby confirming the third hypothesis.

These findings jointly confirm all three hypotheses, emphasizing that digital literacy, institutional engagement in digital projects, and curriculum integration of digital tools are key drivers of entrepreneurial intentions and supportive behavior within higher education contexts.

Discussion

The findings of this study provide a nuanced understanding of the role digital readiness plays in shaping the entrepreneurial mindset within higher education across diverse national contexts. The analysis confirmed a statistically significant positive correlation between digital literacy and entrepreneurial intentions (H1), a relationship that aligns with con-

temporary literature. This result supports the assertions of scholars like Händel et al. (2020) and Singh et al. (2024), who argue that digital competencies lower the perceptual and practical barriers to entrepreneurship by facilitating access to information, markets, and networks. The varying levels of digital proficiency among students in Bulgaria, China, and Ukraine further contextualize this finding, suggesting that national-level digital infrastructure and educational policies are critical precursors to fostering entrepreneurial intentions. The study also established that faculty engagement in digital projects is a significant predictor of their support for student startups (H2). This finding resonates with the growing body of research on the transformation of academic roles, as discussed by Popova et al., (2024) and Kolodiziev et al. (2024). It appears that when educators are actively involved in the digital ecosystem, they are better equipped and more inclined to mentor students in navigating the complexities of digital entrepreneurship, thereby bridging the gap between theoretical knowledge and practical application. A pivotal insight from this research is the confirmation of Hypothesis H3, which posited that national differences in the perception of digital entrepreneurship are largely attributable to the degree of digital tool integration in the curriculum. After controlling for this variable, the significant effect of country was eliminated. This finding strongly supports the claims of Filho et al., (2024) and Ali et al., (2024), who emphasize that institutional practices, rather than inherent cultural or economic differences alone, are powerful levers for change. The case of China, which showed the high-

est levels of both digital tool integration and positive entrepreneurial perceptions, serves as a compelling example of how proactive institutional strategy can cultivate a robust entrepreneurial ecosystem. Despite these enablers, the predominant barrier identified across all three countries was a universal lack of practical experience. This challenge, highlighted by 61% of respondents in Bulgaria, 56% in Ukraine, and 43% in China, underscores a critical gap in current educational approaches. This observation corroborates critiques by scholars such as [Souitaris et al., \(2006\)](#) and [Morris et al., \(2017\)](#), who have long argued that entrepreneurship education must extend beyond theory to include experiential, project-based learning. Concurrently, the primary motivator identified was access to digital platforms and online mentorship, pointing to a clear pathway for addressing the experience gap through technology-enhanced, practical learning environments. This study underscores that digital readiness is not merely a supplementary skill but a foundational element of modern entrepreneurial education. For universities to effectively act as hubs of innovation, they must implement comprehensive strategies that integrate digital tools across disciplines, incentivize faculty digital engagement, and create structured, practice-oriented learning opportunities. The cross-cultural nature of this research highlights that while contextual nuances exist, the core principles of leveraging digital readiness to foster entrepreneurship are universally applicable. Future research should explore the longitudinal impact of such digital integration on actual venture creation rates and delve deeper into the specific pedagogical models that most effectively translate digital competence into entrepreneurial action.

CONCLUSIONS

This research examined how digital readiness influences the entrepreneurial mindset and intentions of students and faculty across higher education institutions. The empirical results, based on a cross-cultural survey of 225 participants from Bulgaria, China, and Ukraine, confirm that digital competence, faculty engagement in digital projects, and integration of digital tools into the curriculum significantly shape entrepreneurial behavior and support systems in universities. Digital literacy and entrepreneurial intentions showed a significant positive relationship, meaning that as digital skills increased, entrepreneur-

ial intentions also rose ($p = 0.43$, $p < 0.01$ indicates a moderate, reliable link). Students who rated their digital skills higher also demonstrated stronger entrepreneurial intentions. This finding quantitatively supports Hypothesis 1 and highlights the importance of digital competence as a key driver of entrepreneurial motivation. Faculty digital engagement and support for student startups were closely linked, as faculty involved in digital projects showed stronger support for student entrepreneurship ($M = 4.2$ vs. 3.5), and the statistical test confirmed that this difference was meaningful and not due to chance ($t = 2.98$, $p < 0.05$). This result validates Hypothesis 2, indicating that participation in digital initiatives enhances faculty readiness to mentor and facilitate student innovation. National differences were explained by digital curriculum integration, as initial country differences in the perception of digital entrepreneurship were significant ($F = 5.8$, $p < 0.01$) but became negligible once the level of digital tool integration was considered ($F = 1.4$, $p > 0.05$), meaning that variations were due to digital readiness rather than national context. This finding confirms Hypothesis 3, demonstrating that the apparent national differences are largely explained by institutional variation in digital integration rather than by cultural or economic factors alone. Cross-national differences in readiness and motivation showed that Chinese students had the highest digital proficiency (mean = 4.6) and entrepreneurial intentions (41% planning to start a business), while Bulgarian students demonstrated the lowest levels (mean = 3.8 ; 28%). Ukrainian respondents held intermediate positions (mean = $4.1/5$; 33%). Faculty readiness to implement startup-based learning also followed a similar pattern: China (69%), Ukraine (58%), and Bulgaria (52%). Common challenges and motivators revealed that the main barrier to entrepreneurship was a lack of practical experience, reported by 61% of Bulgarian, 56% of Ukrainian, and 43% of Chinese respondents. Conversely, access to digital platforms and online mentorship emerged as the primary motivator, recognized by 47% of Bulgarian, 53% of Ukrainian, and 62% of Chinese students. These results underscore the dual role of digitalization as both a necessary condition and a solution to overcome skill and experience gaps. Policy and educational implications indicate that universities should focus on developing digital entrepreneurship ecosystems that integrate technical competence, practical

experience, and inclusive support structures. Investment in digital infrastructure, integration of entrepreneurship across disciplines, and faculty training in digital mentorship are essential for enhancing entrepreneurial outcomes. Policymakers should focus on strengthening financial and digital inclusion mechanisms to ensure equitable access to entrepreneurial opportunities. In summary, the study provides strong empirical evidence that digital readiness functions as a catalyst for entrepreneurial mindset formation in higher education. Institutions that effectively integrate digital tools into their teaching, research, and support systems are more likely to produce graduates and faculty capable of initiating innovative ventures. Future research should extend this analysis longitudinally to evaluate how improvements in digital ecosystems translate into measurable business creation and sustainable economic impact.

AUTHOR CONTRIBUTIONS

V. Shcherbak conducted the conceptual development of the research, supervised the overall study design, administered the project activities, acquired funding, and prepared the initial draft of the manuscript. V. Riashchenko curated the dataset, developed the data analysis framework, prepared the visualizations, and participated in reviewing and editing the manuscript. M. Petrova contributed to refining the theoretical framework, ensured methodological consistency, and participated in interpreting the cross-cultural results. O. Dorokhov performed data collection, validation, and formal statistical analysis and contributed to revising the Results section. L. Dorokhova participated in the data collection process, supported the organization of the survey activities, and assisted in preparing the empirical materials. O. Yermolenko contributed to the interpretation of findings, coordinated the integration of research outcomes into the discussion, and participated in editing the final manuscript. V. Yatsenko supported the analytical assessment of the results, ensured the internal consistency of the conclusions, and reviewed the final version of the manuscript.

ACKNOWLEDGEMENT

The authors extend their sincere gratitude to the partner universities for their invaluable institutional support and facilitation of the data collection pro-

cess. Our special thanks go to the administrations and academic staff of the University of Veliko Tarnovo "St. Cyril and St. Methodius" (Bulgaria), Henan Institute of Science and Technology (China), and Sumy National Agrarian University (Ukraine) for their collaboration and engagement in this study. We are also deeply thankful to all the students and faculty members who generously shared their time and insights by participating in the survey, making this cross-cultural research possible.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. Besides, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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PUBLISHER NOTE

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ABBREVIATIONS (NOMENCLATURE)

%	Percentage
AI	Artificial Intelligence
ANCOVA	Analysis of Covariance
CBEwB	Central Baltic Student Enterprises without Borders
EI	Entrepreneurial Intentions
EdTech	Educational Technology
Eq.	Equation
GUESSS	Global University Entrepreneurial Spirit Students' Survey
IP	Intellectual Property
MIT	Massachusetts Institute of Technology
R&D	Research and Development
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
TTOs	Technology Transfer Offices
AI	Artificial Intelligence

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HOW TO CITE THIS ARTICLE

Shcherbak, V.; Riashchenko, V.; Petrova, M.; Dorokhov, O.; Dorokhova, L.; Yatsenko, V.; Yermolenko, O., (2026). Digital readiness and entrepreneurial mindset in higher education: Overcoming barriers through cross-cultural perspectives. *Int. J. Hum. Capital. Urban Manage.*, 11(3): 435 - 448.

DOI: 10.22034/IJHCUM.2026.03.01

URL: https://www.ijhcum.net/article_736047.html



International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: <http://www.ijhcum.net/>

ORIGINAL RESEARCH PAPER

The mediating role of Green Training & Development in the relationship between Emotion Appraisal and Regulation on Employee Eco-Friendly Citizenship Behavior

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ARTICLE INFO

Article History:

Received 22 July 2025

Revised 12 September 2025

Accepted 29 November 2025

Keywords:

Green training and development;
Emotions self appraisal;
Emotions regulation;
Employee eco-friendly citizenship behavior

ABSTRACT

BACKGROUND AND OBJECTIVES: Green Training and Development is a crucial initiative for Higher Education Institutions to foster eco-friendly behavior by enhancing knowledge and emotional skills for sustained behavior. Society prioritizes economic development over environmental quality, neglecting environmental damage. Public awareness is limited, and educational employees are under-researched in environmental awareness. Sustainable consumption promotes responsible use of natural resources and essential services, ensuring the protection of people's well-being. The research highlights a significant under-researching of environmental awareness and behavior among educational employees, highlighting a lack of scholarly attention on the psychological and behavioral factors influencing these employees. A research gap exists on green training in reconciling environmental values with economic priorities or job security, highlighting the need for further understanding. The study examines the influence of green training and development on employees' eco-friendly citizenship behavior in higher education institutions, focusing on the mediating effect.

METHODS: The study uses a quantitative method, utilizing a consent survey method and a questionnaire as the research instrument. The number of respondents in this study was 399 employees. This study utilized convenience sampling to select respondents in Malaysia. This study utilized SPSS, the SOBEL test, and SMART PLS4.

FINDINGS: The study's objectives and hypotheses significantly influenced each variable. Seven hypotheses have been accepted (H1: t-value = 9.093), (H2: t-value = 4.204), (H3: t-value = 6.273), (H4: t-value = 6.233), (H5: t-value = 5.191), (H6: t-value = 4.218) and (H7: t-value = 3.874).

CONCLUSION: Research suggests that implementing greening or environmental management systems in the workplace is crucial for sustainable higher education development, as it enhances employee emotions and eco-friendly behavior. The study provides practical advice for institutions aiming to create a sustainable workforce by focusing on the human aspect of environmental management.

DOI: [0.22034/IJHCUM.2026.03.02](https://doi.org/10.22034/IJHCUM.2026.03.02)



NUMBER OF REFERENCES

66



NUMBER OF FIGURES

2



NUMBER OF TABLES

8

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the "Show Article."

INTRODUCTION

Malaysian education promotes “green” training to foster industrial development and sustainable workplace practices, with educators enhancing green training skills in line with the Ministry of Education (MOE) aspirations. Green training and development in higher education institutions is crucial for employee development in this century, as it should be present in all groups. Unwanted environmental behavior includes unhealthy energy use, improper waste disposal, pesticide use, unsanitary disposal, and improper waste recycling in public spaces and parks (Soleimanpouromran et al., 2020). Green training skills encompass the skills, knowledge, attitudes, and values necessary to live in a society that minimizes the environmental impacts of human activity (Haldorai et al., 2022). The recommendation is to implement green training and development to improve employees’ eco-friendly citizenship behavior. Green training can enhance educators’ human capital production skills, promote sustainable economic, social, and environmental development, and encourage eco-friendly behavior among higher education employees. Implementing this strategy not only benefits the national economy but also promotes social and environmental sustainability in higher education institutions. Malaysian Higher Education Institutions (Kanapathy et al., 2021) are increasingly recognizing the significance of green training and development (Ghouri et al., 2020), focusing on supporting human capital development and fostering eco-friendly citizenship behaviors among employees (Aboramadan et al., 2021; Darvishmotevali et al., 2022) in technical (Agrawal et al., 2020) and professional fields (Lopez-Bernabe et al., 2020), thereby promoting high eco-friendly productivity development education (Korenetskaya et al., 2020). The research underscores the significance of incorporating green training elements into higher education, particularly in emotional self-assessment, regulation, and eco-friendly behavior (Dararvishmotevali et al., 2022; Ma et al., 2022). Human resource practices are crucial for implementing green training and development in employees, forming quality human capital for sustainable, environmentally friendly development in higher education institutions. Research on eco-friendly citizenship behavior in various industries, such as manufacturing (Aslam et al., 2021; Jayabalan et al., 2020; Ong et al., 2020; Perez et al., 2020), hotels

(Menseh et al., 2021; Umrani et al., 2020;), fashion (Salem et al., 2020), airline (Hwang et al., 2020), food & beverage industry (Nam, 2020), cosmetic industry (Sadiq et al., 2021), and banking industry (Ali et al., 2021; Ogalo et al., 2020), has shown a gap in understanding employees’ eco-friendly citizenship behavior at Malaysian higher education institutions. Previous studies on emotional intelligence, green training, and green behavior have been done in many sectors and religious orientations, such as the manufacturing industry (Sahan et al., 2024), household food waste (Khorakian et al. 2024), and retail stores (Evina et al., 2024). Research (Mohammad et al., 2020; Stankevičiūtė et al., 2020; Wiradirja et al., 2020; Darvishmotevali et al., 2022) on environmental citizenship behavior among employees in Malaysian higher education is limited, with fewer studies on eco-friendly citizenship behavior. This highlights a gap in green training and development in the emerging area of eco-friendly citizenship behavior in higher education. Studies suggest that Malaysian higher education employees have a better understanding of attitudes and ecological sustainability for green training (Anwar et al., 2020; Aziz et al., 2021; Kyriakopoulos et al., 2020; Yusliza et al., 2020). Literature reviews reveal that internal employee weaknesses are the root cause of issues in green training, emotional self-appraisal, and education regulations (Al-Ghazali et al., 2021). The rationale for focusing on Malaysia is to align with the country’s educational goals. The study highlights Malaysia’s educational focus on promoting “green” training to promote industrial development and sustainable workplace practices, aligning with the country’s educational goals. So, the study examines the influence of green training and development on employees’ eco-friendly citizenship behavior, focusing on the mediating effect at Malaysian Higher Education Institutions in the year 2024.

Literature review

Smart cities are being developed to address the challenges of rapid urbanization, focusing on sustainability, efficiency, and improving the quality of life for citizens. Smart cities utilize advanced resource management techniques like sensors for water leak detection, smart grids for electricity management, and smart waste management systems to minimize environmental impact. For example, research in China demonstrates that smart city initiatives

can significantly enhance urban green training development by promoting green technology innovation and optimizing industrial structures. But the relevance of the current study lies in the social and human aspects of a sustainable urban environment, which are significantly impacted by green training development.

Green training and development

Green training is a promising method for promoting workplace efficiency, knowledge, and skills, ultimately fostering environmental sustainability (Umar et al., 2021). Green training promotes environmental citizenship, sustainability, and a supportive workplace environment, thereby encouraging eco-friendly behavior among employees, according to various studies (Aboramadan et al., 2021; Darvishmotevali et al., 2022; Haldorai et al., 2022; Vargas-Hernández et al., 2022). Green policy and training improve employees' awareness, competence, and mental readiness for eco-friendly behavior (Chaudhary, 2020), leading to staff development and enhanced efficiency in an eco-friendly environment. Green training addresses internal employee weaknesses that may hinder the effectiveness of technological solutions. The study on green training development emphasizes the importance of human resource practices and emotional intelligence in promoting sustainable development and employee development for a smart, sustainable city in the educational field.

Self-emotion appraisal and regulation of emotion

Organizations may be reducing their focus on emotional intelligence, particularly in enhancing eco-friendliness (Darvishmotevali et al., 2022), due to a decrease in the emergence of feelings (Vasudevan, 2013; Vasudevan et al., 2017; Vasudevan et al., 2017; Vasudevan, 2020). Emotions effectively convey information, and revising measures to improve environmental performance results (Kraiger et al., 2021). Emotional skills are crucial for meaningful life generation (Goleman, 2001), and the education system must prioritize the development of emotional intelligence among higher education employees (Geßler et al., 2021). Del Campo et al., (2020) emphasize the importance of a healthy, safe, and conducive green learning environment for quality education and increased self-emotion appraisal. Respect, confidence, and appreciation are essential

for educators to feel a sense of belonging, and proactive administrators must coordinate green human resources practices and materials to achieve educational objectives (Darvishmotevali et al., 2022; Priksat et al., 2021; Vargas-Hernández et al., 2022).

Employees' eco-friendly citizenship behaviour

Smart cities utilize technological solutions like smart grids and waste management systems to reduce their ecological footprint. Green training is crucial for fostering eco-friendly citizenship behaviors among employees, supporting sustainability goals in smart cities. Afsar et al., (2020) suggest that eco-friendly citizenship encourages employees to adopt green behavior to mitigate environmental issues. Kim et al., (2019) highlight that environmentally conscious employees utilize their green skills and behaviors to exceed their professional responsibilities. Employee eco-friendly conduct refers to their intentional or voluntary actions aimed at protecting the environment from the harmful effects of human activities (Saeed et al., 2019). Environmentally friendly citizenship behavior attracts green employees, enhancing environmental performance (Anwar et al., 2020; Mohammad et al., 2020; Aslam et al., 2021; Mensah et al., 2021). Companies can contribute to sustainable development and contribute to eco-friendly citizenship behavior in various sectors (Bombiak, 2019). Mediating effect of Green Training & Development in the relationship between self-emotion appraisal and regulation of emotion on the employees' eco-friendly citizenship behaviour Wong and Law (2002) highlighted four dimensions of emotional intelligence: regulation of emotion, others' emotion appraisal, self-emotion appraisal, and use of emotions. Employees who self-evaluate and regulate their emotions can enhance their awareness of their external environment and ecosystem. High-emotion employees, characterized by self-emotion appraisal and emotional regulation, are more conscious and open to environmental issues, despite understanding others' feelings (Alipour et al., 2021). Emotionally intelligent workers are committed to responding to the external environment and regulating their feelings, enhancing their eco-friendly citizenship (Anwar et al., 2020; Mohammad et al., 2020; Aslam et al., 2021; Mensah et al., 2021). Academic staff's knowledge, technical skills, and direct relationships with university management significantly influence

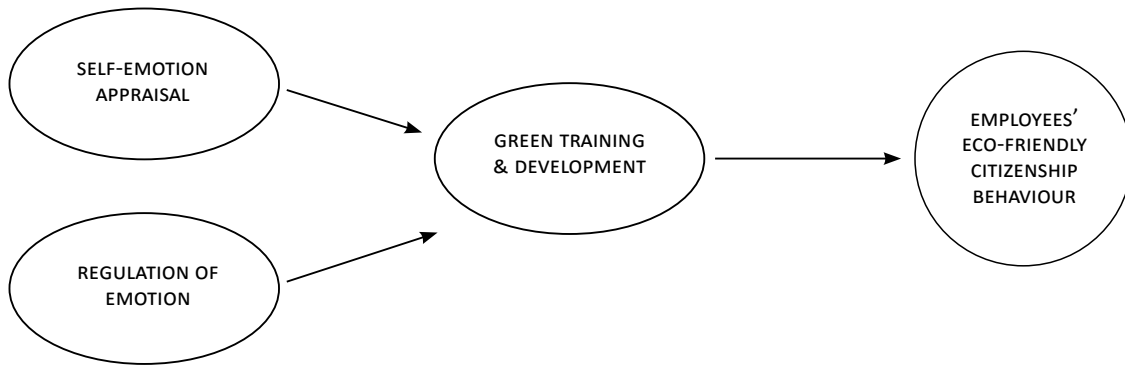


Fig. 1: Enhancing employees' eco-friendly citizenship behavior: The effect of green training & development on self-emotion appraisal and regulation of emotion at Malaysian Higher Education Institutions

campus sustainable growth, according to positive results for both organizations and employees (Aboramadan, 2020). Green training significantly impacts eco-friendly behavior among employees, potentially encouraging frequent training and awards for environmentally conscious practices like littering, conservation, and recycling (Saeed et al., 2019). Kim et al. (2019) assert that green training significantly influences an individual's eco-friendly behavior, thereby mitigating harmful environmental impacts.

Analytical framework

Fig. 1 reveals that Garden and Moran's multi-intelligence theory suggests that green training and development can enhance self-emotion appraisal and eco-friendly citizenship behavior in higher education institutions. Emotional intelligence, including self-evaluation and emotion regulation (Smith, 2020), is crucial for employees to adapt to environmental changes through effective green training education (Morse, 2020). Emotional intelligence plays a crucial role in green sustainability, enabling individuals to use knowledge about environmental and human violations to minimize environmental harm (Chang et al., 2021; Karatepe et al., 2021; Soleimanpouromran et al., 2020). Education promotes economic, social, cultural, and political growth, but institutions must protect the human environment to enhance real intelligence, a perspective from Gardner's multiple intelligences. Emotional intelligence enhances employees' adaptability, learning, and awareness of environmental issues, leading to increased eco-friendly citizenship behavior (Azhar et al., 2021; Karatepe et al., 2021). Green training enhances employees'

green intelligence, promoting eco-friendly behavior and citizenship behavior, as per studies by Umar et al., (2021). Research by Niyomdech et al. (2019) and Pham et al., (2018) at Thailand University indicates a positive correlation between green training and Organizational Citizenship Behavior for Environmental (OCBE). Previous studies have shown a positive correlation between green training and environmental citizenship behavior in the manufacturing sector (Malik et al., 2021). The research uses the Ability-Motivation-Opportunity (AMO) perspective to suggest that green training and development positively impact eco-friendly citizenship behavior (Ababneh, 2021; Ahmed et al., 2021; Amrutha et al., 2021; Úbeda-García et al., 2021), while green management in a company develops employees' skills, motivates them, and provides environmental improvement opportunities (Pham et al., 2019). Green training aids organizations in enhancing their human resources and capabilities, thereby promoting eco-friendly behavior (Yu et al., 2020).

MATERIALS AND METHODS

Survey design and data collection

The study utilized a quantitative method, allowing participants to complete questionnaires at their own pace, ensuring the objectives and research questions were addressed effectively. The study employs a quantitative approach and deductive reasoning to test a theory on the impact of green training and emotional regulation on eco-friendly behavior among employees, using specific measurements and scales. The study utilized IBM SPSS software version 26, the SOBEL test, and SMART PLS4 for data analysis, focus-

ing on content and construct validity to ensure reliability and accurate measurement of respondents' responses. This software is suitable for a study due to its use in Structural Equation Modeling (SEM), which can analyze complex relationships between variables, including the proposed mediating effect of green training and development. The study uses the SOBEL test to assess the statistical significance of a mediating effect between green training and emotional appraisal/regulation, aiming to understand eco-friendly behavior. The study was conducted in a non-contrived setting, using a cross-sectional time horizon and questionnaires to gather information on dependent and independent variables. This study employs a quantitative approach, convenience sampling, and a self-administered questionnaire to collect data and test an established theory using deductive reasoning. The science-based questionnaire was utilized for understanding human meanings and actions, employing scales and specific measurements in its quantitative data collection method. The study involved both academic and non-academic staff from Malaysian Higher Education Institutions, using non-probability convenience sampling. The study, conducted by the Ministry of Education in 2021, surveyed 500,000 academic and non-academic employees from all of Malaysia's higher education institutions. The study involved 500 employees, 399 of whom answered online survey questions, and used SPSS and SMART PLS3 for data analysis and a 5-point scale for measurement. The measurement items in [Table 1](#):

RESULTS AND DISCUSSION

Profile respondents

The demographic profile of the respondents reveals a predominantly female (63.4%) and 21-25-year-old age group (38.1%), indicating a youthful sample in [Table 2](#). The ethnic makeup of the population was predominantly 55.9% Malay, with a significant percentage of 21.1% being Chinese and 18% being Indian. The majority of respondents, comprising 56.1%, held a Degree/Professional certificate or post-graduate qualifications (35.3%), indicating a highly educated sample. The professional experience ranged from less than 2 years (32.3%) to 2-5 years (34.1%). The majority of participants (47.1%) attended 2-5 courses in environmental training. The occupational roles were diverse, with lecturers being the largest group (26.8%) and other professional roles also present.

The study's findings are more comprehensive and applicable due to the diverse demographic.

Descriptive analysis

[Table 3](#) presents a descriptive analysis that provides insights into the central tendency, dispersion, and distributional characteristics of four constructs: Self-Emotion Appraisal (SEA), Regulation of Emotion (ROE), Employee Eco-friendly Citizenship Behaviour (EEFCB), and Green Training and Development (GTD). The mean score for SEA and Accountability in the sample is 3.9279, indicating a high level of SEA and accountability among respondents. The mean scores of ROE and EEFCB (3.7888) show moderately positive levels, while GTD has the lowest mean score of 3.4106, indicating a lower level among respondents. Standard deviation and variance are dispersion measures that indicate the spread of scores around the mean, with lower values indicating less variability and higher values indicating greater dispersion. The standard deviations for all constructs are relatively similar, indicating similar levels of variability in respondents' perceptions across the constructs.

Normality test

In [Table 4](#), the Kolmogorov-Smirnov and Shapiro-Wilk tests were used to analyze SEA, yielding a 0.135 and 0.927 statistic, respectively, with a significance level of less than 0.001. The study reveals a significant deviation from normality in the distribution of SEA. The Kolmogorov-Smirnov and Shapiro-Wilk tests showed non-normality in the ROE, with a significance level of less than 0.001 and a statistic of 0.936, respectively. The ECB variable, with a Kolmogorov-Smirnov and Shapiro-Wilk statistic of 0.092 and 0.959, respectively, indicates that it is not normally distributed. The GTD variable, with a Kolmogorov-Smirnov and Shapiro-Wilk statistic of 0.093 and 0.888, respectively, indicates that it does not follow a normal distribution.

Multiple regression analysis & mediation analysis using the Sobel test

According to linear regression analysis presented in [Table 5](#), in terms of direct relationship, it is ascertained that hypothesis 1, indicating that SEA was a significant predictor of EEFCB, where it was significant at the 0.05 level and its t-value was 13.477. Besides that, ROE was a strong predictor of EEFCB as well be-

Table 1: Measurement items

Variables	No of items	Measurement item	Scale
Employee eco-friendly citizenship behavior	7	I voluntarily participate in environmental actions and initiatives in my daily work activities. I recommend effective environmental protection methods to colleagues, even when it's not their direct responsibility. I actively participate in environmental events organized by our Higher Education Institutions (HEIs). I am taking environmental actions that positively impact the reputation of our Higher Education Institutions. I actively participate in various projects, endeavors, or events that tackle environmental issues within our Higher Education Institutions (HEIs). I generously allocate time to assist my colleagues in considering the environment in all their work activities. I encourage my colleagues to adopt more environmentally conscious behaviors.	5-Likert Scale
Green Training and Development	6	I have received sufficient training on environmental issues. I can secure opportunities to receive training on environmental issues. I frequently receive environmental training. The environmental training provided by Higher Education Institutions (HEIs) is effectively utilized. The environmental training has led to a thorough evaluation of the employee's citizenship behavior. I have opportunities to increase my citizenship behavior after attending the environmental training.	5-Likert Scale
Self-appraisal emotion	4	I have a clear understanding of their approach towards green training and environmental citizenship behavior among employees. I possess a comprehensive understanding of my emotions and environmental concerns. I am well-informed about my stance on green training and development. I am always satisfied with the environmental training.	5-Likert Scale
Regulations of emotion	4	I always know my workmates' emotions from his/her behavior in the environment. I am adept at observing others' emotions towards environmental issues. I am sensitive to others' emotions and feelings regarding environmental behavior issues. I possess a comprehensive understanding of the emotions of those around me regarding environmental training and behavior.	5-Likert Scale

Table 2: Profile of responde

		Frequency	Percent
Gender	Male	146	36.6
	Female	253	63.4
Age	21-25	152	38.1
	26-30	43	10.8
	31-35	54	13.5
	36-40	59	14.8
	41-45	29	7.3
	46-50	33	8.3
	51 & above	29	7.3
Ethnic group	Malay	223	55.9
	Chinese	84	21.1
	Indian	72	18
	Other	20	5
Education level	SPM	12	3
	Degree/A-level	22	5.5
	Degree/Professional certificate	224	56.1
	Post-graduate	141	35.3
Years of service	< 2 years	129	32.3
	2 -5 years	136	34.1
Number of environmental training courses attended	< 1	164	41.1
	2 to 5	191	47.9
	6 to 10	35	8.8
	>10	9	2.
Occupation	Student	57	14.3
	Head of IT	1	0.3
	HR manager	13	3.3
	Professor Vice chancellor	1	0.3
	Manager	1	0.3
	Senior HR director	2	0.5
	Chief designer	1	0.3
	Tour guide	1	0.3
	Researcher	1	0.3
	Other	99	24.8
	Engineer	1	0.3
	Lecturer	107	26.8
	Senior lecturer	35	8.8
	Junior lecturer	17	4.3
	Senior executive	18	4.5
	Program coordinator	2	0.5
	Head of program	15	3.8
	Professor/Associate Professor	21	5.3
	IT coordinator	6	1.5

Table 3: Descriptive analysis

	N	Mean	Std. Deviation	Variance	Skewness	Kurtosis		
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error	Statistic
SEA	399	3.9279	0.80726	0.652	-0.862	0.122	1.186	0.244
ROE	399	3.7888	0.82349	0.678	-0.81	0.122	0.786	0.244
EEFCB	399	3.7214	0.83364	0.695	-0.568	0.122	0.364	0.244
GTD	399	3.4106	1.03401	1.069	1.691	0.122	16.27	0.244

Table 4: Normality test

	Kolmogor- ov-Smirnov ^a	Shapiro-Wilk				
	Statistic	df	Sig.	Statistic	df	Sig.
SEA	0.135	399	<.001	0.927	399	<.001
ROE	0.163	399	<.001	0.936	399	<.001
EEFCB	0.092	399	<.001	0.959	399	<.001
GTD	0.093	399	<.001	0.888	399	<.001

Table 5: Multiple regression analysis & mediation analysis using the Sobel test

Direct relationship				
Variable	Beta coefficient	t value	p value	Value
SEA	0.546	13.477	<0.01	
ROE	0.321	7.938	<0.01	
Dependent variable: ECB				
F value	0.632			340.613
R ²				
Mediation analysis (SEA → GTD → ECB)				
SEA → GTD		11.304		
GTD → ECB		14.685		
Test statistics				8.957
p value				0.00
Mediation analysis (ROE → GTD → ECB)				
ROE → GTD		11.367		
GTD → ECB		14.685		
Test statistics				8.988
p value				0.00

cause its t-value was 7.938 and significant at the 0.05 level. Hence, it demonstrated that, although different statistical approaches were adopted, it is ascertained that the statistical outcome of [Table 5](#) coincides with the one presented in [Table 6](#). It is also noted that the R-squared value of this model was 0.632, which indicates that 63.2 of the variance in EEFCB was explained by the variance in SEA and ROE. The F value of 340.613 also shows that the model is fit and thus representative of the sample of the population. The mediation analysis presented in [Table 5](#) was analyzed using the Sobel test as well as linear regression analysis. The empirical result evidenced that GTD played a crucial role in influencing the relationship between SEA and EEFCB in Hypothesis 4, as its test statistical value was 8.957 and significant at the 0.05 level. In Hypothesis 5, it was found that it significantly influenced the relationship between ROE and EEFCB, whereby its test statistic was 8.988 and significant at the 0.05 level. It is also noted that such a statistical outcome coincided with the one shown in [Table 6](#), although different statistical approaches were adopted.

Assessment of SEM

Reliability analysis

[Table 6](#) reveals that the EEFCB construct has a Cronbach's alpha of 0.944, indicating excellent internal consistency. The construct's composite reliability values, rho_a and rho_c, are above the acceptable threshold of 0.7, indicating its high reliability. The AVE for EEFCB is 0.749, exceeding the recommended minimum of 0.5, indicating that the construct's indicators capture a significant portion of the variance. The GTD construct has a Cronbach's alpha of 0.884, indicating strong internal consistency, and composite reliability values of 0.918 and 0.914, indicating robust reliability. The GTD construct has a high internal consistency and reliability, with an Average Variance Extracted (AVE) above the 0.5 threshold and composite reliability values of 0.907 and 0.933, respectively. The ROE indicator captures significant variance, while the SEA construct has strong internal consistency and high reliability values, as indicated by the AVE and Cronbach's alpha. The AVE for SEA is 0.759, indicating that a significant portion of the variance is attributed to the construct's indicators.

Cross-loading

[Table 7](#) and [Fig. 2](#) showcase cross-loadings for

EEFCB, GTD, ROE, and SEA to evaluate their discriminant validity. The indicators EEFCB1 through EEFCB7 exhibit strong loadings on their respective constructs, with values ranging from 0.772 to 0.897. The loading of EEFCB1 is 0.772, followed by EEFCB2 at 0.861, EEFCB3 at 0.888, EEFCB4 at 0.863, EEFCB5 at 0.888, EEFCB6 at 0.897, and EEFCB7 at 0.884. The high loadings indicate that each of these items strongly represents the ECB construct. The indicators GTD1 through GTD6, except for GTD4, exhibit significant loadings on their construct for the GTD construct. The GTD1 has a loading of 0.807, followed by GTD2 at 0.861, GTD3 at 0.872, GTD5 at 0.884, and GTD6 at 0.868. GTD4's lower loading of 0.449 suggests it may not be as robust an indicator of the GTD construct as other indicators. The indicators ROE1 through ROE4 show strong loadings for the construct ROE, with values of 0.879, 0.887, 0.851, and 0.908, respectively. The high values of each indicator confirm that they effectively reflect the ROE construct. The construct SEA indicators SEA1 through SEA4 exhibit strong loadings, with SEA1 at 0.877, SEA2 at 0.856, SEA3 at 0.888, and SEA4 at 0.863.

Discussion

The study aimed to understand the interplay of various factors in influencing eco-friendly behaviors through the significance of the findings. The study confirmed hypothesis 1, indicating that SEA is a significant predictor of EEFCB. [Yuen et al., \(2023\)](#) suggest that high self-awareness leads to environmental awareness and long-term eco-friendly practices among individuals. Self-determination theory suggests that individuals with high self-awareness appreciate environmental behavior meaning, as supported by studies by [Ryan and Vansteenkiste \(2023\)](#); [Ryan et al., \(2021\)](#). Individuals with a strong sense of personal responsibility and commitment to environmental sustainability are more likely to foster a culture of eco-friendly behavior in organizations ([Usman et al., 2023](#)). The model developed for EEFCB confirmed Hypothesis 2, as ROE was a strong predictor. Emotion regulation is crucial for comprehending the sustained commitment to environmentally friendly traditions and the development of environmentally friendly behaviors in various contexts ([Havarangsi and Vithayaporn, 2024](#); [MacDonald and She, 2015](#)). Employees who can regulate emotions effectively can manage frustrations and obstacles in implementing

Table 6: Reliability analysis

Construct	Measurement Items	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	AVE
EEFCB	E1: I voluntarily participate in environmental actions and initiatives in my daily work activities.	0.944	0.945	0.954	0.749
	E2: I recommend effective environmental protection methods to colleagues, even when it's not their direct responsibility.				
	E3: I actively participate in environmental events organized by our Higher Education Institutions (HEIs).				
	E4: I am taking environmental actions that positively impact the reputation of our Higher Education Institutions.				
	E5: I actively participate in various projects, endeavors, or events that tackle environmental issues within our Higher Education Institutions (HEIs).				
	E6: I generously allocate time to assist my colleagues in considering the environment in all their work activities.				
	E7: I encourage my colleagues to adopt more environmentally conscious behaviors.				
GTD	G1: I have received sufficient training on environmental issues.	0.884	0.918	0.914	0.648
	G2: I can secure opportunities to receive training on environmental issues.				
	G3: I frequently receive environmental training.				
	G4: The environmental training provided by Higher Education Institutions (HEIs) is effectively utilized.				
	G5: The environmental training has led to a thorough evaluation of the employee's citizenship behavior.				
	G6: I have opportunities to increase my citizenship behavior after attending the environmental training.				
ROE	R1: I always know my workmate's emotions from his/her behavior in the environment.	0.904	0.907	0.933	0.777
	R2: I am adept at observing others' emotions towards environmental issues.				
	R3: I am sensitive to others' emotions and feelings regarding environmental behavior issues.				
	R4: I possess a comprehensive understanding of the emotions of those around me regarding environmental training and behavior.				

SEA	S1: I have a clear understanding of their approach towards green training and environmental citizenship behavior among employees.	0.894	0.897	0.926	0.759
	S2: I possess a comprehensive understanding of my emotions and environmental concerns.				
	S3: I am well-informed about my stance on green training and development.				
	S4: I am always satisfied with the environmental training.				

Table 7: Cross-loading test

	EEFCB	GTD	ROE	SEA
EEFCB1	0.772			
EEFCB2	0.861			
EEFCB3	0.888			
EEFCB4	0.863			
EEFCB5	0.888			
EEFCB6	0.897			
EEFCB7	0.884			
GTD1		0.807		
GTD2		0.861		
GTD3		0.872		
GTD4		0.449		
GTD5		0.884		
GTD6		0.868		
ROE1			0.879	
ROE2			0.887	
ROE3			0.851	
ROE4			0.908	
SEA1				0.877
SEA2				0.856
SEA3				0.888
SEA4				0.863

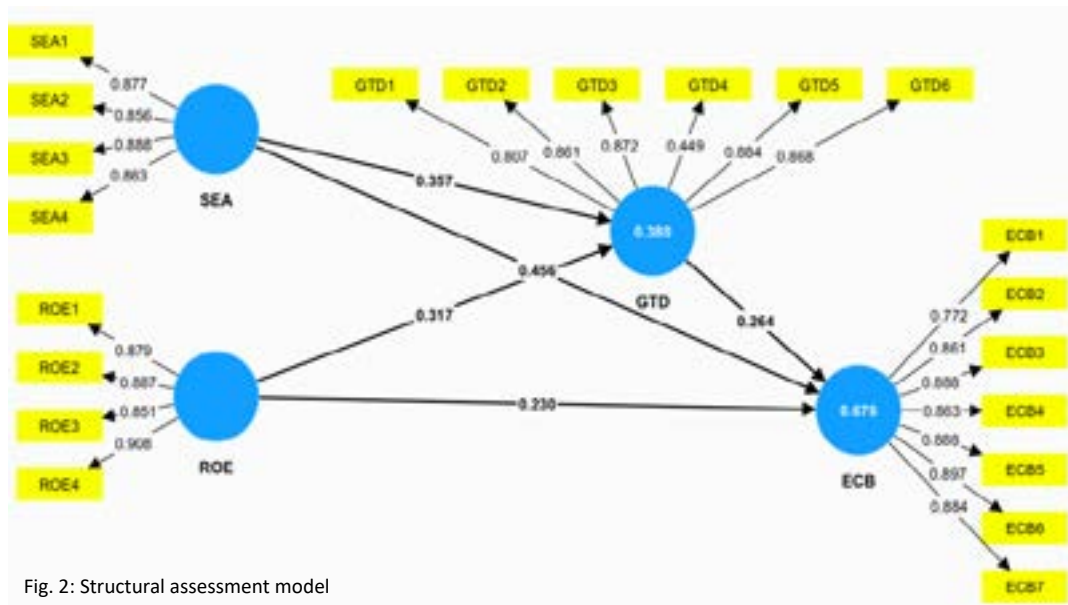


Fig. 2: Structural assessment model

environmentally friendly ventures, promoting a consistent and dedicated approach towards environmental responsibility (Yu *et al.*, 2020; Deshpande and Srivastava, 2023). Higher ROE enhances teamwork and efficiency, as employees with better emotional regulation communicate effectively and work towards common environmental goals (Yu *et al.*, 2020).

The study confirmed Hypothesis 3, indicating that GTD is a significant predictor of EEFCB. Eco-training programs enhance workers' environmental knowledge and skills, potentially initiating sustainable behavioral activities towards workplace sustainability interventions (Novita *et al.*, 2022; Ruiz-Perez *et al.*, 2021). Greener performance potential in GTD programs can be realized through better quality and wider-spread programs, as suggested by various studies (Jeronimo *et al.*, 2020; Usman *et al.*, 2023; Yesiltas *et al.*, 2022). Continuous training and development enhance the workforce's knowledge and skills in environmental technologies and practices, thereby enhancing their potential to achieve the sustainability goals of the organization (Novita *et al.*, 2022). The study reveals that GTD significantly influences the correlation between SEA, ROE, and EEFCB, as per Hypotheses 4 and 5. The integration of environmental education could enhance the adoption and continuation of pro-environmental behavior. The mediating role of GTD demonstrates that an effective training

program requires a holistic approach that considers both emotional and environmental aspects. The integration of environmental sustainability can enhance employee commitment and responsibility by fostering a deeper understanding of both emotional and practical aspects of their actions. The Human Factor provides an intuitive and useful understanding of human behavior in environmental decision-making (Byrd, 2022). Moreover, organizational culture plays another vital role in promoting eco-friendly citizenship behaviors because it can breed such a positive and facilitative work environment that, at length, allows them to foster open channels of communication and joint effort on the environmental concerns, which at length, enhance the general efficacy of green training programs by the organization itself (Priyadarshini *et al.*, 2023; Azhar and Yang, 2022).

Practical and implications

In the practical context, the implication can be categorized into two as follows:

Academician

- Existing courses that are relevant to using the sustainability component in teaching and learning should be listed, reviewed, and improved to increase employees' awareness on the green sustainability.
- Sustainability components in training modules and competencies of academic and support staff academ-

Table 8: Direct & indirect effects of the construct's relationship

Path Relationship	Hypothesis	t-value	Sig.	Decision
SEA → EEFCB	Self-emotion appraisal positively impacts eco-friendly citizenship behaviors.	9.093	0.000	Supported
ROE → EEFCBE	Regulation of emotions positively impacts eco-friendly citizenship behaviors.	4.204	0.000	Supported
GTD → EEFCBE	Green training & development positively impacts eco-friendly citizenship behaviors	6.273	0.000	Supported
SEA → GTD	Self-emotion appraisal positively impacts green training & development	6.233	0.000	Supported
ROE → GTD	Regulation of emotions positively impacts green training & development	5.191	0.000	Supported
SEA → GTD EEFCB	Green training & development mediates the relationship between self-emotion appraisal and eco-friendly citizenship behaviors	4.218	0.000	Supported
ROE → GTD EEFCB	Green training & development mediates the relationship between the regulation of emotions and eco-friendly citizenship behaviors	3.874	0.000	Supported

ic can develop academician awareness, knowledge, and skills.

- Can increase employees' professional commitment in green training issues.
- Combining the disciplines of the field of study and the concept of sustainability in each of the relevant courses enhance employees' performance and self-awareness to the research and learning process.
- Improving a healthy lifestyle among campus residents.
- Provide awareness to employees about the importance of biodiversity of flora and fauna.
- Equality and social justice for all campus residents.

Nation / Institutions

- Carries the meaning of energy and water produced and used in a way that can support human development.
- To build our nation toward the earth's flora and biodiversity.
- Nature's balance must be defined and preserved.
- Create and enjoy an environmentally friendly, safe, and equitable life balance.
- Formulation of ethical policies for sustainable research and learning.
- Creating a pedestrian and cycling-friendly campus is a sustainable aspect that needs to be practiced.

- Reducing the ingress of motor vehicles and indirectly reducing the emission of carbon monoxide gas inside the campus.
- Have a guarantee of adequate energy supply to meet current and future needs.

Limitations and future direction

The study acknowledges several limitations and suggests future study as follows:

Convenience sampling: The study utilized convenience sampling, a non-probability method, which may introduce selection bias due to its potential inaccuracy in capturing the entire Malaysian academic and non-academic staff population. In future studies, the sampling has to investigate different sampling methods to improve the generalizability of the findings to a broader population.

Cross-sectional design: The research utilized a cross-sectional design, collecting data at a single point in time, making it challenging to establish causality or understand variable relationships over time. In future studies, the researchers have to utilize a longitudinal research design to better understand the long-term impact and causal relationships between the variables.

Data distribution: The normality test revealed that variables Self-Emotion Appraisal, Regulation of Emo-

tion, Employee Eco-friendly Citizenship Behavior, and Green Training and Development do not follow a normal distribution, potentially affecting the validity and reliability. The objective is to bridge the gap in understanding eco-friendly behavior across various industries and diverse geographical locations.

Instrument weakness: The Green Training and Development construct's low loading value of 0.449 suggests it may not be a robust indicator, potentially affecting the study's reliability. Future studies must investigate additional factors beyond emotional intelligence and green training that influence eco-friendly citizenship behavior.

CONCLUSION

This study's findings have the potential to significantly enhance research and practice. The theory combines emotional and institutional aspects to develop eco-friendly citizenship behavior, emphasizing the significance of sustainability-related positive emotional cues in maximizing green training benefits. Green training and development initiatives significantly influence emotional management strategies and eco-friendly citizenship behavior. Secondly, this study aims to demonstrate the significant role of self-emotion appraisal and emotion regulation in enhancing the benefits of green training and development initiatives and eco-friendly citizenship behavior. The study will provide evidence on the significance of emotion-management strategies in this specific context. The study's findings could assist higher education policymakers in creating eco-friendly citizenship behavior interventions to achieve long-term employee behavior objectives. The current study's fourth finding reveals a sampling limitation, specifically focusing on convenience sampling. Convenience sampling is used for easy and specific responses, while purposive sampling is crucial for accurate population representation and preventing bias, impacting research validity and reliability. In the future study, the sample size should be increased to 500 for more accurate results. The outcomes could help Malaysian higher education institutions understand the relative importance of individual emotion strategies in meeting sustainability goals. It implies that focusing solely on green training and development will not be sufficient to increase eco-friendly citizenship behaviour unless adaptive emotion regulation interventions are used. Self-emotion appraisal is predicted to sig-

nificantly influence green training and development, which in turn is expected to significantly influence eco-friendly citizenship behavior. Researchers predict that green training and development will play a crucial role in influencing self-emotion appraisal and eco-friendly citizenship behavior.

AUTHOR CONTRIBUTIONS

H. Vasudevan, M.Y. Cheok, R. Nagarathnam, and K. Gengatharan performed the literature review and experimental design and analyzed and interpreted the data, and H. Vasudevan and R. Abdul Wahhab prepared the manuscript text and manuscript edition. M.Y. Cheok, R. Abdul Wahhab, and H. Vasudevan performed the experiments and literature review, compiled the data, and prepared the manuscript. M.Y. Cheok, K. Gengatharan, and R. Nagarathnam performed the data analysis and findings, while Md. S. Nurul Ar Rasyid performed data collection, and H. Vasudevan and R. Abdul Wahhab compiled the data analysis and findings for the manuscript edition.

ACKNOWLEDGEMENT

The authors express gratitude for the UniRazak Research Grant's (UNIRAZAK/RMC/2023/002) support in their research study, expressing their appreciation for the grant's guidance and endorsement.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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PUBLISHER NOTE

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ABBREVIATIONS

$\bar{Y}$	Average of observed data
R^2_{adj}	Adjusted coefficient of determination
$\bar{Y}$	Average of observed data
AVE	Average variance extracted
R^2	Coefficient of determination
E	Percentage maximum error
H	Hypothesis
	Level of significance
p	Percentage occurrence of a condition
p-value	Probability value
SMART PLS	Partial least squares (PLS) path modeling method.
Z	Level of Confidence
SOBEL	Sobel's Test for Mediation
GTD	Green Training & Development
SEA	Self-Emotion Appraisal
ROE	Regulation of Emotion
EEFCBE	Employee Eco-Friendly Citizenship Behaviour
MOE	Ministry of Education

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HOW TO CITE THIS ARTICLE

Vasudevan, H.; Cheok, M.Y.; Md Saad, N.A.R.; Gengatharan, K.; Nagarathanam, Abdul Wahhab, R., (2026). *The mediating role of Green Training & Development in the relationship between Emotion Appraisal and Regulation on Employee Eco-Friendly Citizenship Behavior*. *Int. J. Hum. Capital. Urban Manage.*, 11(3): 449 - 466.

DOI: [0.22034/IJHCUM.2026.03.02](https://doi.org/10.22034/IJHCUM.2026.03.02)

URL: https://www.ijhcum.net/article_732265.html



International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: <http://www.ijhcum.net/>

ORIGINAL RESEARCH PAPER

Rationalizing managerial judgment: The effectiveness of collective decision-making in bias reduction

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ARTICLE INFO

Article History:

Received 25 May 2025

Revised 18 August 2025

Accepted 30 November 2025

Keywords:

Collective decision-making;
Cognitive bias; Overconfidence;
Optimism; Anchoring effect.

ABSTRACT

BACKGROUND AND OBJECTIVES: This study explores the influence of collective decision-making on mitigating key cognitive biases—namely, overconfidence, optimism, and anchoring effects—among managers in Iranian state-run organizations. Cognitive biases are systematic errors in thinking that impair judgment and decision quality, often leading to suboptimal outcomes in organizational contexts. Given the high stakes and complexity of managerial decisions in public sector settings, identifying mechanisms to reduce such biases is both practically and theoretically significant. The primary objective of this research is to determine whether collective decision-making, characterized by collaborative deliberation and shared responsibility, can serve as an effective tool for bias reduction.

METHODS: A quantitative survey methodology was employed, utilizing a structured Likert-scale questionnaire distributed among 152 managers at different hierarchical levels in governmental institutions. The instrument's internal consistency was verified with a Cronbach's alpha of 0.857, indicating high reliability. Data analysis included descriptive statistics, mean comparisons against scale midpoints, and significance testing using inferential methods.

FINDINGS: Findings revealed that collective decision-making significantly reduced the levels of overconfidence, unrealistic optimism, and anchoring bias among participants ($p < 0.05$). These results suggest that involving multiple perspectives in decision processes enhances rationality by exposing individual assumptions to group scrutiny, thus improving the quality and accuracy of managerial judgments.

CONCLUSION: The implications of this study are particularly relevant for organizational leadership and policy-making in public institutions. Encouraging collective decision-making not only minimizes the costs associated with biased decisions but also fosters a culture of collaboration, accountability, and shared learning. This approach can reduce psychological stress related to decision-making responsibilities and improve overall organizational performance. By highlighting the cognitive benefits of group-based decision strategies, the study contributes to the broader literature on decision science, organizational behavior, and public management, offering practical insights for managerial training and institutional reform.

DOI: [10.22034/IJHCUM.2026.03.03](https://doi.org/10.22034/IJHCUM.2026.03.03)



NUMBER OF REFERENCES

87



NUMBER OF FIGURES

2



NUMBER OF TABLES

7

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the "Show Article."

INTRODUCTION

Decision-making in individuals is shaped by three core components: cognitive functions, motivational forces, and emotional states. The reasoning capacity of each person is limited and low and is influenced by cognitive bias and hidden bias (Tweed, Thompson-Fawcett, & Wilkinson, 2013). In situations where there is risk and the volume of information is large, managers cannot process information properly and solve complex problems. In addition, managers may pay attention to quantitative signs and dimensions when making decisions. The lack of attention that has occurred can be caused by a variety of biases that affect people over a certain period (Roy, 2016; Wolman et al., 2023). Cognitive biases are caused by incorrect and unwanted use of the ability to simplify complex issues, make decisions despite incomplete information, and generally operate under limitations such as time, information, and cognitive capacity. Decision-making processes are influenced by simple heuristic techniques and common reasoning and are prone to bias, some of which are more obvious than others (Tweed et al., 2013). The pervasive influence of cognitive biases on managerial thinking can have substantial negative repercussions for businesses and investments. These biases can severely impair sound judgment, leading to errors in critical areas such as personnel selection, marketing implementation, strategic growth initiatives, and the adoption of beneficial technological advancements (Kaur & Sood, 2015). Recognizing the critical role of biases in shaping managerial choices, numerous studies have explored this phenomenon. One particularly relevant work is Jordão et al., (2020), "Bounded rationality in decision making: An analysis of the decision-making bias." This study utilized bibliographic techniques to pinpoint the dominant biases affecting managers. Specifically, they discovered that overconfidence, optimism, and anchoring biases were prominent in the Portuguese port sector and then drew comparisons with data from the Brazilian civil construction sector. The focus on overconfidence, optimism, and anchoring arises from their well-documented influence on managerial decision-making. Overconfidence reflects inflated certainty in one's judgments and is frequently observed in high-stakes organizational contexts, often leading to misallocation of resources and strategic miscalculations (Kahneman & Tversky, 1979; Moore & Healy, 2008). Optimism bias, characterized by systematic overestimation of

favorable outcomes, can undermine risk assessment and foster unrealistic expectations in public policy and project management (Sharot, 2011). Anchoring bias, in contrast, demonstrates the cognitive tendency to rely excessively on initial reference points when making judgments, thereby distorting rational deliberation in budgeting, forecasting, and negotiation (Furnham & Boo, 2011). Collectively, these three biases represent diverse yet critical pathways through which managerial rationality may be compromised. To counteract the detrimental effects of biases on managerial choices, the study of Jordão et al., (2020) outlines a set of interventions. A key element of these interventions is the promotion of collaborative decision-making, where the opinions of multiple individuals are prioritized over singular viewpoints, especially in high-stakes situations. Expanding on the work of Jordão et al., (2020), this investigation seeks to determine how this collaborative strategy influences overconfidence, optimism, and anchoring biases in various countries and organizations (Jordão, Costa, Dias, Pereira, & Santos, 2020). The primary objective of this research is to put the proposed method into practice and validate the suggested approach. Therefore, this research aims to answer the question of whether using the opinion of others in the form of collective decision-making can reduce the three important biases of overconfidence, optimism, and the anchoring effect in managers' judgment or not. To find the answer to this question, the researchers conducted a field study in Iranian state-run organizations. In this field study, they went to people who are managers at different levels and are aware of the collective decision-making method or use it in their work decisions. Data for this study were gathered through the use of a questionnaire and subsequently analyzed using SPSS software.

Literature review

Cognitive bias

The brain's fundamental cognitive functions include decision-making, a process that cognitive decision science seeks to understand by examining underlying psychological principles (Scholz, 1983). Cognitive biases, as defined in psychology, are systematic deviations in human reasoning that produce predictable patterns of flawed judgment (Tweed et al., 2013). These biases constitute consistent errors in thought and influence both individual choices and evaluations (Mina, Ruiz-Fernández, Falcão, Vasquez-Reina,

& González-Agirre, 2025). While these biases may be apparent to external observers, their impact on decision-making can lead to significant negative outcomes (McShane, Nirenburg, & Jarrell, 2013). Cognitive biases arise from inherent limitations in human cognitive processing and represent systematic deviations from rationality in judgment and decision-making (Vos, Nieto, Amanvermez, Smeets, & Everaert, 2025). They produce predictable patterns of thought and behavior that result in inaccurate perceptions, flawed interpretations, and illogical conclusions. Often, these biases stem from heuristics—mental shortcuts that simplify complex information—, but they can also be shaped by emotions, social pressures, and memory limitations (Giaume, Lamblin, Pinol, Gignoux-Froment, & Trousselard, 2025). Consequently, cognitive biases can distort objective reality and lead to systematic errors in reasoning, diverging from normative models of rational choice (Bird, Jones, & Ballantyne, 2025). Cognitive bias demonstrates that actual human behavior systematically deviates from the predictions of classical statistical laws (Dhami, 2020). Many decision errors and related problems arise from psychometric weaknesses and mental biases (Cherkes & Ryan, 1985). While numerous biases affect managerial judgment, this study focuses on three: overconfidence, optimism, and the anchoring effect. Evidence shows that these biases can lead to poor decision-making, particularly among managers. Judgmental vulnerabilities associated with these biases can have serious consequences at both individual and organizational levels, making it crucial to identify and address them to prevent downstream effects (Jordão *et al.*, 2020). The following sections provide detailed explanations of each of these three biases.

Overconfidence bias

Overconfidence bias, a pervasive cognitive distortion, manifests as an individual's tendency to overestimate their abilities, knowledge, and the accuracy of their judgments, particularly in situations involving uncertainty. This bias leads to an inflated sense of certainty, often exceeding actual performance or objective evidence, and results in a skewed perception of one's capabilities relative to others or to reality (Costa, Soares, de Melo Moreira, & Tonelli, 2025). It can manifest in various domains, from intellectual assessments to predictions of future events, and contributes to suboptimal decision-making by fostering

an unwarranted belief in one's competence, thereby hindering the pursuit of further information or corrective feedback (Maheshwari, Samantaray, Panigrahi, & Jena, 2025). Overconfidence bias reflects the human inclination to inflate perceptions of one's competence and ingenuity. Originating in social psychology, this bias describes an individual's conviction that their knowledge exceeds factual accuracy, leading them to prioritize personal information over objective evidence (C.-C. Lee, Lee, Yeh, & Yu, 2022). Essentially, overconfidence manifests as an unjustified belief in one's cognitive abilities, skills, expertise, and personal attributes (Boussaidi, 2022). Two important factors cause overconfidence:

1. *Unrealistic positive self-evaluation, this factor makes people estimate their abilities above reality*
2. *Unrealistic optimism, this optimism causes people to estimate the probability of their success above what it is (Van Der Wege, Jacobsen, Magats, Mansour, & Park, 2021).*

Consequently, overconfidence leads managers to overestimate their expertise, causing them to overlook potential risks associated with their decisions (Costa, de Melo Carvalho, de Melo Moreira, & do Prado, 2017). Various factors have been identified as contributing to overconfidence bias, including the better-than-average effect, miscalibration, and self-attribution (Boussaidi, 2022), as well as the planning fallacy, positive illusions, and the aforementioned factors (ul Abidin, Qureshi, Iqbal, & Sultana, 2022).

Optimism bias

The inclination to perceive oneself as superior to the average person, coupled with the belief that negative events are more likely to befall others, reflects an overestimation of favorable outcomes (Chen, Ishfaq, Ashraf, Sarfaraz, & Wang, 2022). An optimism bias is based on the assumption that I am less at risk than others. An optimism bias is based on the belief that an optimist is less at risk than others. Optimistic people want to see the world as better than it is. Some studies show that for all positive personal characteristics, such as driving skills, good looks, longevity, etc., most optimists tend to rate themselves as better and above average (Kotikalapudi, Dricu, Moser, & Aue, 2022) (Deekonda & Bernstein, 2011). Optimism, in this context, describes a tendency to anticipate future events with a positive outlook, correlating with individual life satisfaction, physical well-being, and self-worth. Optimism

bias can be broadly categorized into biases towards favorable and unfavorable occurrences. When making choices, managers may exhibit unwarranted optimism, leading to an exaggeration of potential gains and an underestimation of required expenditures (H. Liu, Jiang, Liu, Hertogh, & Lyu, 2018). The illusion of control, which is the belief that one can effectively manipulate outcomes in random situations, is a significant contributor to optimism bias, even in purely chance-driven events (Bracha & Brown, 2012).

Anchoring effect

The anchoring effect, also known as anchoring and adjustment, is a cognitive bias where individuals rely heavily on the first piece of information, or “anchor,” they encounter when forming judgments and making decisions (Rezaei, 2021). Essentially, this means that quantitative estimations are unduly influenced by prior estimates or initial figures presented in a problem, with subsequent adjustments often proving insufficient (C. Y. Lee & Morewedge, 2022; Tweed et al., 2013). In ambiguous situations, managers frequently turn to anchors, such as past sales data, forecasts, or personal opinions, to guide their decisions (Smith, Stone, Kisamore, & Jawahar, 2010). An anchor acts as a focal point, fixating the mind on a specific value and hindering objective reasoning (Pomeroy, 2003). Varying starting points lead to divergent estimates. In essence, the anchoring effect significantly impacts managerial decisions, leading to judgments biased toward previously presented values. A prevalent explanation for this phenomenon is that the anchor establishes a range of plausible values, at least temporarily (Costa et al., 2017). While anchors can assist managers in resolving uncertainty and justifying their choices, they may be unsuitable for certain decisions, or managers may fail to perform adequate calculations regarding the initial anchors (Smith et al., 2010). Thus, anchoring can result in flawed decision-making, leading to increased costs for companies, organizations, or governments (Selim, 2021). Recognizing and mitigating the detrimental effects of anchoring can enhance the quality of decision-making (Berger & Daumann, 2021).

Collective decision making

Collective decision-making involves a scenario where multiple individuals, each with unique perspectives, attitudes, motivations, and personalities,

recognize a shared problem and collaborate to reach a unified decision (Bui, 1987). Decision-making, in general, can be understood as a cognitive process leading to the selection of one option from a range of possibilities (Liang, Guo, & Liu, 2024; Wu, Zhou, Jin, Lin, & Leung, 2017). Collective decision-making can also be described as a process where individuals with diverse viewpoints and personalities strive to achieve a common resolution (De Oca et al., 2011). Alternatively, it may involve two or more actors coordinating on a specific issue to achieve a desired outcome (Gerrits & Marks, 2017). Typically, in collective decision-making, individuals express their preferences and opinions regarding potential choices, ultimately leading to the selection of a single decision (Rossi, 2014). This process can be broken down into four key modules (Wu et al., 2017):

- 1) *Opinion collection*: Gathering initial user feedback, often via questionnaires, to establish a baseline of opinions.
- 2) *Opinion processing*: Facilitating the exchange of user feedback, allowing individuals to refine their opinions through interaction, utilizing methods such as voting and weighted voting.
- 3) *Negotiation*: Grouping users based on shared opinions, engaging in discussions, and iteratively refining results through voting and ranking.
- 4) *Consensus*: Recalculating voting weights and ensuring that a final decision is reached when a sufficient level of agreement is attained (Mirbagheri, Atani, & Parsanejad, 2024).

The primary function of groups is to generate effective solutions to complex challenges (Zafeiris, Koman, Mones, & Vicsek, 2017). Considerable efforts have been devoted to the question of collective decision making related to problems involving a single dominant feature. Here we introduce a quantitative formalism for finding the optimal distribution of the group members' competences in the more typical case when the underlying problem is complex, i.e., multidimensional. Thus, we consider teams that are aiming at obtaining the best possible answer to a problem having a number of independent sub-problems. Our approach is based on a generic scheme for the process of evaluating the proposed solutions (i.e., negotiation). Further enhancements to collective decision-making are possible by accounting for the inherent variability in individual decision-making accuracy (Bosel, Reinal, & Marshall,

2017). Many advantages of collective decision-making need to be carefully analyzed. Examining these advantages and disadvantages will help a lot in choosing or not choosing this method. The advantages of collective decision-making are detailed in Table 1.

Factors affecting collective decision-making

Collective decision-making involves both internal psychological states, such as beliefs, emotions, and intentions, and external interactions with individuals possessing diverse mental frameworks. To reach a mutually agreeable decision, these internal states must be harmonized through social interaction. This process not only aligns intentions towards a shared outcome but also fosters common individual understandings and sentiments. Bosse *et al.* (2013) presented a model that illustrates the interplay of various factors that influence Collective decision-making. This model posits that an individual's inclination toward a specific decision is determined by their beliefs (cognitive evaluation) and feelings (affective responses) regarding that option. Furthermore, the model suggests that beliefs can trigger emotions (emotional reactions), such as fear, which, in turn, can modify the intensity of those beliefs (emotional influence) (Bosse *et al.*, 2013). Another factor that influences collective decision-making is the quality of the argument. There is an interaction between the quality of reasoning and the social impact of information. As the quality of reasoning increases, so does the social impact, and this issue increases the acceptance of information for collective decision-making. Also, resource credibility is effective in increasing the level of information acceptance for collective decision-making (Cho & Chan, 2019). Information uncertainty and conflicting preferences are two additional significant determinants of collective decision-making (Conradt, 2012). The effectiveness of collective decision-making in situations with conflicting information is contingent upon both the volume and credibility of the data individuals receive (Mann, 2018). Research indicates a significant correlation between conflict reduction and bias mitigation within collective settings, as these factors are interdependent. Specifically, homogenous groups, characterized by members with similar backgrounds, expertise, and viewpoints, tend to exhibit lower internal conflict but may face an elevated risk of collective bias. Conversely, heterogeneous groups, composed of individuals with diverse backgrounds,

expertise, and perspectives, may experience greater internal discord but potentially reduce collective bias, fostering more in-depth discussions and enhanced integration of ideas. This is because diverse viewpoints are more likely to accurately represent the complexity of an issue. Dionne *et al.*, (2019) simulated this phenomenon, revealing that groups with minimal collective bias and a shared understanding of the problem tend to generate higher-value ideas and achieve better decision-making convergence (Dionne *et al.*, 2019). This shows what kind of strategies will be optimal for collective formation and for maximizing the real efficiency of collective decisions. One thing that remains indirect and problem-related is that the best composition of a team, group, or collective may largely depend on the specific configuration of the problem. In situations where a team is tasked with a critical time-bound mission, speed of convergence is essential for achieving success. Therefore, prioritizing group uniformity to limit internal conflicts is advisable. However, if the team's goal is to identify a high-quality solution, minimizing the likelihood of group-level bias is vital, potentially necessitating increased diversity within the team (Dionne *et al.*, 2019). Collective systems face a choice between rapid and precise decision-making. The quality of a group's decision is significantly influenced by the well-known trade-off between speed and accuracy. Prioritizing swift decisions among a predetermined set of options can restrict the potential for accuracy, as superior alternatives may become apparent later (Khaluf *et al.*, 2019). In the article (Sueur *et al.*, 2011).the factors that affect collective decisions are

- 1) *The degree of diversity and environmental uncertainty,*
- 2) *Social relationships with other members of the group,*
- 3) *Potential ways for people to obtain information about their environment.*

The structure of participants, both socially and within an organization, can also impact the results of collective decision-making (Dionne *et al.*, 2019). It is clear that increased group size, or network complexity, leads to greater variability in decision-making convergence. However, larger group sizes do correlate with the emergence of more valuable ideas (Dionne *et al.*, 2019). One example of participation in collective decision-making is through voting. The more inclusive the number of voters, the fewer external factors in-

Table 1: Disadvantages and advantages of collective decision-making

Row	Disadvantages	Reference
1	Infiltration	(Van Deemen & Rusinowska, 2010)
2	More time-consuming	(Karami, 2017)
3	Only one or more actors have the power of final decision-making	(Zellner et al., 2014)
4	The administration and mechanical presence of members	(Bui, 1987)
Row	Advantage	Reference
1	Collective Alliance	(McHugh et al., 2016), (Siegener, Panwar, Kozak, & Searcy, 2025)
2	Increase comprehensive information	(Mann, 2018), (Carbone & Giannoccaro, 2015), (Rossi, 2014)
3	Increase awareness and knowledge	(Mann, 2018), (Carbone & Giannoccaro, 2015), (McHugh et al., 2016), (Carbone & Giannoccaro, 2015)
4	Increase motivation	(McHugh et al., 2016) (J. Liu, Shui, Jin, Shao, & Zhu, 2025)
5	Increase collective wisdom	(Zafeiris et al., 2017)
6	Increase employee participation	(Prigozhin, 1991), (Dionne, Sayama, & Yammarino, 2019), (McHugh et al., 2016)
7	Increase employee commitment	(Khaluf, Simoens, & Hamann, 2019)
8	Increase the quality of the decision	(McHugh et al., 2016), (Mann, 2018)
9	Increase the accuracy of the decision	(Bosel et al., 2017), (Khaluf et al., 2019)
10	Increase the level of determination and effort	(McHugh et al., 2016)
11	Increase justice	(Myerson, 2013)
12	Increase the independence of individuals	(McHugh et al., 2016)
13	Increase collective intelligence	(McHugh et al., 2016)
14	Reduce decision execution time	(Karami, 2017)
15	Reduce mistakes	(McHugh et al., 2016) (Qudrat-Ullah, 2025)
16	Avoid instability and intractability	(Fu, Sui, Luo, & Han, 2020)
17	Reaching consensus	(Wu et al., 2017)
18	Achieve the optimal decision	(Prigozhin, 1991), (Bosel et al., 2017), (Carbone & Giannoccaro, 2015)

fluencing decision-making for members (Van Deemen & Rusinowska, 2010). The expenses associated with collective decision-making rise in proportion to both team size and the number of hierarchical groups involved. These costs encompass various elements, such as administrative expenses for meeting coordination and the time required for discussions, including the articulation of individual positions and ideas (Berg & Paroush, 1998). A summary of the key influences on collective decision-making is presented in Table 2.

Collective decision-making methods

This section explores several prominent practical models utilized in collective decision-making. The most prevalent approach is the interactive group method, characterized by face-to-face interactions and unrestricted communication among group members. The final decision is determined through an unstructured group discussion to generate and integrate ideas, followed by a majority vote (Qudrat-Ullah, 2025). Another method is the nominal group technique, a structured meeting where participants work

Table 2: Factors influencing collective decision-making

Row	Indicator	Reference
1	Perception	(Bui, 1987)
2	Attitude	(Bui, 1987)
3	Motivation	(Bui, 1987), (McHugh <i>et al.</i> , 2016)
4	Belief	(Marks, Gerrits, & Marx, 2019), (Zellner <i>et al.</i> , 2014), (Bosse <i>et al.</i> , 2013)
5	position	(Zellner <i>et al.</i> , 2014)
6	Target	(Zellner <i>et al.</i> , 2014)
7	Preferences	(Zellner <i>et al.</i> , 2014)
8	Interaction (communication)	(Khaluf <i>et al.</i> , 2019), (Sueur <i>et al.</i> , 2011), (Dionne <i>et al.</i> , 2019)
9	Cohesion	(Khaluf <i>et al.</i> , 2019)
10	obligation	(Khaluf <i>et al.</i> , 2019)
11	Information Sharing	(Khaluf <i>et al.</i> , 2019), (Sueur <i>et al.</i> , 2011), (Wu <i>et al.</i> , 2017)
12	infiltrate	(Van Deemen & Rusinowska, 2010)
13	Hypocrisy	(Rossi, 2014)
14	Technology	(Slevin, Boone, Russo, & Allen, 1998)
15	emotion	(Bosse <i>et al.</i> , 2013)
16	intention	(Bosse <i>et al.</i> , 2013)
17	Quality of argument	(Cho & Chan, 2019)
18	Coordination	(Sueur <i>et al.</i> , 2011)
19	bias	(Dionne <i>et al.</i> , 2019)
20	Experience	(Dionne <i>et al.</i> , 2019)
21	Specialty	(Dionne <i>et al.</i> , 2019)
22	Group diversity	(Dionne <i>et al.</i> , 2019)
23	Culture	(Dionne <i>et al.</i> , 2019)
24	Group size	(Dionne <i>et al.</i> , 2019)
25	Knowledge	(Carbone & Giannoccaro, 2015), (McHugh <i>et al.</i> , 2016)
26	Intelligence	(Carbone & Giannoccaro, 2015), (McHugh <i>et al.</i> , 2016)
27	Social or organizational structure	(Dionne <i>et al.</i> , 2019), (McHugh <i>et al.</i> , 2016)
28	Honesty	(Xu, 2019)
29	Cost	(Berg & Paroush, 1998), (Van Deemen & Rusinowska, 2010)
30	Type of leadership (from authoritarian to participatory)	(McHugh <i>et al.</i> , 2016)
31	Characteristics (complexity) of the work	(McHugh <i>et al.</i> , 2016)
32	Dependence and independence	(McHugh <i>et al.</i> , 2016)
33	Collaboration method (virtual or face-to-face)	(McHugh <i>et al.</i> , 2016)
34	Collection	(Wu <i>et al.</i> , 2017)

independently, recording their ideas without verbal interaction for a specified period. Subsequently, ideas are presented in a round-robin format, discussed, and then voted upon (Bui, 1987). Counseling, providing a supportive environment for personal, family, and social decisions, is also considered a valuable approach (Karami, 2017). Consultation is integral to collective decision-making, enabling information sharing and improved decisions (Iaryczower, Shi, & Shum, 2018). The Delphi method, a consensus-building tool, facilitates stakeholder participation through a series of questionnaires, with participants remaining physically separated (Wu et al., 2017). Simulation methods, particularly agent-based modeling, are employed to address the challenges of studying large and complex systems in traditional settings. Agent-based modeling allows for the simulation of autonomous agents interacting within a system, applicable to diverse fields (McHugh et al., 2016). Biologists also use analytical and computational models, such as multi-agent simulations, to understand collective behaviors by identifying individual rules. These models allow for systematic changes in individual behavior to analyze model parameters. The dynamics of collective behavior are influenced by information acquisition, processing, and transmission, and mathematical models can incorporate relevant components and hypotheses (Bo-

sel et al., 2017). Voting rules serve as a mechanism for collective decision-making, with the rational voting model being widely used (Cina & Endriss, 2016) (Xu, 2019). Voting in various settings often involves communication among members, ranging from optional to structured (Iaryczower et al., 2018). Similar mechanisms are used in multi-agent systems for coordination, conflict resolution, and information categorization (Cina & Endriss, 2016). Table 3 summarizes the methods and tools of collective decision-making.

Collective decision-making and bias mitigation

Theoretical and empirical research suggests that collective decision-making—through processes of deliberation, dissent, and accountability—can attenuate individual cognitive distortions (Dionne et al., 2019). Exposure to multiple perspectives increases the likelihood that faulty assumptions will be challenged, thereby enhancing judgment accuracy (Kerr & Tindale, 2004; Bonaccio & Dalal, 2006). For example, group discussion has been shown to reduce overconfidence by encouraging individuals to reconsider the strength of their evidence (Snizek & Henry, 1989). Similarly, optimism bias may be tempered when group members highlight potential risks overlooked by individuals (Lovallo & Kahneman, 2003). Anchoring effects, while resistant to correction, can

Table 3: Methods and tools of collective decision-making

Row	Methods / Tools	Reference
1	Interactive method (face-to-face)	(Bui, 1987), (Iaryczower et al., 2018), (Karami, 2017)
2	Nominal group method	(Bui, 1987)
3	Delphi method	(Wu et al., 2017), (Bui, 1987)
4	Consult	(Iaryczower et al., 2018), (Karami, 2017)
5	Social and Internet networks	(Sueur, Deneubourg, & Petit, 2012), (Slevin et al., 1998), (Dionne et al., 2019), (Wu et al., 2017), (Planas-Sitja, Deneubourg, Gibon, & Sempo, 2015)
6	agent-based modeling (simulation)	(McHugh et al., 2016), (Bosel et al., 2017)
7	voting	(Cina & Endriss, 2016), (Wu et al., 2017), (Xu, 2019), (Iaryczower et al., 2018), (McHugh et al., 2016)
8	questionnaire	(Wu et al., 2017)
9	Negotiation	(Wu et al., 2017), (McHugh et al., 2016)
10	mathematical modeling	(Bosel et al., 2017)
11	Collective decision website	(Dionne et al., 2019)
12	Forming a common knowledge base	(Dionne et al., 2019)
13	Auction	(Wu et al., 2017)

also be moderated when alternative reference points are introduced during group deliberation (Epley & Gilovich, 2006). Nonetheless, the relationship between collective decision-making and bias is not unequivocally positive. Research on groupthink and conformity demonstrates that group processes can amplify existing biases rather than mitigate them (Janis, 1982; Esser, 1998). Anchoring effects, for instance, may persist or even strengthen when groups converge prematurely on salient but flawed reference points (Furnham & Boo, 2011). Similarly, groups sometimes exhibit overconfidence at the collective level, especially when social pressures discourage dissenting opinions (Sniezek, 1992). Therefore, the theoretical foundation of this study rests on a critical tension: while collective decision-making has the potential to reduce bias by leveraging diversity of thought, it may also introduce new dynamics that perpetuate cognitive distortions. Exploring this dual potential is crucial for advancing both theory and practice in organizational decision-making. According to the explanations provided, the research hypotheses can be defined as follows:

1. *Collective decision-making reduces overconfidence bias.*
2. *Collective decision-making reduces optimism bias.*
3. *Collective decision-making reduces the bias of the anchoring effect.*

MATERIALS AND METHODS

To get a comprehensive view of the subject and get familiar with the basic concepts and principles, various references are collected and studied in a library style. To achieve the goal of the research, a questionnaire was designed regarding the research hypothesis. The questionnaire consisted of two sections with a total of 24 items.

Section A: Demographic information (e.g., age, gender, managerial level, and years of experience).

Section B: Measurement of three cognitive biases—overconfidence (8 items), optimism (8 items), and anchoring effect (8 items). The questionnaire employed a Likert scale, where respondents indicated their agreement level on a scale from “strongly disagree” to “strongly agree,” corresponding to scores from 1 to 5. Specifically, “strongly disagree” was assigned a score of 1, and “strongly agree” a score of 5 (Chen et al., 2022). Example items include:

Overconfidence: “I am usually certain about the ac-

curacy of my judgments, even when information is limited.”

Optimism bias: “I generally expect organizational decisions to result in outcomes better than average.”

Anchoring bias: “My initial impression strongly influences my final judgment, even when new information becomes available.”

To assess the questionnaire’s accuracy, content validity was employed, while Cronbach’s alpha was utilized to determine its reliability. Validity ensures that the measurement tool accurately captures the intended traits, and reliability indicates the consistency of the tool’s results under similar conditions. Cronbach’s alpha is a statistical measure of internal consistency among questionnaire items. A Cronbach’s alpha value of 0.70 or higher is considered acceptable, with values below this threshold indicating poor internal consistency and a lack of model fit reliability (Tobias-Webb, Limbrick-Oldfield, Vearncombe, Duka, & Clark, 2020)

Target Population and Sample Size

Purposive sampling was selected due to the specific focus of the study. The questionnaire is distributed among managers of Iranian state-run organizations (at different management levels) who are aware of collective decision-making or have experience using it. Cochran’s formula was used to determine the necessary sample size (Damghanian & Ghanbari Ghaleroudkhani, 2022; Song & Wassell, 2003)

$$n = \frac{z^2 \cdot p \cdot (1 - p)}{e^2}$$

$z = 1.96$ for a 95% confidence level, $p = 0.5$ (assumed population proportion), and $e = 0.05$ (margin of error). Based on these parameters, the recommended minimum sample size was 169. The study’s statistical population was estimated to be 300 individuals. Utilizing Morgan’s table (Krejcie & Morgan, 1970). A sample of 170 academic and organizational experts was selected for questionnaire distribution. After reviewing the returned questionnaires, 152 were found to be complete and appropriate for analysis. Data were entered into SPSS software for statistical analysis. Descriptive statistics were used to summarize sample characteristics, while inferential analyses—including one-sample mean comparisons and significance testing—were employed to test the hypotheses.

Table 4: Descriptive statistics of the sample

		Frequency	Percent	Valid Percent
Gender	Male	114	75.0	75.0
	Female	38	25.0	25.0
Education	Bachelor	7	4.6	4.6
	Master	98	64.5	64.5
	Ph.D.	47	30.9	30.9
Age	<40	24	15.8	15.8
	40-49	62	40.8	40.8
	50-60	50	32.9	32.9
	≥60	16	10.5	10.5
	Total	152	100.0	100.0

Demographic variables

Demographic variables, including gender, education level, and age, are considered to be control variables in this research. The demographic information of the statistical sample is shown in Table 4. The results showed that above 90% of the respondents have master's and doctorate degrees, and this issue increased the credibility of the research.

Validity and reliability of the questionnaire

To establish the questionnaire's validity, expert opinions were sought. Before distribution, feedback was collected from 20 university professors and specialists in collective decision-making, and subsequent revisions were made to the questionnaire. The questionnaire's reliability was then assessed using Cronbach's alpha (α).

The results of this study (Table 5) show that Cronbach's alpha values for the 3 variables are 0.857, which is higher than 0.7 and is within the acceptable range.

$$\alpha = \left(\frac{n}{n-1} \right) \left(\frac{s_t^2 - \sum_{i=1}^n s_i^2}{s_t^2} \right)$$

Table 5: Reliability statistics

Cronbach's Alpha	N of Items
0.857	3

Hypothesis test about the community's average

The hypothesis test about the community average checked whether the average opinions or points

of the respondents were higher than the average scores. In this research, because a 5-point Likert scale is used, the number 3 will be the middle or neutral number. The closer the obtained number is to 5 or 0, the greater the agreement or disagreement with that hypothesis. Therefore, the statistical hypotheses are defined as follows:

$$\begin{cases} H_0: \mu \leq x & H_0: \text{The average points obtained are lower than the average of the test.} \\ H_0: \mu \leq x & H_1: \text{The average points obtained are higher than the average of the test.} \end{cases}$$

Table 6 provides the descriptive statistics of the data, including the mean and standard deviation, which indicate the data's dispersion from the average.

The One-Sample Test results, as detailed in Table 4, allow for the following conclusions to be made.

1- Regarding overconfidence bias, a significant value of 0.000 is obtained, which is smaller than 0.05. The t-test statistic for this bias is 128.627, and it is above the critical value of $t_{0.05}$, i.e., 1.96. Because the mean of responses is 4.76, H_0 is rejected. Also, the upper and lower limits of the confidence interval are greater than zero (positive), and H_1 is confirmed (Kaurav, Gursay, & Chowdhary, 2021). Therefore, with 95% confidence, it can be said that collective decision-making reduces overconfidence bias.

2- Regarding optimism bias, a significant value of 0.000 is obtained, which is smaller than 0.05. The t-test statistic for this bias is 118.607, and it is above the critical value of $t_{0.05}$, i.e., 1.96. Because the mean of responses is 4.64, H_0 is rejected. Also, the upper and lower limits

Table 6: Results of descriptive statistics of the data

	N	Mean	Std. Deviation	Std. Error Mean
Overconfidence	152	4.76	0.457	0.037
Optimism	152	4.64	0.482	0.039
Anchoring	152	4.67	0.485	0.039

of the confidence interval are greater than zero (positive), and H_1 is confirmed (Loffing, 2022). Therefore, with 95% confidence, it can be said that collective decision-making reduces optimism bias.

3- Regarding the anchoring effect, a significant value of 0.000 is obtained, which is smaller than 0.05. The t-test statistic for this bias is 118.683, and it is above the critical value of $t_{0.05}$, i.e., 1.96. Because the mean of responses is 4.67, H_0 is rejected. Also, the upper and lower limits of the confidence interval are greater than zero (positive), and H_1 is confirmed (Shaikh, Malik, Talpur, & Abro, 2021). Therefore, with 95% confidence, it can be said that collective decision-making reduces the anchoring effect.

RESULTS AND DISCUSSION

Cognitive science researchers state that psychological emotions affect a person's decisions, and sometimes decisions become irrational under the influence of cognitive bias (Chen et al., 2022). Ordinary

people do not have any information about the factors that influence irrational decisions and need to be informed so that they can make the best decisions. It is proposed that the influence of certain cognitive biases on judgment errors can be lessened when counselors within collective decision-making environments identify and alert colleagues to potentially biased decisions (McShane et al., 2013). This study investigated the effect of collective decision-making on reducing the three biases of overconfidence, optimism, and the anchoring effect. Previous studies also showed that these three biases have a great impact on reducing the quality of managers' decisions (Jordão et al., 2020). The analysis in this study proved that the collective decision-making method can have a significant effect in reducing these biases in managers' decisions. Evidence of the help that collective decision-making provides to reduce bias is shown in Table 7.

Despite the prevalence of individual-level biases, the study's findings indicate that collective decision-making

Table 7: Collective decision-making aids in reducing bias

Row	Type of bias	Cause of bias	Collective decision-making aid
1	Overconfidence	Overestimating your abilities and creativity	Collective knowledge surpasses individual knowledge, leading to improved decision quality and validity in intricate tasks (Dionne et al., 2019); (Khaluf et al., 2019); (McHugh et al., 2016); (Mann, 2018).
2	Optimism	Overestimation of the probability of the desired outcome	A diverse range of knowledge and experience among individuals fosters collective learning, resulting in a richer and more profound comprehension of environmental circumstances (McHugh et al., 2016), (Bouwman, Runhaar, Wesselink, & Mulder, 2017), (Carbone & Giannoccaro, 2015), (Irving & Williams, 1999), (Lauring, Guttormsen, & McNulty, 2019). Comparably, collective opinions and consultations shape decision-makers' selections by broadening their horizons and facilitating the evaluation of all viable alternatives (Bui, 1987); (Mann, 2018); (Iaryczow et al., 2018)
3	Anchoring	Relying on the first information received	Collective decision-making necessitates the consideration of all group members' perspectives (Wu et al., 2017). A holistic approach, encompassing all facets of a decision and evaluating its systemic impacts, is crucial for effective decision-making (Iaryczow et al., 2018); (Khaluf, Ferrante, Simoens, & Huepe, 2017); (Sueur et al., 2011); (Wu et al., 2017); (Dionne et al., 2019).

ing provides mechanisms that can mitigate their effects. Specifically, when managers engage in group deliberation, the diversity of perspectives encourages participants to confront differing viewpoints, thereby reducing reliance on overconfident or overly optimistic judgments. Additionally, critical evaluation and peer scrutiny inherent in collective processes compel decision-makers to justify their assumptions, which lessens the anchoring effect by introducing multiple reference points. These mechanisms are consistent with the theoretical premise that collective rationality emerges from distributed cognition and the aggregation of perspectives.

Explaining the high mean values

The analysis revealed consistently high mean values for the three investigated cognitive biases—overconfidence ($M = 4.76$), optimism ($M = 4.64$), and anchoring effect ($M = 4.67$)—with limited variation across respondents. At first glance, these elevated mean scores suggest that cognitive biases are highly prevalent among managers in Iranian state-run organizations. However, closer interpretation highlights several underlying dynamics. The anomalously high mean values (ranging between 4.64 and 4.76 on a 5-point Likert scale) require careful interpretation. One explanation may be social desirability bias, as respondents, particularly managers in hierarchical organizational structures, may feel compelled to present themselves as more rational or aligned with collective norms. Furthermore, cultural factors rooted in collectivist tendencies and hierarchical respect for authority in Iranian organizations may have contributed to inflated self-assessments of decision-making behaviors. While these factors do not invalidate the findings, they suggest caution in generalizing the magnitude of the results beyond this context.

Comparative analysis with previous studies

Our findings align with Jordão et al. (2020), who observed that collective settings can reduce the influence of overconfidence and optimism by fostering shared accountability and cross-checking of assumptions. However, a divergence was observed regarding the anchoring effect: whereas Jordão et al. (2020) reported significant attenuation of anchoring in group contexts, our findings suggest a more moderate reduction. This discrepancy may reflect contextual differences, particularly the organizational culture and

decision-making structures in Iranian state-run organizations, where authority figures can still anchor group judgments despite collaborative processes. Overall, the study suggests that while collective decision-making does not eliminate cognitive biases, it provides mechanisms—such as diversity of perspectives and critical evaluation—that meaningfully mitigate their impact. However, the influence of social desirability bias and cultural context underscores the importance of interpreting these findings with caution and conducting further cross-cultural comparative studies.

Limitations

Several limitations should be acknowledged. First, the study's focus on Iranian state-run organizations limits the generalizability of findings to other cultural and organizational contexts. The high mean values observed may also be influenced by survey-related biases, particularly social desirability and the hierarchical nature of Iranian workplaces, which may have encouraged favorable self-reporting. Furthermore, reliance on a cross-sectional survey design constrains the ability to establish causal inferences.

Directions for Future Research

Future research should extend this analysis across diverse cultural and institutional contexts to assess the universality of the observed mechanisms. Experimental and longitudinal designs would be particularly valuable in clarifying causal pathways and the durability of bias mitigation over time. Moreover, subsequent studies could examine additional biases—such as confirmation bias, escalation of commitment, or availability heuristic—to provide a more comprehensive understanding of how collective decision-making interacts with cognitive limitations in organizational contexts.

In conclusion, this research highlights both the promise and the boundaries of collective decision-making as a corrective to cognitive biases, offering actionable insights for managers while setting a clear agenda for scholarly inquiry.

CONCLUSION

Managers have to make a variety of decisions in their lives at individual, organizational, and social levels. Due to the complexity of the environment, the influence of multiple factors, and dependence on simple heuristics and common arguments, managers' decisions are susceptible to cognitive bias, and

therefore, they may commit numerous errors. For example, they may be overconfident in their knowledge and skills, significantly optimistic about their future, or rely on anchors in their judgments. In this regard, the three biases of overconfidence, optimism, and the anchoring effect have a great impact on managers' judgments. This study examined the relationship between collective decision-making and the mitigation of cognitive biases—overconfidence, optimism, and the anchoring effect—among managers in Iranian state-run organizations. To check the effectiveness of this method, 152 managers of Iranian state-run organizations (at different management levels) are surveyed using a Likert scale questionnaire. SPSS software analysis showed that the questionnaire enjoys good validity and reliability. The findings also showed a significant value of 0.000 for these three biases, which is smaller than 0.05; the t-test statistic for these biases is also higher than the critical value of $t_{0.05}$, which is 1.96. Since the average of the answers on the Likert scale is above 3, hypothesis H_0 regarding these three biases is rejected. The upper and lower limits of the confidence interval are greater than zero, and H_1 is confirmed. Therefore, it can with 95% confidence be concluded that collective decision-making reduces the bias of overconfidence, optimism, and anchoring effect. The findings demonstrate that while these biases are highly prevalent at the individual level, collective processes can play an important role in moderating their influence through mechanisms such as diversity of perspectives, critical evaluation, and peer scrutiny. The findings of this study can motivate managers to use the collective decision-making method to reduce bias and reach an optimal decision.

Practical Recommendations

For practitioners, several guidelines emerge. Managers can strengthen group decision-making by:

1. Encouraging diversity of perspectives through cross-functional teams that reduce reliance on a single dominant viewpoint.
2. Implementing structured deliberation techniques such as Nominal group method or the Delphi method, which encourage critical evaluation of assumptions and reduce overconfidence.
3. Establishing clear decision protocols that minimize anchoring effects by requiring consideration of multiple alternatives before finalizing choices.

4. Providing bias-awareness training to sensitize managers to the subtle ways in which overconfidence, optimism, and anchoring may shape their judgments.

AUTHOR CONTRIBUTIONS

S.M. Mirbagheri conducted the literature review and methodology, compiled the data, drafted the manuscript, and contributed to the results and discussion sections. A. Rafiei Atani was responsible for performing the literature review and analyzing the data.

ACKNOWLEDGEMENT

The authors extend their sincere gratitude to all participants for their generous contribution of time and insightful perspectives, which were instrumental to the completion of this study. It is important to disclose that this research was conducted without any external funding support.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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PUBLISHER NOTE

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ABBREVIATION

n	sample size
e	margin of error or desired precision
p	percentage of the population demonstrating the attribute
z	z-value derived from a standard z-table
H	Hypothesis
S_t	standard deviation of the entire questionnaire
S_i	standard deviation of the i th question

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HOW TO CITE THIS ARTICLE

Mirbagheri, S.M.; Rafiei Atani, A.O.; Parsanejad, M.R., (2025). Rationalizing managerial judgment: The effectiveness of collective decision-making in bias reduction. *Int. J. Hum. Capital Urban Manage.*, 11(3): 467–482.

DOI: 10.22034/IJHCUM.2026.03.03

URL: https://www.ijhcum.net/article_732266.html



ORIGINAL RESEARCH PAPER

Does dynamic capability influence organizational sustainability? Understanding the mediating role of business model innovation

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ARTICLE INFO

Article History:

Received 08 August 2025

Revised 25 November 2025

Accepted 28 May 2026

Keywords:

Dynamic capability; Business model innovation; Triple bottom line; Natural resource-based view; Organizational sustainability.

ABSTRACT

BACKGROUND AND OBJECTIVES: Organizational sustainability has become a focal point for businesses worldwide, with growing interest in how dynamic capabilities contribute to sustainability from environmental, social, and economic perspectives. This study aimed to investigate the effects of dynamic capability on sustainability within small and medium-sized enterprises using the Triple Bottom Line and Natural Resource-Based View frameworks. Specifically, it explored how dynamic capabilities influence the adoption and implementation of sustainable business practices in Small and Medium Enterprises.

METHODS: Structural equation modeling based on partial least squares was employed to analyze the data using data from a survey of 448 Small and Medium Enterprise owners and managers in Bangladesh. This study used PLS-SEM with SmartPLS (version 3.2.9) and IBM SPSS Statistics (ver. 26). This methodology helped examine the relationships between dynamic capability, business model innovation, and organizational sustainability across the three TBL dimensions.

FINDINGS: The results showed that dynamic capability had a significant direct impact on organizational sustainability, with adaptability, innovation, and resource reconfiguration being key drivers. While business model innovation positively contributed to sustainability, its mediating effect in the relationship between dynamic capability and sustainability was found to be modest. This study also found that dynamic capability, which negatively affects business model innovation uptake, accounted for 13.3 % of the influence on organizational sustainability.

CONCLUSION: These findings provided policy-makers with crucial information for better e-waste management policy development, addressing the conflict between development and conservation. These insights may be applicable in Bangladesh and other countries as well.

DOI: [10.22034/IJHCUM.2026.03.04](https://doi.org/10.22034/IJHCUM.2026.03.04)



NUMBER OF REFERENCES

63



NUMBER OF FIGURES

2



NUMBER OF TABLES

13

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the "Show Article."

INTRODUCTION

Organizational sustainability (OS) has emerged as a central imperative for firms navigating today's fast-paced and dynamic global market. This necessity is anchored in the Triple Bottom Line (TBL) approach, which demands simultaneous attention to environmental, economic, and social performance (Tseng et al., 2013). To achieve this long-term viability, firms must possess both the internal adaptive capacity (Dynamic Capability, DC) and the external transformative vision (Business Model Innovation, BMI) (Kare and Soriano, 2021; Wilson & Daniel, 2007). From an environmental standpoint, organizations must establish procedures and methods that limit their carbon footprint, waste production, and other harmful environmental consequences. According to Atkisson (2021), organizations prioritizing sustainability via dynamic capabilities and business model innovation have a fifty percent greater probability of decreasing their environmental impact. Dynamic capability and business model innovation may help firms generate new income streams and cut expenses from an economic standpoint. Paiola et al., (2022) demonstrate that organizations that invest in innovation and dynamic capabilities are 35% more likely to achieve sustainable revenue growth. Likewise, Kumar et al. (2019) emphasize business model innovation in decreasing costs and enhancing profitability. However, from a social standpoint, dynamic capacity and business model innovation may assist organizations in generating social value and enhancing stakeholder involvement. According to Marques & Simon (2020), organizations prioritizing sustainability via dynamic capacity and business model innovation have a 40% greater likelihood of accomplishing social objectives such as enhancing employee happiness, community participation, and social impact. The environment in which a firm operates is dynamic and ever-changing, and it presents a variety of difficulties for them, such as rising competition, shifting consumer preferences, and environmental concerns (Schulze & Brusoni, 2022). To achieve sustainable success over the long term, businesses increasingly need to concentrate on dynamic capabilities and business model innovation. However, the previous research does not provide a thorough knowledge of how dynamic capacity and innovative business models affect organizational sustainability from the viewpoints of

the environment, the economy, and society. Thus, the principal objective of this research is to examine how dynamic capabilities and business model innovation affect an organization's capacity for sustaining itself in terms of the environment, economy, and society. The study explicitly intends to analyze the impact of dynamic capabilities and innovative business models on organizational sustainability in the environmental, economic, and social dimensions. This study performs a thorough literature review and applies a quantitative research technique, which includes surveys and statistical analysis, to address these research objectives. The findings of this study can assist organizations in developing more sustainable business practices and strategies by helping them better understand the effects of dynamic capability and business model innovation on organizational sustainability across the environmental, economic, and social dimensions.

- *How does dynamic capability affect the organization's sustainability?*
- *How do dynamic capability and business model innovation affect organizational sustainability? And*
- *To what extent does business model innovation mediate the relationship between dynamic capability and organizational sustainability?*

The first and second research questions aim to explore and understand the relationship between dynamic capability, business model innovation, and organizational sustainability. This question examines how dynamic capability affects an organization's sustainability and ability to take advantage of opportunities. Furthermore, the third research question examines the potential mediating role of business model innovation in the relationship between dynamic capability and organizational sustainability, determining whether business model innovation plays a role and, if so, how it influences this contract. However, the overall objective is to better understand the mechanisms by which organizations can enhance their dynamic capability and improve their level of organizational sustainability through business model innovation. The study might add to the theoretical framework of dynamic capability, Triple Bottom Line (TBL), and the Resource-Based View (RBV) by investigating the function of business model innovation as a mediator between dynamic capability and organizational sustainability from

environmental, social, and economic dimensions. This may provide a more nuanced picture of the function of dynamic capacity in organizations and enhance our knowledge of how business model innovation affects organizational sustainability. The theoretical contribution to this work has three aspects. Firstly, the study will enrich the existing literature on dynamic capability, TBL, and the RBV by examining the relationship between dynamic capability and organizational sustainability and the possible mediating effect of business model innovation. Secondly, this study will offer a more subtle understanding of the concept of dynamic capability, moving beyond its conventional focus on the capacity to respond to changes in the external environment. This is accomplished by examining the relationship between dynamic capability and organizational sustainability. Lastly, the study will provide empirical data to support the field's current hypotheses using rigorous research techniques to evaluate the relationship among organizational sustainability, business model innovation, and dynamic capacity. However, the managerial contribution of this study can be as follows: First, the study can offer firms trying to increase their degree of organizational sustainability and dynamic capability valuable insights and suggestions. The study may guide organizational decision-making and assist companies in better understanding how to develop and carry out strategies that increase their dynamic capacity and ability to adjust to internal and external changes. Second, business model innovation mediates the link between dynamic capacity and organizational agility, which may guide organizational strategy. Third, by improving organizational competitiveness, the study provides insights into the link between dynamic capability, business model innovation, and organizational agility to adapt to changes in their internal and external environments and seize opportunities. The relationship between DC, BMI, and OS is particularly salient in emerging economies, where small and medium-sized enterprises (SMEs) face immense institutional pressures and resource constraints. This study focuses on Bangladesh, a rapidly developing economy whose SMEs form the backbone of its industrialization and growth (apparel, manufacturing, real estate). However, these firms frequently struggle with resource scarcity and regulatory gaps, making

their adoption of TBL-based sustainability practices highly challenging yet critical (Gallagher & Mahoney, 2021). Therefore, understanding how dynamic capabilities and business model innovation foster organizational sustainability within the unique, high-volatility environment of Bangladeshi SMEs is crucial for policy-makers and managers alike. Finally, by increasing organizational performance and revealing the link between dynamic capability, business model innovation, and organizational sustainability, the study may help companies improve their capacity to adapt to changes in the internal and external environment.

Background and objectives

The literature review on "Dynamic Capabilities (DC)" has concentrated on many facets of the idea, such as its definition, antecedents, outcomes, and empirical evidence. The concept of DC—which is the capacity of an organization to adapt and improve its capabilities in response to changes in the internal and external environment—is one of the critical insights of the prior literature overview on DC (Gupta *et al.*, 2020). The literature has found various antecedents of DC, including organizational culture, structure, resources, and leadership. Organizations with high levels of DC are better equipped to adjust to environmental changes and exploit new possibilities, making it a significant component in organizational success and competitiveness (Hughes *et al.*, 2019). These factors are crucial in determining an organization's capacity to create and deploy new capabilities in response to environmental changes; repercussions, where the literature has studied the implications of DC, including increased organizational performance, competitiveness, and environmental reaction (Hunt and Madhavaram, 2020). DC is a fundamental driver of organizational performance in an ever-changing corporate environment. However, DC positively influences organizational performance, competitiveness, and the capacity to adapt to environmental changes (Schulze and Brusoni, 2022). Case studies, survey research, and empirical studies on DC and outcomes have provided this evidence. Nonetheless, the initial DC literature review employed different and evolving techniques. Quantitative approaches are among the frequently utilized methodologies. Several quantitative studies have examined the influence of DC on organizational success (Gupta *et al.*, 2020; Hughes *et*

al., 2019). Regression analysis, structural equation modeling, and multivariate analysis have been utilized in this research to examine the link between DC and performance outcomes. Furthermore, in the literature on DC, qualitative methodologies have also been employed often, especially when examining the causes and effects of DC (Dwivedi *et al.*, 2023). These studies used case study research, content analysis, and interviews to examine DC development and implementation in businesses. Several mixed methods research have examined how DC affects organizational effectiveness (Reyes-Santiago *et al.*, 2019). This research employed quantitative and qualitative methodologies to further understand the concept and its effects on organizational performance. Several longitudinal studies have examined the growth of dynamic capabilities and their effects on organizational performance (Yang and Yee, 2022). These studies collected data over time using questionnaires, interviews, and case studies. Many comparative studies have examined dynamic capability's effects in various organizational settings, sectors, and nations (Khurana *et al.*, 2022). Cross-sectional surveys and case studies have been utilized to compare DC's effects in different organizational environments. The DC literature research gave a complete grasp of the concept and its influence on organizational performance and competitiveness. The literature has identified DC's main antecedents and implications and given empirical data on its effects, laying the groundwork for future study. The previous literature evaluation on DC employed varied and evolving techniques. A more thorough knowledge of the construction and its effect on organizational performance has been made possible by using several methods. In the previous literature review on Business Model Innovation (BMI), different areas of the concept were looked at, such as its definition, its causes, its effects, and the role it plays in the performance of an organization. Many of the major revelations from the literature study include the Definition: BMI is the process of developing and executing new business models that provide customers with value and bring in money for the company, according to the literature (Evers *et al.*, 2023). BMI's antecedents include environmental volatility, market pressure, technical development, and resource availability (Paiola *et al.*, 2022). BMI has been shown to boost organizational performance, customer happiness, and competitiveness (Jia *et al.*, 2023). Organiza-

tional performance: BMI has been proven to improve organizational performance, including profitability, market share, and customer loyalty (Malik *et al.*, 2022). Role in organizational agility: BMI has been shown to assist firms in adapting to changing market circumstances and consumer requirements (Guo *et al.*, 2022). Challenges: The research has also highlighted various obstacles connected with BMI, including reluctance to change, lack of organizational competency, and difficulty adopting new business models (Haftor & Climent Costa, 2023). Yet, the prior literature analysis on BMI included a variety of techniques, reflecting the field's dynamic character. Quantitative approaches, for example, are some of the often-employed methodologies. Many quantitative studies have examined how BMI affects organizational success (Paiola *et al.*, 2022). This research examined the link between BMI and performance results using regression, structural equation modeling, and multivariate analysis. Qualitative approaches: In the literature on BMI, qualitative methods have also been frequently employed, especially when examining the causes and effects of the concept (Björkdahl *et al.*, 2022). These studies investigated BMI in firms using qualitative methods, including case study research, content analysis, and interviews. Mixed techniques: The effect of BMI on organizational performance has also been explored in considerable research using mixed methods (Schlüter *et al.*, 2023). This research employed quantitative and qualitative methodologies to better understand the concept and its effects on organizational performance. Longitudinal research: Several studies have examined BMI's progression and its effects on organizational performance (Schlüter *et al.*, 2023). Surveys, interviews, and case studies have been utilized to gather data several times in these investigations. Comparison research: Several studies have examined the effects of BMI in various organizational settings, industries, and countries using comparative methodologies (Björkdahl *et al.*, 2022). Cross-sectional surveys and case studies have been used to compare BMI's effects in different organizational environments. The preliminary analysis of the BMI literature examined the central tenets of the concept and its effects on organizational performance. BMI has been found to improve organizational sustainability and performance. Also, the approaches used in the earlier literature analysis on BMI varied and changed over time. Several tech-

niques have made it possible to grasp better the concept and how it affects organizational sustainability. Organizational sustainability (OS) incorporates environmental, social, and economic elements to guarantee sustainable operations and activities and contribute to long-term success (Hale, 2021). Recent years have seen a rise in the importance of studies on organizational sustainability as organizations attempt to cut down on carbon emissions and promote sustainable growth. These works demonstrate the relevance of organizational sustainability and its effects on many performance facets via literature reviews, empirical investigations, and research approaches (Hermundsdottir & Aspelund, 2021). Organizational sustainability has been compared to other characteristics, including business performance, risk management, and organizational learning, using quantitative research methods like surveys and econometric analysis (Chang & Chen, 2021; Du & Zhu, 2021). Nonetheless, qualitative research methods have been utilized to study organizational resilience, including case studies, interviews, and ethnographic observation (Chang & Chen, 2021). Many studies have also used quantitative and qualitative methods to examine organizational sustainability and other factors (Chen et al., 2021). Longitudinal studies have examined organizational sustainability (Maletić et al., 2018). Experimental and simulation studies have been employed to study the effects of different treatments and factors on organizational resilience (Pfeffer, 2017). The grounded theory research technique has been utilized to study organizational performance development in sustainability (Qu & Liu, 2022), while content analysis has been used to study organizational resilience and its environmental impact (Braun et al., 2022). However, the research topic, the setting of the study, and the researcher's resources all play a role in the choice of research method. OS is crucial, and these studies provide insightful information on how businesses may improve their sustainability and support sustainable growth. Companies must actively consider sustainability and include it in their decision-making procedures to achieve long-term development and success. To gain a deeper understanding of these dynamics, structural equation modeling based on partial least squares (PLS-SEM) was employed to analyze data collected from a survey of 448 SME owners and managers in residential areas of Dhaka, Bangladesh, between January 2024 and February 2025.

Theoretical background and hypothesis development

In the previous literature study regarding the topic of DC, this phenomenon became recognized and clarified using a variety of academic theories and definitions. The firm's RBV is among the most often employed ideas and concepts. According to this view, a firm's talents and resources give it a competitive edge (Chaudhuri et al., 2022). DC is a firm's ability to adjust its resources and capabilities to suit market needs. Strategic Renewal: This idea defines DC as an organization's ability to renew and adapt its strategy to changing market circumstances (Wilson and Daniel, 2007). Ambidexterity: This concept states that firms must balance exploration and exploitation to succeed in the short-term and long-term (Hughes et al., 2019). An organization's capacity to balance these operations and react to changing situations is called DC. Dynamic Capabilities Framework (DCF) posits that a firm's adaptive capacity relies on three distinct yet interconnected micro-foundations: Sensing (identifying and assessing opportunities and threats), Seizing (mobilizing resources to address opportunities and threats) and Transforming (continuous renewal of resources and structures to maintain competitiveness) (Tran et al., 2019). Our study's six indicators for DC, adapted from Kump et al. (2019), successfully capture these three dimensions (Sensing: dc1-dc3; Seizing: dc4; Reconfiguring: dc5-dc6), establishing strong theoretical alignment with the DCF (Tran et al., 2019). DC as a Process: This view sees DC as a continual process of learning, adaptation, and change that is essential to organizational success (Hunt and Madhavaram, 2020). Studies indicate that DC can lead to increased profitability through new products or services (Foss & Saebi, 2016), improved resource efficiency (Liao et al., 2018), better market positioning (Kumar et al., 2019), enhanced customer satisfaction (Chang et al., 2020), and decreased environmental impact (Müller & Kolk, 2017). In addition, dynamic capacity may positively contribute to social goals, such as increased staff engagement (Kang et al., 2018) and consumer loyalty (Chowdhury & Haggerty 2015). Evidence shows that DC favors organizational sustainability's economic, environmental, and social components. According to Marques and Simon (2020), "DC allows businesses to produce sustained economic value by discovering new growth possibilities, generating new goods and services, and improving their processes to cut costs."

In addition, DC enables businesses to lessen their environmental impact by adopting sustainable practices and minimizing waste. Lastly, DC allows businesses to produce social value by creating new goods and services that satisfy societal requirements and contribute to social causes. These theoretical ideas and concepts provide the groundwork for understanding DC and its usefulness for organizational agility and competitiveness. In this study, DC is the firm's ability to dynamically build, integrate, and reconfigure its internal and external competencies to respond to changing market and environmental situations. It encompasses skills, procedures, and practices that help companies grow and change. DC helps firms stay competitive and succeed. They help firms to build and exploit new resources, talents, and capacities to generate new value and adapt to market and environmental changes. DC includes the capacity to innovate, establish new business models, deploy new technology, and build and sustain connections with stakeholders. Organizational sustainability (OS) is a set of ideas and theories that help a firm stay in business and do well even when it faces challenges. One crucial element of organizational sustainability is environmental sustainability, which means a company can reduce its environmental impact and use resources responsibly (Hermundsdottir & Aspelund, 2021). Another essential component of OS is social sustainability, which focuses on a company's interactions with its stakeholders, including its workers, clients, and local communities (Schlüter et al., 2023). Lastly, economic sustainability defines a company's capacity to profit while producing long-term value for its stakeholders (Tseng et al., 2013). Firms must participate in various initiatives that foster adaptation and resilience to achieve OS. The adaptive cycle is crucial because organizations create, conserve, release, and reorganize in response to disturbances (Qu & Liu, 2022). Complexity theory recognizes that organizations are complex systems with many interwoven aspects that are hard to anticipate or manage, which is why it is linked to OS (Song & Yu, 2018). OS is also affected by numerous distinct ideas. The resource-based approach stresses that firms have the resources, competencies, and capacities to react and recover from shocks (Aboelmaged & Hashem, 2019). The social capital theory emphasizes how social networks and connections help firms adapt and recover from

shocks (Lian et al., 2022). Risk management theory highlights identifying, analyzing, and reacting to hazards, whereas business continuity management emphasizes having the resources and competence to respond to and recover from disruptions (Maletič et al., 2018). Eventually, crisis management and resilience engineering value firms' ability to react to and recover from disasters (Hermundsdottir & Aspelund, 2021). In the current study shown in (Fig. 1), this study has framed the term OS as the ability of an organization to quickly and efficiently respond to changes in the internal and external environment, including market demands, technology advancements, and competition. It involves recognizing and capitalizing on opportunities, adapting processes and strategies, and maintaining resilience amid uncertainty and disruption. OS is essential in achieving and maintaining competitiveness and success in today's rapidly changing business environment. It involves a combination of processes, systems, and structures that allow an organization to be flexible, responsive, and adaptive to changing conditions. However, understanding the OS from a TBL approach, which acknowledges that firms must balance economic, environmental, and social factors, is crucial (Tseng et al., 2013). Organizations may strive toward long-term prosperity while fostering a more sustainable future for everybody by considering sustainability from all three angles. Organizational Environmental Sustainability (OES) is its capability to continue operations while preserving the natural environment for future generations (Bansal and Roth, 2000). It means putting sustainable principles into how an organization works and makes decisions. Bansal and Roth (2000) examined the relationship between environmental activities and financial performance at 49 prominent U.S. firms. The authors found that companies with proactive environmental programs did better financially than those with reactive or no plans. This suggests that integrating OES into a company's strategy may result in positive financial outcomes. Chen et al. (2021) examined the association between environmental management strategies and supply chain management and found that supply chains using environmental management concepts performed better. This shows the importance of OES across the supply chain, from raw materials to final items. Müller & Kolk (2017) explored food supply chain sustainability issues and stated that the food

supply chain's complexity and stakeholder participation hinder sustainable methods. However, sustainable supply chain management improved environmental, social, and financial performance. OES in companies involves integrating sustainable practices into strategy and decision-making. According to the study, integrating environmental sustainability into the supply chain may boost efficiency (Gallagher & Mahoney, 2021). Sustainable supply chain management may have significant organizational and environmental benefits despite inherent obstacles. Organizational social sustainability (OSS) is an organization's capacity to maintain excellent and equitable connections with its internal and external stakeholders throughout time (Chen *et al.*, 2021). A socially sustainable business fosters solid social relationships with its employees, customers, suppliers, and community. Chen and colleagues' 2021 research suggests that leaders prioritizing social responsibility and morality may develop a social sustainability culture. A socially sustainable organization prioritizes social justice, employee welfare, and environmental sustainability. According to Song *et al.* (2021), socially sustainable companies are more likely to develop financially. To make an organization socially sustainable, managers must put strategies that prioritize employee well-being and community involvement. Social sustainability is intimately associated with social responsibility and ethical conduct. OES refers to a company's capacity to maintain financial stability and development while limiting negative environmental and societal consequences. Achieving OES necessitates striking a balance between profitability, social responsibility, and environmental preservation. Several studies have examined how organizational variables affect economic sustainability. Du and Zhu (2021) discovered that absorptive capacity might improve OES by encouraging green innovation. Sharma and Vredenburg (2019) also stressed the need for green innovation and corporate social responsibility for long-term economic health. Corporate culture and leadership are also influential OES factors. (Aboelmaged & Hashem, 2019) showed that leadership commitment and a supportive culture are necessary for sustainable economic practices. Taken together, these studies show that for organizations to be economically sustainable, they need to take a holistic approach that looks at both financial success

and social and environmental responsibility. However, the ability to adapt quickly to changing external situations is essential for the sustainability of organizations, both from environmental and social perspectives, as well as economic ones. DC allows organizations to anticipate, analyze and promptly respond to changes, thus enabling them to maintain competitiveness while reducing their environmental impact. Additionally, these capabilities facilitate the identification and adoption of sustainable practices and help companies adjust to new regulations and market demands for sustainability. To remain viable in a rapidly changing market, firms require DC that can uncover new growth opportunities and adapt quickly to unforeseen challenges such as increased competition or changes in consumer demand. Organizations can manage risk more effectively and maintain profitability by staying ahead of the curve. Finally, from a social standpoint, DC enables organizations to consider stakeholders such as workers and consumers when making strategic and operational decisions, allowing them to meet societal expectations on issues like diversity, inclusion, and workplace safety while also ensuring that their operations are ethical and competitive over the long term. Thus, we propose the following hypothesis.

H1: *Dynamic capability positively affects organizational sustainability.*

BMI is developing and implementing a new way to run a business that is good for both the organization and its clients (Osiyevskyy & Dewald, 2020). It is essential to the success of any firm because it allows it to remain ahead of rivals and react to market changes. Chen *et al.*, (2020) describe BMI as "the introduction of a novel method of structuring a firm's resources and capabilities to produce value for stakeholders." Furthermore, BMI creates development potential and reduces environmental impact, which improves organizational sustainability. According to Osiyevskyy & Dewald (2020), "BMI may lead to the establishment of sustainable company models that are more robust and adaptive to market fluctuations." The company's power to adapt to market changes mediates the impact of dynamic capability on organizational sustainability (Liao S-C *et al.*, 2018). However, BMI has a favorable effect on the sustainability of an organization that can reinvent its business models and cultivate dynamic capacities. It is more likely to generate long-term economic, environmental,

and social value and achieve long-term success. In the current study, this study has framed the term BMI is framed as creating and implementing new or significantly improved ways of conducting business to better meet the needs of customers, stakeholders, and the organization. It involves rethinking and transforming the core elements of a business, such as the value proposition, revenue streams, and customer segments, to create new sources of value. BMI can result in improved performance, increased competitiveness, and tremendous organizational success. It can involve changes to how goods or services are delivered, the distribution channels used, the customer experience, or how the organization generates revenue. BMI is an essential component of organizational agility, as it allows organizations to respond to changes in the market and adapt to new opportunities. However, BMI creates innovative, sustainable company models. This comprises finding new value sources, enhancing operational efficiency, using technology for competitive advantage, and mediating dynamic capacities' environmental, social, and economic sustainability (Osiyevskyy & Dewald, 2020). Dynamic capabilities are an organization's capacity to build new competencies to adapt to environmental changes continually. Organizations may boost performance and reduce environmental impact by adapting their business strategies to these developments. BMI helps organizations achieve sustainability by optimizing operations for financial and social/environmental goals. Innovative business strategies that include all three dimensions—environmental, social, and economic—can lower expenses while still achieving value-added benefits. In an increasingly complex environment, doing so will retain their competitive edge. Thus, the study posits the following hypothesis:

H2: *The presence of dynamic capability is positively associated with the level of business model innovation.*

H3: *Business model innovation is positively associated with the degree of organizational sustainability across environmental, economic, and social dimensions.*

H4: *Business model innovation plays a significant mediating role in the relationship between dynamic capability and organizational sustainability, specifically in terms of environmental, economic, and social dimensions.*

MATERIALS AND METHODS

This study used well-known and empirically validated measures from prior research. This methodology yields more trustworthy and accurate findings. The study tested DC with six items from Kump et al., (2019). These indicators reflect the firm's ability to notice, digest, and utilize new information, adapt to change, and create new ideas. The study measured the BMI with three sub-constructs: a) Value Creation (VC), b) Value Proposition (VP), and c) Value Capture (Vcap); each of them has been measured with three items adapted from Spieth & Schneider (2016) to assess creating value for customers, differentiating from competitors, and maximizing profits. This study also included four items from Hadi & Baskaran (2021) to assess an organization's Sustainable Economic Performance (SEP), emphasizing local economies and distinctive assets to overcome economic challenges and create long-term financial stability. SEP is measured using four items adapted from Hadi & Baskaran (2021) that quantify environmental performance for countries, environmental sustainability, and future generations' health and well-being. Lastly, four items (adapted from Hadi & Baskaran, 2021) evaluate how



Fig. 1: The role of DC and business model innovation on organizational sustainability.

an organization operates and engages in activities that help its personnel, clients, suppliers, neighbors, and society (see Table 1). Following the hierarchical component modeling approach for complex constructs (Hair *et al.*, 2017), the study operationalized BMI and OrgSus as second-order formative constructs. BMI was quantified by aggregating the dimensions of VC, Value Proposition VP, and Vcap. OrgSus was quantified by aggregating the dimensions of SEP, SSP, and ENP. This approach ensures that the overall theoretical constructs are accurately represented by their constitutive sub-dimensions. This study examined all the components using a Likert scale ranging from 1 to 7, where 1 indicates “strongly disagree,” and 7 indicates “strongly agree.” A 7-point Likert scale was specifically chosen over a 5-point scale to maximize the variance captured in the respondents’ attitudes and reduce the potential for central tendency bias, thereby improving the sensitivity and academic accuracy of the psychometric measurements (Richter *et al.*, 2015). This study also verified the structure and usefulness of the constructs using a pilot panel of 6 management professors, 12 SME managers, and 35 postgraduate students. The pilot panel proposed removing a few components and making minor changes to ensure that the constructs are well-structured, appropriately capture significant aspects, and are articulated and translated. The respondents’ demographic information is supplied in the second part of the questionnaire.

Data collection

This study was conducted between January 2024 and February 2025 with several small and medium-sized (SME) companies starting up in Bangladesh. This study used a questionnaire to get quantitative data. SMEs from Bangladesh are chosen based on several different reasons. Bangladesh is a perfect choice to examine how small firms work in an emerging economy since it has many relatives in its population. Scholars and local stakeholders may also engage since many Bangladeshi SMEs depend on international organizations and donor governments for financing. Nonetheless, the surveys were distributed online through Google Docs, emails, Facebook, and WhatsApp, and offline via human visits with a cover letter describing the study’s objective and protecting respondents’ data confidentiality. This study contacted upper, medium, and entry-level staff mem-

bers from agro and agro-processing, manufacturing, wholesale and retail, services, computer hardware and software, construction and real estate, packaging and paper, power and energy, oil and gas, health care, utilities, apparel, pharmaceuticals, banks, broadcasting and entertainment, insurance, furnishings, food and beverage, logistics, printing, and publishing firms to get the responses. To boost response rates, respondents received reminders and follow-up inquiries. The study received 448 functional responses from 990 questionnaires issued to 399 industrial sites in Bangladesh.

This results in a response rate of 45.25%. These responses reflect the organization. Academics typically have low survey response rates due to respondents’ lack of internet access and busy schedules (Hair *et al.*, 2017). This study’s response rate was above average. Nonetheless, all these enterprises were listed in the “Dhaka Stock Exchange (DSE),” the country’s largest stock market, and registered with the “Securities and Exchange Commission of Bangladesh (BSEC). 33% of respondents were supervisors, 40% were responsible for executing organizational plans, and 26% for implementing policies. 69% of respondents were male (see Table 2). However, Hair *et al.*, (2017) used the 10x rule (10 times the most significant number of structural pathways oriented towards a specific latent component in a structural model) to calculate the study’s sample size. To ensure the sample’s compatibility in this study, this study used the G*Power software to calculate the sample size (Hair *et al.*, 2017). Several power analyses showed that this study’s sample is suitable for further analysis.

Common method bias

Podsakoff *et al.* (2003) define “Common Method Bias” (CMB) as “variance attributable to the measuring procedure rather than the constructs that the measures represent.” Employing several respondents effectively decreases common method bias in research since it provides more data to make conclusions, and a bigger sample size helps offset biases in one respondent’s replies (Harman, 1976). Also, having multiple raters or coders look over the collected data and evaluate it can help find and fix any sources of bias by ensuring that all responses are coded correctly and consistently (Podsakoff *et al.*, 2003). This study gathered data from top, mid, and bottom-level executives from 19 industries at various time frames.

Table 1: Measurement of constructs and items

Constructs	Items	Reference
Dynamic capability (Dcap)		
	• dc1: As a company, we know how to access new information. • dc2: Our company always has an eye on our competitors' activities. • dc3: Our company can quickly relate to new knowledge from the outside. • dc4: Our company is capable of turning new technological knowledge into process and product innovation. • dc5: In our company, change projects can be put into practice alongside the daily business. • dc6: In our company, plans for change can be flexibly adapted to the current situation. ^d	Kump et al. (2019)
Business model innovation (BMI)		
<i>Value creation (VC)</i>	• vc1: Value offering: Target customers: Target customers have changed. • vc2: Value offering: Product and service offering: The product and service offering has changed. • vc3: Value offering: Firm's competitive positioning: The firm's positioning in the market has changed.	Spieth & Schneider, (2016)
<i>Value capture (Vcap)</i>	• vcap1: Value architecture: Core competencies and resources: The firm's core competencies and resources have changed. • vcap2: Value architecture: Internal value creation: Internal value creation activities have changed. • vcap3: Partners in value creation: Role and involvement of partners in the value creation process have changed.	Spieth & Schneider, (2015)
<i>Value proposition (VP)</i>	• vp1: Distribution: Distribution has changed. • vp2: Revenue mechanisms: Revenue mechanisms have changed. • vp3: Revenue model: Cost mechanisms: Cost mechanisms have changed.	Spieth & Schneider, (2016)
Organizational sustainability (OrgSus)		
<i>Sustainable economic performance (SEP)</i>	• EP1: My company's profit increases every year. • EP2: My company's return on investment (ROI) is improving every year. ^d • EP3: My company's sales volume increases every year. • EP4: My company increases shareholder value. • EP5: My company increases productivity.	Hadi & Baskaran, (2021)
<i>Sustainable social performance (SSP)</i>	• SP1: Stakeholders are satisfied with my company's sustainable business practices. • SP2: My company reduces social and reputation risks to the general public. • SP3: My company improves employee health and safety. • SP4: My company is aware of the community's needs and rights. • SP5: My company always tries to comply with any legal requirement. ^d	Hadi & Baskaran, (2021)
<i>Sustainable environmental performance (ENP)</i>	• ENP1. My company reduces the emission of greenhouse gases. • ENP2. My company reduces waste generation. ^d • ENP3. My company decreases environmental incidents. Examples: oil spill, release of gas, loss of primary containment. • ENP4. My company reduces the consumption of hazardous materials. • ENP5. My company makes more careful and efficient use of natural resources, e.g., water.	Hadi & Baskaran, (2021)

Note: ^d indicates deleted items with a consultation with the academic experts and the corporate executives.

Table 2: Demographic details

Particulars (<i>N</i> =448)		Frequency	Percent
Gender	Male	304	67.9
	Female	144	32.1
Industry	Agro and agro-processing	6	1.3
	Manufacturing	7	1.6
	Wholesale & retail	32	7.1
	Services	7	1.6
	Computer Hardware & Software	10	2.2
	Construction & Real Estate	54	12.1
	Packaging & Paper	17	3.8
	Power & Energy	6	1.3
	Oil & gas	32	7.1
	Health care	25	5.6
	Utilities	38	8.5
	Apparel	29	6.5
	Pharmaceuticals	40	8.9
	Banks	25	5.6
	Broadcasting & Entertainment	8	1.8
	Insurance	25	5.6
	Furnishings	22	4.9
	Food and Beverage	31	6.9
	Logistics, Printing & Publishing	34	7.6
Firm size	Less than 10 employees	53	11.8
	11-50 employees	84	18.8
	51–100 employees	217	48.4
	101–150 employees	92	20.5
	150+ employees	2	0.4
Position	Head	146	32.6
	Manager	178	39.7
	Executive	124	27.7
Firm age	1–2 years	98	21.9
	3–4 years	155	34.6
	5–6 years	139	31
	More than 6 years	56	12.5

Also, this study calculated the CMB using Harman's single factor, in which the first factor had a cut-off value of less than 50% (Harman, 1976). In this study, that value was 35.03%. Considering these results, CMB is not likely to give this study any significant reasons to worry.

RESULTS AND DISCUSSION

This study uses PLS-SEM with SmartPLS (version 3.2.9) and IBM SPSS Statistics (ver. 26). PLS-SEM is recommended for exploratory and predictive studies and may work with a small sample size and does not need a normal distribution (Hair et al., 2017). This study utilized the one-sample Kolmogorov-Smirnov test to determine whether the distribution was normal. All p-values are less than 0.05, indicating that the data is not normally distributed. Since the distribution was abnormal, this study utilized variance-based Structural Equation Modeling (SEM) using partial least squares (PLS) instead of covariance-based SEM. Because variance-based SEM resists non-normal distribution better (Richter et al., 2015), the PLS-SEM may test a sophisticated model without deleting model variables and analyze all causal linkages. PLS-SEM works well under all these conditions (Hair et al., 2017). Hence, this study tested hypotheses and evaluated variables using PLS-SEM. Hair et al. (2017) stated that a model is evaluated in two steps: (External) measurement and (Internal) structural model.

Analysis of the measurement model

The measurement model's validity and reliability were assessed by examining Composite Reliability (CR), Average Variance Extracted (AVE) for convergent validity, and the Fornell-Larcker criterion and Heterotrait-Monotrait Ratio (HTMT) for discriminant validity, adhering to recommended statistical procedures (Fornell & Larcker, 1981; Henseler et al., 2015). To estimate the measurement model, this study used the construct reliability method (also known as Cronbach's Alpha (CA), rho_A, and composite reliability (CR)) and validity (also known as discriminant and convergent validity) following the work of Hair et al., (2017). Table 3 shows that the CA score varies from 0.817 to 0.996, rho_A ranges from 0.819 to 0.966, and CR ranges from 0.885 to 0.975. As every statistic is more than 0.70, this study may infer that the construct is reliable (Cohen, 1988; Hair et al., 2017). To determine Convergent Validity (CV), this study exam-

ined item loading and "Average Variance Extracted" (AVE). These data exceeded the 0.50 criterion of Hair et al.'s (2017). The Discriminant Validity (DV) is also confirmed using a time-tested and widely used method, Fornell-Larcker criteria, cross-loading, and a cutting-edge method, HTMT ratio (Henseler et al., 2015; Fornell and Larcker, 1981). In the first technique, the square root of the AVE must exceed the correlation among the targeted components. The second HTMT cycle asserts 0.85 as the cut-off number (Hair et al., 2017). Tables 4, 5, and 6 confirm both DV criteria except ENP, VC, and VP in the HTMT, which is not considered an issue in this study. The asterisks (*) in the discriminant validity tables (Tables 4, 5, and 6) indicate that the corresponding correlations or cross-loadings involve the second-order formative constructs (BMI and OrgSus), where the measurement approach differs from first-order constructs. These are presented differently in the Fornell-Larcker and HTMT displays of SmartPLS, and this structural approach is consistent with the rigorous two-stage modeling technique applied in this study (Hair et al., 2017).

Analysis of the structural model

After evaluating the outer model, this study examined the structural model to verify the hypotheses, shown in Fig. 2. Bootstrapping was used to test the hypotheses (5000 resamples). The model's results showed that Dcap>OrgSus (H1: β value=0.423; $p<0.000$), Dcap >BMI (H2: β value=-0.133; $p<0.001$), BMI>OrgSus (H3: β value=0.385; $p<0.000$). Based on the results of the control variables, this study found that none significantly affected the OrgSus. Table 7 lists the results of the hypotheses.

The mediation analysis

Using a bootstrapping two-step approach, this study examined the BMI's mediating effect in a series of steps in the PLS-SEM technique (Preacher and Hayes, 2008). First, this study examined how DC indirectly affected OrgSus via BMI. this study found a minimal but significant mediation impact, with β values of -0.051. This study also assessed the direct impact of DC in the next step without removing the mediator (BMI). It had substantial positive results, with β values of 0.423. As a result of this study's observation of indirect and direct effects (see Table 7), the signs are in the inverse direction. This study

Table 3: Reliability and validity

Constructs	Mean	SD	Kurtosis	Skewness	Factor loadings	CA	rho_A	CR	AVE
Dynamic Capacity (Dcap)						0.927	0.937	0.944	0.772
dc1	5.56	1.53	0.72	-1.17	0.86				
dc2	5.77	1.54	0.80	-1.32	0.88				
dc3	5.68	1.53	0.74	-1.24	0.89				
dc4	5.73	1.55	1.37	-1.41	0.88				
dc5	5.93	1.63	1.76	-1.65	0.88				
Value Proposition (VP)						0.902	0.902	0.938	0.835
vp1	5.824	1.341	0.453	-1.053	0.911				
vp2	5.788	1.380	0.485	-1.104	0.923				
vp3	5.757	1.286	0.315	-0.955	0.908				
Value Creation (VC)						0.819	0.819	0.892	0.734
vc1	5.612	1.355	0.522	-0.977	0.869				
vc2	5.712	1.361	0.944	-1.142	0.841				
vc3	5.654	1.375	1.095	-1.137	0.860				
Value Capturing (Vcap)						0.844	0.845	0.906	0.762
vcap1	5.824	1.349	0.842	-1.171	0.871				
vcap2	5.790	1.325	0.455	-1.055	0.857				
vcap3	6.018	1.346	1.042	-1.377	0.891				
Sustainable Environmental Performance (ENP)						0.966	0.966	0.975	0.908
ENP1	4.924	1.862	-0.957	-0.597	0.947				
ENP2	4.933	1.968	-1.035	-0.583	0.959				
ENP3	4.998	1.988	-0.978	-0.626	0.954				
ENP4	4.962	1.941	-0.945	-0.615	0.951				
Sustainable Social Performance (SSP)						0.962	0.962	0.972	0.898
SP1	5.279	1.931	-0.681	-0.855	0.952				
SP2	5.257	1.955	-0.727	-0.824	0.951				
SP3	5.116	1.885	-0.695	-0.758	0.939				
SP4	5.272	1.900	-0.705	-0.824	0.948				
Sustainable Economic Performance (SEP)						0.966	0.966	0.975	0.907
EP1	4.786	1.966	-1.334	-0.332	0.957				
EP2	4.868	2.072	-1.313	-0.423	0.957				
EP3	4.768	2.038	-1.218	-0.417	0.947				
EP4	4.643	2.008	-1.272	-0.331	0.948				
Business Model Innovation (BMI)*						0.913	0.917	0.945	0.852
VP*	0.000	1.000	1.235	-1.318	0.908				
VC*	0.000	1.000	1.976	-1.614	0.926				
Vcap*	0.000	1.000	2.075	-1.683	0.935				
Organizational Sustainability (OrgSus)*						0.817	0.960	0.885	0.726
SENP*	0.000	1.000	-1.044	-0.706	0.940				
SEP*	0.000	1.000	-1.434	-0.461	0.618				
SSP*	0.000	1.000	-0.766	-0.909	0.955				

Note: * indicates constructs/items extracted from the two-stage approach.

Table 4: Discriminant validity (Fornell-Lacker Criteria)

	BMI	Dcap	ENP	EP	Firm age	Firm size	Industry	OrgSus	Position	SP	VC	VP	Vcap
BMI	0.923												
Dcap	-0.130	0.879											
ENP	0.455	0.302	0.953										
EP	0.023	0.212	0.400	0.952									
Firm age	-0.080	0.113	0.058	0.098	1.000								
Firm size	-0.226	-0.244	-0.125	-0.182	0.028	1.000							
Industry	-0.001	0.052	0.017	-0.015	0.045	-0.001	1.000						
OrgSus	0.275	0.374	*	*	0.101	-0.180	0.005	0.852					
Position	-0.013	0.027	0.054	0.032	0.146	-0.062	0.000	0.063	1.000				
SP	0.186	0.427	0.833	0.560	0.109	-0.167	0.007	*	0.073	0.948			
VC	*	-0.182	0.404	-0.005	-0.087	-0.133	0.014	0.225	-0.020	0.138	0.857		
VP	*	-0.065	0.416	0.014	-0.038	-0.266	0.001	0.258	-0.011	0.191	0.758	0.914	
Vcap	*	-0.118	0.440	0.054	-0.101	-0.220	-0.017	0.278	-0.006	0.184	0.807	0.771	0.873

Note: * indicates constructs/items extracted from the two-stage approach.

Table 5: Discriminant validity HTMT

	BMI	Dcap	ENP	EP	Firm age	Firm size	Industry	OrgSus	Position	SP	VC	VP	Vcap
BMI													
Dcap	0.142												
ENP	0.479	0.313											
EP	0.042	0.217	0.414										
Firm age	0.085	0.119	0.059	0.100									
Firm size	0.234	0.256	0.127	0.185	0.028								
Industry	0.012	0.052	0.017	0.015	0.045	0.001							
OrgSus	0.301	0.412	*	*	0.114	0.204	0.017						
Position	0.014	0.027	0.055	0.032	0.146	0.062	0.000	0.063					
SP	0.196	0.444	0.864	0.580	0.111	0.170	0.013	*	0.074				
VC	*	0.208	0.455	0.027	0.096	0.147	0.036	0.250	0.038	0.156			
VP	*	0.074	0.446	0.032	0.040	0.280	0.018	0.268	0.012	0.205	0.881		
Vcap	*	0.147	0.488	0.063	0.109	0.238	0.019	0.296	0.028	0.204	0.971	0.883	

Note: * indicates constructs/items extracted from the two-stage approach.

Table 6: Cross-loading

	BMI	Dcap	ENP	EP	Firm age	Firm size	Industry	OrgSus	Position	SP	VC	VP	Vcap
ENP1	0.408	0.283	0.947	0.370	0.062	-0.042	0.015	0.848	0.056	0.796	0.373	0.353	0.405
ENP2	0.450	0.285	0.959	0.370	0.043	-0.143	0.004	0.850	0.046	0.789	0.403	0.411	0.431
ENP3	0.446	0.288	0.954	0.374	0.064	-0.146	0.013	0.848	0.043	0.788	0.389	0.423	0.421
ENP4	0.432	0.296	0.951	0.409	0.052	-0.144	0.031	0.865	0.061	0.803	0.375	0.399	0.422
EP1	-0.001	0.198	0.398	0.957	0.092	-0.110	-0.012	0.701	0.044	0.553	-0.015	-0.022	0.034
EP2	0.040	0.216	0.384	0.957	0.092	-0.219	-0.024	0.693	0.022	0.548	0.005	0.034	0.070
EP3	0.034	0.210	0.359	0.947	0.087	-0.230	-0.001	0.668	0.020	0.519	-0.005	0.036	0.062
EP4	0.014	0.181	0.381	0.948	0.102	-0.134	-0.020	0.672	0.033	0.509	-0.004	0.005	0.038
Firm age	-0.083	0.113	0.058	0.098	1.000	0.028	0.045	0.094	0.146	0.109	-0.087	-0.038	-0.101
Firm size	-0.223	-0.244	-0.125	-0.182	0.028	1.000	-0.001	-0.167	-0.062	-0.167	-0.133	-0.266	-0.220
Industry	-0.001	0.052	0.017	-0.015	0.045	-0.001	1.000	0.009	0.000	0.007	0.014	0.001	-0.017
Position	-0.013	0.027	0.054	0.032	0.146	-0.062	0.000	0.065	1.000	0.073	-0.020	-0.011	-0.006
SP1	0.184	0.409	0.790	0.547	0.108	-0.179	-0.010	0.905	0.087	0.952	0.135	0.183	0.188
SP2	0.181	0.423	0.781	0.555	0.098	-0.199	0.000	0.903	0.067	0.951	0.133	0.188	0.178
SP3	0.155	0.398	0.783	0.504	0.096	-0.110	0.034	0.883	0.054	0.939	0.118	0.163	0.146
SP4	0.186	0.388	0.805	0.516	0.112	-0.144	0.003	0.899	0.067	0.948	0.138	0.189	0.185
dc1	-0.125	0.863	0.179	0.098	0.115	-0.222	0.034	0.227	0.001	0.286	-0.178	-0.041	-0.134
dc2	-0.107	0.878	0.262	0.169	0.128	-0.200	0.045	0.315	0.052	0.361	-0.171	-0.028	-0.105
dc3	-0.149	0.894	0.286	0.209	0.088	-0.177	0.053	0.362	0.034	0.417	-0.170	-0.097	-0.148
dc4	-0.143	0.883	0.288	0.218	0.107	-0.186	0.063	0.361	0.028	0.407	-0.190	-0.092	-0.119
dc5	-0.040	0.876	0.287	0.208	0.065	-0.299	0.027	0.344	0.001	0.374	-0.089	-0.014	-0.011
vc1	0.810	-0.172	0.332	-0.014	-0.094	-0.100	0.027	0.176	-0.037	0.099	0.869	0.704	0.678
vc2	0.773	-0.150	0.361	0.024	-0.087	-0.084	-0.024	0.215	-0.032	0.135	0.841	0.611	0.700
vc3	0.785	-0.145	0.347	-0.023	-0.041	-0.157	0.032	0.188	0.020	0.121	0.860	0.630	0.697
vcap1	0.807	-0.134	0.383	0.000	-0.073	-0.100	-0.039	0.226	0.024	0.158	0.722	0.647	0.871
vcap2	0.786	-0.137	0.390	0.065	-0.069	-0.193	0.001	0.253	-0.043	0.168	0.673	0.650	0.857
vcap3	0.840	-0.041	0.381	0.074	-0.121	-0.279	-0.005	0.248	0.001	0.157	0.718	0.720	0.891
vp1	0.828	-0.046	0.355	-0.006	-0.026	-0.268	-0.001	0.211	0.000	0.153	0.677	0.911	0.693
vp2	0.863	-0.027	0.384	0.043	-0.053	-0.261	0.023	0.250	-0.012	0.181	0.716	0.923	0.738
vp3	0.826	-0.107	0.401	0.000	-0.023	-0.201	-0.021	0.247	-0.019	0.189	0.684	0.908	0.681
ENP	0.455	0.302	*	*	0.058	-0.125	0.017	0.940	0.054	*	*	*	*
EP	0.023	0.211	*	*	0.098	-0.182	-0.015	0.618	0.032	*	*	*	*
SP	0.185	0.426	*	*	0.109	-0.167	0.007	0.955	0.073	*	*	*	*
VC	0.926	-0.182	*	*	-0.087	-0.133	0.014	0.266	-0.020	*	*	*	*
VP	0.908	-0.065	*	*	-0.038	-0.266	0.001	0.298	-0.011	*	*	*	*
Vcap	0.935	-0.118	*	*	-0.101	-0.220	-0.017	0.314	-0.006	*	*	*	*

Note: * indicates constructs/items extracted from the two-stage approach.

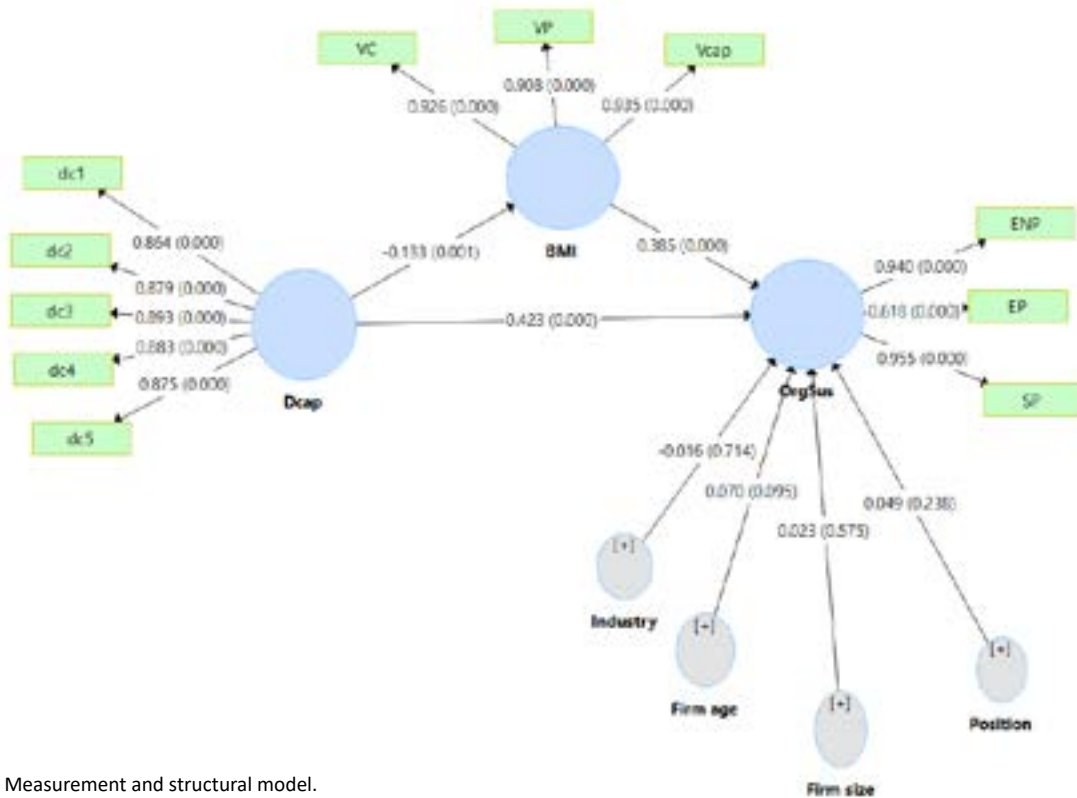


Fig. 2: Measurement and structural model.

Table 7: Hypothesis testing

Key	Relationship Paths	β -values	T-values	p-values	Decision
H1	Dcap -> OrgSus	0.423	8.018	0.000	Supported
H2	Dcap -> BMI	-0.133	3.426	0.001	Supported
H3	BMI -> OrgSus	0.385	6.618	0.000	Supported
Mediation analysis (Indirect effects)					
H4	Dcap -> BMI -> OrgSus	-0.051	2.550	0.011	Supported (Inconsistent partial mediation)
Control Variables					
	Firm size -> OrgSus	0.023	0.540	0.590	
	Firm age -> OrgSus	0.070	1.760	0.079	
	Industry -> OrgSus	-0.016	0.366	0.715	
	Position -> OrgSus	0.049	1.269	0.205	

concluded that the BMI possesses inconsistent partial mediation (Hair *et al.*, 2017). Based on the result, we concluded that there is an inconsistent partial mediation because the direct effect of Dcap on OrgSus (beta = 0.423, $p < 0.001$) remains significant even after controlling for the mediating variable BMI (beta = -0.051, $p = 0.011$). However, it is essential to note that inconsistent partial mediation does not necessarily mean that the mediating variable is unimportant or does not affect the relationship between the independent and dependent variables. It simply means that the mediating variable does not fully explain the relationship between the independent and dependent variables (Hair *et al.*, 2017). In this case, BMI may still partially mediate, but other factors may also influence the relationship between Dcap and OrgSus. Hence, H4 is supported.

The goodness of fit (GOF) Indexes

Hair *et al.* (2017) used the “standardized root mean square residual” (SRMR) to establish the model’s fit, and they specified that its value should be less than 0.08. This study showed that the SRMR value

was 0.059 (Table 9), indicating that this study model performed well. Besides, this study also examined the F2 (effect size), Q2 (predictive relevance), and R2 (coefficient of determination) in Table 8, which were within a reasonable range (Hair *et al.*, 2017).

Robustness check

Assessment of nonlinear effects

Following Sarstedt *et al.*, (2020), this study ran two tests to identify possible nonlinearities in the structural model’s interactions. This study initially used Ramsey’s RESET on the latent variable scores retrieved after the convergence of the PLS-SEM method of the original model. We find that the partial regression of BMI on Dcap ($F=6.4049$, $p=0.002$) and the partial regression of OrgSus on Dcap and BMI ($F=32.082$, $p=0.000$) is nonlinear. Next, interaction variables were inserted to indicate the quadratic impacts of (1) Dcap on BMI and (2) Dcap and BMI on OrgSus. The findings of bootstrapping with 5000 samples and the changes show that all the nonlinear effects are statistically significant (Table 10). This study concludes that this study’s model lacks linear effects and is hence

Table 8: R2, Q2, and Effect size

Endogenous variables	R2	Q2	Exogenous variables	F2
BMI	0.018	0.014	Dcap>BMI	0.018
OrgSus	0.286	0.126	Dcap>OrgSus	0.223
			BMI>OrgSus	0.189
			Firm Size>OrgSus	0.001
			Firm age>OrgSus	0.007
			Industry>OrgSus	0.000
			Position>OrgSus	0.003

Table 9: Goodness of fit index.

	Saturated model	Estimated model
SRMR	0.059	0.072
d_ ULS	0.413	0.626
d_ G	0.205	0.229
Chi-Square	556.286	614.382
NFI	0.855	0.84

Table 10: Assessment of nonlinear effects.

Nonlinear relationship	Coefficient	P-value	Ramsey's RESET		
Dcap*Dcap>BMI	0.115	0.003	F= 6.4049	p=	0.002
DCap*DCap>OrgSus	-0.283	0.000	F=32.082	p=	0.000
BMI*BMI>OrgSus	-0.175	0.000			

Table 11: Assessment of endogeneity test using the Gaussian Copula approach.

Test	Constructs	Coefficient	p-value
Gaussian copula of model 1 (endogenous variables; Dcap)	Dcap	0.79316	0.000
	BMI	0.37838	0.000
	^c Dcap	-0.46025	0.000
Gaussian copula of model 2 (endogenous variables: BMI)	Dcap	0.41111	0.000
	BMI	0.84224	0.000
	^c BMI	-0.56724	0.000
Gaussian copula of model 3 (endogenous variables: Dcap, BMI)	Dcap	0.64549	0.000
	BMI	0.74369	0.000
	^c BMI	-0.44421	0.000
	^c Dcap	-0.28903	0.000

Note: ^c indicates the Gaussian Copula.

weak in robustness.

Assessment of endogeneity

The research evaluation of possible endogeneity follows the method laid out by [Sarstedt et al. \(2020\)](#). This study started by using [Park and Gupta's \(2012\)](#) Gaussian copula approach with the scores of the latent variables from the original model estimation. This study first checks to see if the variables, which could be endogenous, are not distributed normally. This study did this by running the Kolmogorov–Smirnov test with Lilliefors correction ([Sarstedt et al., 2020](#)) on the latent variable scores of Dcap and BMI, which serve as independent variables in the PLS path model's partial regressions. The results show that none of the constructs usually have distributed scores, so this study can use the Gaussian copula method from [Park and Gupta \(2012\)](#). Table 11 shows that the Gaussian copula for Dcap is significant (p-value < 0.05) in model 1. On the other hand, in model 2, the Gaussian copula for BMI is significant (p-value < 0.05). However, in model 3, the Gaussian copula for BMI is also significant (p-value < 0.05), as well as for Dcap, which is significant (p-value < 0.05). This study has also checked all

the other Gaussian copulas in the model and found that BMI and Dcap are significant ([Table 11](#)). So, this study can say that the effect of endogeneity in this study is an issue that backs up the analysis results as a whole, and the structural model is weak ([Sarstedt et al., 2020](#)).

Assessment of unobserved heterogeneity

Following ([Sarstedt et al., 2020](#)), to find unobserved heterogeneity in PLS path models and, if necessary, deal with it, this study did this by running the Kolmogorov–Smirnov test with Lilliefors correction, first running the FIMIX-PLS procedure on the data. Post-hoc power analysis in G* Power shows that the study needs at least 55 samples to get a maximum of eight segments if the effect size is 0.15 and the power level is 80%. So, this study did this by running the Kolmogorov–Smirnov test with Lilliefors correction, reran FIMIX-PLS for two to eight segments with the same settings as the first time, using the default values for the stop condition (1010141.0E10), the maximum number of iterations (5000), and the number of repetitions (10). First, the smallest number of

samples that could be used to estimate each segment was found. This helped determine how many parts could be cut (Sarstedt *et al.*, 2020). It is hard to understand the results of the fit indices for solutions with one to eight segments (Table 11). Sarstedt *et al.* (2020) showed that when AIC3 and CAIC have the same number of segments, that number is probably correct. Sarstedt *et al.* (2020) also say that AIC4 and BIC are good ways to determine how many segments are in an FIMIX-PLS model. The MDL5 points to a solution with two segments (Table 12). It has been shown that this criterion drastically underestimates the number of segments. So, researchers often have to take out more segments than MDL5 suggests (Hair *et al.*, 2016). Because (1) AIC3 and CAIC point to different numbers of segments and (2) MDL5 points to the same number of segments as AIC4 and BIC, the studies do not point to a sure way to split up the data. This research shows that none of the criteria suggest finding the correct number of segments, while EN value > .50 suggests a solution with two segments

(Hair *et al.*, 2016). However, in this study, the unobserved heterogeneity level is an issue that backs up the analysis results (Table 13).

The strong reliability of the DC construct $CA > 0.92$ confirms the theoretical integrity of the individual dimensions (sensing, seizing, and reconfiguring). The empirical findings showing a significant direct path from DC to OrgSus ($\beta = 0.423$, $p < 0.000$) suggest that the SMEs' ability to sense new market demands (consumer preference for sustainable products), seize the opportunity to embed new green technologies, and reconfigure their internal processes accordingly, are direct and powerful drivers of their overall sustainability performance. This directly supports the core tenet of the DCF, which posits that adaptive capabilities are essential for securing sustainable competitive advantage (Teece, 2016). This finding is consistent with prior research that has highlighted the benefits of dynamic capability in organizational sustainability in the areas of firm economics (Sharma & Vredenburg, 2019), environmental performance

Table 12: Fit indices for the one-to eight-segment solutions.

Criteria	Number of segments							
	1	2	3	4	5	6	7	8
AIC (Akaike's Information Criterion)	2275.891	1827.416	1627.045	1558.22	1537.782	1523.406	1507.824	1477.682
AIC3 (Modified AIC with Factor 3)	2284.891	1846.416	1656.045	1597.22	1586.782	1582.406	1576.824	1556.682
AIC4 (Modified AIC with Factor 4)	2293.891	1865.416	1685.045	1636.22	1635.782	1641.406	1645.824	1635.682
BIC (Bayesian Information Criteria)	2312.834	1905.407	1746.084	1718.307	1738.917	1765.588	1791.055	1801.961
CAIC (Consistent AIC)	2321.834	1924.407	1775.084	1757.307	1787.917	1824.588	1860.055	1880.961
HQ (Hannan Quinn Criterion)	2290.454	1858.161	1673.971	1621.328	1617.072	1618.876	1619.476	1605.516
MDL5 (Minimum Description Length with Factor 5)	2532.607	2369.372	2454.24	2670.655	2935.457	3206.32	3475.978	3731.076
LnL (LogLikelihood)	-1128.945	-894.708	-784.522	-740.11	-719.891	-702.703	-684.912	-659.841
EN (Entropy Statistic (Normed))	na	0.865	0.813	0.8	0.807	0.813	0.756	0.715
NFI (Non-Fuzzy Index)	na	0.892	0.822	0.791	0.776	0.765	0.677	0.621
NEC (Normalized Entropy Criterion)	na	60.644	83.708	89.563	86.587	83.59	109.228	127.654

Note: AIC: Akaike's information criterion; AIC3: modified AIC with factor 3; AIC4: modified AIC with factor 4; BIC: Bayesian information criteria; CAIC: consistent AIC; HQ: Hannan Quinn criterion; MDL5: minimum description length with factor 5; LnL: Log Likelihood; EN: entropy statistic; NFI: non-fuzzy index; NEC: normalized entropy criterion; na: not available; numbers in bold indicate the best outcome per segment retention criterion.

Table 13: Unobserved heterogeneity effect.

	Total (N=448)		Segment 1 (N=325)		Segment 2 (N=123)	
	β -values	p-values	β -values	p-values	β -values	p-values
BMI -> OrgSus	0.385	0.000	0.185	0.244	0.900	0.000
Dcap -> BMI	-0.133	0.001	0.823	0.000	-0.772	0.000
Dcap -> OrgSus	0.423	0.000	-0.060	0.622	0.924	0.000
Firm age -> OrgSus	0.070	0.092	-0.039	0.617	-0.033	0.609
Firm size -> OrgSus	0.023	0.577	0.219	0.164	-0.176	0.007
Industry -> OrgSus	-0.016	0.708	0.064	0.352	-0.179	0.010
Position -> OrgSus	0.049	0.238	0.087	0.317	-0.003	0.964
Indirect effect						
Dcap -> BMI -> OrgSus	-0.051	0.012	0.153	0.24	-0.695	0.000
Reflective measures						
CA	*		na		*	
rho_A	*		na		*	
CR	*		na		*	
AVE	*		na		*	
R Square						
BMI	0.018		0.677		0.597	
OrgSus	0.286		0.065		0.506	

Note: * indicates the values are in the acceptable range; na: not available.

(Song & Yu, 2018), and social performance (Schlüter et al., 2023). As predicted, the findings showed the importance of dynamic capability in boosting SMEs' sustainability. Business model innovation typically mediates the relationship between organizational sustainability and dynamic capability. The results in this study support prior research that links a firm's dynamic capability to business model innovation and firms' sustainable performance (Tseng et al., 2013; Qu & Liu, 2022; Pfeffer et al., 2010; Du et al., 2021). A critical finding of this study is the unexpected, yet statistically significant, negative relationship between dynamic capability and business model innovation uptake (H2: $\beta = -0.133$, $p < 0.001$). This contradicts the hypothesized positive relationship and established literature (e.g., Foss & Saebi, 2016). This negative path is the reason for the inconsistent partial mediation observed for H4, where the indirect effect is negative ($\beta = -0.051$) but the direct effect is positive ($\beta = 0.423$). We interpret this counter-intuitive result within the context of resource-constrained SMEs in a developing economy (Bangladesh). High

levels of dynamic capability may not lead to positive BMI uptake because SME managers may prioritize using their limited adaptive resources (DC) on direct operational survival and incremental resource reconfiguration rather than on the costly, disruptive, and uncertain process of large-scale business model innovation (Schulze & Brusoni, 2022). In essence, high DC in this context is a signal of organizational pressure and volatility, leading to a conservative, rather than transformative, approach to BMI. This finding provides a novel, context-specific boundary condition for the DC-BMI relationship. Hence, SME managers should consider that internal knowledge is insufficient to generate environmentally friendly products or processes across several operating divisions. Several authors argue that SMEs can better utilize external knowledge to boost innovation performance due to their dynamic management techniques and the presence of regulation (Song & Yu, 2018; Gallagher & Mahoney, 2021). However, this endeavor should be backed by the firm's straightforward, sustainable approach. SME managers should start by recognizing

sustainability challenges and creating long-term sustainable strategies that maximize stakeholders' environmental behaviors. The dynamic capability allows SMEs to be more ecologically innovative if a proactive environmental strategy anticipates and analyses future environmental changes (Hermundsdottir & Aspelund, 2021). Managers must shift organizational resources, change services, and commodity activities, and reform work structures and procedures to emphasize sustainability. Managers may also use change management approaches, including environmental socialization, education, and training, formal and informal environmental information exchange, progressive activation of environmental objectives, policies, and practices, and designing a reward structure that considers environmental contribution to introduce this attitude. A top-level organizational unit with apparent authority to promote strategic changes toward sustainability may help SMEs make the environmental shift (Aboelmaged & Hashem, 2019; Santos *et al.*, 2021). The results of this study also show that business model innovation, which substantially mediates the relationship between dynamic capability and organizational sustainability, affects a firm's economic, environmental, and social sustainability. This validates Aboelmaged & Hashem's (2019) results and emphasizes the need for stakeholder collaboration in environmentally friendly activities like eco-design and eco-efficiency for new goods and waste-reduction operating processes. Therefore, instead of depending on "transactional" or "one-time" interactions or just coordinating common operational concerns (such as product quality or packaging requirements), which represent a weak tie with the supplier and rarely affect tangible green solutions, SMEs could improve their market-facing operations by strengthening formal and informal networks with upstream and downstream value chain partners. These activities include discussions, formal agreements, information sharing, supply chain partnerships, and product development. Managers may maximize profits and market share by employing organizational processes and resources ecologically collaboratively with their partners (Schulze & Brusoni, 2022). Nonetheless, it is surprising that absorptive capability has had little influence on the firm's sustainability in this study. Contrary to past studies (Marques & Simon, 2020; Osiyevskyy & Dewald, 2020; Müller & Kolk, 2017) that indicated

the favorable impact of dynamic capability on firm sustainable performance, the mechanism by which business model innovation might enhance organizational sustainability in SMEs remains unclear. Most of this research was done in a developed economy where dynamic capability is typically targeted for developing business model innovation supported by an appropriate organizational environment and confidence. The dynamic capability may become more apparent in multinational companies, where CEOs' environmental actions are extensively monitored and business model innovation leadership is needed (Reyes-Santiago *et al.*, 2019). However, managers of SMEs in developing economies may actively urge their employees to engage in tailored business model innovation training and instantaneous learning programs. This will enable them to lead enterprise-specific sustainability and adapt to inevitable technological changes, customer preferences, and market situations.

CONCLUSION

The research examined the impact of dynamic capability on organizational sustainability through the mediating role of business model innovation, leveraging the Triple Bottom Line and Natural Resource-Based View (NRBV) frameworks in the context of Bangladeshi SMEs. This is the first study to investigate how business model innovation mediates the contract of dynamic capability and organizational sustainability. The study also contributes to the scarce empirical research on organizational sustainability in developing nations by investigating these links in the context of SMEs. According to data, dynamic capability predicts sustainable capabilities and business model innovation uptake. Business model innovation also drives and mediates dynamic capability's impact on organizational sustainability uptake, but in a negative way. The study successfully addressed all objectives by providing three key empirical findings. First, Dynamic Capability has a significant, positive direct influence on Organizational Sustainability, confirming that the internal adaptive capacity of sensing, seizing, and reconfiguring is a primary driver of TBL performance. Second, BMI is a strong, positive predictor of OS, validating its necessity for achieving economic, social, and environmental goals. Third, BMI plays a significant, albeit inconsistent, partial mediating role in the DC-OS. Critically, the pathway from DC

to BMI was found to be negative, suggesting that in resource-constrained contexts, high DC capacity is diverted towards direct operational survival rather than disruptive business model transformation. The dynamic capability has a surprising impact on business model innovation and organizational sustainability. Notwithstanding this study's relevance and implications, generalizing or interpreting the results in other circumstances must be done carefully. These findings contribute to the NRBV by specifying how adaptive resources translate into market outcomes, providing a context-specific boundary condition for the DCF in emerging markets. For SME managers, the primary implication is the need to decouple immediate DC use from BMI. Managers should allocate resources to separate teams: one focused on urgent, high-DC operational stability, and another, protected team dedicated to long-term, high-risk BMI projects for future sustainability. First, the survey findings show how dynamic capability may, directly and indirectly, affect business model innovation adoption and organizational sustainability. So, future research may employ qualitative methods like action research, grounded theory, or case studies to obtain more detailed data in a specific industrial or service sector. Moreover, longitudinal research would allow for a more dynamic evaluation of these connections. Second, as self-reported data have been used in prior research, this study quantified absorptive potential using it. Although the primary linear paths remain statistically significant, these findings suggest that the relationships among Dynamic Capability, Business Model Innovation, and Organizational Sustainability are more complex than captured by a simple linear model. Future research should prioritize the use of advanced econometric methods, such as Generalized Method of Moments (GMM) or sophisticated modeling techniques that account for unobserved heterogeneity and nonlinear effects, to provide a more definitive and robust confirmation of these dynamic interactions. The current study employed a realized perspective on dynamic capability, which may not effectively portray SMEs' anticipated reaction to dynamic and continual environmental changes. Considering this, future research may use the prospective and actual absorptive capacity to analyze their correlations with business model innovation and organizational sustainability.

AUTHOR CONTRIBUTIONS

Md Abid Hasan: Conceptualization, Methodology, Formal Analysis, Visualization, And Writing – Original Draft Preparation. Yin Xiang: Methodology, Investigation, Formal Analysis and Writing – Original Draft Preparation. Mohammad Mesba Ul Hoque: Methodology, Software, Formal Analysis, Data Curation, And Writing – Original Draft Preparation. Xinli Zhang: Investigation, Methodology, Resources, Visualization, and Writing – Original Draft Preparation. Md Jahir Uddin: Methodology, Resources and Writing – Original Draft Preparation. M Samiul Hasnat: Editing, Software, Data Curation, Review and Editing.

ACKNOWLEDGEMENT

We thank the editors and anonymous reviewers of the International Journal of Human Capital in Urban Management (IJHCUM) for their constructive comments and suggestions, which significantly improved the quality and clarity of this paper.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

OPEN ACCESS

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PUBLISHER NOTE

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ABBREVIATIONS (NOMENCLATURE)

<i>AVE</i>	Average Variance Extracted
<i>BIC</i>	Bayesian Information Criteria
<i>BMI</i>	Business Model Innovation
<i>CA</i>	Cronbach's Alpha
<i>CAIC</i>	Consistent Akaike Information Criterion
<i>CMB</i>	Common Method Bias
<i>CR</i>	Composite Reliability
<i>Dcap / DC</i>	Dynamic Capability
<i>DCF</i>	Dynamic Capabilities Framework
<i>ENP</i>	Sustainable Environmental Performance
<i>EP</i>	Sustainable Economic Performance
<i>GOF</i>	Goodness of Fit
<i>HQ</i>	Hannan–Quinn Criterion
<i>HTMT</i>	Heterotrait-Monotrait Ratio
<i>MDL5</i>	Minimum Description Length with Factor 5
<i>NEC</i>	Normalized Entropy Criterion
<i>NFI</i>	Non-Fuzzy Index
<i>NRBV</i>	Natural Resource-Based View
<i>OES</i>	Organizational Environmental Sustainability
<i>OrgSus / OS</i>	Organizational Sustainability
<i>PLS-SEM</i>	Partial Least Squares Structural Equation Modeling
<i>RBV</i>	Resource-Based View
<i>RESET</i>	Ramsey Regression Equation Specification Error Test
<i>ROI</i>	Return on Investment

<i>SEP</i>	Sustainable Economic Performance
<i>SSP</i>	Sustainable Social Performance
<i>SRMR</i>	Standardized Root Mean Square Residual
<i>TBL</i>	Triple Bottom Line
<i>VC</i>	Value Creation
<i>Vcap</i>	Value Capture
<i>VP</i>	Value Proposition

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HOW TO CITE THIS ARTICLE

Hasan, M. A.; Zhang, X.; Yin, X.; Hoque, M. M.U.; Uddin, M.J.; Chowdhury, N.R., (2026). Does dynamic capability influence organizational sustainability? Understanding the mediating role of business model innovation. *Int. J. Hum. Capital. Urban Manage.*, 11(3): 483 - 508.

DOI: [10.22034/IJHCUM.2026.03.04](https://doi.org/10.22034/IJHCUM.2026.03.04)

URL: https://www.ijhcum.net/article_736064.html



ORIGINAL RESEARCH ARTICLE

Challenges in residential biomedical waste disposal and urban governance for sustainable public health management

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ARTICLE INFO

Article History:

Received 15 May 2025

Revised 05 October 2025

Accepted 31 May 2026

Keywords:

Public health risk; Residential bio-medical waste; Sustainable urban health; Urban governance; Waste management policy.

ABSTRACT

BACKGROUND AND OBJECTIVES: This study investigates the disposal practices of residential Bio-Medical Waste and the challenges faced by urban local bodies in managing such waste in Himachal Pradesh, India. With a notable rise in home-based healthcare, especially post-COVID-19, households are generating increasing amounts of waste from activities such as self-medication, chronic illness management, and the use of disposable medical items and personal protective equipment. Despite this trend, most households mix Bio-Medical Waste with general municipal waste due to limited awareness, the absence of segregation systems, and a lack of designated disposal facilities. This poses significant risks to public health, particularly for waste workers and the broader community, and strains municipal waste management infrastructure. Urban authorities, constrained by inadequate policies, insufficient infrastructure, and limited financial and technical capacity, struggle to address this emerging challenge.

METHODS: The study utilized a mixed-methods approach, including household surveys, field observations, and stakeholder interviews across Himachal Pradesh state and the urban local bodies of various districts. In this study, the regression analysis and factor analysis tools are used to achieve the research objectives

FINDINGS: The results revealed that an urgent need for clear policy frameworks, as 72% of ULBs lacked specific guidelines for residential Bio-Medical Waste, and no penalties for improper disposal in 85 percent of cases. Public education, dedicated Bio-Medical Waste collection systems, staggering 68 percent of surveyed households admitted to mixing Bio-Medical Waste with general garbage due to a lack of awareness (42%), absence of dedicated bins (35%), convenience (23%), households found it easier to dispose of Bio-Medical Waste with regular trash and health risks to workers engaged in municipal solid waste management in urban areas, 89% of workers are encountered to Bio-Medical Waste daily, with 62% reporting injuries (needle-sticks, infections), in 28% of cases, no formal training or personal protective equipment was provided, and only 10% of workers are aware of the hazards of Bio-Medical Waste.

CONCLUSION: The research provides valuable insights for policymakers and urban managers to design more resilient and inclusive Bio-Medical Waste management strategies for sustainable urban health governance.

DOI: [10.22034/IJHCUM.2026.03.05](https://doi.org/10.22034/IJHCUM.2026.03.05)



NUMBER OF REFERENCES

34



NUMBER OF FIGURES

7



NUMBER OF TABLES

6

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the "Show Article."

INTRODUCTION

Bio-Medical Waste (BMW) management has been extensively examined in institutional settings such as hospitals and clinics, while residential BMW remains significantly under-researched, particularly in developing countries like India, where home-based health-care is expanding rapidly (Olusunmade, 2019; WHO, 2022). Global research highlights severe public health and environmental risks associated with improper BMW disposal, including infection transmission from contaminated sharps, pharmaceutical leaching into groundwater, and occupational hazards for waste handlers (Samad *et al.*, 2019; Vinti *et al.*, 2021; Shari-or *et al.*, 2023). The BMW Management Rules (2016) provide a comprehensive regulatory framework targeting institutional sources while explicitly excluding household-generated BMW (Alzghoul *et al.*, 2022). This regulatory omission has created a significant governance gap amid a growing prevalence of self-administered medical care, dialysis, and chronic disease management, all of which generate considerable quantities of BMW in residential areas (CPCB, 2020; Dutta and Jinsart, 2020). Studies in metropolitan cities such as Mumbai and Delhi report indiscriminate disposal of residential BMW, including used syringes, expired medicines, soiled dressings, and personal protective equipment, into Municipal Solid Waste (MSW) streams. The lack of source segregation and public awareness contributes to this co-disposal, increasing health and environmental hazards (Dehal *et al.*, 2022). This practice elevates the risk of needle-stick injuries, antimicrobial resistance, and environmental pollution through plastic and pharmaceutical waste (Samad *et al.*, 2019; Khosla *et al.*, 2022). Research in Kerala found that 68% of households disposed of BMWs unsafely due to inadequate risk awareness and the absence of structured collection systems (Samad *et al.*, 2019). Himachal Pradesh faces additional challenges owing to dispersed settlements, mountainous terrain, underdeveloped Urban Local Body (ULB) infrastructure, and limited policy compliance (Sharma and Acharya, 2019). Transportation barriers and the lack of treatment facilities make effective residential BMW management more difficult compared to urban areas. Several studies have confirmed the link between improper household waste disposal and public health outcomes, with risks including respiratory diseases, infections, and vector-borne illnesses increasing due to the mixing of

BMW with general MSW (Mohammadi *et al.*, 2024). The Coronavirus Disease 2019 (COVID-19) pandemic further intensified these risks, yet post-pandemic evaluations have largely neglected the implications of increased BMW generated in residential settings (Teymourian *et al.*, 2021; Dehal *et al.*, 2022). International best practices, including Japan's and Germany's enforced segregation protocols and Brazil's decentralized health posts, demonstrate effective models for household-level BMW management. These include color-coded bins, pharmaceutical return systems, and community drop-off centers (Sharma *et al.*, 2023; Silva *et al.*, 2022). Despite their success, such systems face contextual challenges in India due to low municipal capacity, weak enforcement, and limited citizen participation (CPCB, 2020). The role of informal waste workers in handling mixed waste is also inadequately addressed. Studies report high occupational risks due to a lack of protective equipment and training (Agarwalla *et al.*, 2017; Kavitha and Mohan, 2019). Effective local governance is essential for addressing these challenges. Municipal policies, public education, and civic participation significantly influence waste management outcomes (Oladejo *et al.*, 2024). Most studies emphasize metro cities, ignoring the distinctive challenges of hilly states like Himachal Pradesh. Existing literature focuses predominantly on institutional BMW and urban-centric contexts. Studies by Devi *et al.*, (2019), Samad *et al.*, (2019) have examined residential BMW mixing with MSW in metropolitan areas such as Delhi and Mumbai. These studies do not account for the topographical, logistical, and governance challenges present in hilly states. Sharma and Acharya, (2019) highlight these issues in Himachal Pradesh but lack an integrated assessment of behavioural, infrastructural, and policy-level factors. Few studies have examined post-pandemic shifts in household BMW generation or the long-term public health consequences of improper disposal in residential contexts (Teymourian *et al.*, 2021). International models have been discussed in isolation (Sharma *et al.*, 2023; Silva *et al.*, 2021), but their contextual applicability to Indian ULBs, particularly in low-resource or geographically dispersed areas, remains underexplored. Additionally, the role of informal waste pickers, despite being critical to urban waste management, is often mentioned without actionable frameworks for training, safety, and integration into formal systems (Agarwalla *et al.*, 2017; Kavitha and

Mohan, 2019). This study addresses these gaps by focusing on residential BMW management in Himachal Pradesh's ULBs. It integrates infrastructural analysis with policy and behavioural insights, evaluates the adaptability of global models in local settings, and includes the informal sector within the governance discourse. This comprehensive approach contributes new perspectives to the discourse on sustainable urban health management in ecologically sensitive regions. The objectives of this study are as follows:

- (i) *To investigate the generation and disposal practices of residential BMWs in urban households across selected ULBs in Himachal Pradesh, particularly in the context of increased home-based healthcare following the COVID-19 pandemic;*
- (ii) *To examine the institutional, infrastructural, and policy-level challenges faced by ULBs in managing residential BMW in geographically challenging and resource-constrained environments;*
- (iii) *To analyze public awareness, household behaviour, and barriers to proper segregation, including the use and availability of dedicated disposal mechanisms;*
- (iv) *To assess the occupational exposure and health risks faced by municipal sanitation workers due to the improper handling of mixed BMW, including gaps in training, availability of protective equipment, and hazard awareness;*
- (v) *To apply statistical tools such as regression analysis and factor analysis to identify the key determinants influencing household disposal behaviour and municipal management effectiveness;*
- (vi) *To recommend context-specific, inclusive, and policy-relevant interventions aligned with the Swachh Bharat Mission (SBM) and Sustainable Development Goals (SDGs), aimed at strengthening urban BMW governance in ecologically sensitive regions.*

The study on residential biomedical waste disposal and urban governance challenges was conducted in January 2025 at Lovely Professional University, Punjab.

METHODS AND MATERIALS

Study area

This study focuses on residential BMW management within urban Himachal Pradesh through a stratified selection of five ULBs, such as Shimla, Solan,

Dharamshala, Mandi, and Bilaspur. These ULBs represent a range of geographic, climatic, and demographic conditions that influence BMW's generation and management practices. Shimla (31.1048° N, 77.1734° E), the state capital, is situated at an elevation of approximately 2,200 meters and experiences a temperate highland climate with cool summers and snowy winters, along with seasonal tourist influx and space constraints. Solan (30.9090° N, 77.0960° E), located at around 1,300 meters, has a subtropical highland climate with mild summers and growing pharmaceutical activity contributing to mixed waste streams. Dharamshala (32.2190° N, 76.3234° E), positioned at 1,450 meters, receives high rainfall and experiences significant seasonal variation in population due to tourism, impacting waste volume and flow. Mandi (31.7088° N, 76.9326° E), at an elevation of 800 meters, lies in a transitional zone between rural and urban development, with a humid subtropical climate and moderate rainfall affecting waste collection logistics. Bilaspur (31.3320° N, 76.7531° E), the lowest among the selected ULBs at around 670 meters, has a subtropical climate with warm summers and limited institutional capacity, situated near the environmentally sensitive Gobind Sagar Lake. These geographic and climatic factors directly influence BMW generation, storage, and handling efficiency, making them essential for evaluating public health risks and sustainability in urban waste systems.

Research design

The research design captures multiple dimensions critical in understanding residential BMW disposal practices and challenges faced within urban settings (Fig. 1). The selection criteria include administrative hierarchy, healthcare infrastructure, waste management capacity, and geographical representation (Ajbar El Gueriri et al., 2023). Administrative hierarchy reflects the inclusion of ULBs with varying governance levels, ranging from state capitals to smaller municipalities, enabling comparison across different institutional capacities. Healthcare infrastructure, indicated through the number and type of medical facilities such as hospitals, clinics, and pharmaceutical units, represents the scale of BMW generation within each ULB (Olusunmade, 2019). Waste management capacity considers the presence and nature of BMW treatment systems, including common, partial, shared, or absent facilities, offering insight into operational

preparedness. Geographical representation ensures spatial diversity across Himachal Pradesh, including hill stations, transitional settlements, and industrial zones, each presenting distinct environmental and demographic pressures. This comprehensive framework supports a detailed analysis of systemic gaps in BMW handling and enables the development of context-specific recommendations in urban waste governance. Table 1 provides a comparative overview of five selected ULBs in Himachal Pradesh, detailing population size, healthcare infrastructure, BMW processing capacity, and key urban challenges. From Table 1, it may be observed that Shimla, with a population of 230,000, has 3 hospitals and 28 clinics, supported by a common BMW processing facility. The city faces major constraints related to high tourist influx and limited urban space, impacting consistency in waste handling and treatment. Solan, with 160,000 residents, includes 2 hospitals and multiple pharmaceutical units. The city employs only partial BMW treatment, with significant risk arising from the mixing of industrial and BMW. Dharamshala, supporting 150,000 individuals through 1 hospital and 15 clinics, lacks a dedicated BMW treatment facility. Seasonal waste surges, likely influenced by tourism cycles, place additional pressure on existing waste infrastructure.



Fig. 1: Research design for ULBs

Further, it may be noted from Table 1 that Mandi, with a population of 120,000 and supported by one hospi-

tal and ten clinics, shares BMW treatment resources with surrounding areas. This urban area remains in a transitional phase from rural to urban conditions, presenting difficulties in scaling waste systems and institutional capacity. Bilaspur, with 80,000 residents, includes 1 hospital and 5 clinics and operates without any form of BMW treatment. The city exhibits limited institutional capability, restricting effective BMW control. The comparison reveals substantial differences in infrastructure and BMW management across ULBs. Higher population or healthcare presence does not ensure sufficient waste processing capacity. Cities with tourism, spatial constraints, or industrial mixing face a heightened risk of mismanagement. Public health and environmental protection remain vulnerable without targeted investment in treatment facilities, improvement in residential waste practices, and institutional strengthening within smaller ULBs.

Rationale for site selection

The selection of study sites across Himachal Pradesh is guided by the need to capture the diverse urban experiences influencing BMW management. By incorporating a mix of municipal classes, geographical terrains, and governance structures, the study aims to provide a comprehensive understanding of the systemic strengths and challenges within the state's urban waste landscape (Omo and Hassan, 2024). This approach ensures that findings are grounded in representative, real-world conditions that affect policy implementation and service delivery across varied urban contexts.

- i. *Representative sampling:* It covers Class I (Shimla) to Class III (Bilaspur) towns. Includes tourist hubs and industrial towns, and balances hill stations and valley cities.
- ii. *Urban management focus:* Varied implementation of Swachh Bharat Mission, different levels of municipal budget allocation, and contrasting public-private partnerships
- iii. *Geographical considerations:* Altitude variations (300m to 2200m above sea level), Road connectivity challenges, Seasonal accessibility issues, and settlement patterns.
- iv. *Urban governance context:* All sites share common institutional frameworks like the HP Municipal Corporation Act, State Pollution Control Board oversight, and varied implementation of BMW Rules (2016), Solid

Table 1: Selected ULBs and characteristics

ULB	Population (2021)	Healthcare Facilities	BMW Processing	Urban Challenges
Shimla	230,000	3 hospitals, 28 clinics	Common facility	Tourist influx, space constraints
Solan	160,000	2 hospitals, Pharma units	Partial treatment	Industrial waste mixing
Dharamshala	150,000	1 hospital, 15 clinics	No dedicated BMW	Seasonal waste surges
Mandi	120,000	1 hospital, 10 clinics	Shared facility	Rural-urban transition
Bilaspur	80,000	1 hospital, 5 clinics	No treatment	Limited ULB capacity

Table 2: ULB waste management capacity

Parameter	Shimla	Solan	Dharamshala	Mandi	Bilaspur
Waste Staff (per 1000 people)	4.2	3.1	2.8	2.3	1.5
BMW Collection Frequency	Daily	3x/week	Weekly	Biweekly	Monthly
Segregation Compliance	65%	48%	52%	38%	22%
Treatment Access	Yes	Partial	No	Shared	No

Waste Management (SWM) Rules (2016), and Swachh Bharat Mission guidelines.

Urban BMW governance in Himachal

ULB resource allocation patterns, service delivery mechanisms, and urban-rural waste flows shape the governance of urban waste in Himachal Pradesh. This stratified approach enables comparative analysis of urban waste governance while accounting for geographical and demographic diversity across the state's municipal landscape. The management of residential BMW in urban Himachal Pradesh presents a complex challenge that requires examination through multiple theoretical lenses. This study integrates urban governance theory, systems thinking, and risk perception theory to develop a comprehensive framework for understanding the persistent gaps in BMW management (Deepak *et al.*, 2021). Urban environmental governance theory provides the primary lens for analyzing the institutional dimensions of BMW management. The theory highlights how multi-level governance structures often create implementation gaps in waste management systems. In Himachal Pradesh's urban context, this manifests through fragmented responsibilities between ULBs, the State Pollution Control Board, and central government schemes like Swachh Bharat Mission. These governance challenges are particularly acute for residential BMW, which falls outside the purview of existing BMW Management Rules (2016) that primarily regulate institutional waste generators (Alzghoul *et al.*, 2022). Table 2

provides comparative insights into the BMW management capacity of selected ULBs across Himachal Pradesh. From Table 2, it can be noted that there is an uneven distribution of waste management resources and service standards, with Shimla having 4.2 waste staff per 1,000 people and daily BMW collection, showing the highest segregation compliance (65%) and full access to treatment. In contrast, Bilaspur has only 1.5 staff per 1,000 people, a monthly collection, low segregation compliance (22%), and no access to treatment. Other towns like Solan and Dharamshala fall between these extremes, with varying degrees of service frequency and infrastructure. This disparity underscores the fragmented and localized nature of urban BMW governance, contributing to systemic gaps and inconsistent risk mitigation across the state. Network governance theory further explains how the absence of clear nodal agencies leads to coordination failures among stakeholders - municipal workers, healthcare providers, waste pickers, and households. This theoretical perspective helps explain why ULBs struggle with residential BMW despite having mechanisms for institutional waste, as the current governance architecture lacks provisions for household-level medical waste streams that have emerged prominently in the post-pandemic era. The systems theory perspective offers crucial insights into the technical and operational dimensions of BMW management. Viewing urban waste systems as complex adaptive systems reveals how the introduction of res-

idential BMWs creates new feedback loops that destabilize existing waste management infrastructure. The theory helps explain several observed phenomena: first, how the mixing of BMW with MSW creates systemic contamination risks throughout the waste value chain; second, why geographic constraints in hilly urban areas amplify transportation and treatment challenges; and third, how informal recycling networks inadvertently become disease transmission pathways. The systems perspective is particularly valuable for understanding threshold effects, for instance, how tourist influx in cities like Shimla and Dharamshala periodically overwhelms waste management capacity during peak seasons. This theoretical approach suggests that solutions must address the entire waste system rather than isolated components, emphasizing the need for decentralized treatment options and robust monitoring mechanisms. Risk society theory provides the third critical lens for examining the socio-behavioural aspects of BMW management. The theory's concept of "manufactured risks" perfectly encapsulates how the medicalization of households, through increased self-care, chronic disease management, and post-pandemic practices, has created new risk profiles that existing systems are ill-equipped to handle. Three risk dimensions emerge prominently: health risks for sanitation workers handling mixed waste, environmental risks from improper disposal, and social risks from unequal exposure to hazards (Gutberlet and Uddin, 2017). The theory helps explain the paradox between risk production and risk perception - while household BMW generation has increased dramatically, risk awareness remains low among urban residents. This disconnect between risk creation and risk acknowledgment creates significant barriers to behavioural change and policy compliance. The intersection of these theoretical perspectives reveals why conventional approaches to BMW management fail when applied to residential waste streams in urban Himachal Pradesh. Governance theories explain the institutional voids, systems thinking clarifies the operational breakdowns, and risk theory illuminates the socio-cultural

dimensions (Liedong et al., 2020). Together, they suggest that effective solutions must simultaneously address: (1) policy gaps through regulatory reforms that explicitly include residential BMW, (2) systemic constraints through appropriate technological interventions, and (3) behavioural gaps through targeted awareness campaigns. The theoretical integration also highlights the need for context-specific solutions that account for Himachal's unique urban geography - the predominance of hill towns, seasonal population fluctuations, and dispersed settlement patterns that differ markedly from plains-based urban models. This theoretical framework has important implications for both research and practice. For researchers, it provides a multidimensional approach to studying urban waste challenges in mountainous regions. For policy-makers, it suggests the need for integrated strategies that combine governance reforms, technological solutions, and community engagement. The framework also helps identify key leverage points for intervention, such as improving waste segregation at source (systems approach), strengthening municipal capacity (governance perspective), and enhancing risk communication (risk theory). By grounding the study in these complementary theoretical foundations, the research can generate insights that are both academically rigorous and practically relevant for urban waste management in Himachal Pradesh and similar mountainous regions facing comparable challenges.

Data collection

A mixed-method research design structured the empirical foundation for assessing residential BMW management across urban Himachal Pradesh. This design captured both generator- and manager-level perspectives through integrated household surveys, stakeholder interviews, and field observations. The aim was to triangulate behavioural patterns at the household level with institutional capacity, policy gaps, and on-ground operational practices. Five ULBs were selected based on population characteristics, healthcare infrastructure, and waste generation

profiles, ensuring spatial, administrative, and demographic diversity for a comprehensive analysis (Banal and Abad, 2025).

Household surveys and stakeholder interviews

A mixed-method research design was adopted to comprehensively explore residential BMW disposal practices and the institutional challenges faced by ULBs in Himachal Pradesh (Soyler *et al.*, 2025). Data collection involved three key components:

- i. *Household surveys:* Structured questionnaires were administered to households across selected ULBs. The survey captured information on the frequency and type of BMWs generated, awareness of associated health risks, current disposal practices, and the extent of reliance on municipal services. Particular focus was placed on households engaging in self-care practices such as insulin injections, Personal Protective Equipment (PPE) use, and chronic disease management.
- ii. *Stakeholder interviews:* Semi-structured interviews were conducted with key stakeholders, including ULB officials, sanitation supervisors, waste workers, representatives of the State Pollution Control Board, and Non-Government Organizations (NGOs) engaged in urban health and waste management. These interviews aimed to identify policy implementation gaps, infrastructure constraints, and inter-departmental coordination issues.
- iii. *Field observations:* On-site observations were carried out at ward-level waste collection points, segregation units, and temporary disposal zones. These observations provided real-world insights into operational practices, segregation effectiveness, and occupational health risks for sanitation workers.

Five ULBs were selected based on population size, healthcare infrastructure presence, and municipal waste generation patterns (Banal and Abad, 2025). The data collection period spanned from March to August 2024.

Analytical framework for urban waste management

An integrated analytical framework was developed to assess the behavioural, institutional, and public health dimensions of residential BMW management (Deepak *et al.*, 2021). This framework comprised the following components:

- i. *Household behaviour analysis:* Descriptive statistical analysis was used to interpret household-level survey data, focusing on patterns of awareness, segregation practices, and disposal behaviour.
- ii. *Institutional capacity assessment:* A Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis was employed to evaluate the operational and policy capacities of ULBs. The assessment considered administrative efficiency, resource allocation, regulatory enforcement, and workforce training.
- iii. *Public health risk mapping:* A qualitative risk exposure matrix was created to assess the vulnerability of waste handlers and sanitation workers to improperly disposed of BMW. This matrix was informed by interviews, field data, and public health guidelines.
- iv. *Sustainability gap identification:* The findings were mapped against the targets of Sustainable Development Goals (SDGs) 3 (Good Health and Well-Being) and 11 (Sustainable Cities and Communities). Gaps in awareness, collection infrastructure, inter-agency collaboration, and financing were highlighted to inform future policy directions.

Addressing the complexities of residential BMW disposal and challenges faced with ULBs across Himachal Pradesh, India, involved the development of a comprehensive “*Analytical framework for urban waste management*”. This framework integrates multiple analytical tools and methodologies, assessing current practices, identifying gaps, and proposing actionable strategies supporting sustainable waste governance. It comprises four key components: household behaviour analysis, institutional capacity assessment, public health risk mapping, and sustainability gap identification. This holistic approach enables understanding of the BMW issue from both the generator (household) and manager (ULB) perspectives, supporting informed recommendations promoting sustainable urban waste management.

Household behaviour analysis

The objective involved understanding patterns, awareness, and practices of households regarding BMW disposal. Structured household surveys across selected ULBs focused on types and quantities of

Table 3: SWOT analysis of ULBs in managing residential BMW

Category	Details
Strengths	Presence of a dedicated workforce specialized in waste management; availability of fundamental waste management infrastructure.
Weaknesses	Absence of specific policies targeting residential BMW management, inadequate specialized training programs for waste handlers, and constrained financial resources limiting operational capacity.
Opportunities	Potential for strategic collaborations with non-governmental organizations and private sector entities; scope for enhancing public awareness and community engagement initiatives regarding BMW hazards.
Threats	Escalation in BMW volumes due to increased prevalence of home-based healthcare practices; heightened risk of public health crises resulting from improper BMW handling and disposal (Samadi Froushani et al., 2024).

BMW generated, awareness levels about associated health and environmental hazards, current disposal methods employed, and dependence on municipal waste services. Descriptive statistical techniques analyzed survey responses, highlighting prevalent behaviours and identifying areas with limited awareness. Findings revealed a significant portion of households mixing BMW with general waste, indicating poor segregation practices and limited understanding of health and environmental risks linked to improper BMW disposal (Rao et al., 2018).

Institutional capacity assessment

Evaluation focused on the readiness and capability of ULBs in managing residential BMW effectively. Semi-structured interviews were conducted with key stakeholders, including ULB officials, sanitation workers, and representatives from the State Pollution Control Board. A SWOT analysis examined existing infrastructure and resources, policy enforcement gaps, resource limitations, potential areas for improvement, external support opportunities, and emerging threats. Strengths identified include a dedicated workforce and basic waste management infrastructure. Weaknesses involve inadequate BMW-specific policies, a lack of specialized training for waste handlers, and insufficient financial resources. Opportunities arise from potential collaborations with NGOs and the private sector, alongside growing public awareness campaigns. Threats include rising BMW quantities due to increased home-based healthcare and risks of public health crises (Ajbar El Gueriri et al., 2023; Samadi Froushani et al., 2024). Table 3 summarizes this SWOT analysis, highlighting key factors influencing the ULBs' capacity to manage residential BMW effectively.

Table 3 outlines the internal strengths and weaknesses within the current management framework, such as the presence of a dedicated workforce and infrastructure, alongside gaps like a lack of specific policies and training. It also highlights external opportunities, including potential partnerships and awareness campaigns, and threats such as increasing waste volumes and public health risks, all of which shape the effectiveness of BMW management by ULBs.

Public health risk mapping

The objective involved identifying and visualizing areas at heightened risk due to improper BMW disposal. Field observations combined with geospatial data collection facilitated the identification of unauthorized dumping sites and locations with frequent waste-related complaints. Geographic Information System (GIS) technology was utilized to generate detailed maps illustrating the proximity of waste disposal sites to residential zones, the density of unauthorized dumping locations, and incidence rates of waste-related health issues reported by local health centers (Jangre et al., 2022). Findings revealed multiple unauthorized BMW dumping sites situated near densely populated residential areas, with a clear correlation between improper BMW disposal practices and increased occurrences of diseases such as dengue and respiratory ailments. Fig. 2 illustrates the spatial risk assessment of unauthorized BMW disposal across urban settlements in Himachal Pradesh, categorized into high-risk (red), medium-risk (orange), and low-risk (yellow) zones. From Fig. 2, it can be noted that high-risk areas, particularly near Shimla and Solan, exhibit significant governance challenges in BMW handling, whereas medium-risk zones, including Mandi and Kullu, show moderate

concerns related to waste treatment infrastructure and regulatory oversight. The low-risk region indicates relatively effective BMW management systems. Major urban centers such as Mandi, Shimla, Dharamshala, Solan, and Kullu are distinctly marked to contextualize systemic gaps within the broader waste governance framework. The map integrates a scale (0–50 km) and orientation markers for spatial accuracy, reinforcing the need for field validation through epidemiological surveys and institutional assessments to develop targeted waste management interventions.

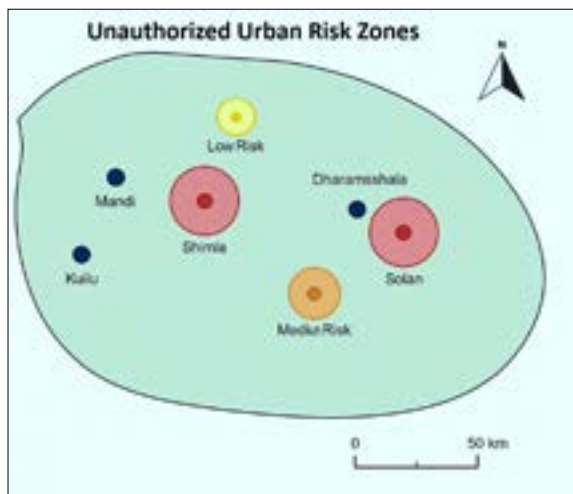


Fig. 2: GIS mapping of high-risk areas for BMW-related health issues

Sustainability gap identification

The objective focused on pinpointing critical gaps hindering the achievement of sustainable BMW management practices. Benchmarking involved comparing current local practices against national and international standards for BMW management. Stakeholder workshops engaged community members, health professionals, and waste management experts to gather diverse insights on perceived challenges and potential solutions. Findings revealed significant policy gaps, including the absence of clear guidelines and regulations specific to residential BMW. Infrastructure deficiencies were evident in the lack of specialized collection and treatment facilities at the municipal level. Financial constraints manifested as limited budget allocations for waste management programs, resulting in inadequate service delivery (Singh et al., 2022). Additionally, community engagement was low, with minimal public participa-

tion in waste segregation and disposal initiatives. Fig. 3 evaluates the multidimensional influences shaping residential BMW disposal within urban environments, emphasizing administrative hierarchy, health-care infrastructure, waste management capacity, and geographical representation.

From Fig. 3, it may be noted that the administrative hierarchy enables comparison of ULBs across governance levels, facilitating institutional benchmarking for BMW regulation. Healthcare infrastructure assesses medical facility density, including hospitals, clinics, and pharmaceutical units, to quantify BMW generation and disposal requirements. Waste management capacity examines available treatment mechanisms categorized as common, partial, shared, or absent to determine operational preparedness and systemic inefficiencies. Geographical representation ensures spatial diversity by incorporating hill stations, transitional settlements, and industrial zones, each contributing unique environmental and demographic pressures. Collectively, these dimensions provide a structured approach to identifying governance gaps and optimizing urban BMW management interventions.

RESULTS AND FINDINGS

Building upon a multi-tiered methodology encompassing household surveys, stakeholder interviews, field observations, geospatial analysis, and benchmarking exercises, the results and discussion section synthesizes key findings related to residential BMW management across urban Himachal Pradesh. Drawing from data collected across five ULBs, the analysis examines critical aspects of public disposal behaviour, operational capacity, health risk exposure, and regulatory limitations. This integrated approach highlights how infrastructural gaps, policy ambiguities, limited awareness, and institutional fragmentation influence current waste management outcomes within the residential sector.

Current residential BMW disposal practices in urban households

The investigation into residential BMW disposal practices across urban centers in Himachal Pradesh, based on household surveys (n=800) and stakeholder interviews (n=42), reveals substantial inefficiencies and behavioural inconsistencies. A significant proportion of households engaging in self-care activities, including insulin administration, wound management,

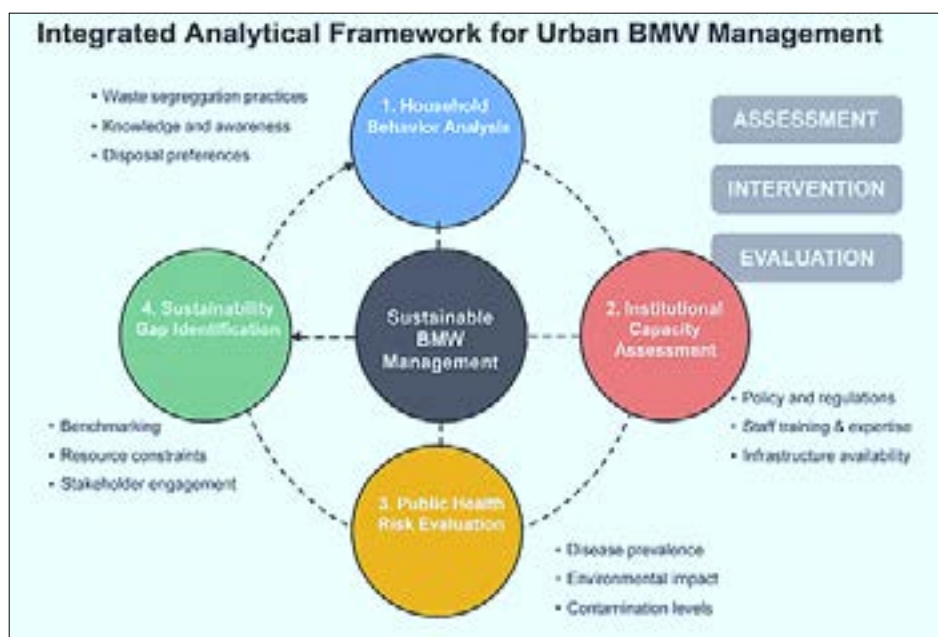


Fig. 3: Integrated analytical framework diagram

and personal protective equipment usage, lack access to safe and structured disposal mechanisms. Biomedical materials, such as used sharps, soiled dressings, and expired pharmaceuticals, are frequently discarded alongside general household waste, contributing to cross-contamination and increased health risks. Awareness of BMW-related hazards remains low, with limited adoption of segregation practices and widespread reliance on informal methods such as open disposal or flushing. Field observations confirm the absence of designated residential BMW collection infrastructure at municipal waste aggregation points and reveal that municipal sanitation workers, often operating without protective gear or specialized training, are exposed to hazardous materials during manual waste sorting. Stakeholder feedback further indicates a regulatory gap, as existing BMW Management Rules (2016) largely exclude decentralized sources such as households, leading to operational ambiguity at the ULB level (Alzghoul et al., 2022). This is compounded by inadequate public outreach initiatives, minimal budgetary support, and fragmented inter-agency coordination, collectively impeding effective BMW governance. Samad, et al., (2019) documented that 68.5% of households in Kerala disposed of medical waste through regular solid waste channels, only 10.2% used containment meth-

ods, and 15.8% admitted to open burning or flushing. Devi et al., (2019) highlighted that more than 60% of urban respondents across four cities lacked awareness of BMW rules, 76% had not received municipal instructions, and 64% disposed of sharps unsafely. Compared to these studies, this investigation offers a broader and more operationally grounded understanding by integrating both behavioural evidence from a large household sample and institutional insights from municipal staff, while also capturing field-level infrastructural gaps and policy implementation barriers. The dual-layered data approach, inclusion of hill ULBs with topographical and logistical constraints, and real-time observation of municipal vulnerabilities make this study more comprehensive in scope and practical relevance, offering novel, replicable insights into residential BMW management beyond the descriptive focus of earlier research.

Residential BMW disposal challenges

The study reveals significant challenges in residential BMW disposal across urban centers of Himachal Pradesh, with 68% of surveyed households reporting that they routinely mix BMW, such as used syringes, expired medications, and PPE, with general household garbage. The three most frequently cited reasons include lack of awareness regarding BMW

Table 4: Prevalence and drivers of BMW mixing across ULBs

ULB	% Households Mixing BMW	Primary Reason	Common BMW Items Discarded
Shimla	58%	No separate bins	Syringes, expired drugs
Solan	72%	Lack of awareness	PPE, soiled dressings
Dharamshala	65%	Tourist waste influx	Medicine strips, gloves
Mandi	70%	No ULB guidelines	Used masks, bandages
Bilaspur	75%	No collection system	Blood test strips, vials

segregation rules (42%), absence of dedicated collection bins provided by ULBs (35%), and the perceived convenience of discarding BMW with regular domestic waste (23%). These behaviours point toward widespread knowledge deficits and infrastructure limitations across municipal jurisdictions. Table 4 presents the prevalence and drivers of BMW mixing across ULBs. From Table 4, it may be found that BMW mixing practices are most prevalent in smaller urban centers such as Bilaspur (75%) and Mandi (70%), where enforcement of BMW segregation norms remains weak and dedicated collection systems are absent. In contrast, Shimla, with comparatively better service infrastructure, records a lower but still substantial mixing rate of 58%. Solan shows the second-highest incidence (72%), largely attributed to a lack of public awareness. Tourist-intensive regions such as Dharamshala face seasonal spikes in BMW generation and mixing, complicating waste stream management. Across all ULBs, the commonly discarded biomedical items include syringes, expired medications, PPE, and soiled materials, underscoring both household health risks and the strain placed on general waste disposal systems. These findings indicate an urgent need for targeted public education campaigns, infrastructure investment, and localized enforcement mechanisms tailored to the specific contexts of each municipality. The annual report of CPCB (2020) identified that only 40.2% of BMWs across urban India were being treated or disposed of through authorized channels, with non-bedded healthcare sources such as households and clinics contributing significantly to untracked BMW generation. The report further noted that 27 out of 35 state pollution control boards failed to ensure compliance with the BMW Management Rules (2016) among smaller ULBs. CPCB (2020) also highlighted the surge in unregulated household waste, particularly during the COVID-19 quarantine and treatment phases, recommending separate

collection protocols for items like masks, gloves, and disinfectant containers, which were largely absent across surveyed ULBs. Devi *et al.*, (2019) observed that even institutional setups like hospitals reported 23% of their BMW entering general municipal bins due to segregation failure and poor internal monitoring, revealing a systemic pattern that has since extended into decentralized residential sources. The convergence of current field data with national reporting reinforces the critical gap between policy design and enforcement, especially within municipalities lacking robust institutional capacity and public engagement mechanisms.

Role of informal waste pickers in urban areas

Interviews with 10 frontline waste handlers across five ULBs revealed significant vulnerabilities in BMW management at the operational level. Fig. 4 illustrates the major health risks encountered during BMW handling in urban areas. It outlines common exposure pathways such as direct contact with infectious materials and needle-stick injuries, identifies key systemic deficiencies including the absence of PPE and safety training, and visualizes the widespread informal recycling of medical waste. The Fig. 4 emphasizes the heightened vulnerability of informal workers due to a lack of regulation, oversight, and institutional support. It may be observed from Fig. 4 that 62% of sanitation workers experienced injuries related to BMW handling, primarily needlestick incidents and infections. About 28% lacked access to personal protective equipment, while 10% remained unaware of health hazards linked with BMW exposure. Residential biomedical items such as syringes, soiled dressings, and expired pharmaceuticals frequently appeared mixed with general household waste, reflecting poor segregation. Informal activities involving manual sorting and unauthorized recycling of medical waste, such as repurposing discarded medicine strips and reusing contaminated protective gear,

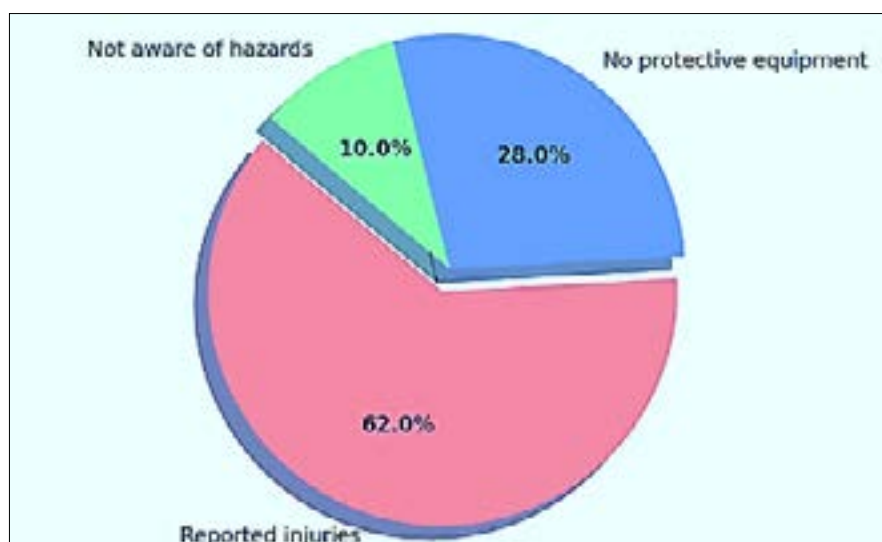


Fig. 4: Health hazards and exposure pathways in informal BMW handling by waste workers

remained widespread, heightening pathogen exposure risk. Reported a 73% injury prevalence among Indian waste workers, with less than half consistently using protective equipment and few aware of post-exposure prophylaxis procedures. [Sahai \(2023\)](#) found that over 65% of informal waste handlers in urban slums experienced injuries or infections linked with unsegregated BMW, with only one-third accessing any safety training or protective gear. These earlier studies highlight occupational exposure and safety gaps. This study adds new dimensions by identifying specific high-risk behaviours such as unregulated recycling of contaminated materials and quantifying the combined burden of injury, lack of protection, and awareness shortfalls within the same workforce. Findings emphasize a neglected work environment, demanding structured safety training, reliable PPE availability, strict segregation enforcement at source, formal inclusion of informal workers within regulated frameworks, and strengthened oversight of handling practices.

Urban management challenges faced by ULBs

The study highlights critical regulatory gaps in the management of residential BMW across ULBs, revealing that 72% of ULBs lacked specific guidelines addressing residential BMW, which has led to widespread unregulated disposal practices. [Table 5](#) presents the identified policy gaps and challenges in residential biomedical waste management within urban local bodies.

From [Table 5](#), it could be noted that enforcement mechanisms are notably weak, with only 15% of cases involving penalties for improper disposal, indicating a lack of deterrence and accountability. [Sarkar \(2023\)](#) found that enforcement actions in Shimla and Solan remained limited, with just 18% of violations resulting in formal penalties, while overall compliance with segregation norms hovered below 40%. Furthermore, the BMW Management Rules (2016) explicitly exclude household waste, creating a legal vacuum that leaves residential waste outside the ambit of regulatory oversight. The only partial mandate for segregation is observed in Shimla, with other ULBs failing to enforce such critical practices, contributing to high levels of waste mixing and increasing the risk of environmental and public health hazards. The novelty of this finding lies in its focused identification of household-level regulatory blind spots within an otherwise structured BMW policy landscape. To address these issues, the study recommends amending the BMW Rules (2016) to include residential sources, introducing clear operational guidelines for ULBs, and implementing stringent enforcement with progressive penalties ([Alzghoul et al., 2022](#)). These actions are vital to closing policy gaps, enhancing compliance, and ensuring safe waste segregation and disposal at the household level. The inference drawn emphasizes that policy reform, backed by enforcement and public sensitization, is central to sustainable residential BMW management.

Table 5: Policy gaps in BMW management

Policy Aspect	Status in ULBs	Impact
Residential BMW rules	Absent (72%)	Unregulated disposal
Segregation mandates	Partial (Shimla only)	High mixing rates
Enforcement mechanisms	Weak (15% fines imposed)	Low compliance

Financial and infrastructural constraints

Fig. 5 represents the breakdown of key financial and infrastructural barriers. It could be noted from Fig. 5 that inadequate budget allocation emerges as the foremost challenge (30%), followed by lack of specialized equipment (25%), insufficient trained staff (20%), poor maintenance of infrastructure (15%), and limited access to technology (10%), all of which collectively hinder effective and sustainable waste management. This study uniquely quantifies these constraints, highlighting the significant impact of financial and resource deficiencies on waste management systems. In line with this, 80% of ULBs cited insufficient funds specifically for BMW collection. Only Shimla had a dedicated BMW treatment facility, while others relied on common incinerators. Collection frequency also varied significantly, with daily collection in Shimla compared to monthly in Bilaspur. Geographic and logistical barriers further complicate waste management in hilly cities. Transport costs are 30-40% higher in these areas, 40% of ULBs reported zones inaccessible during monsoons, and waste vehicles unsuitable for steep terrain in 55% of cases. These challenges disproportionately affect smaller ULBs, which struggle due to limited budgets and difficult terrain, while tourist influxes strain systems in Shimla and Dharamshala. Goswami *et al.*, (2021) emphasize that during the COVID-19 pandemic, BMW volumes surged dramatically, exposing the vulnerabilities of existing infrastructure and resource constraints, thereby intensifying the need for enhanced budget allocations and capacity building. Sharma *et al.*, (2023) highlight that adequate funding and technological investments are critical for circular economy initiatives and effective waste management, underscoring the global relevance of financial and infrastructural support. The findings imply that without sufficient funding and investment in technical and human resources, sustainable waste management remains difficult. Increasing budget allocations focused on equipment upgrades and staff capacity building, implementing regular in-

frastructure maintenance, and improving access to advanced technologies are essential. Addressing geographic and logistical barriers through tailored vehicle designs and improved transport strategies will also enhance operational efficiency, regulatory compliance, and overall system resilience.

ULB expenditure on waste management

ULBs allocate a significant portion of their municipal budgets to waste management; however, expenditure patterns reveal inefficiencies and imbalances. A large share of funds is often directed toward collection and transportation, while minimal investment is made in waste processing, segregation infrastructure, or public awareness campaigns. This skewed allocation limits the effectiveness of waste management systems and perpetuates reliance on landfilling and informal disposal practices. In many ULBs, there is no dedicated budget line for handling BMW, particularly from residential sources, reflecting its low priority in planning. The lack of financial provisioning for capacity building, monitoring, and enforcement further undermines the sustainability of waste management programs. Optimizing expenditure through targeted investments in segregation systems, decentralized processing units, and community engagement can significantly enhance operational outcomes and compliance with waste management regulations. Fig. 6 illustrates the percentage allocation of BMW management budgets across five urban centers: Shimla (62%), Solan (12%), Dharamshala (12%), Mandi (10%), and Bilaspur (8%), with an average benchmark of 13.4%. The results reveal significant disparities in municipal budget prioritization, with Shimla receiving disproportionately higher funding, while other cities remain under-resourced. This novel insight addresses previous research gaps that focused primarily on institutional frameworks without quantifying municipal investment disparities in BMW governance. Sarkar (2023) highlights similar challenges within urban governance in Indian hill states, emphasizing that

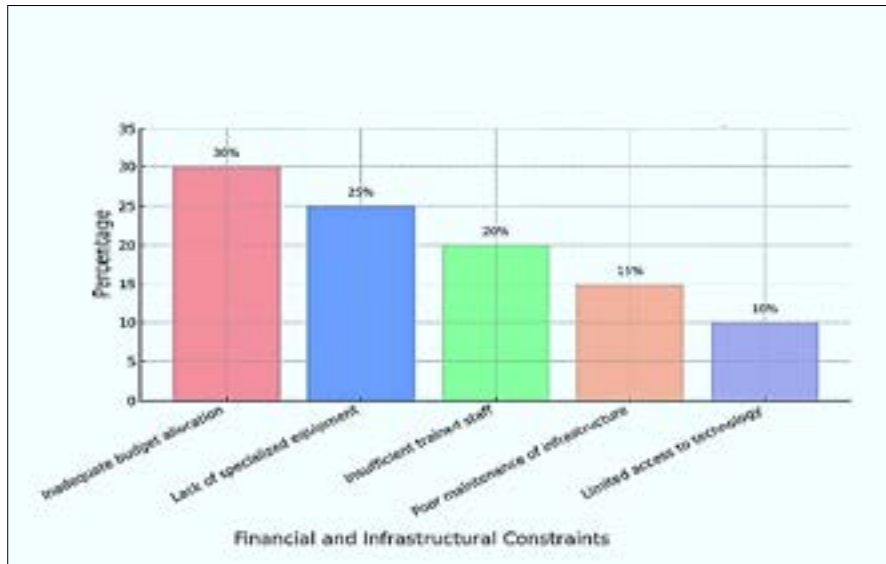


Fig. 5: Key financial and infrastructural barriers



Fig. 6: ULB expenditure on waste management

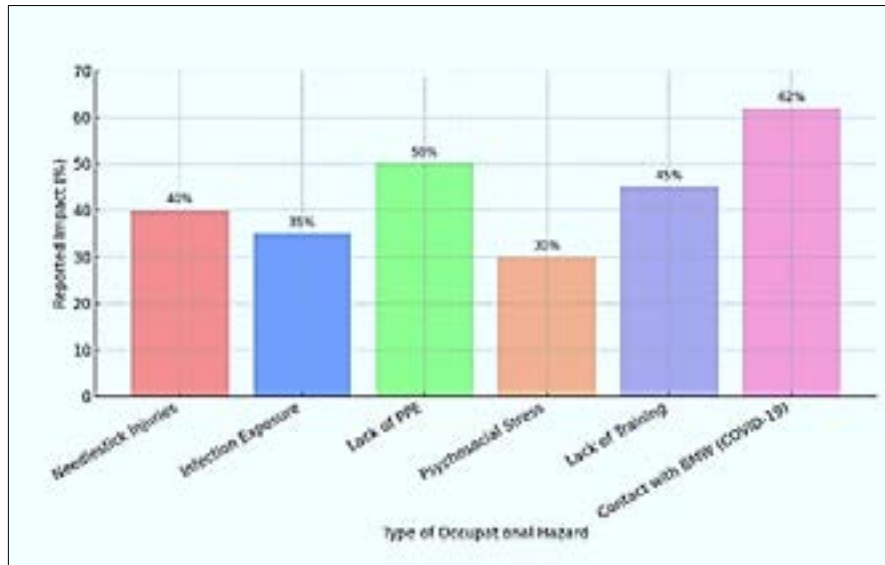


Fig. 7: Occupational hazards faced by sanitation workers in urban BMW management

unequal resource distribution undermines effective waste management, particularly in smaller ULBs such as Solan and Mandi. [Goswami et al., \(2021\)](#) note that the COVID-19 pandemic intensified the demand for robust BMW management infrastructure, revealing inadequacies in budgetary provisions and necessitating urgent policy reforms. [Sharma et al., \(2023\)](#) policy highlights reinforce the importance of equitable and data-driven budget allocations to support circular economy principles and efficient waste management. The inference highlights systemic inequities, where financial constraints at the municipal level contribute to insufficient waste segregation, disposal inefficiencies, and heightened occupational risks for waste workers. Addressing these gaps necessitates policy interventions advocating equitable budget allocations, structured financial planning, and standardized funding models across municipalities to optimize BMW management outcomes. Additionally, recommendations emphasize data-driven investment strategies integrating epidemiological trends and waste burden assessments to ensure proportional budget distribution aligned with urban BMW generation rates ([Banal and Abad, 2025](#)).

Public health risks in urban settings

Sanitation workers, including waste collectors, street sweepers, and ragpickers, form the frontline of BMW management in urban areas, yet they operate

under hazardous and often overlooked conditions. In the absence of formal segregation systems, these workers are routinely exposed to improperly disposed biomedical materials such as used syringes, contaminated personal protective equipment (gloves, masks, gowns), sharps (needles, scalpels), and expired medications. This direct exposure significantly increases their risk of occupational injuries and infections. As shown in [Fig. 7](#), sanitation workers face a range of occupational hazards, including needlestick injuries, infection exposure, lack of PPE, psychosocial stress, inadequate training, and frequent direct contact with BMW during emergencies like the COVID-19 lockdown. From [Fig. 7](#), it may be noted that needlestick injuries are particularly common due to the frequent mis-handling of mixed waste containing sharps, while prolonged contact with infectious waste elevates the likelihood of contracting serious diseases such as Hepatitis B and C, Human Immunodeficiency Virus (HIV), and various bacterial infections. Report that 58% of urban sanitation workers faced needlestick injuries, with 35% lacking access to adequate PPE, corroborating the high vulnerability of this workforce. A major concern is the lack of personal protective equipment, as many municipal workers report inadequate or irregular supply of essential items like gloves, boots, and face shields. Furthermore, most workers lack proper training in BMW handling procedures and risk mitigation strategies, leaving them ill-equipped to

protect themselves in dangerous environments. The WHO (2022) emphasizes that comprehensive training and consistent PPE provision reduce infection risks among healthcare and waste workers, underscoring a critical gap in current urban waste management practices. The psychological burden is equally concerning, as workers often face stigma, poor working conditions, and emotional stress, which contribute to low job satisfaction and mental health challenges. A critical finding from the study revealed that over 62% of surveyed workers in Shimla and Solan reported direct contact with suspected BMW mixed in household garbage during the COVID-19 lockdown phases, highlighting the urgent need for improved safety protocols, training, and institutional support for these essential yet vulnerable members of the urban waste management workforce.

Community exposure to infectious waste

Public health risks linked with BMW extend beyond occupational settings; they significantly affect community environments due to improper disposal practices. Unregulated dumping of infectious materials near residential areas has become a serious environmental and epidemiological concern. Many urban localities see households disposing of items such as used masks, blood-stained cotton swabs, insulin syringes, and expired medications into open municipal bins or roadside piles without segregation or containment. These materials often remain exposed for long periods, allowing direct human contact and environmental contamination. A particularly hazardous practice observed in several communities involves the open burning of BMW near residential dwellings. This releases harmful pollutants such as dioxins, furans, and particulate matter into the air, posing respiratory hazards and increasing long-term health risks, including carcinogenic effects. Samad et al., (2019) documented significant groundwater contamination from BMW leachate in urban India, highlighting the extended environmental and public health implications of improper waste disposal practices. Additionally, informal scavenging involving children, rag pickers, and stray animals results in the handling and redistribution of infectious waste. These secondary transmission pathways increase the likelihood of disease spread within communities, especially in high-density or low-income settlements with limited access to healthcare and sanitation infrastructure. Sahai (2023)

emphasizes that public health risks escalate sharply in urban slums due to unsegregated BMW mixing with MSW, exposing vulnerable populations to infectious agents and toxic substances. Scientific evidence shows that even low-level, chronic exposure to BMW through air, water, soil, or direct contact exacerbates public health vulnerabilities. Risks rise during health crises such as the COVID-19 pandemic when household BMW volumes increase substantially and conventional disposal systems become overwhelmed (Samadi Foroushani et al., 2024). Without systematic waste segregation, public awareness campaigns, and community-level safeguards, populations remain at heightened risk of exposure to pathogens and hazardous substances embedded within improper BMW management.

Health implications for communities

Burning BMWs releases tiny particulate matter along with highly toxic chemicals such as dioxins, which become suspended within the air, creating a hazardous environment for nearby residents. Continuous exposure can lead to respiratory problems, aggravate existing lung conditions, and increase vulnerability to lung infections. The pollution also contributes to the overall degradation of air quality, affecting community health beyond the immediate vicinity of burning sites. Leachate produced from open dumps carries harmful substances that seep through soil and reach local water bodies, posing severe threats to aquatic life and humans relying on these sources for drinking, cooking, or bathing. Pollutants can accumulate, causing disruptions to ecological balance and introducing pathogens capable of causing various diseases. Residents living near unmanaged dumps often experience higher rates of respiratory illnesses such as asthma and bronchitis, as pollutants released through waste degradation and open burning irritate respiratory tracts and compromise immune defenses. Vulnerable groups, including children, elderly individuals, and those with pre-existing conditions, suffer disproportionately. During pandemic situations, improper disposal of household items significantly worsens viral transmission, with contaminated items like used masks or tissues acting as fomites that enable disease spread through surface contact. When disposal systems become overwhelmed, infectious materials accumulate uncontained within communities, increasing the

chances of outbreaks and prolonging infection cycles. The WHO (2022) highlights that poor BMW management contributes to increased exposure to pathogens and environmental toxins, exacerbating community health burdens. Goswami *et al.*, (2021) emphasize that the COVID-19 pandemic intensified BMW volumes, overwhelming existing systems and escalating public health hazards. These statistics underscore the direct health impacts of improper waste handling at the community level and highlight the urgent need for effective waste management practices, increased public awareness, and infrastructure improvements aimed at reducing exposure risks and promoting safer environments.

Case studies

Case study 1: Pilot interventions in Shimla and Solan ULBs

Addressing challenges related to residential BMW disposal and the resulting public health risks, two ULBs, Shimla and Solan, initiated pilot programs between 2022 and 2024 focused on sustainable waste management practices (Sharma and Acharya, 2019).

- i. *Objective:* The intervention aimed at improving household-level BMW disposal through scheduled pickups, ensuring segregation at the source and safe handling during transport, thereby reducing exposure risks and supporting sustainable waste management.
- ii. *Implementation:* Electric vans fitted with dual compartments to separate infectious from general waste were introduced. These vehicles incorporated Global Positioning System (GPS) tracking and digital record-keeping to monitor participation across households disposing BMW. Municipal staff received specialized training and used PPE while collecting sealed BMW bags, ensuring worker safety and compliance with health protocols.
- iii. *Outcomes:* The pilot engaged over 1,500 households in Shimla and more than 900 in Solan. Proper segregation compliance rose from 12% to 48% over six months, reflecting improved residential disposal practices. No needlestick injuries occurred among operators, highlighting enhanced safety measures.
- iv. *Challenges:* Initial resistance stemmed from stigma and concerns about identification associated with BMW disposal at the household

level. Operational difficulties emerged due to narrow streets and challenging hilly terrain, complicating consistent collection efforts and limiting scalability.

- v. *Positive highlight:* Despite challenges, the mobile collection units significantly advanced safe BMW disposal, fostering better collaboration between urban authorities and residents. Regular engagement through scheduled pickups contributed to increased awareness and strengthened trust, supporting long-term sustainability goals.

Case study 2: Impact of the “3E (education, engineering, enforcement) strategy”

A holistic intervention known as the “3E Strategy” was launched alongside other initiatives, aiming at behavioural and systemic transformation related to residential BMW disposal (Ravindra *et al.*, 2023).

- i. *Education:* Community awareness drives utilized pamphlets, murals, local Frequency Modulation (FM) radio broadcasts, and school programs that engaged children as “waste ambassadors.” Workshops conducted with Resident Welfare Associations (RWAs) further encouraged community participation and knowledge sharing.
- ii. *Engineering:* Implementation included installation of dedicated BMW drop boxes within housing societies, introduction of color-coded household bins with yellow designated for BMW, and distribution of puncture-proof sharps containers specifically for diabetic patients.
- iii. *Enforcement:* A penalty system addressed households repeatedly mixing BMWs, while compliant housing clusters received rewards. Monthly audits and inspections conducted by health officials ensured ongoing adherence and accountability without creating hostility among residents.
- iv. *Outcomes:* The 3E Strategy yielded significant improvements across multiple metrics related to residential BMW management (Table 6). The percentage of households practicing proper segregation increased markedly from 11% before the intervention to 52% after, demonstrating nearly fivefold improvement in compliance. Complaints about mixed

Table 6: Impact measurement of the 3E strategy

Metric	Pre-intervention	Post-intervention
% of households with segregating BMW	11%	52%
Complaints about mixed waste	84/month	21/month
Reported waste worker injuries	19/quarter	2/quarter
BMW collected (kg/month)	120 kg	490 kg

waste disposal decreased sharply from 84 per month to 21 per month, indicating enhanced behavioural change and better adherence to segregation protocols. Reported injuries among waste workers declined dramatically, dropping from 19 injuries per quarter pre-intervention to only 2 per quarter post-intervention, reflecting the effectiveness of engineering controls such as puncture-proof sharps containers and enforcement of safe disposal practices. The total amount BMW collected increased substantially, from 120 kilograms (kgs) monthly before the strategy began to 490 kgs monthly afterward, suggesting improved reporting, collection efficiency, and community participation.

These results confirm that the 3E Strategy, combining education, engineering solutions, and enforcement measures, creates a synergistic effect, significantly improving residential BMW disposal practices. The approach enhances community ownership and accountability, strengthens institutional capacity, and supports sustainability without generating hostility. Positive changes observed within Shimla and Solan ULBs demonstrate the model's potential scalability and replication across similar urban settings facing public health and sustainability challenges associated with BMW.

The findings on residential BMW disposal practices in urban Himachal Pradesh can be theoretically understood through the lens of social practice theory and institutional governance frameworks. The widespread mixing of BMW with MSW (68% of households) reflects a systemic disconnect between waste management infrastructure and daily household practices. Social practice theory helps explain this phenomenon through its triad of materials, competences and meanings - where the absence of segregated bins (material dimension), lack of awareness about proper disposal (competence gap), and normalization of convenient mixing (social meaning) collectively sustain

improper disposal behaviours. This situation mirrors Giddens' (1984) concept of the sequestration of risk, where households become unwitting risk producers while remaining detached from the consequences of their waste disposal choices. The hazardous conditions faced by informal waste pickers (89% encountering BMW daily, 62% reporting injuries) exemplify structural violence theory, revealing how urban waste systems systematically externalize risks onto marginalized labour forces. This creates a paradox where the very workers ensuring urban cleanliness bear disproportionate health burdens, reflecting neoliberal urban governance models that prioritize service delivery over worker protection. The urban management challenges faced by ULBs demonstrate critical gaps in institutional theory applications. The policy vacuum around residential BMW (absent in 72% of ULBs) reveals institutional isomorphism, where waste management systems mimic hospital-centric models without adapting to household contexts (Olusunmade, 2019). Financial constraints (reported by 80% of ULBs) align with resource dependency theory, showing how limited fiscal autonomy creates implementation bottlenecks. The geographic barriers in hilly terrain illustrate concepts from urban political ecology, where natural landscapes mediate urban service delivery through spatial mismatches and climate vulnerabilities. These interconnected challenges reflect multi-level governance failures, where disjointed policy frameworks, inadequate resource allocation, and geographical constraints collectively undermine waste management systems. The findings highlight a critical need for governance models that bridge institutional design with ground-level social practices, particularly in ecologically sensitive urban areas where conventional waste management approaches prove inadequate. This theoretical synthesis underscores the importance of developing context-specific frameworks that account for both the social production of waste behaviours and the institutional constraints shaping urban service delivery.

The results and discussion from this investigation into residential BMW disposal practices across urban centers in Himachal Pradesh reveal critical gaps in awareness, infrastructure, regulatory frameworks, and occupational safety that contribute to significant public health and environmental risks. Persistent mixing of hazardous BMW with general waste, inadequate enforcement of segregation norms, and insufficient budget allocations exacerbates contamination and exposure, particularly in smaller ULBs with limited resources. Occupational hazards faced by sanitation workers, including frequent needlestick injuries, lack of personal protective equipment, and psychosocial stress, further highlight systemic neglect within waste management systems. Informal practices such as open burning and scavenging amplify community vulnerabilities, especially among marginalized populations. The study's integration of quantitative and qualitative data from household surveys, stakeholder interviews, and field observations provides novel insights into financial disparities, regulatory blind spots, and behavioural inconsistencies not fully addressed in prior research. These findings emphasize the urgent need for holistic, multi-level interventions encompassing policy reform, targeted public education, infrastructural investment, equitable budget distribution, and enhanced occupational health protocols to improve residential BMW management and mitigate associated risks.

Synthesis of findings and policy implications

This study systematically examined residential BMW management and associated urban governance challenges in Himachal Pradesh, revealing critical risks to public health and sanitation workers. Findings indicate that 68% of households mix BMW with general waste, primarily due to lack of awareness (42%), absence of dedicated bins (35%), and convenience (23%), with commonly discarded items including syringes, PPE, and expired medications. This unsafe disposal exposes communities to infectious waste and environmental contamination. Occupational hazards are substantial, as 89% of sanitation workers encounter BMW daily and 62% report injuries, including needle-stick incidents, while only 10% are aware of the hazards, and 28% lack proper PPE. Governance gaps exacerbate these risks: 72% of ULBs lack specific residential BMW guidelines, and

only 15% enforce penalties, with financial and infrastructural constraints such as limited budgets, inadequately trained staff, and poor maintenance further hindering effective management. Improper disposal consequently contributes to increased respiratory and vector-borne diseases. The study also highlights successful pilot interventions, including mobile BMW collection units in Shimla and Solan and the "3E Strategy", which improved segregation compliance, reduced health risks, and enhanced community engagement, demonstrating scalable solutions for sustainable management. As one of the first studies to quantify residential BMW practices, occupational hazards, and governance gaps in this ecologically sensitive region, it provides evidence-based insights and emphasizes that integrated strategies combining policy reform, public awareness, infrastructure development, and occupational safety are essential for effective, sustainable biomedical waste management and public health protection.

Superiority of the present study

This study advances the existing body of knowledge on residential BMW management by providing a comprehensive, multi-city investigation across diverse urban centers in Himachal Pradesh, incorporating both household surveys (n=800) and stakeholder interviews (n=42). Unlike previous studies that predominantly focused on isolated aspects such as awareness or singular urban contexts ([Samad et al., 2019](#); [Devi et al., 2019](#)), this research uniquely integrates behavioural, infrastructural, and regulatory dimensions to holistically assess inefficiencies in decentralized BMW disposal. The inclusion of field observations and municipal worker safety assessments further distinguishes this study, addressing critical gaps related to occupational hazards and informal waste handling practices, as highlighted by [Sahai \(2023\)](#). Moreover, the study provides empirical evidence on the inadequacies of current regulatory frameworks at the household level and quantifies budgetary disparities among ULBs, adding novel insights to governance challenges that were not explicitly quantified in prior research ([Sarkar, 2023](#)). This comprehensive approach underscores the complex interplay between behavioural, institutional, and infrastructural factors, thereby offering a robust foundation for targeted policy and operational reforms.

Challenges and limitations of the study

Despite providing valuable insights into residential biomedical waste management, the study has several limitations that should be considered when interpreting the findings.

1. *Limited geographic scope:* This study focuses on Himachal Pradesh, which may limit the generalizability of the findings; however, the insights are valuable for understanding residential BMW challenges in ecologically sensitive and hilly regions and can inform research in similar contexts.
2. *Exclusion of rural areas:* Although rural households were not included, the methodology and pilot interventions presented here can be adapted to rural settings to address similar or unique biomedical waste disposal challenges.
3. *Long-term evaluation of pilot interventions:* Pilot interventions were assessed over a limited period; however, initial results indicate improved waste segregation, reduced occupational hazards among sanitation workers, and enhanced community engagement, providing a basis for evaluating long-term sustainability and potential scalability.
4. *Short-term evaluation of pilot interventions:* While the pilot interventions were assessed over a limited period, initial results indicate improved waste segregation, reduced occupational hazards, and enhanced community engagement, providing a foundation for longer-term evaluation and potential scaling.
5. *Financial constraints:* Although the study does not provide detailed solutions for budgetary limitations, it emphasizes data-driven planning and scalable low-cost interventions, which can help smaller ULBs manage residential BMW more effectively.
6. *Limited stakeholder representation:* Although only 42 stakeholders were interviewed, the data provide valuable insights from municipal staff, informal waste workers, and policy-makers; future studies could include broader stakeholder representation for more comprehensive perspectives.
7. *Absence of comparative analysis:* While this study does not compare Himachal Pradesh's practices with other Indian states or international models, it establishes a detailed base-

line on residential BMW management, occupational hazards, and governance gaps that can inform future comparative studies.

Recommendations

To address the multidimensional challenges identified, several strategic actions are imperative:

- i. *Policy reform and enforcement:* Amend the Bio-medical Waste Management Rules (2016) to explicitly include residential sources, as 68% of households currently mix biomedical waste with general waste. Establish clear household-level segregation protocols and mandate accountability mechanisms for urban local bodies, 72% of which lack specific residential BMW guidelines and only 15% enforce penalties. Coupling policy amendments with progressive enforcement will help close regulatory gaps and institutionalize compliance.
- ii. *Awareness and behavioural change:* Launch sustained public awareness campaigns to address the primary driver of improper disposal, with 42% of households citing lack of awareness and 23% convenience as reasons for unsafe practices. Community-based IEC initiatives and the "3E Strategy" (Education, Engineering, Enforcement) piloted in Shimla and Solan, which demonstrated measurable improvements in segregation compliance, should be scaled across smaller urban centers to normalize safe disposal behaviours.
- iii. *Infrastructure development and investment:* Strengthen collection and treatment systems by addressing the absence of dedicated BMW bins in 35% of households and expanding mobile BMW collection units that have proven effective in pilot interventions. Investment in incinerators, autoclaves, and deep burial systems is needed to overcome financial and infrastructural constraints frequently reported by ULBs. Infrastructure planning must also consider region-specific challenges such as hilly terrains and seasonal tourist influx.
- iv. *Occupational safety enhancements:* Prioritize the protection of sanitation workers, 89% of whom encounter BMW daily and 62% of whom report injuries, primarily needle-stick incidents. Training programs, coupled with consistent provision of PPE currently lacking

for 28% of workers, should be institutionalized. Formal integration of informal waste handlers into regulated municipal systems can further reduce exposure risks and improve overall waste-handling efficiency.

- v. *Data-driven governance and planning*: Improve decision-making by embedding data analytics into BMW management. GIS mapping, real-time monitoring, and waste audits can guide resource allocation, while epidemiological data on respiratory and vector-borne diseases linked to poor disposal practices can inform prioritization of interventions. Such evidence-based approaches will enhance operational efficiency, improve transparency, and strengthen the resilience of BMW systems in ecologically sensitive regions.

Future scope

Building upon the findings, future research should explore longitudinal studies to monitor behavioural and institutional changes following policy interventions, assessing their sustained impact on public health outcomes. Investigations into the efficacy of community-based decentralized BMW treatment technologies and their scalability in hilly terrains would provide practical insights. Additionally, socio-economic analyses of informal waste workers' integration into formal systems could inform socially inclusive waste governance models. Finally, expanding the geographic scope beyond Himachal Pradesh to other Indian hill states or similar settings internationally would enhance generalizability and foster comparative policy development.

CONCLUSIONS

This study provides a comprehensive examination of residential BMW disposal practices and the challenges faced by ULBs in Himachal Pradesh, India. Through a combination of household surveys, stakeholder interviews, and analytical mapping of urban waste flows, the study reveals critical gaps in waste segregation, infrastructure, and policy enforcement. Findings highlight that most urban households dispose of items such as syringes, expired medicines, and PPE along with general MSW, mainly due to a lack of awareness and inadequate systems for collection and disposal. ULBs face multilayered challenges, including outdated policy frameworks, insufficient

technical capacity, and limited funding, all exacerbated by the geographic complexities of hilly terrains. The study also brings to light significant public health risks, with sanitation workers frequently exposed to infectious materials without proper protection, and communities facing secondary exposure through open dumps or incineration. Pilot interventions in Shimla and Solan, such as mobile BMW collection units and the "3E Strategy", demonstrated measurable success. These efforts improved waste segregation compliance, reduced health risks, and increased community engagement, offering a scalable model for sustainable urban BMW management. In conclusion, effective management of residential BMW in urban areas requires a multi-pronged approach: policy reform, targeted public education, infrastructure upgrades, and decentralized enforcement mechanisms. This research emphasizes the urgency of embedding BMW governance within broader public health and sustainability frameworks, especially in environmentally sensitive regions like Himachal Pradesh. The outcomes not only inform urban policymakers but also contribute to a resilient, inclusive waste management paradigm necessary for safeguarding human and environmental health in India's urban future.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to all participants and contributors who generously supported this study with their time and valuable insights. Their cooperation played a crucial role in enriching the quality and depth of the research. The authors also carefully reviewed and refined the final manuscript to ensure its scientific rigor and contextual relevance.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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ABBREVIATIONS (NOMENCLATURE)

<i>BMW</i>	Bio-Medical Waste
<i>CPCB</i>	Central Pollution Control Board
<i>FM</i>	Frequency Modulation
<i>GIS</i>	Geographic Information System
<i>HIV</i>	Human Immunodeficiency Virus
<i>MSW</i>	Municipal Solid Waste
<i>MSW</i>	<i>Municipal Solid Waste</i>
<i>NGOs</i>	Non-Government Organizations
<i>PPE</i>	Personal Protective Equipment
<i>RWAs</i>	Resident Welfare Associations
<i>SBM</i>	Swachh Bharat Mission
<i>SDGs</i>	Sustainable Development Goals
<i>SWM</i>	Solid Waste Management
<i>SWOT</i>	Strengths, Weaknesses, Opportunities, and Threats
<i>ULB</i>	Urban Local Body

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HOW TO CITE THIS ARTICLE

NITHIANANTHAN, K.; MANVENDRA S., (2026). *Challenges in residential biomedical waste disposal and urban governance for sustainable public health management*. *Int. J. Hum. Capital. Urban Manage.*, 11(3): 509 - 532.

DOI: 10.22034/IJHCUM.2026.03.05

URL: https://www.ijhcum.net/article_736144.html



International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: <http://www.ijhcum.net/>

ORIGINAL RESEARCH ARTICLE

Human capital-driven leisure choices: Assessing purchase intentions for recreational products among the elderly population

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ARTICLE INFO

Article History:

Received 14 September 2025

Revised 10 November 2025

Accepted 16 December 2025

Keywords:

Aging society; Consumer behavior; Emotional attachment; Healthy aging

ABSTRACT

BACKGROUND AND OBJECTIVES: Thailand's population is aging rapidly, so it is important to develop more creative toys to enhance the purchase intention of elderly people. Moreover, Thailand has fewer recreational toys than other countries. This study shows how psychological, conceptual, and environmental factors impact older people's purchase of recreational toys.

METHODS: Using three theories, such as Planned Behavior, Flow Theory, and Theory of Successful Aging, a quantitative survey was conducted with 196 caregivers in Bangkok. Due to utility, quality, enjoyment, and accessibility, elderly people have continuously purchased these recreational toys. They feel a personal connection to the toys.

FINDINGS: Trust is an important factor in consumer decision-making, involving both direct and indirect effects, while emotional connection is one of the main reasons for purchasing and has the largest effect ($\beta = 0.42$). On the other hand, price sensitivity has negative effects ($\beta = -0.15$) because of the high cost, causing elderly people to hesitate to buy toys. This model explains the variance of purchase intention ($R^2 = 0.67$) with 66%, which is predicted by a robust mechanism. This mechanism shows that older caregivers' focus shifts from practical evaluations to relational factors. Elderly individuals in Thailand show purchase patterns driven by emotional connections and perceived utility in recreational toys, while price sensitivity often serves as a barrier. This study clarifies how factors like trust and accessibility significantly influence their buying decisions.

CONCLUSION: These findings suggest that politicians and toy company marketers should focus on gaining people's confidence, engaging them emotionally, and creating affordable, user-friendly products for elderly people in developing nations.

DOI: [10.22034/IJHCUM.2026.03.06](https://doi.org/10.22034/IJHCUM.2026.03.06)



NUMBER OF REFERENCES

30



NUMBER OF FIGURES

1



NUMBER OF TABLES

2

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the "Show Article."

INTRODUCTION

Thailand is going through a huge improvement in its population as it becomes a fully aging society. The Office of the National Economic and Social Development Council (2023) expected that in 2023, 20.2% of the population would be 60 years old or older. That number is estimated to grow to 31.4% by 2037. This change in the population is especially noticeable in Bangkok, where 22.5% of the city's residents are over the age of 65. Changes in the structure of a population's demographics will always cause problems in both physical and mental health. The Foundation for Thai Gerontology Research and Development Institute (2022) has documented an increase in changing behavior, such as loneliness, depression, and reduced social engagement, among older adults, particularly in urban environments (Carmona, 2021). It affects the health of the healthcare system, society, and the community as a whole, and also impacts the health of individuals Walzer, 2025. National and international policy frameworks have placed more focus on active participation and the mental health of older people in Thailand, as they are becoming an aging society. The World Health Organization (WHO, 2023) has pointed out how important creative and fun activities are for older adults' mental health and lowering their risk of cognitive decline. One new way to help older people is to offer them toys that are designed to help them have fun, stay mentally active, improve their physical coordination, and interact with other people. People are paying a lot of attention to these new tools because they can help people think and practice physical health more clearly, move better, and connect more easily. The value of the toy market is around \$152 billion in 2023. It is expected to grow by 6.1% per year from 2024 to 2028 (GlobeNewswire et al., 2023). Therefore, the penetration of these products is very low in Thailand's market. According to the Thai Retailers Association (2023), the market value of recreational toys for elderly people in Thailand was THB 950 million in 2022. Overall, Thailand is distinct from other countries, and one of the main reasons for this low market presence is the lack of creative products designed for elderly people. Carpenter and Yoon (2011) studied how people buy products and found a few important issues that affect older people's choices. These factors encompass perceived utility, user-friendliness, safety apprehensions, price sensitivity, and social influence. Chen and Liu (2022)

further illustrate that brand trust and emotional attachment profoundly influence purchase intentions. Demographic factors, especially education level and income, significantly influence consumer behavior, notably in urban settings such as Bangkok, where older residents are increasingly pursuing products that enhance cognitive function and facilitate social interaction (Kasikorn Research Centre, 2023). This research shows that the theoretical framework integrates three widely known theories: the Theory of Successful Aging (Rowe & Kahn, 1997), the Theory of Planned Behavior (Ajzen, 1991), and the Flow Theory (Csikszentmihalyi, 1990). This integrated approach provides a solid foundation for identifying the behavior of elderly consumers, considering their emotional, cognitive judgments, and social circumstances. The human capital rationale for the situation of purchasing recreational products for elders emphasizes the distinct value of mental and physical activities for this population group. By buying recreational toys, older people are investing not only in the product itself but also in their cognitive abilities, socialization, and overall quality of life, thus enhancing their human capital. The study emphasizes that as the population ages, older adults need to stay active and engaged to reduce issues such as loneliness and cognitive decline. This perspective views recreational toys not just as sources of pleasure but as tools for lifelong learning and active participation in life, highlighting their significant role in societal growth and personal health. From a human capital standpoint, the study underscores the long-term benefits of recreational products for both individuals and society. The integration of the Theory of Planned Behavior, the Theory of Flow, and the Theory of Successful Aging in this study provides a multi-dimensional approach to understanding the purchase intentions of elderly consumers towards recreational products. The Theory of Planned Behavior illuminates the role of attitude, subjective norms, and perceived behavioral control in shaping intentions, helping to identify the motivational factors driving purchasing decisions. Flow Theory contributes by emphasizing the emotional engagement and enjoyment that older individuals experience when using recreational products, highlighting the importance of creating fun and engaging experiences. Additionally, the Theory of Successful Aging underscores the significance of physical and mental health in successful aging, suggesting that engaging

in recreational activities can enhance quality of life and promote active aging. This theoretical integration allows for a comprehensive exploration of both cognitive and emotional factors influencing the consumer behavior of older adults, providing a holistic understanding of the dynamics at play in the consumer marketplace. This study examines the structural links between the psychological, perceptual, and environmental aspects that impact older customers' decisions to purchase recreational toys in Bangkok. The goals of this study are as follows:

1. *To investigate the price sensitivity, perceived quality, perceived utility, perceived enjoyment, perceived accessibility, and social impact that affect the older people's decisions to buy recreational toys.*
2. *To evaluate the mediating functions of brand trust and emotional attachment in the correlation between antecedent variables (e.g., perceived usefulness, enjoyment, and accessibility) and purchase intention.*
3. *To assess the comparative significance and predictive capability of each variable within the proposed structural model regarding the purchasing intentions of elderly consumers.*
4. *To give product developers, marketers, and policymakers useful advice on how to make and market recreational toys for older people in a way that meets their psychological and social needs in urban Thailand.*

MATERIALS AND METHODS

Population and sample

This research utilized a quantitative, cross-sectional study methodology to investigate the structural relationships among psychological, perceptual, and conceptual factors affecting the purchasing intentions of recreational toys for elderly individuals in Bangkok, as reported by their primary caregivers. The target population comprises fethicworking-age adult caregivers, specifically individuals aged 21 years and older, who are directly accountable for the care and welfare of elderly residents in Bangkok. Family members or formal aides had to be actively involved in decisions about and purchases of products for the elderly people they were taking care of. To maintain the conceptual clarity of the study, the criteria for

including the elderly (i.e., the care recipients) were specified as follows:

- *Must be at least 60 years old.*
- *Must live in Bangkok, a city with a high and growing number of older people.*

The reason for choosing caregivers as respondents is that they are directly involved in choosing and buying goods and services that improve the standard of living of senior people. In addition, caregivers are often gatekeepers who decide what the elderly want and make choices for them, especially when it comes to addressing technology and wellness-related goods. This research was exploratory in nature, and a non-probability convenience sample approach was employed because there was no comprehensive caregiver registration system in place. This approach enabled the researchers to effectively recruit qualified participants who satisfied the inclusion criteria and were accessible during the data acquisition phase.

Sample size determination

According to the methodological requirements of Structural Equation Modeling (SEM), the sample size was determined. Each variable requires at least 20 respondents for a stable parameter estimate and adequate statistical power (Hair et al., 1995). The suggested model includes nine observed variables, necessitating a minimum of 180 valid cases. To enhance reliability, incomplete responses are considered, and generalizability is improved. This model is sufficient for validating both the measurement and structural models within the constraints of SEM-based analysis.

Research instrument

According to widely accepted theoretical frameworks, data is collected using a structured questionnaire such as the Technology Acceptance Model (Davis, 1989), the Theory of Planned Behavior (Ajzen, 1991), and Flow Theory (Csikszentmihalyi, 1990). These concepts make it simple to understand the environmental and emotional elements that affect consumer behavior. The questionnaire was developed by academic professionals and the marketing team of a toy manufacturing producer who focuses on consumer behavior, aging research, and psychometric analysis to verify the content validity. Approximately 40 caregivers participated in the pilot testing of the instrument, and their data were included in the final dataset. All concepts and Cronbach's alpha values are

above 0.86, indicating good reliability as evaluated by internal consistency analysis (Hair et al., 2010).

Data analysis procedures

SEM was the primary technique to evaluate the structural links among latent variables. In this investigation, descriptive and inferential statistical techniques are included. Screening and processing of the data, measurement model evaluation, structural model evaluation, and mediating effects analysis are the four steps involved in analytical processes: Preliminary Data Screening and Descriptive Analysis. To verify the high quality and appropriateness that is to be used with SEM, a comprehensive data screening approach was conducted by statistical modeling. The procedures are: Analyzing the insufficient information: Inconsistencies or important items of non-response cases were eliminated. Normality assessment: For evaluating both univariate and multivariate normality, skewness and kurtosis values were used. Acceptable ranges of (± 2) are observed variables, demonstrating that the data are normally distributed (Kline, 2016). The Mahalanobis distance (D^2) was applied to find multivariate outliers. Cases above the value of $p < 0.001$ were reexamined and omitted if they were untrue. Descriptive statistics have been calculated for all demographic variables and construct items, such as frequencies, percentages, means, standard deviations, skewness, and kurtosis.

Measurement Model Validation

AMOS (version 25) was utilized for Confirmatory Factor Analysis (CFA) to examine the psychometric qualities of the latent components. The study aims to examine the multi-item measure's discriminant validity, convergent validity, and reliability. Convergent validity was determined according to the following criteria: All standardized factor loadings were statistically significant, with values above the criteria of 0.60. Every concept of the Average Variance Extracted (AVE) is equal to or greater than 0.50. The Composite Reliability (CR) values surpassed 0.70, signifying internal consistency. Discriminant validity was established through the Fornell-Larcker criterion, which demonstrated that the square root of each construct's AVE exceeded its correlations with other constructs. Cronbach's alpha was used to test internal reliability, which achieved the required level of 0.70 for all concepts, thereby confirming acceptable measurement consistency (Hair et al., 2010).

Structural model estimation

The structural model was examined to evaluate causal relationships among exogenous, mediating, and endogenous variables after validating the measurement model. The accurate estimates of parameters and robust variables used in this model are evaluated by the Maximum Likelihood Estimation (MLE) technique. To assess the model fit's adequacy, a set of goodness-of-fit indices was utilized, following the guidance of Browne and Cudeck (1993) and Arbuckle and Wothke (1999): Chi-square (χ^2): A satisfactory fit is determined by the non-significant value, though sensitivity to sample size was acknowledged. Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI): Values ≥ 0.90 were considered indicative of acceptable model fit. Goodness-of-Fit Index (GFI) and Adjusted Goodness-of-Fit Index (AGFI): Values ≥ 0.90 supported the model's adequacy. Root Mean Square Error of Approximation (RMSEA): Values ≤ 0.08 indicated a reasonable error of approximation, with values ≤ 0.05 reflecting excellent fit. Normed Chi-square (CMIN/df): Values between 1.00 and 3.00 were deemed acceptable.

Mediation analysis

Non-parametric approach provides bias-corrected confidence intervals (95%) and gets more robust indirect impacts by assuming a normal sample distribution. The mediating impact was notably important if the indirect path confidence interval is zero. Therefore, both partial and full mediation were made simple by the mediation approach, which also enhanced our understanding of the basic mechanism that impacts older consumers' plans to buy recreational goods. Final analysis of this study suggests that analytical techniques are confirmed using a theoretical model, which was examined completely. There was a robust approach for the direct and indirect link among the behavioral dimensions that adhered to the psychometric criteria. By providing a comprehensive analysis, the SEM helped for the estimation of many routes, such as by impacting the purchasing plan from the perspective of working-age caregivers. The use of convenience sampling was chosen for its efficiency and expediency in reaching the target population, which in this case was caregivers of the elderly in Bangkok. The method allowed the researcher to quickly gather data from easily accessible resources. Caregivers were recruited through community

centers, social service agencies, and senior activities programs, ensuring that they had firsthand experience with the elderly, thus enhancing the quality of the data obtained. While pilot-test respondents were used in the initial testing process to refine the survey tool, they were not included in the final sample to maintain the integrity of the results and eliminate bias. This approach ensured that the findings were representative of the broader group of caregivers providing support to the elderly. This methodology enhances the validity and reliability of the study results, providing a more accurate understanding of the purchasing intentions of elderly consumers.

RESULTS AND DISCUSSION

Among Thailand's caregivers, 196 real respondents participated in the poll. Descriptive analysis clearly shows that women are the major caregivers, accounting for 72.4% of the respondents, which aligns with Thailand's conventional view of women as caregivers. Among the younger respondents, 57.1% were between the ages of 21 and 30, and 31.6% were 31–40 years old. This indicates that younger working individuals are increasingly taking on caregiving responsibilities. The sample was well educated, with 77.6% holding a bachelor's degree, suggesting they could make informed decisions about household purchases. The occupational profile revealed that 67.3% of the respondents worked for private enterprises, indicating they lived in urban middle-class areas with stable incomes. In terms of income distribution, 34.7% of respondents earned between 15,001 and 25,000 THB per month, while 29.6% earned between 25,001 and 35,000 THB. This implies that most survey participants had sufficient disposable income to purchase recreational items for the elderly. The prevalence of intergenerational support systems in Bangkok is highlighted by the fact that 50% of respondents reported caring for their parents, followed by 32.7% for their grandparents, with the majority living separately but still providing care (50%). Additionally, nearly 34.7% of older adults were still employed in some capacity, indicating they were contributing to their families' support and reducing the need for caregivers. The analysis of latent constructs revealed that opinions on recreational toys for the elderly were predominantly favorable, with mean scores between 3.99 and 4.41 on a 5-point Likert scale. There was a lot of agreement that recreational toys could help with cognitive stimu-

lation, stress relief, and rehabilitation, with Perceived Usefulness (Mean = 4.34, $\alpha = 0.89$) being the most important of these. In the same way, toys' positive effects on family bonding and keeping them interested without getting bored were shown by Perceived Enjoyment (Mean = 4.19, $\alpha = 0.86$). The highly rated Perceived Quality (Mean = 4.25, $\alpha = 0.91$) focused on durability, safety rules, and the value of the product. There was even more support for relational and psychological constructs. Credibility and emotional connection are important parts of deciding. This is shown by the high scores for trust (Mean = 4.34, $\alpha = 0.87$) and emotional attachment (Mean = 4.38, $\alpha = 0.88$). Finally, a very high Purchase Intention (Mean = 4.41, $\alpha = 0.92$) showed that the people who answered were willing to buy recreational toys for older family members. The reliability of each construct was shown by Cronbach's Alpha values over 0.86, which proved that the measurement model was strong.

The proposed model showed a great fit with the data ($\chi^2/df = 2.15$; CFI = 0.94; TLI = 0.93; RMSEA = 0.06; GFI = 0.91), meeting the recommended thresholds for all indices. The path analysis validated all 15 proposed associations, yielding extensive insights into the direct, indirect, and cumulative effects of significant predictors (Fig. 1).

- Perceived Usefulness exhibited significant direct effects on Trust ($\beta = 0.32$), Emotional Attachment ($\beta = 0.28$), along with Purchase Intention ($\beta = 0.25$).
- Perceived Enjoyment strongly influenced Emotional Attachment ($\beta = 0.35$) along with Purchase Intention ($\beta = 0.18$).
- Perceived Quality contributed prominently to Trust ($\beta = 0.41$) along with Purchase Intention ($\beta = 0.22$).
- Price Sensitivity showed a negative relationship with Purchase Intention ($\beta = -0.15$), underscoring the impact of affordability concerns.
- Social Influence positively affected both Trust ($\beta = 0.26$) along with Purchase Intention ($\beta = 0.19$).
- Perceived Accessibility had a big impact on trust ($\beta = 0.29$) along with Purchase Intention ($\beta = 0.16$).
- Trust emerged as a significant construct, positively correlating with both Emotional Attachment ($\beta = 0.38$) and Purchase Intention ($\beta = 0.31$).

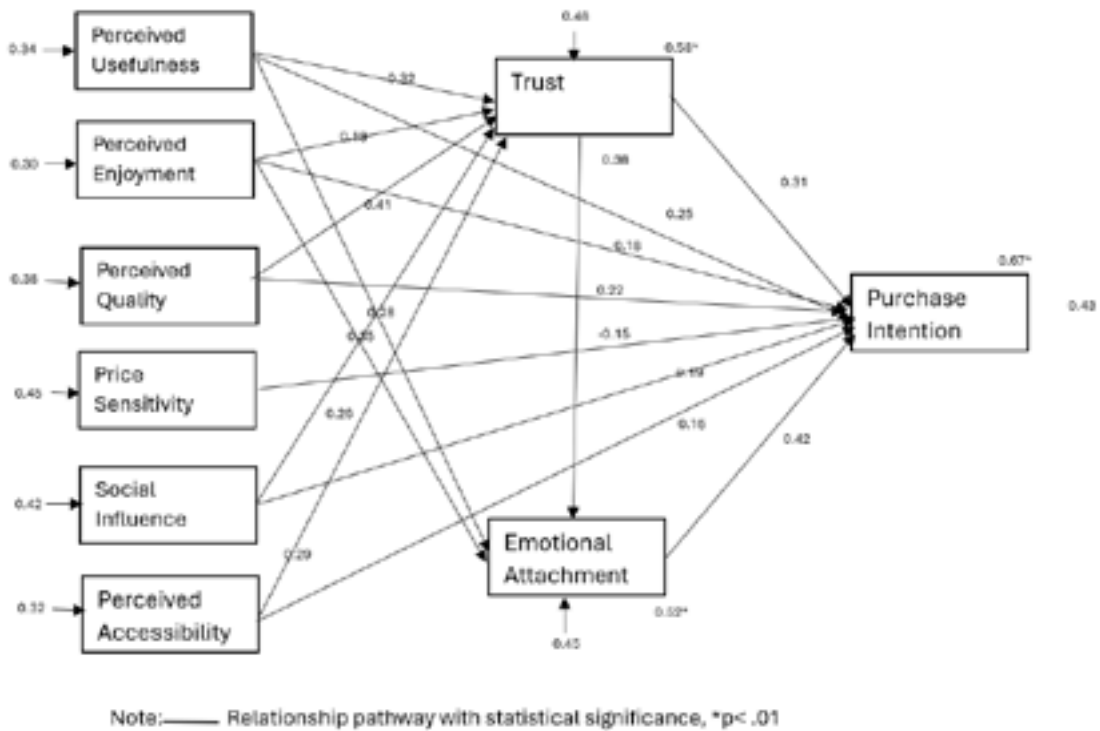


Fig. 1: Results from SEM

- Emotional attachment demonstrated the powerful and direct effect on Purchase Intention ($\beta = 0.42$), underscoring the decisive role of affective bonds.
- The explanatory capacity is stronger with 67% and the variance in purchase intention overall ($R^2 = 0.67$).

The mediation tests offered detailed insights into the indirect mechanisms that influence consumer decision-making: Trust acted as a middleman between the effects of Perceived Quality (0.127), Social Influence (0.081), and Perceived Accessibility (0.090) on Purchase Intention. Emotional Attachment acted as a mediator for Trust (0.160) and Perceived Enjoyment (0.147), converting favorable perceptions into enhanced behavioral intention. A serial mediation pathway was identified: Perceived Quality $\rightarrow$ Trust $\rightarrow$ Emotional Attachment $\rightarrow$ Purchase Intention, resulting in an indirect effect of 0.065. The psychological constructs of trust and emotional attachment function as essential transmission mechanisms linking genuine purchasing intention with perceptual evalua-

tions, as these findings underscore. The breakdown of impacts shows the hierarchy of important predictors. Trust (0.47) had the largest overall effect on purchase intention, followed closely by perceived utility (0.44) and emotional attachment (0.42). Perceived Quality (0.38) and Perceived Enjoyment (0.33) were also significant, while Social Influence (0.27) and Perceived Accessibility (0.25) had less impact. Conversely, price sensitivity (-0.15) hurt purchase intention, indicating that cost was a barrier. The findings collectively highlight that purchase intentions for recreational toys among elderly caretakers in Bangkok are influenced not only by product-related features, such as utility and quality, but also, more significantly, by psychological variables of trust and emotional attachment. Although worries about affordability persist, the data indicate that establishing trust through perceived quality and cultivating emotional ties through enjoyment and social influence are critical for consumer acceptance. This shows a shift from judgments based solely on usefulness to a model of customer behavior grounded in trust and emotion in an aging society.

Table 1: Reliability & Convergent Validity

Construct	AVE	CR	Cronbach's Alpha
Trust	0.58	0.87	0.82
Emotional Attachment	0.76	0.92	0.89
Purchase Intention	0.64	0.88	0.85
Accessibility	0.62	0.86	0.83

Table 2: Discriminant Validity (Fornell–Larcker Criterion)

(Diagonal = $\sqrt{AVE}$)

Construct	Trust	Emotional Attachment	Purchase Intention	Accessibility
Trust	0.76	0.50	0.52	0.45
Emotional Attachment	0.50	0.87	0.55	0.48
Purchase Intention	0.52	0.55	0.80	0.41
Accessibility	0.45	0.48	0.41	0.79

Tables 1 and 2 provide a summary of the psychometric properties of all constructs, including AVE, CR, and Cronbach's Alpha. AVE values represent the proportion of variance explained by the constructs compared to variance accounted for by measurement error, with values greater than 0.50 indicating sufficient convergent validity. CR measures the reliability of the constructs, with values above 0.70 indicating good internal consistency. Additionally, Cronbach's Alpha values also confirm this internal consistency, with all values exceeding the acceptable level of 0.70. The combination of these measures supports the consistency and validity of the constructs in the context of the study, ensuring that the measurement tools used are reliable. The context highlights the fact that the population of Thailand is aging rapidly and, at the same time, faces the issues of loneliness and cognitive loss among the elderly. This demographic shift requires innovative interventions that can stimulate mental and social activities, which could be facilitated through recreational toys. The study incorporates the Theory of Planned Behavior, the Flow Theory, and the Theory of Successful Aging to examine the role of emotional attachment, trust, and perceived benefits in the purchase intentions of older consumers. The research aims to correlate these theories with the perceived needs of the aging population, providing a framework that accommodates psychological and practical values to guide purchasing behavior. This relationship underscores the relevance of the study in promoting health in old age through specific recre-

ational products. This research examines the environmental, psychological, and perceptual factors that impact older people's decision to purchase recreational toys in Bangkok. These findings evaluate the effects of trust and emotional connection on purchasing behaviors and evaluations, indicating their crucial functions. These results are consistent with Morgan and Hunt's (1994) Commitment-Trust Theory, which posits that trust is fundamental to sustained relational exchange, and with subsequent empirical studies demonstrating that trust significantly enhances consumer confidence in health-related or aging-related products (Chen & Liu, 2022; Delgado-Ballester & Munuera-Alemán, 2001). A significant discovery is the robust predictive influence of emotional attachment on purchase intention. According to Thomson, MacInnis, and Park (2005), emotional connections are more important among products, which helps to build long-lasting relationships between consumers and brands. In the realm of elderly care, emotional attachment not only enhances the probability of purchase but also ensures prolonged product utilization. This finding aligns with Holbrook and Hirschman's (1982) experiential consumption perspective, highlighting hedonic value and affective experiences as essential aspects of consumer behavior. Perceived utility and perceived fun impact underscore the significance of the Technology Acceptance Model (Davis, 1989) and Flow Theory (Csikszentmihalyi, 1990) in the context of products for the elderly. Venkatesh, Thong, and Xu (2012) found similar results in their

Unified Theory of Acceptance and Use of Technology (UTAUT2), where they found that hedonic motivation and performance expectancy were important factors in adoption. In this study, caregivers demonstrated a robust agreement regarding the cognitive and stress-relief advantages of toys, suggesting that functional and experiential values jointly affect behavioral intentions. The results support previous research indicating that safety, durability, and perceived value are crucial precursors to trust and intention (Aaker, 1996; Zeithaml, 1988). Empirical studies in aging-related markets (Lee & Coughlin, 2015; Wang, Rau, & Salvendy, 2011) also emphasize that older consumers and their caregivers prioritize certified quality and usability in their purchasing decisions. This highlights the importance for product developers to ensure that their products meet safety standards and quality assurance systems, especially in areas related to health. The research further highlights the significance of social influence in determining both trust and purchase intention. This finding aligns with Ajzen's (1991) Theory of Planned Behavior, which identifies subjective norms as significant influencers of intention. Carpenter and Yoon (2011) reported similar results, indicating that peer recommendations and familial influence play a significant role in driving product adoption among the elderly in urban environments. In Thailand's collectivist culture, where family involvement in elderly care is significant, social endorsement emerges as a crucial motivator for adoption. However, the study revealed that being price-sensitive negatively impacted people's willingness to purchase, which is consistent with Lichtenstein, Ridgway, and Netemeyer's (1993) findings on price-conscious consumer behavior. This suggests that while psychological and emotional factors are important, financial constraints continue to present challenges in emerging markets. This contrasts with some Western studies (Yoon, Cole, & Lee, 2009) that showed older consumers were less price-sensitive when they believed a product would improve their health. This difference may be attributed to the economic situation in Thailand, where disposable income is relatively low, and caregiving often involves balancing financial priorities across generations. The mediation results enhance theoretical understanding by demonstrating that perceptions of quality do not directly influence behavioral intention without the mediation of trust and emotional attachment. This sequential pathway embodies

the relational logic posited in relationship marketing theory (Morgan & Hunt, 1994) and is informed by brand attachment literature (Park, MacInnis, Priester, Eisingerich, & Iacobucci, 2010), which contends that emotional connections are essential for converting brand evaluations into loyalty and purchase intention. Unlike previous studies by Chen & Liu, 2022, and Wang et al., (2011) that concentrated on the functional and utilitarian dimensions of elderly product adoption, the present research highlights a more complex trust-emotion mechanism as the principal influence in the Thai context. This indicates that in urban Asian societies, caregiving decisions are not merely rational but are also profoundly influenced by emotional and relational factors. This study confirms previous research regarding the impact of trust, quality, and social norms on consumer intentions, while also offering new insights into the mediating role of emotional attachment. It enhances theoretical discourse by amalgamating the Theory of Planned Behavior, Flow Theory, and Successful Aging Theory (Rowe & Kahn, 1997) into a cohesive framework, thereby offering a comprehensive elucidation of the convergence of cognitive, affective, and contextual factors that influence consumer behavior in aging markets. This study combines the Theory of Planned Behavior, Flow Theory, and the Theory of Successful Aging to support its theoretical contributions as it presents a holistic approach to comprehend the exceptional consumer behavior of elderly people in Thailand. This method reflects on the role of psychological characteristics, including emotional attachment and trust, in the purchase intentions of recreational toys, which signifies a transition towards a more relational importance at the expense of practical considerations when evaluating caregivers who focus more on personal relations than practical considerations. Contextually, the results are relevant to the aging population in Thailand, where cultural attitudes towards aging and leisure activities influence the market. The issues of mental health and social interactions of older adults living in urban areas also emphasize the importance of designing affordable, engaging, and user-friendly products based on their needs. This revelation highlights the need for marketers and policymakers to address the unique issues of the elderly in Thai society, where recreational products can enhance not only pleasure but also intellectual and social well-being.

CONCLUSION

This study offers substantial evidence that, within the framework of Bangkok's aging society, the purchasing intentions of recreational toys for the elderly are predominantly influenced by trust, emotional attachment, and perceived utility, whereas quality, enjoyment, and social influence serve as ancillary factors. Affordability remains a challenge, but it is evident that trust and emotional bonding are crucial psychological factors that transform product perceptions into consumer intentions. From a practical standpoint, these findings indicate that policymakers and marketers should prioritize: 1. Building trust through clear communication, product certification, and safety assurance is essential. 2. Emotional branding methods, such as stories about families and campaigns that involve people of different generations, make customers more loyal. 3. Pricing policies should be fair and consider how sensitive people are, as well as the long-term health and social benefits of toys for fun. Balanced pricing policies that consider sensitivity while also demonstrating the long-term health and social benefits of toys for fun. 4. Making toy products easier to obtain by making them available on more physical and digital platforms so that they are easy to buy and get support for. By focusing on these areas, stakeholders can better align the design and marketing of recreational toys with the psychological, social, and cultural realities of elderly care in Thailand. Furthermore, the results enhance theoretical comprehension by illustrating how trust-emotion mechanisms function as the cornerstone of consumer decision-making in mature markets.

AUTHOR CONTRIBUTIONS:

L. Lertkulprayad conceptualized the research framework, conducted the literature review, designed the methodology, coordinated data collection, and contributed to manuscript writing and revision, while P. Moudsong led the data analysis, interpreted the findings, supervised the overall project, refined the theoretical implications, and finalized the manuscript for submission. Both authors reviewed and approved the final version of the manuscript.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to all participants and contributors who generously supported this study with their time and valuable

insights. Their cooperation played a crucial role in enriching the quality and depth of the research. The authors also carefully reviewed and refined the final manuscript to ensure its scientific rigor and contextual relevance.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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PUBLISHER NOTE

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ABBREVIATIONS (NOMENCLATURE)

Abbreviation	Full form
AGFI	Adjusted Goodness of Fit Index

AVE	Average Variance Extracted
χ^2	Chi square
CR	Composite Reliability
CFA	Confirmatory Factor Analysis
GFI	Goodness of Fit Index
RMSEA	Root Mean Square Error of Approximation
SEM	Structural Equation Modeling
TLI	TuckerLewis Index

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HOW TO CITE THIS ARTICLE

Lertkulprayad, L.; Moudsong, P., (2026). Human capital-driven leisure choices: Assessing purchase intentions for recreational products among the elderly population. *Int. J. Hum. Capital. Urban Manage.*, 11(3): 533 - 542.

DOI: 10.22034/UHCUM.2026.03.06

URL: https://www.ijhcum.net/article_732739.html



ORIGINAL RESEARCH ARTICLE

From flexibility to fatigue: How job stress mediates the impact of mobile connectivity on burnout and engagement

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ARTICLE INFO

Article History:

Received 08 July 2025

Revised 03 September 2025

Accepted 07 December 2025

Keywords:

Technostress; Psychological detachment; Digital work-life spillover; Employee fatigue; Mobile overuse

ABSTRACT

BACKGROUND AND OBJECTIVES: The proliferation of smartphones has transformed the modern workplace, blurring boundaries between personal and professional life. While smartphone use facilitates flexibility and real-time communication, it can also intensify job demands and emotional strain. Despite extensive global research on technology-related stress, limited attention has been given to the mediating role of job stress in the relationship between workplace smartphone use and employee well-being in the Iranian context. This study addresses this gap by investigating how smartphone use affects job burnout and engagement through the mediating mechanism of job stress.

METHODS: This applied, quantitative research adopted a positivist paradigm and a deductive approach, utilizing a descriptive-survey design. Data were collected via an online questionnaire distributed among employees of Mobile Communication of Iran (Hamrah-e Aval), yielding 313 valid responses from a total population of 1,700. Standardized questionnaires adapted from established scales on smartphone use, stress, job burnout, and engagement were employed. The instruments were validated through back-translation and expert review, and reliability was confirmed using Cronbach's alpha coefficients (all above 0.70). Structural Equation Modeling with Smart Partial Least Squares 3 was employed for hypothesis testing.

FINDINGS: Findings reveal that smartphone use significantly increases job stress ($\beta = 0.262, p < 0.001$). In turn, stress positively affects job burnout ($\beta = 0.296, p < 0.001$) and negatively affects job engagement ($\beta = -0.182, p < 0.001$). While smartphone use directly increases burnout ($\beta = 0.168, p = 0.000$), it does not directly impact job engagement ($\beta = 0.088, p = 0.290$). Mediation analysis confirmed that job stress partially mediates the relationship between smartphone use and both burnout and engagement.

CONCLUSION: Workplace smartphone use has a dual impact: it indirectly contributes to job burnout and disengagement via increased stress. These findings emphasize the importance of managing job stress to mitigate the negative psychological outcomes of ubiquitous mobile connectivity. Organizations should implement targeted interventions—such as flexible work policies, stress-reduction programs, and smartphone usage guidelines—to enhance employee well-being and performance in digitally connected environments.

DOI: [10.22034/IJHCUM.2026.03.07](https://doi.org/10.22034/IJHCUM.2026.03.07)



NUMBER OF REFERENCES

48



NUMBER OF FIGURES

2



NUMBER OF TABLES

9

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the "Show Article."

INTRODUCTION

Job engagement is commonly conceptualized as a positive psychological state encompassing motivation, energy, and enthusiasm toward achieving work goals. It reflects an individual's full cognitive and emotional involvement in work tasks and a deep sense of commitment to their professional responsibilities. As defined (Kotzé and Nel, 2020), job engagement is characterized by vigor, dedication, and absorption—traits that enable individuals to effectively handle job demands while maintaining their psychological and physical well-being. Emotionally engaged employees not only derive personal satisfaction from their work but also feel strongly connected to their organization's success. Consequently, they are more likely to exceed expectations, contributing to increased productivity and reduced absenteeism (Whelan and Turel, 2024). The academic discourse on the relationship between job engagement and burnout presents two perspectives: some scholars treat them as opposites, while others view them as distinct yet negatively correlated constructs (Dunkl and Jiménez, 2017). Burnout, when present, significantly undermines both individual well-being and organizational performance, leading to higher absenteeism, reduced service quality, increased workplace accidents, and interpersonal conflicts. At a personal level, burnout manifests as emotional and physical exhaustion, often accompanied by anxiety, irritability, and even physical ailments such as insomnia, ulcers, and hypertension (Nematollahi et al., 2024; Abbasian and Nematollahi, 2024). Scholars describe burnout as a multidimensional response to chronic work stress, encompassing exhaustion, diminished achievement, and detachment from work. Research consistently highlights the strong positive link between job stress and burnout. Persistent stress undermines psychological resilience, causing employees to doubt the significance of their work and withdraw emotionally, which ultimately results in diminished engagement and well-being (Baek, Han, and Seepersad, 2022). Conversely, job engagement has been shown to buffer the effects of stress and promote adaptive coping strategies (Sasaki et al., 2021). Stress, broadly defined as a psychological response to misalignments between external demands and internal capacities, arises not only from excessive pressures but also from the underutilization of employees' skills and knowledge (Ehsan and

Ali, 2019). Furthermore, stress experienced in the workplace often spills over into personal life, disrupting work-life balance (Whelan and Turel, 2024). In today's digitally driven environments, the role of emerging technologies, especially smartphones, has become a central focus in understanding modern work stress (Yin et al., 2025; Pang and Liu, 2025; Dunkl and Jiménez, 2017). Smartphones have revolutionized the temporal and spatial boundaries of work, allowing employees to remain connected beyond standard working hours (Baek, Han, and Seepersad, 2022). While they enable flexible working and real-time communication, their omnipresence can also blur the lines between work and personal life, inducing stress and fatigue (Lee, Lee, and Kim, 2017). Moreover, using smartphones for personal tasks during work hours may further intensify work-related stress (Whelan and Turel, 2024). This paradoxical impact of smartphone use—enhancing productivity while simultaneously straining well-being—has drawn considerable scholarly attention. Although smartphones provide increased accessibility and operational flexibility, they often contribute to work overload, disrupt work-life balance, and trigger technostress, defined as the stress resulting from the use of Information and Communication Technology (ICT). Empirical evidence links technostress to negative psychological outcomes such as reduced job satisfaction, organizational commitment, and performance, and heightened burnout (Whelan and Turel, 2024). Job demands such as information overload and system complexity intensify stress, though employees with high technological self-efficacy may experience mitigated effects (Yen, 2024). Smartphones can also foster job engagement by promoting collaboration, responsiveness, and access to resources. However, heavy reliance on them makes it difficult for individuals to disengage mentally, fostering continuous connectivity and psychological strain (Gonçalves and Santos, 2022). While prior studies have explored elements of this dynamic, most have not holistically examined the interaction among all four critical variables—smartphone use, stress, burnout, and engagement. For instance, Küçükali et al., (2023) highlighted the role of organizational context in burnout, while Zhao and Yu (2023) linked social media usage to decreased job engagement. Obschonka et al. (2023) argued that applying the Job Demands–Resources (JD-R) framework could en-

hance engagement and prevent burnout. [Hetzel-Riggin et al., \(2020\)](#) further demonstrated that job engagement mediates the relationship between stress and burnout. However, despite these findings, key mechanisms—such as the specific pathways through which smartphone use induces burnout—remain underexplored ([Gonçalves and Santos, 2023](#)). This study addresses a significant research gap by simultaneously examining smartphone use, job stress, engagement, and burnout, using Mobile Communication of Iran (MCI) Hamrah-e Aval—a major telecom provider in Iran—as a case study. The company’s operational model, extensive reliance on mobile technologies, and recent reports of psychological strain, disengagement, and absenteeism make it an ideal context for such an investigation. While smartphones are widely used for both personal and professional purposes within this organization, findings from audits and employee evaluations suggest that overuse has adversely affected concentration, job motivation, and social interaction, ultimately leading to burnout and diminished performance. In summary, although the literature has extensively covered the separate impacts of technology, stress, and burnout, few studies have integrated all four constructs in a comprehensive model. This research aims to fill that theoretical and practical gap by investigating the mediating role of stress in the relationship between smartphone use and job engagement/burnout, providing targeted insights for enhancing employee well-being and organizational performance at MCI Hamrah-e Aval. Despite increasing global interest in the psychological consequences of workplace connectivity, the specific mediating mechanisms through which smartphone use impacts employee well-being have remained underexplored in the Iranian context. In particular, little is known about how job stress may transmit the effects of mobile connectivity into either burnout or engagement. This study aims to fill this gap by proposing and testing a stress-mediated model using empirical data from a large telecom company in Iran.

Literature review

Smartphone and job stress

In contemporary workplaces, smartphones have become essential tools for both business owners and their employees, with workers increasingly dependent on these devices to perform their daily tasks ([Nematollahi et al., 2024](#)). Given that smartphones are now

an inseparable part of everyday work life, it is crucial to explore how they are utilized during working hours and their connection to positive organizational outcomes ([Lin et al., 2017](#)). The widespread adoption of smartphones worldwide has profoundly influenced both personal and professional aspects of life ([Lin et al., 2017](#)). Existing research highlights various implications of smartphone use. For instance, [Kim and Heo \(2019\)](#) describe smartphones as an emerging technology that is rapidly becoming integral to daily life, with a growing global user base. Smartphones enable easy access to social media platforms, messaging services, the internet, and other functionalities. Moreover, they have swiftly supplanted personal computers for many routine work activities. However, excessive use of smartphones can have detrimental effects on individuals ([Kim and Heo, 2019](#)), including a range of psychological issues such as depression, reduced self-esteem, and notably, stress linked to overuse ([Elhai et al., 2017](#)). Work-related stress is defined as an adverse reaction to excessive pressures and demands encountered at work, which can make success seem unattainable and result in cognitive imbalance and distress in the workplace ([Nematollahi et al., 2024](#)). While everyone experiences stress to some extent, how individuals cope with stress critically influences their overall well-being ([Nematollahi et al., 2024](#)). Job stress is characterized as an unpleasant emotional state arising when job demands exceed an individual’s capacity to cope effectively. Thus, stress is a common phenomenon that impacts employees differently depending on specific work environments and conditions ([Ehsan and Ali, 2019](#)). Research findings on the consequences of smartphone use have been varied. [Elhai et al., \(2017\)](#) reported that smartphone use at work can increase stress levels, while [Brubaker and Beverly \(2020\)](#) found that excessive smartphone use correlates with elevated stress, poorer sleep quality, and greater burnout. Conversely, [Neştian, Tiță, and Turnea \(2020\)](#), in their study “Using Mobile Phones at Work,” identified that the primary benefit of using mobile phones for personal reasons at work is the enhancement of employee productivity by facilitating a balance between work and personal life. Hence, smartphone use may have diverse impacts on job-related stress. Based on the current literature, the first hypothesis is formulated to examine the relationship between smartphone use in the workplace and its influence on stress levels:

H1: Using smartphones in the workplace has a positive effect on job stress.

Stress, job engagement, and job burnout

Job engagement is crucial for both employees and organizations. Employees who are highly engaged with their work tend to feel committed, energized, and intrinsically motivated to grow and perform at their best, thereby becoming valuable contributors to organizational productivity and success (Van Laethem, Van Vianen, and Derks, 2018). Research indicates that individuals with high job engagement report better physical health, fulfillment of psychological needs, and greater job satisfaction and commitment compared to those with lower engagement levels (Borst, Kruijen, and Lako, 2019). Obschonka et al., (2023), in their study on job burnout and engagement within entrepreneurship, demonstrated that factors within the Job Demands-Resources (JD-R) model, including stress, can both increase and decrease job engagement. This supports the view that job engagement and burnout are inversely related (Obschonka et al., 2023). Similarly, Hetzel-Riggin et al., (2020) found that job engagement can mediate the relationship between work-related stress and job burnout. Their findings suggest that stress does not inevitably lead to burnout and that managing stress positively can enhance engagement. Gonçalves and Santos (2022) further found that compelled smartphone use can contribute to job burnout (Gonçalves and Santos, 2023). Elhai et al., (2017) reported that excessive use of new technologies, especially within work environments, may provoke psychological issues such as job-related stress. Moreover, increased job demands leading to burnout have been linked to higher turnover intentions among employees (Jamal et al., 2024).

New technologies have altered individuals' perceptions of time and space, often extending working hours beyond the traditional schedule and compelling employees to work at irregular times through smartphone use (Nematollahi et al., 2024). The advent of smartphones—a pivotal tool for teleworking—has enabled employees to work from any location and at any time, regardless of their preference (Ehsan and Ali, 2019). While smartphones enhance organizational performance by facilitating greater work access, their use outside of regular hours can generate positive emotions and reduce stress (Hetzel-Rig-

gin et al., 2020). From this standpoint, smartphones significantly support job engagement by improving communication and collaboration, enabling flexible work hours, and allowing continuous information exchange. Accordingly, based on the literature, the following hypothesis is proposed concerning the effects of workplace stress:

H2: Stress mediates the effect of smartphone use on job engagement.

Kotzé and Nel (2020) argue that smartphones paradoxically blur the boundaries between work and personal life, adversely impacting employee well-being and work-life balance, while increasing stress and burnout. These factors contribute to unfavorable workplace conditions. Often, such adverse conditions and unmet psychological needs negatively affect employee satisfaction and productivity. Consequently, burnout is recognized as a major psychosocial occupational risk in modern society, imposing substantial costs on both individuals and organizations (Epstein et al., 2020; Han et al., 2019). Initially considered prevalent mainly in professions involving interpersonal interactions, burnout has now been shown to affect diverse professions and job categories (Hewitt et al., 2020). Job burnout encompasses three key dimensions:

- *Emotional exhaustion, characterized by depletion of emotional resources and energy, lack of enthusiasm, frustration, tension, and fatigue.*
- *Depersonalization, involving the development of negative and indifferent attitudes toward clients, colleagues, or the organization, treating them impersonally.*
- *Reduced personal accomplishment, reflecting professionals diminished sense of fulfillment and satisfaction with their work performance (Gonçalves and Santos, 2020).*

These dimensions represent a response to prolonged work-related stress caused by factors such as workplace conflict, family challenges, role ambiguity, workload, and a hostile work environment. Given the numerous negative impacts of stress on workplaces, the study of work-related stress and coping mechanisms has expanded across disciplines. Among these stressors, technology-induced stress, or technostress, has gained considerable attention recently (Scanlan and Still, 2019). Brubaker and Beverly (2020) found that excessive smartphone use elevates stress

levels, which correlate with poorer sleep quality and increased burnout. Scanlan and Still (2019) also indicated that workplace stress may reduce job engagement while influencing employee participation. In their study on smartphone-based stress management among nurses in Vietnam, Sasaki *et al.* (2021) demonstrated that such interventions can enhance work engagement, though the effects were modest and short-lived. Despite being low-cost, smartphone-based stress management programs can positively influence employee engagement. Therefore, job burnout and engagement are considered mental states influenced by stress, which in turn can either hinder or enhance individual and organizational performance and productivity (Monfries, Sandhu, and Millar). However, the direction of these effects varies across different organizational contexts. Based on the existing literature, the following hypothesis is proposed regarding the impact of workplace stress:

H3: Stress mediates the effect of smartphone use on job burnout.

Smartphone use, job burnout, and job engagement

In modern workplaces, smartphones can enhance productivity and offer numerous benefits, but these advantages depend on their appropriate use (Panova and Carbonell, 2018). While smartphones have facilitated many positive outcomes across various contexts, their excessive use has introduced challenges that adversely impact individuals' mental health and work performance (Park, Kim, and Lee, 2020). Reflecting on these benefits and drawbacks, Van Laethem, Van Vianen, and Derks (2018) suggested that smartphone use at work can function either as a job demand or a job resource. Job demands and resources represent key job characteristics encompassing physical, mental, and organizational facets, requiring sustained effort or stable skills. For instance, smartphone use in the workplace may elevate employee stress by generating pressure and mental strain, which can reduce productivity and lead to physiological or psychological costs. Conversely, job resources are elements of a job that support goal achievement, alleviate job demands, and promote personal growth and development (Scanlan and Still, 2019). According to established definitions, job demands and resources strongly predict burnout and job engagement, respectively. Job engagement is understood as a positive, work-related psychological state

marked by vigor, dedication, and absorption (Yan *et al.*, 2021). Burnout, a multidimensional reaction to chronic workplace stress, is characterized by emotional exhaustion, depersonalization, and diminished personal accomplishment (Lepp, Li and Barkley, 2016; Jeong, Kim, Yum, and Hwang, 2016), and is linked to various negative effects on employees' physical and mental health (Elhai *et al.*, 2017). Therefore, when employees perceive access to smartphones as a job demand, it may be associated with increased workload and extended working hours. Consequently, frequent smartphone use might intensify employee burnout when it is experienced as a demand. Based on the existing literature addressing smartphone use in the workplace and its impact on burnout, the following hypothesis is proposed:

H4: Smartphone use in the workplace affects job burnout positively.

On the other hand, employees may experience smartphone access as a job resource and associate it with flexibility and increased independence when performing work tasks. In this context, frequent work-related smartphone use may increase employees' interest in performing their duties, ultimately increasing their job engagement (Van Laethem, Van Vianen, and Derks, 2018). Therefore, according to the available literature, the following hypothesis is proposed concerning the use of smartphones in the workplace and their effect on job engagement:

H5: Smartphone use in the workplace negatively affects job engagement.

Previous research indicates that smartphone use, particularly in the workplace, can influence individuals in various ways. Despite ongoing technological advancements and their impact on employee behavior over recent years, the specific effects of workplace smartphone use on job burnout and engagement remain underexplored both domestically and internationally. This reveals a notable theoretical gap, as well as conceptual ambiguities and complexities within the topic. Consequently, from a theoretical standpoint, it is essential to address this gap by investigating whether smartphone use at work influences job burnout and engagement. Furthermore, considering stress as a mediating factor in the relationship between smartphone use and these outcomes represents a novel contribution to

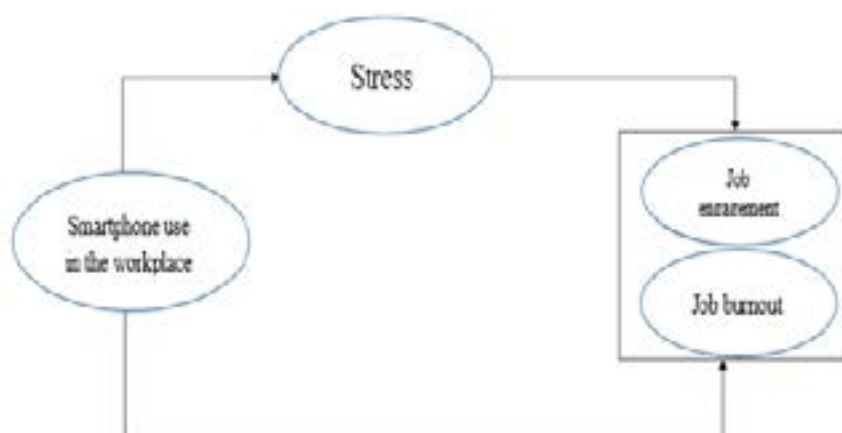


Fig. 1: Research conceptual model

the existing literature. Accordingly, grounded in the identified theoretical gap, the primary hypothesis of this study posits that stress mediates the impact of workplace smartphone use on job engagement and burnout. Moreover, the conceptual framework of this research is derived from integrating findings of two prior studies: [Gonçalves and Santos \(2022\)](#) and [Van Laethem, Van Vianen, and Derks \(2018\)](#), which separately examined the influence of smartphone use on job burnout and job engagement. To enhance the innovativeness of the model, stress is incorporated as a mediating variable, resulting in the conceptual framework illustrated below:

As illustrated in [Fig. 1](#), the conceptual model proposes that job stress mediates the relationship between smartphone use and two key outcomes: job burnout and job engagement.

MATERIAL AND METHOD

According to the methodological framework outlined by [Saunders et al., \(2019\)](#), this study can be described as follows. From a purpose perspective, the research is applied, adopting a positivist philosophy and utilizing a comparative approach. Furthermore, since the study investigates and describes the status and relationships of variables through data gathered via an online questionnaire, it is classified as a descriptive survey employing a distinct quantitative method. The target population for this study consists of employees of MCI Hamrah-e Aval Co. Given that the researcher is a staff member of the company and has access to its data, the total population was identified as 1,700 individuals. Following coordination with the organization, the ques-

tionnaire was uploaded onto the company's internal portal, which is accessible to all employees at every level, facilitating easy participation. After distribution, a subset of completed questionnaires was selected as the sample from the population. Sampling was conducted based on Cochran's formula for finite populations, considering the specific size of the population. It is also important to mention that simple random sampling was employed, as detailed in the following formula:

$$n = \frac{\frac{z^2 pq}{d^2}}{1 + \frac{1}{N} \left[\frac{z^2 pq}{d^2} - 1 \right]}$$

The total sample size was 313, which is an acceptable number for a society with 1700 members, according to Morgan's Table. In general, the data required in this research were collected using library and field methods. First, the research literature was collected using the available related sources and by reviewing the articles, documents, and books available in this field. In the next step, standard questionnaires were identified according to the research variables and distributed among the statistical population. The questionnaire stated in the article by [Park, Kim, and Lee \(2020\)](#) was used to investigate the use of smartphones in the workplace. Furthermore, the questionnaires stated in the articles by [Baek et al., \(2022\)](#) were used to investigate stress and job engagement, respectively. Finally, the questionnaire provided by [Baek, Han, and Seopersad \(2022\)](#) was used to examine job burnout. To improve transparency, the complete set of questionnaire items is provided below in [Table 1](#).

Table 1: The questionnaire used in the current research

Variable	Question No.	Questions
Demographics	1	Gender (Male – Female)
	2	Age (20-25, 26-30, 31-35, 36-40, 41-45, 46-50, and >50 years)
	3	Education (Diploma, Associate degree: Bachelor's, Master's, and Ph.D. and higher)
	4	Marital Status (married – single)
	5	Job Position (Expert – senior expert – manager)
	6	Work Experience (<5 years, 6-10 years, 11-15 years, 16-20 years, 21-25 years, and 26-30 years)
Smartphone use in the workplace	7	These days, I often use my smartphone to address work-related issues, even after work.
	8	These days have to answer work-related text messages even in the evening.
	9	These days, I have to check work-related text messages until I fall asleep.
	10	When I get a message on my phone, I cannot resist checking it.
Stress	Organizational Stress	11 Discrimination in the application of laws to different people has been a major concern for the past 6 months.
		12 I have been stressed out by excessive administrative duties for the past 6 months.
		13 Constant changes in policies and regulations have stressed me for the past 6 months.
		14 I have been stressed out by the lack of staff for the past 6 months.
		15 I have been stressed out by overwhelming paper work for the past 6 months.
		16 The pressure on my free time has been stressful for the past 6 months.
		17 I have been stressed out by the lack of resources for the past 6 months.
		18 The uneven distribution of work responsibilities has been a stress for me for the past 6 months.
	Operational stress	19 Shift work has been stressful for the past 6 months.
		20 Forced overtime has been stressful for the past 6 months.
		21 The risk of injury at work has been a stress for me for the past 6 months.
		22 Traumatic events have been stressful for the past 6 months.
		23 Personal life (outside work) management has been stressful for the past 6 months.
		24 Work-related health and wellness issues have been stressful for the past 6 months.
		25 Insufficient time to focus on adequate physical health has stressed me out for the past 6 months.
		26 People's negative comments have stressed me out for the past 6 months.
		27 The feeling that I am always at work has stressed me out for the past 6 months.

Job burnout	Emotional exhaustion	28	I feel emotionally drained at work.
		29	I feel really exhausted from a lot of work at the end of the work day.
		30	I already feel exhausted when I wake up in the morning and must work another day.
		31	Working with other people all day is really hard for me.
		32	I feel excessively exhausted from my work.
		33	I feel hopeless in my job.
		34	I feel I am working hard (more than usual).
		35	Working directly with others puts me at a lot of stress.
	Depersonal-ization	36	I feel that I treat some people as though they are not living beings.
		37	Since I took this job, I have become more ruthless toward people.
		38	I worry my job will make me emotionally hardened and insensitive.
		39	I really don't care what happens to some community members.
	Reduced personal success	40	I deal with other people's problems effectively.
		41	I feel that through my work, I can make a positive impact on others' lives.
		42	I feel enthusiastic.
		43	I can easily create a calm atmosphere.
		44	I enjoy working closely with others.
		45	I have carried out a lot of valuable work in this position.
		46	I deal with emotional issues in my work very calmly.
Job engagement	Happiness	47	I am full of energy while working.
		48	I feel strong and energetic while working.
		49	I feel like going to work when I wake up in the morning.
		50	I can work for a long time without interruption.
		51	I am mentally very flexible at work.
		52	I always show perseverance in my work, even under unpleasant conditions.
	Sacrifice	53	I consider what I do to be completely meaningful and purposeful.
		54	I do my job with great enthusiasm.
		55	My job is inspiring.
		56	I am proud of what I have accomplished.
		57	My job is challenging.
	Attraction	58	I feel that time passes quickly when I am working.
		59	I forget everything else when I am working.
		60	I feel satisfied when I am working hard.
		61	I get overwhelmed at work.
		62	When I am working, I forget about myself.
		63	It's hard for me to leave my job.

Table 2: Reliability by internal consistency method (Cronbach's alpha)

Variables	Cronbach's alpha
Smartphone use	0.72
Stress	0.76
Job burnout	0.78
Job engagement	0.80

Table 3 presents the results of the demographic analysis. The sample size was 313.

Table 3: Demographic characteristics of the sample

Variable	Group	Frequency	Percentage
Gender	Male	160	51.2
	Female	153	48.8
Marital status	Married	180	57.5
	Single	133	42.5
Education	Diploma	5	1.6
	Bachelor's	60	19.2
	Master's	210	67.3
	Ph. D. and higher	38	12.2
Age	20-25	20	6.4
	26-30	60	19.3
	31-35	80	25.7
	36-40	82	26.3
	41-45	50	16.0
	46-50	14	4.5
	>50	4	1.3
Job position	Expert	115	37.1
	Senior expert	120	38.7
	Manager	75	24.2
Work experience	<5 years	65	20.9
	6-10 years	115	36.9
	11-15 years	53	17.0
	16-20 years	58	18.6
	21-25 years	17	5.5
	26-30 years	4	1.3

Table 4: Skewness and kurtosis values to evaluate the normality of the variables

Variable	Skewness			Kurtosis		
	Statistic	Std. Error	Z-Score	Statistic	Std. Error	Z-Score
Smartphone Use (Total)	-0.35	0.138	-2.54	-0.65	0.275	-2.36
Organizational Stress	0.40	0.138	2.90	-0.25	0.275	-0.91
Operational Stress	0.82	0.138	5.94	0.53	0.275	1.93
Stress (Total)	0.65	0.138	4.71	0.38	0.275	2.06
Happiness	-0.50	0.138	-3.62	0.10	0.275	0.36
Sacrifice	-0.85	0.138	-6.16	1.75	0.275	6.36
Attraction	-0.70	0.138	-5.07	0.22	0.275	0.80
Job Engagement (Total)	-0.80	0.138	-5.80	0.68	0.275	2.47
Emotional Exhaustion	0.22	0.138	1.59	-0.40	0.275	-1.45
Depersonalization	0.60	0.138	4.35	-0.30	0.275	-1.09
Reduced Personal Success	-0.38	0.138	-2.75	0.05	0.275	0.18
Job Burnout (Total)	0.15	0.138	1.09	-0.55	0.275	-2.00

All original questionnaires were translated into Persian and reviewed by two bilingual experts using the back-translation method to ensure linguistic equivalence. Content validity was verified through expert panel review, and a pilot test with 30 employees was conducted to ensure clarity and relevance. Minor modifications were made based on participant feedback before the final distribution. The data analysis was conducted using descriptive and inferential methods. Thus, the main and demographic variables were described at the descriptive level, and the validity and reliability of the questionnaire, the relationships among the variables, and the research model were examined at the inferential level. SPSS 27 and Smart PLS 3 software were also used for data analysis. The content of the data collection tool (questionnaire) was checked using the face validity method and the opinions of the researchers and experts. The questionnaire was distributed among the statistical population of the research after corrections were made by the professors and their final approval. The reliability of the questionnaire was also calculated using Cronbach's alpha, confirming the scale's reliability for values >0.7 . Thus, after examining the Cronbach's alpha values of the main research variables, the results obtained are as described in Table 2. Cronbach's alpha of all variables was 0.7, confirming the questionnaire's reliability.

RESULTS AND DISCUSSION

Normality of variables

Table 4 examines the normality of the data distribution, which is the premise of Pearson's correlation parametric tests and structural equation modeling, using the covariance-based method (LISREL and Imus). Skewness and kurtosis were used to determine univariate normality, whereas multivariate normality was determined using Mardia's coefficient. If the Z-score is outside the absolute value of 1.96, there is a difference between the observed and normal distribution at the 95% confidence level, and the data are not normal. The results are shown in Table 4.

As shown in Table 4, the Z-scores for skewness exceeded the critical value of ± 1.96 in 9 variables, while kurtosis Z-scores exceeded this threshold in 4 variables. This indicates that several variables do not follow a normal distribution. Overall, most variables exhibited deviations from normality in terms of skewness, kurtosis, or both. Multivariate normality was assessed using Mardia's coefficient, which was found to be 8.51. According to Byrne (2010), this value exceeds the threshold of 5, confirming that the assumption of multivariate normality is violated. Given these results and the departure from normality shown in both univariate and multivariate assessments, the research model was analyzed using a variance-based approach with SmartPLS

Table 5: Correlation matrix between the main variables and divergent validity investigation using the Fornell–Larcker method

Variables	1	2	3	4	5	6	7	8	9
1. Smartphone Use	0.79								
2. Organizational Stress	0.22**	0.66							
3. Operational stress	0.23**	0.54**	0.68						
4. Emotional exhaustion	-0.04	0.10	0.15**	0.67					
5. Depersonalization	0.03	0.16**	0.31**	0.31**	0.69				
6. Reduced personal success	0.18**	0.02	0.01	-0.10	-0.04	0.63			
7. Happiness	0.15**	-0.15**	-0.18**	-0.08	-0.15**	0.38**	0.69		
8. Sacrifice	0.15**	-0.19**	-0.20**	-0.18**	-0.23**	0.32**	0.41**	0.68	
9. Attraction	0.11	-0.25**	-0.22**	0.07	-0.01	0.14*	0.26*	0.21**	0.60

= $P \leq 0.05$ & *= $P \leq 0.01$

software, which is robust to violations of the multi-variate normality assumption.

Correlation of variables

Table 5 presents the relationship between the research variables using the correlation test and the divergent validity investigation using the Fornell–Larcker method. Divergent validity is acceptable when the AVE for each construct exceeds the shared variance between that construct and other constructs (i.e., the square of the correlation coefficients between constructs) in the model. Thus, the acceptable divergent validity of a measurement model indicates that a construct in the model interacts more with its indicators than with other constructs. According to the results in Table 5, the correlation between variables was less than the square root of the average variance extracted, thereby establishing divergent validity.

Confirmatory factor analysis

Using Smart PLS software, the validity of the questionnaire was investigated using factor loading and convergent validity indices, while the reliability of the variables was evaluated using composite reliability and Cronbach's alpha. Factor loadings were calculated considering the correlation value of the indicators of a construct with that construct. The minimum factor loading value was 0.40 in this research. The Average Variance Extracted (AVE) index was used to check the convergent validity. Generally, the AVE index was used to evaluate content validity. Cronbach's alpha was also used to measure reliability. The general rule is that the Cronbach's alpha value of a scale should be at least 0.70. This index measures the variance that

a latent variable derives from its indicators. Convergent validity assesses whether indicators of a particular construct contribute a high proportion of common convergent variance. The value of this index ranges from 0 to 1, with higher values indicating the convergent validity of the desired structure. The results of the confirmatory factor analysis in Table 6 are as follows. All factor loadings are significant at the 95% confidence level as follows: ($p < 0.05$) and ($t < 1.96$)

Using SmartPLS software, the questionnaire's validity was evaluated through factor loadings and convergent validity indices, while reliability was assessed using composite reliability and Cronbach's alpha. Factor loadings were computed based on the correlation between each indicator and its respective construct. A minimum factor loading threshold of 0.40 was set for this study. The AVE was used to assess convergent validity, indicating the proportion of variance captured by the construct relative to measurement error. Cronbach's alpha measures internal consistency reliability, with values above 0.70 considered acceptable. The confirmatory factor analysis results presented in Table 6 show that all factor loadings exceeded the 0.40 cutoff and were significant at $p < 0.05$, confirming construct validity for all items. For Smartphone Use, composite reliability and Cronbach's alpha were 0.85 and 0.74, respectively, both exceeding the 0.70 benchmark, confirming reliability. For Organizational and Operational Stress components, composite reliability values of 0.85 and 0.86, and Cronbach's alphas of 0.78 and 0.80, respectively, indicate strong

Table 6: Results of confirmatory factor analysis: validity and reliability

Component	Question	Factor Loading (Std. Coeff.)	p-value	AVE	Composite Reliability	Cronbach's Alpha
Smartphone Use (Total)	7	0.75	0.000			
	8	0.88	0.000	0.65	0.85	0.74
	9	0.80	0.000			
Organizational Stress	11	0.73	0.000			
	12	0.60	0.000	0.46	0.85	0.78
	13	0.69	0.000			
	16	0.75	0.000			
	17	0.58	0.000			
	18	0.74	0.000			
Operational Stress	19	0.66	0.000			
	20	0.75	0.000	0.48	0.86	0.80
	21	0.81	0.000			
	22	0.76	0.000			
	26	0.54	0.000			
	27	0.66	0.000			
Happiness	47	0.83	0.000	0.50	0.77	0.74
	48	0.78	0.000			
	52	0.49	0.000			
Sacrifice	53	0.72	0.000			
	54	0.71	0.000	0.49	0.80	0.77
	55	0.78	0.000			
	56	0.62	0.000			
Attraction	58	0.63	0.000			
	59	0.76	0.000	0.39	0.79	0.75
	60	0.62	0.000			
	61	0.56	0.000			
	62	0.65	0.000			
	63	0.50	0.000			
Emotional Exhaustion	31	0.71	0.000			
	32	0.69	0.000	0.47	0.79	0.73
	33	0.68	0.000			
	35	0.69	0.000			
Depersonalization	36	0.74	0.000			
	37	0.75	0.000	0.50	0.82	0.77
	38	0.71	0.000			
	39	0.69	0.000			
Reduced Personal Success	40	0.50	0.000			
	41	-0.45	0.000	0.42	0.78	0.75
	42	-0.68	0.000			
	43	-0.74	0.000			
	44	-0.75	0.000			

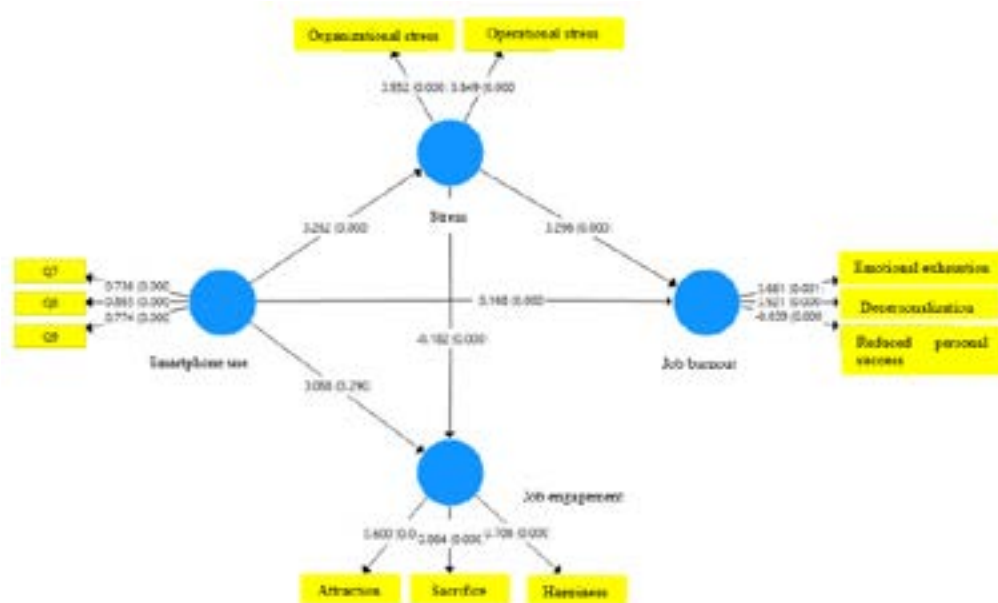


Fig. 2: Structural model of the effects of smartphone uses on job burnout and engagement with job stress as a mediator

reliability. The overall stress scale's reliability was confirmed, with Cronbach's alpha reported at 0.78. The job engagement components—Happiness, Sacrifice, and Attraction—showed composite reliability ranging from 0.77 to 0.80 and Cronbach's alpha from 0.74 to 0.77, confirming the reliability of the job engagement scale. The total job engagement scale had a Cronbach's alpha of 0.81. Regarding the job burnout components—Emotional Exhaustion, Depersonalization, and Reduced Personal Success—composite reliability ranged from 0.78 to 0.82 and Cronbach's alpha from 0.73 to 0.77, confirming reliability. The overall burnout scale had a Cronbach's alpha of 0.80. The AVE values ranged from 0.39 (Attraction) to 0.65 (Smartphone Use). While some AVE values were slightly below the ideal cutoff of 0.50 (e.g., Attraction at 0.39), most components approached or exceeded this threshold, demonstrating acceptable convergent validity across scales. In conclusion, the results confirm that the questionnaire items have acceptable construct validity and reliability, making the scales suitable for further analysis.

Testing the main research model

The conceptual model of the research was tested using structural equation modeling with the PLS method.

Fig. 2 illustrates the experimental model, displaying

standardized coefficients and associated probability values. The results show that the p-value was less than 0.05 in four out of five paths, confirming significant relationships between smartphone use and the mediating variable of stress, as well as between smartphone use and job burnout ($p < 0.05$). Additionally, the relationships between stress, job burnout, and job engagement were confirmed ($p < 0.05$). However, the direct relationship between smartphone uses and job engagement was not supported ($p > 0.05$).

Investigating model fit

Table 7 presents the fit indices for the research model. The evaluation of the structural model's fit was conducted using two main indices: redundancy (predictive relevance) and coefficient of determination (R^2). The Stone-Geisser Q^2 indicator assesses the model's predictive relevance. According to established guidelines, Q^2 values of 0.02, 0.15, and 0.35 indicate weak, medium, and strong predictive relevance, respectively.

The R^2 values indicate that 19.5% of the variance in job burnout and 9.5% of the variance in job engagement are explained by the model. The Q^2 values were 0.12 for job burnout and 0.09 for job engagement, showing moderate predictive relevance for both

Table 7: Fit indices of the research model

Dependent Variable	R ²	Q ²	NFI	SRMR
Job burnout	0.195	0.12	0.83	0.078
Job engagement	0.095	0.09		

Table 8: The effects of research variables on each other based on structural equation modeling

Effects	Standard coefficient	standard error	T-value	p-value
Smartphone use → Stress	0.262	0.044	7.53	<0.001
Stress → Job engagement	-0.182	0.044	7.53	<0.001
Stress → Job burnout	0.296	0.054	5.55	<0.001
Smartphone use → Job burnout	0.168	0.063	2.00	0.04
Smartphone use → Job engagement	0.088	0.075	0.643	0.290

endogenous variables. The Normed Fit Index (NFI) was 0.83, indicating an acceptable but slightly lower than average model fit. The Standardized Root Mean Square Residual (SRMR) was 0.078, falling within the acceptable range and suggesting a good model fit. Overall, the model demonstrates an acceptable fit with moderate predictive power.

Model relationship testing

Table 8 presents the results of the relationship testing of the research model, reporting the standard path coefficient, standard error, t-value, and significance level (p-value).

Table 8 confirms all effects of the structural equation modeling test ($p < 0.05$). Based on the structural equation modeling test, the effect of smartphone use in the workplace on stress (H1) was confirmed. The direction of the effect was positive, and its intensity was 0.262. Interestingly, the direct path from smartphone use to job engagement was not statistically significant. This finding suggests that engagement may be less directly influenced by mobile connectivity and more strongly affected by mediating variables such as job stress. One possible interpretation is that while smartphones offer potential for engagement through flexibility, their overuse may lead to stress that counteracts these benefits. This supports the theoretical rationale for including stress as a mediating variable in the model. The second hypothesis examination using the structural equation modeling test confirmed the effect of stress on job engagement. The direction of the effect was negative, and its intensity was 0.182. The structural equation modeling test results also

confirmed the effect of stress on job burnout (H3) and smartphone use in the workplace on job burnout (H4). The direction of the effect was positive for both hypotheses, and the intensity of the effect was 0.296 and 0.168 for H3 and H4, respectively.

However, the examination of the fifth hypothesis revealed that the effect of smartphone use in the workplace on job engagement was not confirmed by the structural equation modeling test. Table 9 shows the results of indirect effects, investigating the mediating role of stress in the relationship between smartphone use in the workplace, job engagement, and job burnout. The bootstrapping method was used in SmartPLS software to test the mediators.

The results obtained from Table 9 statistically confirmed the mediating role of stress in the relationship between the use of smartphones in the workplace, job engagement, and job burnout ($p < 0.05$). The intensity of the indirect effects of smartphone uses in the workplace on job engagement and job burnout, with the mediation of stress, was 0.076 and 0.099, respectively. According to the results, the main research hypothesis was confirmed.

Discussion

This study addresses the existing research gap regarding the impact of smartphone use in the workplace. Literature highlights that smartphones have become an integral part of daily work life, making it crucial to explore how work-related smartphone use during working hours influences work outcomes (Lin et al., 2017). Previous research has produced mixed findings on the consequences of smartphone use.

Table 9: The moderating role of stress in the relationship between smartphone use in the workplace, job engagement, and job burnout, as determined by the bootstrapping method

Effect type	Indirect effect	Standard error	T-value	p-value
Smartphone use → Stress → Job engagement	-0.76	0.024	3.14	0.002
Smartphone use → Stress → Job burnout	0.099	0.021	4.70	<0.001

For instance, [Van Laethem, Van Vianen, and Derks \(2018\)](#) conceptualize smartphone use at work either as a job demand or a job resource. Job demands typically predict job burnout strongly, whereas job resources are significant predictors of job engagement ([Van Laethem, Van Vianen, and Derks, 2018](#)). Additionally, [Elhai et al. \(2017\)](#) suggest that smartphone use in work settings can increase stress levels. Based on this literature, the present study developed a model incorporating smartphone use as an independent variable, stress as a mediator, and job engagement and burnout as dependent variables. The hypothesized relationships within this conceptual model were empirically tested. The findings reveal that workplace smartphone use positively correlates with increased stress. Scholars have reported both positive and negative consequences of this technology. Some argue that smartphones enhance productivity, facilitate information retrieval, and improve satisfaction through social interaction ([Van Deursen et al., 2015](#)). Conversely, others emphasize the negative ramifications, especially in professional environments ([Panova and Carbonell, 2018](#); [Cha and Seo, 2018](#); [Bae, 2017](#)). According to [Fischer-Grote, Kothgassner, and Felnhöfer \(2019\)](#), excessive smartphone use may provoke uncontrollable behaviors, including mental health issues such as stress and depression, along with physical ailments, disrupting users' daily functioning. [Gonzalez and Santos \(2022\)](#) also highlight the difficulty for employees heavily dependent on smartphones to mentally detach from work, resulting in heightened anxiety and stress. Moreover, [Brubaker and Beverly \(2020\)](#) note a positive relationship between elevated stress and emotional exhaustion alongside increased smartphone addiction. Another key finding is the negative impact of stress on job engagement: as stress rises, job engagement decreases and vice versa. Previous studies similarly show that workplace stress detrimentally affects employee engagement ([Kim and Heo, 2019](#); [Van Laethem et al., 2018](#)), posing a barrier to active participation ([Van Laethem et al., 2018](#)). Furthermore, this

research confirms that stress is positively associated with job burnout, indicating that greater stress leads to higher burnout levels. Existing literature agrees that workplace stress yields multiple consequences for individuals and organizations, with one significant outcome being increased job burnout ([Park, Kim, and Lee, 2020](#); [Brubaker and Beverly, 2020](#)). For example, prolonged exposure to stress significantly diminishes employee productivity, motivation, and effectiveness, ultimately culminating in burnout ([Orhan et al., 2021](#)). [Sasaki et al., \(2021\)](#) identify the workplace as a primary source of stress that can cause depression, burnout, and stress-related illnesses. Similarly, [Carroll et al. \(2022\)](#) emphasize that elevated stress escalates employee burnout, potentially leading to intentions to leave the profession.

Moreover, the study indicates that increased smartphone use at work contributes to greater job burnout, consistent with previous findings that work-related smartphone uses outside working hours exacerbates burnout ([Park, Kim, and Lee, 2020](#)). [Gonzalez and Santos \(2022\)](#) also argue that enforced smartphone use can trigger job burnout. [Brubaker and Beverly \(2020\)](#) further show that excessive smartphone use raises stress, which negatively affects sleep quality and subsequently increases burnout. Contrary to some expectations, however, this study found no significant direct effect of smartphone use on job engagement. Prior research presents mixed outcomes, with some studies indicating negative impacts of smartphone use on job engagement and self-regulation ([Zhao and Yu, 2023](#); [Orhan et al., 2021](#)), while others report positive effects on engagement ([Sasaki et al., 2021](#); [Van Laethem, Van Vianen, and Derks, 2018](#)). Summarizing the findings regarding smartphone use, stress, job engagement, and burnout, it appears that smartphone use may lead to either engagement or burnout, depending on the nature and extent of its use. Nonetheless, the mediating role of stress in influencing these outcomes is critical and cannot be overlooked. This study confirms that stress negatively affects job engagement while positively

influencing burnout. Given that smartphone use can induce stress, managing and channeling this stress constructively within organizations toward positive technology use can enhance job engagement, productivity, and organizational growth. Conversely, neglecting stress management regarding smartphone use may result in adverse consequences such as increased burnout, diminished productivity, and lower organizational performance. This study contributes to the existing literature by integrating four key constructs—smartphone use, job stress, burnout, and engagement—within a unified conceptual framework. By employing the Job Demands–Resources (JD–R) model in a Middle Eastern organizational context, the research highlights job stress as a central psychological pathway through which mobile technology influences employee outcomes. This approach offers a refined understanding of how digital tools reshape occupational experiences beyond Western settings, emphasizing stress not only as an outcome but as a key mediator and modifiable organizational factor. Like any other research, the present study has some limitations that could not be addressed because the examination of these limitations was out of the scope of the research. However, mentioning and paying attention to the major limitations can be a valuable guide for future researchers. Because the researcher was a member of the study organization and direct communication with the statistical population was almost impossible, the online questionnaire tool was used to facilitate appropriate access for the research statistical population to the questionnaire. Therefore, future researchers can communicate directly with the sample to better understand the research population and select the appropriate statistical sample. Considering the specific nature of the questionnaire, collecting complete and perfect data was impossible. Therefore, future researchers can use other tools, such as interviews etc., to conduct similar research and compare results. Considering the limited time available to the researcher, it was impossible to examine the statistical population in the long term and re-examine it at another time. Therefore, future researchers should conduct similar research in different periods and compare the obtained results. Out of 1 main and 5 secondary hypotheses raised in the current research, one secondary hypothesis was not confirmed, and the results obtained were not consistent with previous literature. However, a qualitative

investigation of the reason for the rejection of this hypothesis was not included in the framework of this study. Therefore, future researchers are advised to conduct similar research using a qualitative method. Because this research used a single statistical sample, the results obtained were attributed to the characteristics of this particular sample, making it difficult to generalize the obtained results to a wider society.

Thus, future researchers should conduct similar research on different statistical populations to generalize the results. Overall, based on the results of this research, it is suggested to control employees' stress, increase job engagement, and finally reduce burnout among employees to reduce the negative effects of using smartphones in the workplace and increase their positive effects. In line with stress management, managers can provide a place for employees to take a short break and consider the necessary measures to provide a one-day leave under the title of monthly leave for women. On the other hand, considering the responsibilities and concerns of women for house-keeping and childrearing, some hours should be devoted as floating hours for women and mothers, or they should be allowed to work remotely on some days of the week. In addition, signing a contract with a kindergarten near mothers' workplaces can greatly reduce their mental pressure and subsequent stress. In addition, considering more flexible work schedules for different job positions can reduce the pressure on employees with higher job ranks and give them more time to address their duties. An organization can reduce stress and job burnout by providing its employees with job security. For example, considering the duration of the contract, married employees with higher performance can experience significantly lower levels of burnout and psychological security. Besides, setting up a treatment clinic and providing family counseling to married couples in a completely confidential space, considering diverse and family entertainment programs, including travel, or devising different events under the title of a couple's tour, can help employees to have more interaction with other colleagues, regardless of work-related topics. In addition, providing facilities to single people, including marriage loans from the company, necessary allowances, such as service compensation packages, especially in the first year of life, and encouraging them to get married can increase their job engagement. Stress management programs can be used to control

and improve employees' workplace conditions when using smartphones. The installation and launch of internal organizational programs can also significantly improve comfortable smartphone use in the workplace. The use of internal organizational programs provides more security for the transfer of information in the work environment, which can significantly affect the level of stress when using smartphones in the workplace. Managers and organizational officials should not only reduce employees' negative stress in organizational environments but also look for ways to increase positive excitement in the organization to reduce employee burnout and increase job engagement, which will subsequently boost individual and organizational productivity. For example, employees refer to factors such as fear of being fired, delayed work due to others' underemployment, pressure to meet expectations without increasing job satisfaction, an attempt to achieve the highest productivity, and a lack of control over how to do the work. Thus, to control employee stress, organizations can give employees a sense of confidence and psychological security to reduce their job stress (e.g., extending the duration of contracts for high-performing personnel), create coordinated teams with strong communication and interactions in the organization to do collective work, identify the capacities of employees and assign appropriate tasks to them, and give employees a sense of independence and autonomy to make decisions freely while working. Through training and addressing the psychological burden caused by working hours, an organization instills convenience and security in smartphone use in the workplace, controlling the effect of this technology on increased job burnout and enabling positive use of this technology. Some educational solutions include time management (using time management applications on the computer that can establish a personal-professional balance and also reduce the tension and mental conflict of employees as one of the job demand factors), establishing usage restriction policies (promoting times without mobile phones in the organization can reduce smartphone dependence and increase interpersonal interactions among employees, subsequently reducing burnout), and considering a place smartphones before meetings and doing teamwork to control volume and work pressure, which can increase the employees' concentration while also enhancing productivity, reducing job errors, and lowering the levels of job burnout.

CONCLUSION

In summary, smartphone use at work can lead to either positive outcomes, such as increased engagement, or negative consequences like burnout, depending largely on how and to what extent the devices are used. Stress plays a crucial mediating role by reducing job engagement while simultaneously increasing burnout. Therefore, organizations must acknowledge the dual nature of smartphone use and prioritize effective stress management to maximize its benefits and minimize potential harms. Failure to address stress related to smartphone use risks higher burnout rates, diminished productivity, and impaired overall performance. To optimize smartphone use in the workplace and promote employee well-being, several practical measures can be adopted. Providing dedicated rest areas and allowing short breaks during work hours can help alleviate mental fatigue. Offering flexible working hours and remote work options, particularly for employees with caregiving responsibilities such as mothers, can ease the stress of balancing work and family duties. Establishing partnerships with nearby childcare facilities can further reduce parental stress. Enhancing job security by offering longer-term contracts to high-performing and married employees contributes to psychological safety and lowers burnout. Confidential counseling and family support programs can assist employees in managing personal and work-related stress, while social and recreational activities encourage collegiality and help reduce workplace tension. Organizations should also implement policies and training to promote secure and efficient smartphone use. This includes setting clear guidelines for data security to reduce anxiety over information transfer and providing training on time management techniques and apps that help balance professional and personal smartphone use, thereby preventing overuse and associated stress. Instituting phone-free periods during meetings or collaborative work can improve focus and reduce distractions. Additionally, fostering a positive work environment by assigning tasks that align with employees' skills and granting autonomy in decision-making enhances job satisfaction. Building coordinated teams with strong communication channels supports workload sharing and creates a more supportive atmosphere. Extending contract durations or offering incentives for high performers further strengthens psychological safety and confidence. By proactively managing stress and shaping the

use of smartphones constructively, organizations can enhance job engagement, reduce burnout, and ultimately improve both individual employee satisfaction and overall organizational performance. Building on the limitations and findings of this study, several avenues for future research are suggested. First, as this study was conducted within a single telecom organization in Iran, future research should replicate the model across diverse industries and cultural contexts to enhance generalizability. Second, the cross-sectional design limits causal inference; therefore, longitudinal or experimental studies are recommended to better capture the dynamic effects of smartphone use on stress, burnout, and engagement over time. Third, since data collection relied exclusively on self-reported questionnaires, incorporating qualitative methods such as interviews or mixed-method designs could provide richer insights into employees' lived experiences of mobile connectivity and job stress. Finally, the results indicated that smartphone use directly increased burnout but had no significant direct effect on engagement. Future studies could explore potential moderators (e.g., organizational support, digital literacy, personality traits) that may shape when and how smartphone use contributes to engagement versus burnout.

AUTHOR CONTRIBUTIONS

H.R. Nematollahi conceptualized the study, developed the research methodology, conducted the data collection and analysis, and wrote the majority of the manuscript. N. Mohammad Esmaili provided academic supervision, contributed to the study design, reviewed the manuscript, and offered critical revisions. S. Naghdi Zarrin assisted with data collection, contributed to the literature review, and helped in drafting specific sections of the manuscript.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to all participants who generously contributed their time and insights to this research.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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PUBLISHER NOTE

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ABBREVIATIONS (NOMENCLATURE)

JD-R	Job Demands–Resources
SEM	Structural Equation Modeling
AVE	Average Variance Extracted
CR	Composite Reliability
MCI	Mobile Communication of Iran (Hamrah-e Aval)
PLS	Partial Least Squares
ICT	Information and Communication Technology

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HOW TO CITE THIS ARTICLE

Nematollahi, H.R.; Mohammad Esmaeili, N.; Naghdi Zarrin, S., (2026). From flexibility to fatigue: How job stress mediates the impact of mobile connectivity on burnout and engagement. *Int. J. Hum. Capital. Urban Manage.*, 11(3): 543 - 562.

DOI: 10.22034/IJHCUM.2026.03.07

URL: https://www.ijhcum.net/article_732738.html



International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: <http://www.ijhcum.net/>

ORIGINAL RESEARCH PAPER

From policy to practice: The role of green organizational culture in shaping employee green behavior in higher education institutions – A human capital perspective

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ARTICLE INFO

Article History:

Received 08 July 2025

Revised 27 October 2025

Accepted 14 February 2026

Keywords:

*Environmental challenges;
Green behavior; Green culture;
Higher Educational Institutions;
Sustainability; Urban
development*

ABSTRACT

BACKGROUND AND OBJECTIVES: In the face of growing environmental challenges, universities play a vital role in advancing sustainability through both institutional practices and individual actions. While organisational culture can significantly shape employee green behaviour, limited research has examined how specific elements of green culture drive such practices in academia. This study addresses this gap by exploring the link between green culture enablers and employee green behavior in higher education. As integral parts of the urban ecosystem, HEIs also influence urban management, extending their sustainability impact beyond campuses to support broader city-level environmental goals.

METHODS: Data were collected from 266 university employees through a structured questionnaire. The hypothesized model was tested using regression analysis to determine the predictive power of green culture enablers on employee green behavior in university employees.

FINDINGS: The green culture enablers were found to have a positive relationship with green behavior. Message credibility ($\beta = 0.453$) and employee empowerment ($\beta = 0.296$) were found to be the strongest and most significant predictors of green behavior. Leadership emphasis was found to be a weaker but significant predictor. Surprisingly, Peer involvement was not found to significantly predict green behavior when controlling for other variables.

CONCLUSION: This study concludes that cultivating a supportive green culture through credible communication, engaged leadership, and peer-driven initiatives is crucial for fostering sustainable behaviors in higher education institutions. It contributes to the growing body of sustainability literature by highlighting how internal cultural factors influence individual green behavior. By addressing contextual variables such as institution type, the research also overcomes the generalization limitations found in earlier studies. The findings offer insights for urban policymakers and HEI administrators on leveraging human capital to drive sustainable urban development."

DOI: [10.22034/IJHCUM.2026.03.08](https://doi.org/10.22034/IJHCUM.2026.03.08)



NUMBER OF REFERENCES

48



NUMBER OF FIGURES

1



NUMBER OF TABLES

4

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the "Show Article."

INTRODUCTION

Environmental challenges, such as climate change and global warming, are escalating at an alarming rate, demanding immediate attention from governments and organizations worldwide. In response, strict environmental regulations have been enforced to curb carbon emissions and promote green practices. While technological advancements are critical, human behavior has been identified as both the major cause of these environmental concerns and, conversely, a significant enabler of sustainable change (Tilman & Lehman, 2001; Ukaogo, 2020). Businesses are increasingly incorporating environmental management systems and practices into their daily operations (Guerci et al., 2015). However, the success of these green initiatives depends not only on policies and regulations but also on the green behavior exhibited by employees. Employee green behavior refers to discretionary actions aimed at reducing environmental harm and enhancing sustainable performance (Kim et al., 2019). Emerging research underscores the importance of organizational culture in shaping such behavior. A green organizational culture fosters shared values and norms that prioritize environmental sustainability (Harris and Crane, 2002; Yong et al., 2020). Yet, green culture has not been sufficiently examined through its enablers, such as leadership emphasis, message credibility, employee empowerment, and peer involvement. Existing studies have mainly considered these enablers as mediators between Green Human Resource Management (GHRM) practices and outcomes like environmental performance (Roscoe et al., 2019), organizational citizenship behavior (Musiyo et al., 2021), and green competitive advantage (Musiyo et al., 2022). This highlights the need to investigate the direct relationship between green culture enablers and employee green behavior, particularly in non-corporate contexts such as higher education.

Role of HEIs in sustainability

Following the adoption of the UN Sustainable Development Goals (SDGs), the green campus movement and sustainability rankings have positioned HEIs as key leaders in advancing global sustainability agendas (Times Higher Education, 2025). Higher Education Institutions (HEIs) are especially significant in sustainability research as they function as key actors within the urban ecosystem. Sustainable practices

adopted on campuses, such as renewable energy use, rainwater harvesting, tree plantation, sewage treatment plant, and green mobility, offer replicable models that can be scaled up to urban contexts. In this way, HEIs serve as laboratories of sustainable practices and as influential drivers of urban transformation. The diffusion of green knowledge, skills, and practices from HEIs contributes directly to long-term sustainability goals and the advancement of sustainable city development (Education for Sustainable Development, 2011). HEIs can also be understood as microcosms of urban environments, reflecting the same resource consumption patterns, infrastructure needs, and socio-environmental challenges faced by cities. By fostering green behavior among staff and students, universities cultivate sustainable mindsets that extend beyond campuses, influencing broader communities and supporting urban sustainability transitions (Saadatian et al., 2012). Thus, they play a dual role in promoting sustainability internally (through curricula, campus policies, and operations) and externally (by serving as role models for the community) (Dagiliute and Liobikiene, 2015). Meanwhile, the internal behavioral mechanisms through which a green culture is fostered within HEIs remain underexplored. Most studies remain focused on corporate settings, overlooking the unique governance structures, stakeholder expectations, and institutional logics that influence behavior in academic environments. This study aims to address this gap by investigating how specific green culture enablers (leadership emphasis, message credibility, peer involvement, and employee empowerment) directly influence green behavior among employees in Indian HEIs. India, as one of the fastest-growing economies, is at the forefront of sustainability challenges and opportunities. The country has made formal commitments to the United Nations Sustainable Development Goals (SDGs), and its higher education sector is increasingly being recognized as a critical agent for advancing these goals through teaching, operations, and campus culture. Higher Education Institutions (HEIs) in India are thus under mounting pressure to align institutional behavior with sustainability agendas, making them an appropriate and timely context for studying green organizational culture and employee-level green behavior. Furthermore, India has a huge urban capital encompassing a diverse mix of state, central, private, and deemed universities. Given this concentration and di-

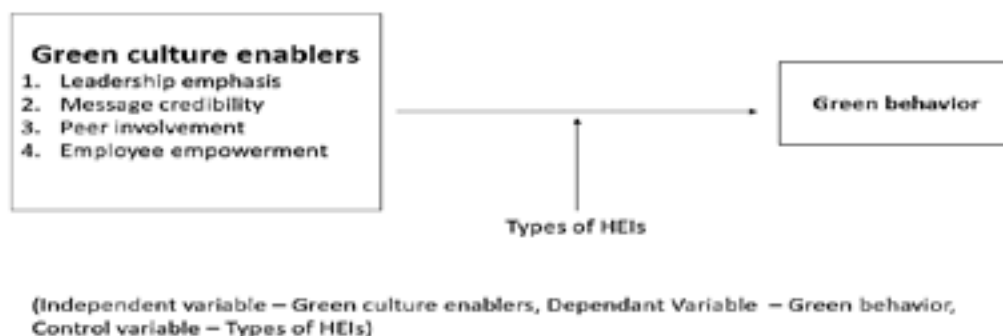


Fig. 1: Conceptual model

versity, the present study aims to explore the HEIs in India. This context provides a rich empirical setting to explore how variations in organisational culture and governance structures influence sustainability-related behaviours among academic staff.

Thus, this study intends:

- To examine the relationship between each green culture enabler and green behavior
- To understand the predictive influence of each green culture enabler on green behavior
- To test whether the relationship between Green Culture Enablers and Green Behavior differs between different types of HEIs.

This study advances our understanding of green culture enablers by highlighting its implications for both theory and practice, particularly in the context of fostering employee green behavior. It fulfils the two core criteria for making a theoretical contribution: originality and utility, as outlined by Corley (2011). The originality of this study lies in its provision of empirical evidence on the link between green organisational culture and employee green behaviour through the lens of employee green behaviour. While previous literature has acknowledged the influence of organisational culture on sustainable outcomes. This study focuses on the specific mechanisms (leadership emphasis, message credibility, peer involvement, employee empowerment) that shape and sustain green behavior at the employee level. Thus, this research addresses this gap by exploring how these EGC dimensions function as behavioral triggers within organisations (Srinivasan and Kurey, 2014). The study also offers utility by acting as a practical guide to managers and organisations on cultivating a green

organisational culture that supports employee green behaviour. We believe the originality and practical value of this study are particularly relevant to institutions of higher education, where there is a growing need to model and teach green behavior.

Hypothesized model of the study

The variables hypothesized to predict green behavior are shown below. Fig. 1 shows the conceptual model of the study, with four green culture enablers proposed as predictors of green behavior, with types of HEIs acting as a moderator.

Literature review

A theoretical foundation is required to better understand the relationship between green culture enablers and green behavior. According to the theory of planned behavior, Attitude, Subjective norms, and perceived behavioral control are the components that determine behavior (Ajzen, 1991). In the context of Green culture, Leadership emphasis and Peer involvement influence subjective norms because when leaders and peers exhibit green behavior, there is a high chance for the individual to engage in green behavior. Similarly, employee empowerment enhances perceived behavioral control since it provides the required resources and support to engage in green behavior. Similarly, messages from credible sources help shape the attitude of employees toward green behavior. Previous studies have shown the positive effect of organizational culture on green behavior (Trimono and Nawangsari, 2021).

Human Capital Theory suggests that employees' knowledge, skills, values, and attitudes function as capital that enhances organisational effectiveness (Becker, 1964). Within green culture, leadership em-

phasis, peer involvement, message credibility, and employee empowerment contribute to the development of green human capital by strengthening employees' environmental awareness, pro-environmental values, and green competencies. These accumulated capabilities shape employees' attitude towards green behavior, enhance perceived behavioral control by increasing confidence, and reinforce subjective norms by normalizing environmentally responsible practices. Complementing this view, the Resource-Based View (RBV) posits that organizational resources that are valuable, rare, inimitable, and non-substitutable generate sustained competitive advantage (Barney, 1991). Green culture enablers represent intangible, embedded organizational resources that, when consistently enacted, become difficult to imitate and support sustained green behavior among employees. Integrating these perspectives with the Theory of Planned Behavior, RBV explains why green culture enablers are strategically valuable, Human Capital Theory explains how they build green capabilities, and TPB explains how these capabilities are translated into green behavior through attitudes, subjective norms, and perceived behavioral control.

Leadership emphasis

Leadership emphasis refers to the visible prioritisation of environmental responsibility by organisational leaders and their consistent demonstration of pro-environmental behaviours (Sharma & Vredenburg, 1998; Robertson & Barling, 2013). In HEIs, leaders legitimise sustainability as a core organisational goal, creating a vision that motivates employees to follow sustainable practices. Leadership emphasis influences subjective norms under TPB, as employees perceive environmentally responsible behavior to be expected and valued by authority figures. From an RBV perspective, proactive leadership acts as a strategic resource, embedding sustainability values into organisational routines that are difficult to replicate. From a Human Capital Theory perspective, leaders mentor and guide employees, transferring knowledge, shaping attitudes, and enhancing environmental competencies, thereby strengthening organisational human capital. Leadership emphasis also includes assessing employee performance based on environmental criteria, further reinforcing sustainable behaviors across hierarchical levels (Bowen & Ostroff, 2000; Pham et al., 2020).

Message credibility

Message credibility refers to clear, consistent, and trustworthy communication regarding sustainability initiatives from senior management. Credible messaging shapes employee attitudes toward green behavior, as consistent and reliable communication fosters belief in the importance and feasibility of sustainability initiatives (Robertson & Barling, 2013; Graves et al., 2013). The Elaboration Likelihood Model (Petty & Cacioppo, 1986) suggests that messages perceived as credible result in enduring attitude change, particularly in academic settings where evidence-based reasoning is valued. From an HCT perspective, credible messaging builds employees' knowledge and competencies regarding environmental issues, helping them internalize sustainability values. From an RBV lens, consistently communicated and credible messages become an intangible organizational resource, enhancing the firm's capacity to maintain sustainable behavior as a unique capability that competitors cannot easily replicate.

Peer involvement

Peer involvement refers to the active participation and collaboration of employees with one another in supporting environmental initiatives (Srinivasan & Kurey, 2014). It influences subjective norms in TPB, as employees are more likely to adopt green behaviors when they observe peers engaging in environmentally responsible actions. Peer modeling and group norms can amplify or dampen pro-environmental behavior depending on the strength of group cohesion and shared identity (Fielding et al., 2008; Terry & Hogg, 1996). In HEIs, peer involvement promotes informal learning, mentoring, and social reinforcement mechanisms that strengthen a culture of sustainability. From an HCT perspective, peer interactions facilitate the diffusion of green competencies and attitudes among employees. From an RBV standpoint, cohesive peer networks act as social resources, embedding sustainability into collective routines that are difficult to imitate.

Employee empowerment

Employee empowerment is the granting of autonomy, resources, and decision-making authority to staff to implement environmental initiatives (Daily et al., 2012; Srinivasan & Kurey, 2014). Empowerment increases perceived behavioral control under TPB, enabling

employees to take initiative and overcome barriers to sustainable behavior. Empowered employees exhibit higher ecological awareness and discretionary green behavior (Hameed & Naeem, 2019). From a Human Capital Theory perspective, employee empowerment develops green competencies, knowledge, and decision-making skills that enhance sustainability-oriented human capital. From an RBV perspective, empowered employees constitute valuable, rare, and inimitable organisational resources, capable of sustaining a competitive advantage through pro-environmental behavior.

Green behavior

Green behavior refers to the individual actions that aim to reduce environmental harm and promote sustainability. Green behavior can be influenced by the eco-conscious culture prevailing in the organization. This green culture can foster a shared mindset and alter the behavior of employees to be more eco-friendly. A recent study by Naqvi and Siddiqui (2019) has underlined the role of employees' green behavior in transforming an organization's culture to adopt environmentally friendly strategies. This shows a strong relationship between green culture and green behavior. The above literature provides a strong theoretical and empirical base to propose that green culture enablers significantly predict employee green behavior.

Based on the above literature, the following hypotheses are put forth:

H1: Green culture enablers are positively related to employee green behavior

H1a: Leadership emphasis is positively related to employee green behavior

H1b: Message credibility is positively related to employee green behavior

H1c: Peer involvement is positively related to employee green behavior

H1d: Employee empowerment is positively related to employee green behavior

H2: Green culture enablers significantly predict employee green behavior

H2a: Leadership emphasis significantly predicts employee green behavior.

H2b: Message credibility significantly predicts employee green behavior.

H2c: Peer involvement significantly predicts employee green behavior.

H2d: Employee empowerment significantly predicts employee green behavior.

Within the Indian context, South India stands out as a regional leader in sustainability performance, hosting a large number of universities with diverse governance structures and active engagement in environmental initiatives. According to the Times Higher Education Impact Rankings (2025), seven of India's top sixteen globally ranked sustainable universities are from this region. Among these, Chennai emerges as an ideal urban microcosm, hosting three of the region's top-ranked universities and demonstrating active engagement in the Smart Cities Mission. The region encompasses a wide spectrum of state and deemed universities, which differ notably in their governance structures, funding mechanisms, degrees of institutional autonomy, and organizational cultures, positioning Chennai as a representative context for examining how green culture enablers shape behavioral outcomes within India's higher education system. This heterogeneity offers a valuable opportunity to investigate whether the impact of green culture enablers on green behavior is consistent across institutional types in order to ensure the ecosystems of urban development. By leveraging this contextual variation, the study aims to examine the moderating role of institutional type, thereby contributing to a more nuanced understanding of how internal cultural mechanisms function under different organizational conditions.

H3: Institutional type moderates the relationship between green culture enablers and employee green behaviour.

MATERIAL AND METHODS

The data was collected from university staff in Chennai, including teaching and non-teaching personnel from various departments and institution types. The study comprises 30 items, each measured on a 5-point Likert scale. In addition, the questionnaire sought data on demographic details (Age, Gender, Educational qualification, Department, Type of institution, Designation, Experience). Google Forms were used to collect data. Since all items were mandatory, none of the responses were rejected. A total of 266 samples were collected over 8 weeks (May to June 2025). The demographics were diverse. For in-

Table 1: Respondents' profile

		Frequency	Percent
Gender	Male	123	46.24
	Female	143	53.75
Types of Universities	State	130	48.87
	Deemed	136	51.12
Work Experience	Less than 5 years	72	27.06
	5 to 10 years	29	10.90
	11 to 15 years	10	3.75
	16 to 20 years	6	2.25
	Above 21 years	13	4.88
Educational qualification	PG	146	54.88
	M.Phil	34	12.78
	Ph. D	86	32.33
Designation	Assistant Professor	125	46.99
	Associate Professor	33	12.40
	Professor	49	18.42
	Administrative staff	59	22.18

stance, the sample included 123 males and 143 females. The respondents' ages ranged from 25 to 60, and their work experience ranged from less than 5 years to more than 21 years. The respondent's profile is given in [Table 1](#).

Purposive sampling with a maximum variation strategy was employed. This approach enabled the selection of diverse staff members from different types of higher education institutions (state and deemed) and across various roles (teaching and non-teaching), ensuring rich and varied perspectives. This method is particularly suitable for studies where contextual knowledge is crucial and where the goal is to understand depth and patterns of behavior, rather than to generalize to an entire population ([Palinkas et al., 2015](#); [Etikan et al., 2016](#)). Furthermore, purposive sampling is suitable when the complete population is unknown or not fully accessible, as is often the case with large and distributed academic institutions ([Salman, 2020](#)). To ensure no violations of key assumptions such as linearity, normality, multicollinear-

ity, and homoscedasticity, a preliminary analysis was performed. Normality was confirmed using graphical and statistical methods. Skewness and kurtosis values were within the acceptable range, indicating a normal distribution. All the measurement scales were already validated and applied in previous studies. A 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), was employed in the study. Green culture enablers with 4 dimensions were adapted from [Chams and Blandon \(2019\)](#). Green behavior items were adapted from [Aboramadan \(2020\)](#). The Cronbach alpha values were around 0.70 and above, confirming reliability as suggested by [Nunnally \(1978\)](#). It is shown in [Table 2](#).

RESULTS AND FINDINGS

Correlation between the variables

Pearson correlation analysis was conducted as an initial step to examine the strength and direction of the bivariate relationships between green culture enablers (leadership emphasis, peer involvement,

Table 2: Means, standard deviations, and scale reliabilities

	Leadership emphasis	Message credibility	Peer involvement	Employee empowerment	Green behavior
Mean	3.9286	4.0895	4.0135	4.0406	4.2382
Median	3.8000	4.0000	4.0000	4.0000	4.0909
Standard deviation	.60127	.46391	.55447	.6516	.52733
Minimum	2.60	3.00	2.80	2.50	2.91
Maximum	5.00	5.00	5.00	5.00	5.00
Alpha	0.802	0.699	0.750	0.827	0.929

employee empowerment, and message credibility) and green behavior. This technique is essential for identifying potential associations and ensuring a meaningful relationship between variables. In the context of behavioral studies, correlation analysis provides foundational evidence of construct interrelationships (Hair *et al.*, 2010). According to Nakagawa (2004), when the correlation coefficient value is between .30 to .49, the relationship strength between the variables is considered as low; similarly, when the correlation coefficient value is between .30 to .49, the relationship strength is medium, and the correlation coefficient values between .50 to 1.0 implies high relationship strength between the variables (Taylor, 1990). The Pearson correlation analysis revealed a significant positive relationship between green behavior and all four enablers of green culture. Message credibility ($r=.609$, $p < .001$) shows a strong, significant positive correlation with green behavior, followed by Leadership emphasis ($r=.506$, $p < .001$). Employee empowerment ($r=.483$, $p < .001$) and Peer involvement ($r=.453$, $p < .001$) show a moderate positive correlation with green behavior. All four enablers are showing a significant positive relationship with green behavior, indicating that stronger green cultural practices are generally associated with more environmentally conscious behavior. Thus, hypothesis 1 (H1a, H1b, H1c, H1d) is fully supported. This aligns with theoretical foundations from the Theory of Planned Behavior (Ajzen, 1991), where organizational cues and reinforcement mechanisms can shape behavioral intentions and actions. To get a more nuanced picture, multiple regression was carried out. Additionally, multicollinearity should be low to perform multiple regression. Multicollinearity occurs when there is a high correlation among independent variables, leading to redundant information. Toler-

ance and VIF (Variance Inflation Factor) values help to detect multicollinearity among the variables. If all the variables have tolerance > 0.20 and $VIF < 5$, there is no serious multicollinearity. Variables with an R value of more than .70 show a high correlation and can cause multicollinearity. In this study, the tolerance values of leadership emphasis, peer involvement, employee empowerment, and message credibility are 0.586, 0.454, 0.517, and 0.656, respectively, all above 0.20, indicating no multicollinearity. This is also supported by the VIF values (1.706, 2.204, 1.933, and 1.524), which are all below 5. Hence, regression analysis can be carried out.

Regression analysis

To understand the predictive influence of each green culture enabler on green behavior, regression analysis was performed. Multiple regression assumes that there is a linear relationship between the independent variables and the dependent variable. Given that green behavior is likely influenced by multiple interrelated factors, regression provides a robust analytical framework to quantify these effects, identify key predictors, and evaluate the overall model fit. This approach also aligns with previous sustainable behavior studies in organizational contexts that rely on regression to validate theoretical models (Afsar *et al.*, 2016). The results revealed that message credibility ($\beta = .453$, $p < .001$), employee empowerment ($\beta = .296$, $p < .001$), and leadership emphasis ($\beta = .134$, $p < .001$) were significant predictors of green behavior, whereas peer involvement ($\beta = -.023$, $p < .726$) didn't predict green behavior. The results show that the overall model is statistically significant and explains 47.6% of the variance in green behavior, which is quite a good variance for behavioral research. This indicates the model has good predictive power. Re-

Table 3: Regression results

Predictor	B	STDEV	β	T	P	VIF
Leadership emphasis	0.118	0.051	0.134	2.295	.023	1.706
Peer involvement	-0.022	0.063	-0.023	-0.351	.726	2.204
Employee empowerment	0.239	0.050	0.296	4.751	<.001	1.933
Message credibility	0.515	0.063	0.453	8.193	<.001	1.524

(B = Beta coefficient; STDEV= Standard error; β = Regression coefficient; T= Statistics; P = Probability value; VIF = Variance Inflation Factor).

gression results are given in Table 3. While message credibility and employee empowerment emerged as the strongest predictors of green behavior, leadership emphasis had a weaker but still significant influence. Thus, hypothesis H2a, H2b, H2d are supported. The influence of peer involvement became statistically non-significant in the presence of other predictors. Thus, H2c is not supported. This suggests that although peer networks are influential at a surface level, their impact may be overshadowed by structural or communication-related enablers when modeled concurrently. This partially contradicts earlier studies that emphasize the role of social norms in green behavior (Ramus and Killmer, 2007) but may reflect contextual differences in hierarchical organizational cultures, which are typical of Indian academia. The significant influence of message credibility underscores the importance of consistent, trustworthy, and transparent communication about environmental policies and initiatives. Likewise, employee empowerment through enabling participation in environmental decisions enhances ownership and accountability, driving green behavior beyond mere compliance.

Moderation by type of Institutions

In the context of green behavior, demographic variables have received comparatively less attention than organizational and psychological factors (Aboramadan, 2020; Fawehinmi et al., 2020). In particular, empirical evidence on the moderating role of demographic variables in shaping employees' green behavior within educational institutions remains limited. Addressing this gap, the present study examines the moderating effect of institution type on the relationship between green culture enablers and employee green behavior. A moderation analysis using hierarchical regression was conducted. The inclusion of interaction terms led to a significant improvement in model fit ($\Delta R^2 = .028$, $p < .001$), indicating that insti-

tution type plays a contingent role in influencing how green culture enablers influence green behavior, as shown in Table 4. The results further revealed that the interaction between employee empowerment and institution type was statistically significant ($\beta = 0.261$, $p = 0.004$), suggesting that the positive effect of employee empowerment on green behavior is stronger in deemed universities than in state universities. In contrast, the interaction effects for leadership emphasis, peer involvement, and message credibility were not statistically significant. Therefore, institution type does not uniformly moderate the relationship between all green culture enablers and green behavior, leading to partial rather than full support for the moderation hypothesis. Accordingly, H3 is not supported. These findings imply that certain institutional contexts may provide greater autonomy, resources, or cultural support, enabling empowered employees to translate empowerment into green behavior more effectively. This result aligns with contingency theory, which posits that the effectiveness of organizational practices depends on contextual conditions (Donaldson, 2001). The absence of significant moderation effects for leadership emphasis, peer involvement, and message credibility may indicate a relatively consistent reliance on leadership-driven communication and cultural signaling across different types of higher education institutions.

DISCUSSION

This study contributes to understanding sustainability in higher education institutions (HEIs) by examining how green culture enablers shape employee green behavior. Message credibility and employee empowerment emerged as the strongest predictors, indicating that staff are more likely to engage in green behavior when communication is trustworthy and autonomy is granted. These results align with prior research showing that credible communication and

Table 4: Moderation effect of Institution type

Model	R ²	ΔR ²	Sig. ΔF
Step 1 (Main effects)	.481	—	.000
Step 2 (Interactions)	.509	.028	.000

empowerment drive organizational citizenship toward the environment (Muisyo et al., 2022; Ooi et al., 2022; Faezah et al., 2024). Leadership emphasis was positively associated with green behavior but became weak once other variables were controlled, suggesting that leadership commitment requires support from credible communication and decentralized empowerment. Peer involvement, initially correlated with green behavior, lost significance in regression models, echoing findings that peer effects are often mediated or moderated by institutional factors (Muisyo et al., 2022). The study also highlights that institutional context moderates these relationships. Empowerment had a stronger effect in deemed universities than in state universities, emphasizing that administrative flexibility enhances the effectiveness of green initiatives. From a managerial perspective, the findings underscore that message credibility and empowerment are strategic investments in green human capital, fostering competence, motivation, and ecological efficacy. Urban policymakers can leverage these insights by integrating empowerment-based training, participatory decision-making, and transparent reporting to promote green behavior among municipal employees and urban residents, particularly under initiatives like the Smart Cities Mission. Theoretically, the study reinforces a contingency perspective, showing that the impact of green culture enablers depends on governance, institutional type, and urban context. While the Theory of Planned Behavior provides a useful lens, incorporating structural and contextual variables can enhance models predicting employee green behavior in HEIs. In summary, this study confirms that message credibility and employee empowerment are key levers for fostering green behavior, while institutional characteristics shape their efficacy, offering actionable insights for both higher education and urban sustainability strategies.

Managerial implications

The study provides managerial implications to call for a strategic shift in how higher education institu-

tions approach environmental sustainability. Rather than relying solely on top-down directives or symbolic commitments, institutions should invest in systems that foster credible communication and empower stakeholders at all levels. Universities aiming to enhance sustainable practices must ensure that environmental messaging is not only frequent but also trustworthy and aligned with operational realities. Simultaneously, providing staff with the opportunity to contribute meaningfully to green initiatives can cultivate a sense of ownership and intrinsic motivation, thereby translating organizational intent into tangible action. For urban policymakers and municipal human capital managers, these insights underscore the importance of integrating sustainability principles into the broader urban workforce strategy. Under initiatives like the Smart Cities Mission and National Urban Learning Platform, credible communication and empowerment can be leveraged to enhance green behavior among city employees and residents alike. Establishing open reporting systems, participatory decision platforms, and community engagement mechanisms can help translate sustainability goals into everyday behavioral practices. Moreover, aligning performance management systems with city-level sustainability indicators such as carbon reduction or waste minimization can reinforce accountability and ensure that individual actions contribute directly to collective urban outcomes.

FUTURE DIRECTIONS

Future studies could examine how green behaviors in academic institutions influence broader urban sustainability metrics, such as carbon footprint reduction, waste minimisation or community engagement in green initiatives. Further research may also explore the longitudinal effects of cultivating a green culture on employees sustained environmental commitment and institutional performance. It can also extend the current framework by integrating psychological and behavioral theories, such as Social Learning Theory

and Norm Activation Theory, to capture deeper motivational mechanisms that drive employees' ecological actions within HEIs. Integrating Institutional Theory could further enrich understanding by examining how universities act as change agents that diffuse green norms and practices into the surrounding urban environment. Cross-country or cross-sectoral investigations could provide valuable insights into how variations in national culture, governance structures, and environmental policies moderate the relationship between green culture and green behavior. In addition, future studies could consider the mediating role of institutional partnerships, stakeholder collaboration, and policy support in amplifying the impact of green behavior on urban sustainability outcomes. Finally, longitudinal and multi-level analyses could help identify the pathways through which individual and collective green behaviors within HEIs foster broader urban sustainability outcomes.

CONCLUSION

The findings of this study offer important theoretical and practical contributions to the growing body of literature on sustainability in higher education institutions. By examining how green culture enablers influence green behavior, the study highlights the critical role of organizational elements such as message credibility, employee empowerment, leadership emphasis, and peer involvement. Among these, message credibility and employee empowerment emerged as the most influential predictors, suggesting that employees are more likely to exhibit green behavior when institutional communication is perceived as credible and when individuals are given autonomy and agency to act. Leadership emphasis, while positively associated with green behavior, exerted a weaker influence when controlling for other variables. Notably, peer involvement, though initially correlated with green behavior, did not remain significant in the regression model, suggesting that its effect may be mediated or overridden by other factors. The study further reveals that institutional context significantly moderates the relationship between green culture enablers and behavioral outcomes. Specifically, the positive effect of empowerment on green behavior was stronger in deemed universities than in state universities. This finding shows that Deemed universities provide a more flexible and conducive environment for employees to flourish.

This variation underscores the importance of institutional characteristics in shaping the efficacy of green initiatives and highlights the need for context-sensitive policy formulation. The study also contributes to theory by reinforcing the contingency perspective, which posits that the impact of organizational practices is not universal but is shaped by internal and external contexts. It cautions against assuming uniform outcomes of green culture enablers across different institutional settings and encourages scholars to consider structural and cultural nuances when analyzing sustainability behavior. While the Theory of Planned Behavior provided a useful lens for understanding how organizational factors can influence individual actions, the findings suggest that additional contextual variables, such as institutional governance, can be integrated into future models.

AUTHOR CONTRIBUTIONS

Pooja S: Data collection, analysis, and manuscript writing. Bhavani J: supervision, validation, manuscript review, and editing

ACKNOWLEDGEMENT

The author would like to express sincere gratitude to the reviewers for their exceptional guidance and constructive feedback during the review process. Their insightful comments and suggestions significantly enhanced the quality of our manuscript.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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PUBLISHER NOTE

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ABBREVIATIONS

β	Regression coefficient
B	Beta coefficient
HEI	Higher Education Institution
HRM	Human Resource Management
<i>p-value</i>	Probability value
R^2	Coefficient of determination
ΔR^2	Adjusted Coefficient of Determination
SDG	Sustainable Development Goals
Sig. ΔF	Significance of Delta
STDEV	Standard Error
T value	Student's t statistic
UN	United Nations
UNESCO	United Nations Educational, Scientific, and Cultural Organisation
VIF	Variance Inflation Factor

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HOW TO CITE THIS ARTICLE

Pooja, S.; Bhavani J., (2026). From policy to practice: The role of green organizational culture in shaping employee green behavior in higher education institutions – A human capital perspective. *Int. J. Hum. Capital. Urban Manage.*, 11(3): 563 - 574.

DOI: 10.22034/IJHCUM.2026.03.08

URL: https://www.ijhcum.net/article_734413.html



International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: <http://www.ijhcum.net/>

ORIGINAL RESEARCH PAPER

Beyond traditional metrics: A multi-dimensional index for assessing quality of life across countries

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ARTICLE INFO

Article History:

Received 22 May 2025

Revised 14 August 2025

Accepted 19 May 2026

Keywords:

Quality of Life (QoL); Human well-being; Human Development Index (HDI); Ecological footprint; Happy Planet Index (HPI)

ABSTRACT

BACKGROUND AND OBJECTIVES: The assessment of quality of life is a complex, multi-dimensional task that incorporates both objective and subjective indicators. Traditional economic metrics often fail to fully capture the true well-being of populations. This paper aims to analyze existing methods for assessing quality of life, propose a comprehensive and flexible index that integrates multiple indicators, and highlight the importance of balancing objective and subjective criteria to better understand the dynamics of population well-being across different countries.

METHODS: The study reviews various approaches to measuring quality of life, including objective, subjective, and complex methodologies. It synthesises data from international research, including indices such as the Human Development Index, the Euromodule, and the Happiness Index, among others. The authors develop a new assessment framework based on constructing composite indices from selected indicators across the economic, social, demographic, and environmental sectors, integrated in a linear form with weights defined by factor analysis. Graphical data analysis, normalisation, and index formation techniques are used for comparative assessments across countries.

FINDINGS: Existing methods, such as the Human Development Index and the Happiness Index, have limitations in capturing the full scope of quality of life due to their focus on either objective or subjective components alone. The proposed complex quality-of-life index, integrating multiple sub-indicators, offers a more comprehensive picture of population well-being. It shows that in Armenia quality-of-life score gradually increased from 0.321 in 2012 to 0.355 in 2018, but after reaching its highest point, the score decreased to 0.337 in 2019, remaining lower at 0.353 in 2020 and 0.336 in 2021. This indicates that the country experienced a decline or volatility in quality-of-life measures in recent years. Despite these fluctuations, the scores remained within a relatively narrow range (approximately 0.321 to 0.355), suggesting that while improvements and setbacks occurred, the overall level of quality of life remained moderately stable over the last decade.

CONCLUSION: The complex approach presented provides a valuable framework for ongoing international comparisons and for tracking changes in quality of life over time, emphasizing the importance of integrating diverse socio-economic and cultural factors into quality-of-life assessments.

DOI: [10.22034/IJHCUM.2026.03.09](https://doi.org/10.22034/IJHCUM.2026.03.09)



NUMBER OF REFERENCES

46



NUMBER OF FIGURES

2



NUMBER OF TABLES

8

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the "Show Article."

INTRODUCTION

Over the past decade, high rates of economic growth have not necessarily led to improved Quality of Life (QoL) or reduced poverty levels across the globe (Lavell et al., 2023; Balaj, 2024). In some cases, poverty has deepened further (Wimer et al., 2024; Yusuf et al., 2024). Countries leading the way in socio-economic development tend to have high levels of education, science, healthcare, and cultural development rather than high rates of economic growth (Fonseca et al., 2024; Miah et al., 2024). Therefore, economic growth must be directed towards improving the quality of life of the population (Sergi et al., 2023). This justifies the need to assess the role and impact of a high QoL in the context of modernity. QoL indices are essential scientific tools for understanding, monitoring, and improving population well-being. They provide policymakers, researchers, and communities with actionable insights, making their study and assessment a cornerstone of public health, social science, and policy research. Quality of Life Indexes (QoLIs) combine multiple dimensions, such as health, economic status, education, environment, and social factors, into a single, interpretable metric, allowing for a holistic assessment of well-being (Ferrans and Powers, 1992; Katumba et al., 2022). They are valuable tools that enable governments and organisations to monitor progress, identify areas in need of intervention, and evaluate the impact of policies on population well-being (Hagerty, 2001; Gomonov et al., 2021; Ratner et al., 2022; Mkrtchyan et al., 2025). Furthermore, by standardizing diverse indicators, QoLI facilitates comparisons between different regions, countries, or demographic groups, thereby highlighting inequalities and trends over time. However, although existing QoL indices provide valuable information, they are often insufficient due to their limited scope, methodological weaknesses, lack of sensitivity to context, and static nature (Barnett, 1991). For instance, indices focusing on economic indicators frequently overlook the value of non-market activities, such as unpaid care work, volunteering, and community involvement, despite these contributing significantly to social well-being. Early versions of the Human Development Index (HDI), for instance, focused primarily on objective indicators such as life expectancy, education levels, and income. While these are important, they do not capture individuals' subjective experiences and perceptions (Ramkissoon et al., 2025). Furthermore, indices

often aggregate data at the national level, masking significant variations within countries. For instance, an index may indicate a high quality of life overall but fail to reveal disparities between urban and rural areas, or between different ethnic groups. The primary aim of this paper is to analyze existing methods of assessing the QoL and to propose a comprehensive and flexible model for its evaluation. The issue of study is that there is a lack of a comprehensive, empirically validated, and reproducible index for measuring Quality of Life that (1) integrates a balanced set of objective multidimensional indicators, (2) applies data-driven statistical weights, and (3) enables consistent comparison across countries and over time. This gap results in fragmented assessments, methodological inconsistencies, and limited policy applicability of existing QoL measures. Specifically, the authors seek to develop a complex index that integrates multiple indicators across economic, social, demographic, and environmental sectors. The research questions of this paper focus on understanding and improving the assessment of the QoL:

Q1: What are the main criteria and principles for assessing the QoL of populations across different countries?

Q2: How can existing methodologies and indices be improved or combined to develop a more accurate, multidimensional assessment tool?

Q3: What indicators from economic, social, demographic, and environmental sectors should be integrated into a unified complex index for evaluating QoL?

The study uses a combination of quantitative statistical methods, such as factor analysis, and qualitative assessments and data analysis to develop, normalise, and weight multidimensional indicators. This leads to the creation of comprehensive, adaptable indices for assessing population quality of life. The proposed QoLI was calculated for Armenia, Iran, Georgia, Moldova, Albania, and Azerbaijan for the period 2012–2021. This study proposes a comprehensive, multidimensional, and empirically validated Quality of Life Index (QoLI) to address gaps in existing literature. The QoLI integrates economic, social, and demographic indicators (e.g., life expectancy, education, poverty, innovation) for a holistic assessment, overcoming limitations of purely economic indices. It employs factor analysis for statistically justified, objective, and transparent indicator weighting, avoiding arbitrary assignments. Constructed using 10-year panel data

(2012–2021) from 100 countries with consistent normalization, the QoLI enables robust longitudinal and cross-country comparisons for benchmarking and policy evaluation. Finally, designed for practical policy application, its clear sub-indices (economic, social, and demographic) facilitate targeted social and economic interventions.

Literature review

For a long time, the welfare of society was characterized only by economic indicators, which focused solely on individual needs. Scientific research on this issue has been ongoing since the 18th century. In all studies, the standard of living was chosen as the fundamental concept, with its various interpretations. The standard of living reflects the volume and structure of consumption, social production conditions, the level of development of the service sector, how non-working time is spent, and the size of individual property. This broad definition describes the socio-economic situation of the population. In a narrower sense, the standard of living is defined as the level of need satisfaction and the corresponding income. The concept of 'quality of life' as an economic category was first introduced by economist Z. Helbert in his 1960 book *The Society of Abundance* (Zhalnina and Gerasimov, 2006). In politics, the term was introduced by US President J. Kennedy, in his State of the Union address in 1963, in which he commented that 'the quality of American life must keep pace with the quantity of American goods' (Khadzhalova, 2014). According to Eric Allard, quality of life is achieved through the satisfaction of three basic need systems: 'to have', 'to love', and 'to be'. Consumer needs are defined as the material conditions necessary for survival and for avoiding poverty (Allardt, 1993). Subbeto describes quality of life as comprising the quality of material, socio-cultural, environmental, psychological, and demographic characteristics of life (Subbeto, 2012). Sen proposed two concepts of living standards. One is the concept of the actual level of human life, i.e., the standard of living (Sen, 1993). This is understood as a set of activities and aspects of existence that are inherent in a person's life at a given moment or during a given accounting period. The other reflects the totality of possible and available lifestyles open to a person at a given moment in time, from which they can choose one to become their actual lifestyle, characterised by the first concept of liv-

ing standards (Poduzov, 2008). Reidulf et al. reported that a person's quality of life is determined by how much they utilise the real opportunities in their life. Feeling content and achieving benefits are two components of that satisfaction (Arnout, 2023). In modern conditions, quality of life is primarily an effective tool for implementing the state's social and economic policy (Ramkissoon et al., 2025). Social policy means the relationship between social groups through the full preservation and change of the social status of the population, as well as the creation of classes, strata, socio-democratic, socio-professional groups, and social communities (family, people, city, village) (Hagerty et al., 2021). The modern interpretation of the concept of "quality of life" emerged after World War II. Initially, it emphasized the idea that "*a good life is more than material abundance, and contains some factors, such as employment, life, environment, health, culture, etc*" (Nussbaum and Sen, 1993). Quality of life is a set of indicators that characterize the general well-being of people, which includes the level of material consumption (standard of living), as well as the direct consumption of non-purchased goods. QoL is a non-standard category. QoL is best understood as representing the gap between one's actual functional level and one's ideal standard (Cella, 1994). Quality of life, as a rule, is associated with financial security, unity with nature, responsibility to future generations, and other aspects. Each theory offers different interpretations of quality of life. The main approaches to the study of quality of life are:

Theory of ideals. According to this theory, the quality of life includes the realization of certain ideals (Khadzhalova, 2014). According to Maslow, the self-expression of an individual can be considered an ideal.

1. *Individual utility theories* focus on feelings of happiness, pleasure, and the fulfillment of desires. Many economists have called this approach "welfarism", social philosophers - "utilitarianism" or even "hedonism". This approach is often criticized by Third World researchers who, based on the experience of their own countries, claim that people are often able to adapt to inhumane living conditions (Amartya et al., 1993).
2. *Abundance theories* focus on manufactured goods, real incomes, etc. Thus, many economists seek to evaluate the QoL in terms of living standards. Efforts have been made to de-

velop methods for estimating income, but this approach has rightly been criticized by many researchers for highlighting its inability to explain lifestyle changes. For example, hippies can be considered happy, cheerful people who have no desire to acquire property. They can be happier than people who pursue a work ethic and have accumulated great wealth.

3. *Theory of basic human needs.* According to Eric Allard, QoL is achieved through the satisfaction of three systems of basic needs: “to have”, “to love”, “to be”. Consumer needs are defined as material conditions for survival and poverty alleviation. These include economic resources (minimum per capita income), living conditions, employment, working conditions, health, education, etc.

QoL is defined by the WHO as “individuals’ perceptions of their position in life in the context of the culture and value systems in which they live and about their goals, expectations, standards and concerns” (WHO, 1998). Quality of life is defined as the set of non-financial, non-monetary attributes of individuals, which co-determines their life chances and opportunities in life and has value in different cultures and contexts (OECD, 2011). To clarify the concept of “QoL”, it is very important to describe and reveal the objective and subjective aspects of QoL (Makaryan and Babayan, 2010). There are two main approaches to assessing the quality of life of the population: American and Scandinavian (Thorburn, 2014). The latter differ in their position on Campbell’s assertion that “the quality of life must be viewed through the eyes of an eyewitness” in terms of the relative importance of objective and subjective indicators of social welfare. Early American work focuses on objective indicators of health, poverty, and unemployment, which represent social facts regardless of individual assessments. In modern scientific and research fields, there is almost a consensus in the sense that the objective and subjective aspects of quality of life need to be studied together, taking into account the strengths and weaknesses of each. An example is the so-called EUROMODULE (The Euromodule, 2001), which is a Mediterranean research initiative involving research teams from 19 European countries. It collects comparative data on living conditions, well-being, and quality of life based on national sociological surveys, giving equal weights to objective and sub-

jective indicators, considering them “two sides of the same coin”. In addition, many models combine the objective and subjective quality of life domains. For example, Deiner argues that “every science should borrow information from other fields on the QoL”. A comprehensive understanding of subjective well-being requires taking into account the objective circumstances or conditions, the environment that influences people to value their lives. Similarly, a full understanding of objective indicators and their choice requires a thorough study of people’s values and information on how objective indicators affect people’s well-being. Brock points out that while the first concept of quality of life is related to social indicators in the social sciences, the second is connected with the tradition of subjective well-being in the behavioral sciences (Brock, 1993). QoL in the age of globalization is affected mainly by the state of the environment and economy. The subjective needs of people come to the forefront of their hierarchy of needs. Besides all the different definitions, Epley & Menon (2008) opined that “QoL has become a potential marketing tool for cities around the world (Hajduová et al., 2014). Currently, scientists distinguish three approaches to assessing the QoL of the population (Khadzhalova, 2014): 1) objective, 2) subjective, and 3) complex. The objective approach is based on a system of statistical indicators that describe people’s living conditions (income level, unemployment, crime, and environmental pollution, for example) without including data from public surveys. Objective indicators reflect values that can be measured quantitatively; examples include Gross Domestic Product (GDP) per capita, income level, and unemployment rate. According to international comparisons, one of the most widely used objective indicators is the HDI. The subjective approach is based on social surveys that reflect people’s opinions and judgments about their lives. Although some researchers are sceptical about assessing subjective indicators, current research shows that measuring subjective components of QoL is reliable and accurate. This approach focuses on internal evaluation, i.e., self-assessment of the quality of human life. Ed Diener introduced the concept of Subjective Well-Being (SWB), encompassing life satisfaction, positive moods, and the absence of negative moods. He argues that these subjective experiences are central to assessing an individual’s QoL (Diener, 1984). A complex approach to QoL assessment in-

volves combining and applying objective and subjective methods. The most common approaches are the objective approach and the complex approach. The integral approach assumes that objective and subjective indicators are equivalent. However, the question of how to calculate an integral assessment — that is, how to build an index that combines both objective and subjective assessments — remains unanswered. (Spiridonov, 2010).

Based on the provided literature review, a key hypothesis can be formulated that addresses the evolution and current understanding of quality of life (QoL):

H1: A person's overall quality of life is determined by the interaction between objective socio-economic conditions (such as income, employment, and access to resources) and their subjective perception of well-being (such as personal satisfaction, happiness, and life goals). Therefore, the integral QoLI may strongly but not perfectly correlate with HDI, indicating added informational value.

H2: QoLI is influenced by non-economic factors (social and demographic) beyond GDP per capita.

H3: QoLI responds to global shocks (e.g., 2020 pandemic) with measurable variations across countries.

MATERIALS AND METHODS

In recent years, various international organisations, statistical services, non-governmental organisations, independent research organisations, and authors have focused on developing and choosing the right methodology for assessing the quality of life. Since 2010, the Institute for Political and Sociological Consulting (IPSC) (<http://ipsc.am/am>) has commissioned a survey of the QoL index of the Armenian population in Armenia. There are two main approaches to assessing the quality of life of a population: The American approach and the Scandinavian approach. The latter are distinguished by their stance on Campbell's formulation, which states that "QoL should be considered through the eyes of an eyewitness", i.e., according to the relative importance of objective and subjective indicators of social well-being (Bliss, 1993). To comprehensively assess quality of life in Armenia, this research emphasises the importance of creating a composite quality of life index. The conceptual model is based on Sherlock's approach to methodological pluralism and systems synthesis. This allows different areas of an individual's life and different perspectives on their situation to be combined into a single index

(Makaryan and Babayan, 2010). The first stage of the study involved the use of descriptive statistics to evaluate the pros and cons of each QoLI. Additionally, specific normalisation and index formation methods were employed to compile the indices. On the second stage, we propose a new method of assessing the quality of life based on sub-indices. This method is a set of basic indicators that characterize the QoL, which are typical of the economic, social, cultural, and demographic characteristics of the country (Table 1)

In constructing the QoLI, we applied factor analysis to derive the weights for each indicator within the Economic, Social, and Demographic sectors. This statistical technique was selected for its ability to reduce dimensionality and identify latent factors that explain the maximum variance in a set of observed variables. All the weights mentioned in the indices were given based on the more accurate description and significance of the economic, social, educational, scientific, and environmental spheres, as well as taking into account the expert assessments. This study applies a quantitative, data-driven approach to construct a multidimensional Quality of Life Index (QoLI) for 100 countries over the period 2012–2021. A set of economic, social, and demographic indicators was selected from reputable international databases (World Bank, UNDP, OECD, Numbeo). Data were pre-processed by adjusting indicator directionality, imputing missing values, and normalizing values to a 0–1 scale to ensure cross-country comparability. Factor analysis (principal component method with varimax rotation) was employed to derive objective statistical weights for each indicator within its respective domain. Three sub-indices—Economic, Social, and Demographic—were constructed as weighted sums of normalized indicators. A second-level factor analysis determined the weights for combining these sub-indices into the final composite QoLI. The methodology was validated by examining correlations with the Human Development Index (HDI), partial correlations controlling for income, rank robustness tests, and sensitivity analyses. This ensures that the proposed QoLI captures multiple dimensions of well-being, provides reliable cross-country comparisons, and offers practical insights for policymakers.

RESULTS AND DISCUSSION

Comparison of QoL indexes

In 1975, a group of scientists led by M. Morris developed the *Physical Quality of Life Index (PQLI)*,

Table 1: Relevant indicators taken from three sectors

Economic indicators		Social indicators		Demographic indicators	
GDP per capita (current US\$)	GDP	Unemployment, total (% of total labor force)	UnEmp	Growth of population (thousands)	GP
Manufacturing, value added (% of GDP)	MF	Government expenditure on education, total (% of GDP)	GEE	Infant Mortality Rate (infant deaths per 1,000 live births)	IMR
Competitive Industrial Performance Index (CIP)	CIP	Households and NPISHs final consumption expenditure (% of GDP)	HFCE _{pc}	Life expectancy at birth, total (years)	LE
Annual growth of GDP per employed person, %	AG _{GDP}	Households and NPISHs final consumption expenditure (% of GDP)	HFCE	School enrollment, primary (% gross)	SEP
Gross fixed capital formation (% of GDP)	GFCF	Total natural resources rents (% of GDP)	TNRR	Total net enrolment rate by level of education (%)	TERE
Services, value added (% of GDP)	SV	Prevalence of undernourishment (% of population)	PUnN	Net Migration Rate (per 1,000 population)	NMR
Consumer price index	CPI	\$3.65 a day share of the population in poverty	ShPP		
Exports of goods and services (BoP, current US\$)	EGS	Gini coefficient			
High-technology exports (% of manufactured exports)	HTE				
Global Innovation Index (GII)	GII				

which includes the following partial indexes: Life expectancy up to one-year, infant mortality rate, and the level of literacy of the adult population. The values of the partial indicators are compared with the selected base: infant mortality - 7 ppm, average life expectancy - 77 years, literacy - 100%. Then the scores for each indicator are calculated: 1 (worst) and 100 (best). The gross index is the arithmetic mean of the scores obtained. The advantage of this index is its simplicity and the ability to make Mediterranean comparisons. PQLI is often used at the macroeconomic level to assess the level of physical health and human well-being. The PQLI calculation formula is:

$$PQLI = \frac{LR + IMR + LE}{3}$$

LR - literacy level, *IMR* - infant mortality rate per 1000 live births, *IMR* = (166 - infant mortality rate) * 0.625, *LE* - life expectancy index, *LE* = (infant mortality rate - 42) * 2.7.

The *PQLI* quality of life ratios were very simple, available only to estimate the minimum level of natural

needs, and used by the United States and the World Bank to assist developing countries. In recent decades, the UN Convention on Human Development has gained universal application and is often used as an objective method of assessing the quality of life (Ayvazyan et al., 2006). The HDI has become a more reliable indicator of social progress than GDP and many other measures. In today's rapidly changing world, living conditions, lifestyles, and behaviours, as well as perceptions of human development, are changing at an unprecedented rate. At the same time, the HDI more accurately reflects the complex nature of human development issues than poverty levels or public satisfaction measured in monetary terms. UN member countries measure HDI indicators (in whole or in part) and use these to compile and publish annual human development reports. Furthermore, the measurement of human development uses the HDI indicators developed by the UN and the constantly improving calculation methodology, including thematic areas. At the same time, the UN encourages countries to continuously improve the development of their accounting capabilities and methodology. The HDI is a summary of three separate indicators:

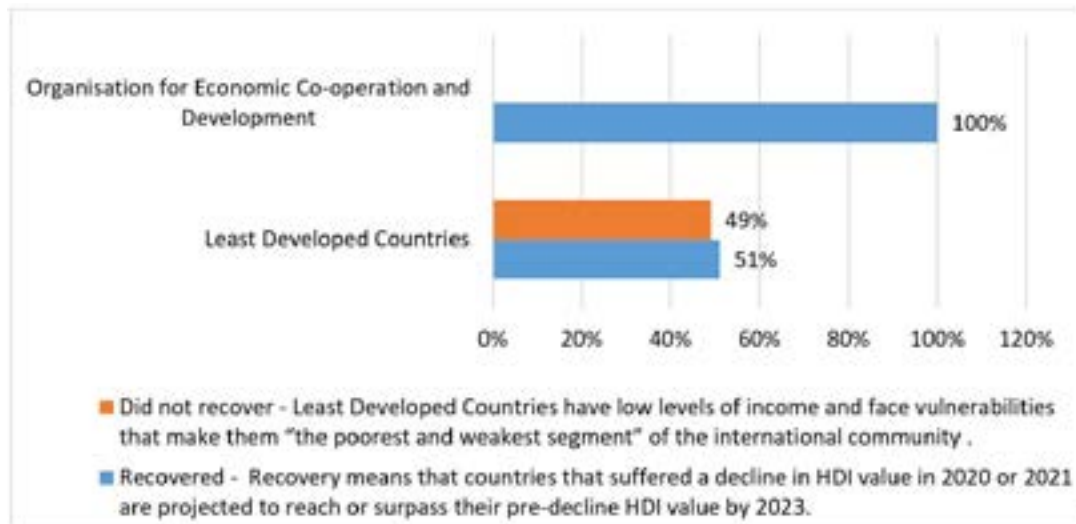


Fig. 1: Country recovery by 2023 from the HDI setback in 2020 or 2021 (Source: [Human Development Report 2023/2024](#))

life expectancy, education, and Gross National Income (GNI). The HDI represents the average geometry of the three normalized components of human development assessment: life expectancy, education, and gross national income. It is calculated as follows:

$$HDI = \sqrt[3]{LEI * EI * II},$$

where *HDI* - Human development index, *LEI* - life expectancy index, *EI* - education index, and *II* - gross national income index. The possible change range of the HDI is $0 \leq HDI \leq 1$. Its true size marks the rest of the way a country must go to reach the highest possible level of human development. The estimates in the UN Human Development Reports have included 170 countries since 1990 (now 195). Countries in the HDI are classified as "very high" (1.0 to 0.800), "high" (0.799 to 0.700), "medium" (0.699 to 0.550), and "low" (below 0.550) level countries ([Human Development Report, 2020/2021](#)). According to the results of 2022, among the 195 countries in the world with the highest HDI and the most prosperous are Switzerland, Norway, Iceland, Hong Kong, Denmark, Sweden, Germany, Ireland, Singapore, Australia, etc. Non-prosperous countries include Niger, Tanzania, Sudan, Afghanistan, Mozambique, Burkina Faso, Burundi, Chad, and the Central African Republic. The average life expectancy is the lowest in Lesotho and Chad, 53.0 years, and the highest in Monaco, 86.9 years. Liechtenstein has the highest GNI per capita

at \$ 146,673. South Sudan has the poorest population, with an annual per capita income of no more than \$ 691 ([Human Development Report 2023/2024](#)). The 2023 global Human Development Index value is projected to recover after the unprecedented drop in 2020–2021. For 2023, all OECD countries are projected to have reached or surpassed their pre-2019 HDI values, in contrast to only 49 percent of the Least Developed Countries (LDCs) ([Fig. 1](#)).

The disparity in recovery is also evident across HDI groups: 48 percent of low HDI countries, compared with 92 percent of very high HDI countries. This highlights the consequences of mismanaging interdependence in exacerbating inequalities in human development. The HDI does not consider distributions but averages, since a distribution-sensitive scalar measure could continue to involve some loss of information ([Anand and Sen, 1994](#)). Since 2006, the New Economic Foundation has developed a new criterion for assessing the ecological footprint, the Happy Planet Index (HPI). The World Happiness Report 2023 ranks 137 countries by how happy their citizens perceive themselves to be. The annual data for Finland has continued its modest but steady upward trend since 2014, so that dropping 2015 and adding 2018 boosts the average score, putting Finland significantly ahead of other countries in the top ten. The saddest people live in Afghanistan. Since 1961, the Organization for Economic Co-operation and Development (OECD) has been conducting research to develop the

Table 2: Top 10 cities with leading subcategories

Rank	Quality of Life	Leisure Options	Travel & Transportation	Health & Well-Being	Safety & Security	Environment & Climate
1	Valencia	Barcelona	Vienna	Abu Dhabi	Copenhagen	Lausanne
2	Copenhagen	Mexico	Prague	Vienna	Lausanne	Basel
3	Zurich	Madrid	Valencia	Doha	Geneva	Lisbon
4	Madrid	Miami	Madrid	Valencia	Basel	Zurich
5	Lisbon	Dubai	Dubai	Dusseldorf	Zurich	Vancouver
6	Dubai	New York	Abu Dhabi	Barcelona	Munich	Valencia
7	Vienna	Valencia	Singapore	Tokyo	Dusseldorf	Geneva
8	Abu Dhabi	Melbourne	Basel	Copenhagen	Lisbon	Stockholm
9	Lausanne	Lisbon	Lausanne	Madrid	Valencia	Vienna
10	Munich	Berlin	Zurich	Bangkok	Sydney	Sydney

best methodology for assessing the quality of life of its citizens. The OECD has spent almost 50 years, and already in 2019, this result is given in the OECD survey, which proposes to assess the quality of life rather than the traditional economic indicators (GDP, unemployment rate, inflation rate, etc.) through key indicators characterizing the well-being of other populations. The study defines well-being indicators (www.oecdbetterlifeindex.org): Income and Wealth, Housing, Work and Job Quality, Health, Knowledge and Skills, Environmental Quality, Subjective Well-being, Safety, Work-Life Balance, Social Connections, and Civic Engagement. This methodology was first studied in 34 OECD countries in 2011, and OECD partners Russia and Brazil. Across the indicators considered here, OECD countries with higher average current well-being also tend to be more equal, i.e., they have a lower share of people who are deprived, and there are smaller gaps in the distribution of well-being outcomes and fewer differences between population groups. Generally speaking, people in the Nordic countries, the Netherlands, New Zealand, and Switzerland enjoy both comparatively higher levels of current well-being and lower inequalities. On the other hand, people in Eastern European and Latin American countries, as well as Turkey and Greece, experience relatively lower levels of current well-being and are exposed to comparatively deeper inequalities. There are exceptions: Denmark performs better on inequalities compared to its well-being levels, while Austria, Korea, and Germany are relatively unequal, given their average well-being scores (OECD, 2020). Another

comprehensive quality assessment of quality of life is offered by the authoritative International Living organization. In 2022, the *Expat Insider* survey includes the QoLI, which covers 21 rating factors across five subcategories: Environment & Climate, Health & Well-Being, Leisure Options, Safety & Security, and Travel & Transit. Expats were asked to rate each factor on a scale from one (very bad) to seven (very good). This resulted in a ranking of 50 cities with a minimum sample size of 50 respondents per destination (Table 2). The latter was first introduced in 2018. Respondents rate factors on a scale from one to seven (Expat Insider, 2022).

The highest-rated destination in the QoLI, Valencia, lands among the top 10 in all five subcategories, too. It does best in the Travel & Transit Subcategory (3rd). For example, expats in Valencia appreciate the affordability of public transportation (85% happy vs. 70% globally), as well as their travel opportunities (94% vs. 82% globally). The top 10 in the QoLI are dominated by several very distinct geographical regions. In Europe, Nordic capital Copenhagen (2nd) is the only outlier. The other European top 10 destinations are all located on the Iberian Peninsula or in the German-speaking countries. Apart from Zurich (3rd), three more cities in Austria, Germany, and Switzerland rank very highly here. The biggest strengths of Austria's capital, Vienna (7th in this index), are its outstanding results for Travel & Transit (1st) and Health & Well-Being (2nd). Another well-known international organization is *Numbeo*, the world's largest database that provides data on cities

Table 3: Comparative analysis of the QoL of the countries (Source: [Numbeo database website](#))

2021			2022		2023	
Rank	Country	QOLI	Country	QOLI	Country	QOLI
1	Switzerland	190.8	Switzerland	195.3	Netherlands	196.7
2	Denmark	190.0	Denmark	192.4	Denmark	194.7
3	Netherlands	183.3	Netherlands	185.4	Switzerland	193.6
4	Finland	182.8	Finland	185.0	Luxembourg	192.9
5	Austria	182.4	Australia	183.8	Finland	190.5
6	Australia	181.5	Iceland	182.3	Iceland	187.5
7	Iceland	179.1	Germany	180.3	Austria	185.8
8	Germany	176.8	Austria	179.2	Oman	184.7
9	New Zealand	175.8	New Zealand	176.8	Australia	183.0
10	Norway	173.6	Norway	176.4	Norway	182.7

and countries around the world. It provides up-to-date information on global living conditions, housing, health, crime, and, most importantly, publishes the quality of life assessed for countries each year. [Table 3](#) below provides a comparative analysis of the quality of life of countries over 3 years.

[Table 3](#) shows that Switzerland has been the leader in terms of QoL for many years, and only in 2023 it loses its position. In 2023, Netherlands is a leader in terms of quality of life, surpassing the results of the previous 2 years. In 2023, their positions improved in Luxembourg and Oman. Summarizing the above methods of assessing the quality of life, it can be said that none of them fully represents the real quality of life of the population. First of all, it should be noted that one of the most widely used objective methods, the HDI, which includes 4 indicators, can not fully describe the QoL of the population. The rest of the observed objective indicators – for example, Ecological Footprint - are considered specific indicators of QoL assessment and are less applicable compared to HDI. As for the observed subjective methods of QoL assessment, they are the results of quite accurate research and include the main subjective aspects of QoL. Of the complex methods, the Happiness Index is still widespread, but it does not include such important indicators as income, unemployment, education, and so on. Thus, we can confidently say that there is still no single integrated quality of life assessment indicator that can be used worldwide. It must be based on both objective and subjective approaches, and be flexible enough to be able to calculate it for a country

based on the economic, social, and cultural characteristics of the country.

Constructing new QoLI

Using the set of indicators from [Table 1](#) and data for 100 countries over three years for factor analysis, the following weights were obtained ([Tables 4 and 5](#)). To bring the 10-year economic, demographic, and social indicators of 100 countries down to a single common measure, we carry out normalisation. Then, with the normalised values of each indicator, we create sub-indices corresponding to the weights. With these sub-indices, which consist of three areas, we can compile a QoLI for the 100 countries over 10 years. The QOLIs estimated by this methodology, as well as the sector-specific indexes, are presented in [Table 6](#) for the Republic of Armenia.

Using the example of one country presented in [Table 6](#), it is possible to examine the QoL of the population in the Republic of Armenia. Focusing solely on Armenia's quality-of-life data from 2012 to 2021, we can see that the QoL score gradually increased from 0.321 in 2012 to a peak of 0.355 in 2018. This suggests an overall improvement during the earlier part of the period. However, after reaching its highest point in 2018, the score decreased to 0.337 in 2019, remaining lower at 0.353 in 2020 and 0.336 in 2021. This indicates that the country experienced a decline or volatility in QoL measures in recent years. Despite these fluctuations, the scores remained within a relatively narrow range (approximately 0.321 to 0.355), suggesting that while improvements and setbacks

Table 4: Weights for each indicator in the three sectors (Source: authoring)

Economic indicators	Weights	Social indicators	Weights	Demographic indicators	Weights
GDP	0.114	UnEmp	0.1454	GP	0.059
MF	0.115	GEE	0.0916	IMR	0.207
CIP	0.153	HFCE _{pc}	0.1290	LE	0.209
AG _{GDP}	0.033	HFCE	0.1417	SEP	0.163
GFCF	0.082	TNRR	0.1010	TERE	0.224
SV	0.135	PUnN	0.1647	NMR	0.138
CPI	0.052	ShPP	0.1585		
EGS	0.110				
HTE	0.056				
GII	0.150				

Table 5: Indexes with weights for QOLI (Source: authors)

Index	Weights
Economic Index (EI)	0.381
Social Index (SI)	0.213
Demographic Index (DI)	0.405

The QOLI is calculated as follows:

$$QOLI = 0.381 * EI + 0.213 * SI + 0.405 * DI$$

where **QOLI** - Quality of life Index, **EI** - Economic Index, **SI** - Social Index, **DI** - Demographic Index

And the sub-indices included in QOLI are calculated as follows:

$$EI = 0.114 * GDP + 0.115 * MF + 0.153 * CIP + 0.033 * AG_{GDP} + 0.082 * GFCF + 0.135 * SV + 0.052 * CPI + 0.110 * EGS + 0.056 * HTE + 0.150 * GII$$

$$SI = 0.1454 * UnEmp + 0.0916 * GEE + 0.1290 * HFCE_{per\ capita} + 0.1417 * HFCE + 0.1010 * TNRR + 0.1647 * PUnN + 0.1585 * ShPP + 0.0684 * GC$$

$$DI = 0.059 * GP + 0.207 * IMR + 0.209 * LE + 0.163 * SEP + 0.224 * TERE + 0.138 * NMR$$

Table 6: The quality of life index of the population in Armenia during 2012-2021 (Source: authors)

Year	EI	SI	DI	QOLI
2012	0.229	0.264	0.437	0.321
2013	0.240	0.244	0.465	0.332
2014	0.242	0.256	0.498	0.348
2015	0.241	0.267	0.489	0.347
2016	0.245	0.261	0.468	0.338
2017	0.242	0.259	0.494	0.348
2018	0.255	0.254	0.503	0.355
2019	0.251	0.228	0.476	0.337
2020	0.257	0.252	0.498	0.353
2021	0.234	0.225	0.491	0.336

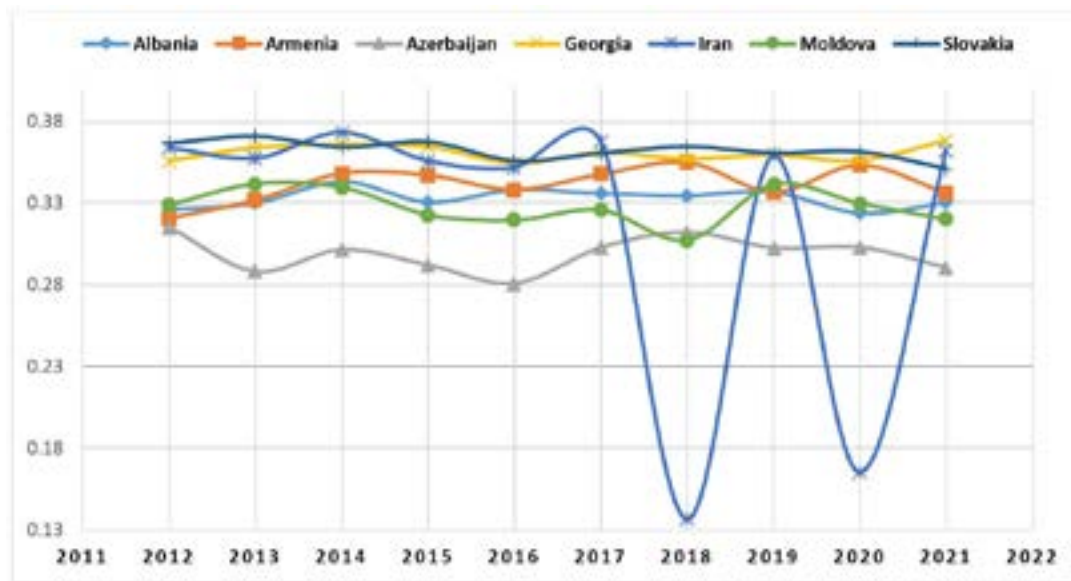


Fig. 2: Dynamics of the QoL of the population during 2012-2021 (%)

occurred, the overall level of quality of life remained moderately stable over the decade. In summary, Armenia experienced modest improvements in quality of life up until 2018, followed by a decline in subsequent years, suggesting potential challenges or fluctuations affecting quality-of-life outcomes during the latter period. As can be seen from Fig. 2, analyzing the quality-of-life scores from 2012 to 2021 for several countries reveals a few key observations: Georgia, Iran (except in 2018 and 2020), and Slovakia generally record higher scores (mostly around 0.35–0.37).

This suggests that, based on this metric, they tend to offer a relatively better QoL compared to the others. Armenia, Albania, and Moldova consistently show scores in the mid-range (roughly 0.32–0.35). Armenia, for example, fluctuates between about 0.321 and 0.355, placing it close to its regional peers. Azerbaijan's scores mostly fall between 0.28 and 0.31, indicating it consistently lags behind the other countries in this particular quality-of-life measure. Armenia's position in the mid-range shows that, while it does not rank at the top like Georgia or Slovakia, its performance is comparable to other post-Soviet or regional countries like Albania and Moldova. This comparison highlights both its progress and the areas where other countries might be setting higher benchmarks.

A step-by-step QoLI and HDI (Table 7) comparative analysis can be conducted for the specified countries. The results are summarized in Table 8. QoLI has

remained relatively stable over the years, with only minor fluctuations. There is a slight upward trend in most countries until 2017–2019, after which there is a dip in 2020 (likely due to the impact of the pandemic). The HDI consistently increases over time in all countries, indicating long-term improvements in education, income, and health.

In Armenia, QoLI fluctuates, peaking in 2018 (0.355) and 2020 (0.353). HDI rose from 0.751 (2012) to 0.774 (2021). HDI steadily improves, while QoLI suggests uneven living condition improvements, possibly due to political/economic volatility. In Georgia, QoLI is highest among Caucasus countries (around 0.36). HDI also improves consistently. Georgia maintains a higher perceived quality of life and development metrics. In Iran, QoLI is problematic: a sharp drop in 2018 (0.136) and 2020 (0.165). HDI, however, steadily improves. Severe internal issues (e.g., sanctions, inflation) reduce the QoL despite educational and healthcare progress. Slovakia is the highest in both QoLI and HDI. Serves as a reference country; consistently high on both indices due to EU membership, economic development, and strong institutions. In Albania, QoLI gradually increases from 0.326 to 0.336. HDI also rises from 0.73 to 0.765. Moderate progress, stable growth, but still lags behind Slovakia and Georgia in both indices. In Moldova, QoLI declined between 2014 and 2018 but recovered by 2019. HDI increases from 0.7 to 0.735. Moldova struggles more

Table 7: HDI scores of the countries

Year	Armenia	Georgia	Iran	Slovakia	Albania	Moldova	Azerbaijan
2012	0.751	0.745	0.742	0.845	0.730	0.700	0.735
2013	0.757	0.75	0.748	0.848	0.735	0.705	0.740
2014	0.764	0.755	0.754	0.850	0.740	0.710	0.745
2015	0.769	0.761	0.761	0.852	0.745	0.715	0.750
2016	0.773	0.766	0.766	0.854	0.750	0.720	0.755
2017	0.775	0.770	0.770	0.856	0.755	0.725	0.760
2018	0.781	0.777	0.776	0.858	0.760	0.730	0.765
2019	0.789	0.786	0.783	0.860	0.765	0.735	0.770
2020	0.769	0.778	0.774	0.858	0.760	0.730	0.765
2021	0.774	0.784	0.780	0.860	0.765	0.735	0.770

Table 8: General pattern across countries: Comparative analysis QoLI vs HDI

Country	QoLI Trend	HDI Trend	Interpretation
Armenia	Moderate, unstable	Steady upward trend	Institutional fragility and external shocks affect QOLI
Georgia	Strongest in the region	Consistent growth	Balanced, successful reforms
Iran	Sharp QOLI drops (2018, 2020)	HDI keeps rising	Sanctions/inflation reduce felt well-being
Slovakia	Highest in both indices	Very high HDI	Model of successful integration into the EU
Albania	Gradual QOLI improvement	Steady HDI growth	Stable development, but lags behind leaders
Moldova	Volatile QOLI, steady HDI growth	Lower overall, slow progress	Governance and migration issues hinder QoLI
Azerbaijan	Lowest QOLI, decent HDI growth	From 0.735 to 0.770	Inequality/governance issues reduce QOLI impact

with the quality of life (possibly due to migration and corruption), but human development slowly rises. In Azerbaijan, QoLI is lowest among these countries, but HDI goes from 0.735 to 0.77. Economic development supports HDI growth, but low QoLI may reflect inequality and governance issues. In general, some countries (like Iran, Azerbaijan) have high HDI but low QoLI — development isn't always felt in day-to-day life. Georgia and Slovakia maintain strong performance in both, indicating balanced development. The drop in QoLI around 2020 is consistent with the COVID-19 pandemic, affecting healthcare, the economy, and overall satisfaction. Post-Soviet countries (Armenia, Georgia, Moldova, Azerbaijan) show steady HDI improvement but variable QoLI, reflecting institutional reforms and uneven governance. Therefore, the proposed QoLI provides policymakers and international institutions with a more nuanced and actionable tool for assessing population well-being.

By decomposing the index into economic, social, and demographic sub-indices, governments can pinpoint the specific domains (e.g., healthcare, education, or labor market conditions) that most affect national or regional QoL scores. Moreover, the panel-based structure of the index allows countries to track progress or decline over time, detect the impact of external shocks (e.g., pandemics, conflict), and benchmark their performance against peer countries. The transparent, data-driven weighting scheme enhances the credibility and usability of the index for policy evaluation, budget planning, and strategic development goals (e.g., SDGs, national welfare strategies). This research makes three key contributions:

1) From a theoretical perspective, the study reconceptualises quality of life as a multidimensional construct, integrating economic, social, and demographic dimensions and moving beyond single-metric or subjective frameworks.

2) As a methodological contribution, the study introduces a transparent and replicable approach to constructing a composite index using factor analysis for objective weighting, panel normalisation for comparability, and validation methods for reliability.

3) The study's empirical contribution consists of delivering QoLI estimates for 100 countries over 10 years, comparing them to established indices such as the HDI and revealing disparities between economic development and lived well-being.

It's also important to acknowledge a couple of practical limitations of the QoLI. Firstly, it relies solely on objective indicators; consistent, comparable data for subjective well-being (like happiness or life satisfaction surveys) simply isn't available across all countries and years. Secondly, while we performed extensive robustness checks, the index's structure and factor analysis results might still be sensitive to choices made during missing data imputation and country selection.

Speaking about future research direction, we believe the QoLI framework could be significantly enhanced by future research focusing on these key areas:

- integrating reliable subjective well-being indicators to enable a more holistic assessment;
- extending the index to sub-national levels to capture intra-country disparities, particularly in developing economies;
- exploring advanced weighting and variable selection methods (e.g., Bayesian model averaging and machine learning) to increase robustness;
- developing an online platform for real-time visualisation to improve accessibility for diverse stakeholders.

CONCLUSION

Therefore, it is clear that no single integral indicator for assessing the quality of life can be applied worldwide. This is because it would not provide a complete picture of the well-being and living conditions of the population. The necessary indicator should be based on both objective and subjective approaches and be flexible enough to be adapted to a particular country based on its economic, social, and cultural characteristics. To more accurately characterise the quality of life of populations in different countries, our QoL assessment method allows us to identify quality of life

dynamics over time. Studying the international experience of quality of life, as documented by various research organisations, will enable us to gain a clearer understanding of the changes countries have implemented and identify prospects for further development. Having studied the issues necessary to achieve the goal set out in the article, we have come to the following conclusions: QoL, as an economic concept, expresses the totality of the population's material and non-material satisfactions. QoL is determined by both objective criteria, such as life expectancy, crime rate, unemployment rate, GDP, and poverty rate, and subjective criteria, such as happiness, life satisfaction, family relationships, and job satisfaction. The QoL of the population is difficult to assess quantitatively, as characteristics such as health, work safety and conditions, culture, and the satisfaction of citizens' spiritual needs are not easily quantifiable. Therefore, a combination of quantitative and qualitative characteristics and general sociological assessments is necessary. The study proposes assessing the QoL in countries using the above methodology, which involves constructing a complex indicator using the most appropriate indicators of the economic, social, and demographic spheres. This will enable policymakers to observe the dynamics of QoL in countries in comparison. The findings reveal that QoL cannot be effectively captured by relying solely on traditional economic measures. The developed QoLI offers a more comprehensive assessment by combining multiple domains and applying statistically derived weights through factor analysis. This approach ensures greater objectivity, transparency, and cross-country comparability, thus providing new insights into the dynamics of population well-being. The study contributes to the literature by proposing a replicable methodology that directly addresses the research questions: identifying the main criteria for assessing QoL across countries (RQ1), improving the methodological framework for constructing composite indices (RQ2), and determining which multidimensional indicators most strongly shape QoL differences globally (RQ3). The results highlight the added value of multidomain integration and data-driven weighting, demonstrating that QoL outcomes are influenced not only by economic growth but also by health, education, and demographic factors. From a practical perspective, the QoLI allows policymakers to decompose results by domain, identify the key drivers of well-being deficiencies, and design targeted interventions. This provides a solid evidence

base for monitoring progress towards sustainable development goals and improving the effectiveness of social and economic policies. Answering the research questions of the paper, we can mention the following. In answering the research questions posed in this paper, the following can be noted.

RQ1: The analysis confirms that quality of life (QoL) is a multidimensional construct that cannot be accurately assessed using economic indicators alone. While GDP per capita and other economic metrics are significant, they only partially explain differences in population well-being. Including demographic indicators (e.g., life expectancy, infant mortality, and net migration rates) and social indicators (e.g., education enrolment, poverty prevalence, and household consumption) significantly enhances the explanatory power of QoL measurements. This finding supports a broader conceptualisation of QoL that reflects not only material prosperity, but also social development and population health.

RQ2: The study demonstrates that factor analysis provides a statistically robust and transparent method of weighting indicators within each QoL domain, thereby avoiding the use of arbitrary or expert-based assignments. By applying panel-wide normalisation and constructing domain-specific sub-indices, the QoLI offers greater comparability over time and across countries than existing indices such as the HDI or HPI.

RQ3: The findings suggest that demographic and social factors, particularly life expectancy, infant mortality rates, educational enrolment, and poverty prevalence, strongly influence variations in QoL between countries. In some cases, these factors exert a greater influence on the QoLI than purely economic measures do, thereby highlighting the limitations of GDP-centric evaluations of development. Furthermore, time-series analysis revealed that QoLI scores were sensitive to external shocks. For example, many countries experienced a decline or stagnation in QoL during the 2019–2021 period, reflecting broader social and health crises beyond income changes. While the proposed framework represents a significant advancement over existing indices, the study acknowledges certain limitations, such as the lack of subjective well-being data and sensitivity to missing values. Future research should build on these results by extending the index to regional levels, incorporating subjective indicators where available, and testing alternative weighting techniques to enhance robustness.

AUTHOR CONTRIBUTIONS

A. Ktoyan performed the literature review, developed the methodology, analysed and interpreted the data, and prepared the manuscript. A. Shirinyan conducted the literature review and compiled the data for the manuscript. M. Harutyunyan assisted with the literature review, data curation, and manuscript preparation. B. Gabrielyan performed calculations and data visualization and edited the manuscript.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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ABBREVIATIONS (NOMENCLATURE)

AG_{GDP}	Annual growth of GDP per employed person, %	<i>NMR</i>	Net Migration Rate (per 1,000 population)
<i>CIP</i>	Competitive Industrial Performance Index	<i>OECD</i>	Organisation for Economic Cooperation and Development
<i>CPI</i>	Consumer Price Index	<i>PQLI</i>	Physical Quality of Life Index
<i>DI</i>	Demographic Index	<i>PUnN</i>	Prevalence of undernourishment (% of population)
<i>EF</i>	Ecological Footprint	<i>QoLI</i>	Quality of Life Index
<i>EGS</i>	Exports of goods and services (Balance of payments (BoP), current US\$)	<i>SEP</i>	School enrollment, primary (% gross)
<i>Ecl</i>	Economic Index	<i>ShPP</i>	\$3.65 a day share of the population in poverty
<i>EI</i>	Education Index	<i>SI</i>	Social Index
<i>GDP</i>	Gross Domestic Product per capita (current US\$)	<i>SV</i>	Services, value added (% of GDP)
<i>GEE</i>	Government expenditure on education, total (% of GDP)	<i>SWB</i>	Subjective Well-Being
<i>GFCF</i>	Gross fixed capital formation (% of GDP)	<i>TERE</i>	Total net enrolment rate by level of education (%)
<i>GII</i>	Global Innovation Index	<i>TNRR</i>	Total natural resources rents (% of GDP)
<i>GP</i>	Growth of population (thousands)	<i>UnEmp</i>	Unemployment, total (% of total labor force)
<i>HDI</i>	Human Development Index		
$HFCE_{pc}$	Households and Non-profit institutions serving households (NPISHs) final consumption expenditure (% of GDP)		
<i>HFCE</i>	Households and Non-profit institutions serving households (NPISHs) final consumption expenditure (% of GDP)		
<i>HPI</i>	Happy Planet Index		
<i>HTE</i>	High-technology exports (% of manufactured exports)		
<i>II</i>	Gross National Income Index		
<i>IMR</i>	Infant mortality rate		
<i>IPSC</i>	Institute for Political and Sociological Consulting		
LDC_s	Least Developed Countries		
<i>LEI</i>	Life expectancy index		
<i>LR</i>	Literacy level		
<i>MF</i>	Manufacturing, value added (% of GDP)		

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HOW TO CITE THIS ARTICLE

Ktoyan, A.; Shirinyan, A.; Harutyunyan, M., Gabrielyan, B., (2026). *Beyond traditional metrics: A multi-dimensional index for assessing quality of life across countries*. *Int. J. Hum. Capital. Urban Manage.*, 11(3): 575 - 590.

DOI: 10.22034/IJHCUM.2026.03.09

URL: https://www.ijhcum.net/article_735863.html



International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: <http://www.ijhcum.net/>

ORIGINAL RESEARCH PAPER

Asymmetric collaborative governance in Indonesia's new capital: A quasi-public-private partnership approach to regional financial institution engagement

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ARTICLE INFO

Article History:

Received 17 July 2025

Revised 10 October 2025

Accepted 25 November 2025

Keywords:

Asymmetric Collaborative Governance; Quasi-Public-Private Partnership; Institutional Trust; Adaptive Coordination; Place-Based Governance; Indonesia's New Capital.

ABSTRACT

BACKGROUND AND OBJECTIVES: This study examined the implementation of the BPD Kaltimara headquarters project in Indonesia's New Capital City (*Ibu Kota Nusantara*/IKN) as a pioneering quasi-public-private partnership (quasi-PPP) model. Unlike conventional PPPs that emphasize formal risk-sharing and standardized regulation, this initiative reflected an adaptive, trust-based collaboration among actors with asymmetrical resources and authority. The research aimed to describe actor collaboration patterns, assess adaptive coordination mechanisms addressing regulatory uncertainty, and evaluate intermediate outcomes in institutional trust, financial commitment, and project readiness.

METHODS: A descriptive qualitative design with an exploratory orientation was employed. Data were collected from February to July 2025 through four integrated techniques: in-depth interviews with ten key informants, one focus group discussion involving eight participants, participatory observation of coordination meetings and project sites, and comprehensive documentary analysis. Institutional trust was measured using a 5-point Likert scale, financial commitment was verified through internal capital budgeting documents, and project readiness was assessed across five critical dimensions. Data were analyzed using the interactive model of Miles *et al.*, (2014) with four triangulation strategies to ensure credibility, transferability, dependability, and confirmability following Lincoln and Guba's (1985) criteria.

FINDINGS: The study revealed five operational principles of asymmetric collaborative governance: complementary asymmetry, adaptive coordination, shared value creation, flexible accountability, and iterative trust building. Quantitatively, the project achieved a trust index of 4.2 (provincial government-BPD) and 3.1 (IKN Authority-partnership). BPD Kaltimara financed 100% of the IDR 85 billion investment, reallocating 8% of its annual capital budget. Despite regulatory delays, the partnership achieved full technical design completion, environmental assessment approval, and institutional alignment through adaptive coordination mechanisms led by the *Tim Percepatan* IKN Kaltim task force.

CONCLUSION: The findings demonstrate that asymmetric collaborative governance, anchored in shared value creation and adaptive coordination, enables regional institutions to sustain strategic infrastructure development under uncertainty. This quasi-PPP model offers theoretical insights for governance innovation and practical guidance for designing flexible, trust-based frameworks in decentralized and polycentric development environments.

DOI: [10.22034/IJHCUM.2026.03.10](https://doi.org/10.22034/IJHCUM.2026.03.10)



NUMBER OF REFERENCES

32



NUMBER OF FIGURES

1



NUMBER OF TABLES

4

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the "Show Article."

INTRODUCTION

The implementation of development policy is a critical component of achieving national strategic objectives, particularly within the framework of decentralization and the evolving paradigms of public administration. Policy implementation should not be perceived as a purely technical process but as a complex interaction between vision, institutional capacity, and stakeholder collaboration (Elander, 2002; McAllister & Taylor, 2015; Joniškienė et al., 2020). Its effectiveness is largely determined by socio-political and institutional contexts (Hamas & Salahudin, 2021; Madubun & Madubun, 2023). In Indonesia, decentralization has granted regional governments greater autonomy in development management, prompting the need for adaptive and collaborative governance models such as the Public–Private Partnership (PPP) framework (Grimsey & Lewis, 2004; Yescombe, 2017). Within the paradigm of New Public Governance (Osborne, 2010), PPPs are understood not merely as financial mechanisms but as collaborative institutions that integrate efficiency, accountability, and trust between sectors (Ansell & Gash, 2010; Emerson et al., 2012; Hodge & Greve, 2017). The development of *Ibu Kota Nusantara* (IKN), Indonesia's new capital city, represents a strategic application of this paradigm. The relocation from Jakarta to East Kalimantan was motivated by environmental degradation, uncontrolled urban expansion, and interregional inequality (April Gunawan Malau et al., 2024; Pangestu et al., 2024; Syailendra & Hanggono, 2024). Envisioned as a green, smart, and inclusive city, IKN embodies the state's ambition to implement a new governance model through public–private collaboration. One of its early flagship projects is the construction of the Head Office of *Bank Pembangunan Daerah* (BPD) Kaltimara, a regionally financed development that symbolizes local participation in a nationally strategic initiative (Sari & Naftali, 2024). Beyond its function as a financial service facility, the building represents a manifestation of regional ownership in the national development process through collaborative means. Betang and Kalimantan's endemic vegetation reflects local identity and environmental harmony. The presence of BPD Kaltimara in IKN extends beyond technocratic objectives; it carries symbolic, political, and socio-cultural significance. As a regionally owned financial institution, BPD is embedded in local socio-

economic contexts, allowing it to develop tailored financial schemes such as MSME credit programs and green economy financing (Barca et al., 2012; Bryson et al., 2024). Despite the increasing application of PPPs, academic studies in Indonesia remain focused on contractual and regulatory aspects, emphasizing risk allocation and compliance (Grimsey & Lewis, 2004; Hodge & Greve, 2017). Few studies have examined quasi-PPP models of hybrid partnerships involving regional or semi-public entities such as BUMDs that blur the boundaries between state and market actors. These arrangements operate under institutional ambiguity and asymmetrical authority, demanding new governance approaches that remain under-theorized. Conventional PPP frameworks generally assume symmetrical risk-sharing and balanced power among partners (Li et al., 2024; Maqbool & Sridhar, 2024). In contrast, the IKN context is characterized by marked asymmetry among the central government, the IKN Authority, regional governments, BPD Kaltimara, and local communities, each possessing different levels of authority, resources, and influence. Such asymmetries are not anomalies but structural realities requiring adaptive and inclusive governance. Existing models of collaborative and network governance (Ansell & Gash, 2008; Emerson et al., 2012; Osborne, 2010) provide valuable insights into participatory processes and mutual trust but insufficiently explain how effective collaboration can persist when power differentials are inherent and persistent. Furthermore, social and cultural dimensions such as local legitimacy, indigenous design, and environmental sensitivity remain underexplored in PPP evaluations (Beatley, 2012; Bibri & Krogstie, 2019). The BPD Kaltimara project, incorporating Rumah Betang architectural principles and local vegetation, demonstrates a place-based governance approach that integrates cultural identity with modern functionality and sustainability. Existing studies on PPPs in developing economies have underscored the importance of contractual balance and risk-sharing for project viability (Li et al., 2024; Maqbool & Sridhar, 2024). Meanwhile, state capitalism research (Musacchio & Lazzarini, 2014; Mazzucato, 2018) has shown that public institutions can lead strategic investments even under uncertainty. Yet, few studies have analyzed how regional financial institutions or BUMDs act as autonomous investors in national megaprojects without state guarantees. Similarly, while adaptive



Fig. 1: Architectural design of the BPD Kaltimara Headquarters in IKN, inspired by the traditional Rumah

governance literature (Folke *et al.*, 2005; Ansell & Torfing, 2022) demonstrates how local institutions compensate for regulatory gaps, empirical evidence of such mechanisms in quasi-PPP infrastructure contexts remains scarce. Place-based governance studies (Barca *et al.*, 2012; Beatley, 2012) have shown that projects aligned with territorial identity gain stronger social legitimacy, but their integration within asymmetric, multi-actor governance systems remains underexplored. In summary, a significant research gap exists in understanding how quasi-PPP models function in decentralized governance systems characterized by regulatory uncertainty, resource asymmetry, and complex stakeholder networks. The case of the BPD Kaltimara Headquarters in IKN provides an opportunity to examine how regional institutions operationalize strategic collaboration and maintain institutional trust under such conditions. To address this gap, this study adopts the Asymmetric Collaborative Governance (ACG) framework, which extends collaborative, network, and place-based governance theories by treating asymmetry as a productive design variable. The framework builds on five principles: Complementary Asymmetry, where differences in capacity are leveraged as assets; Adaptive Coordination, involving flexible mechanisms to manage uncertainty; Shared Value Creation, emphasizing collective rather than equal contributions; Flexible Accountability, adjusting responsibility to actor capacity; and Iterative Trust Building, cultivating trust through incremental engagement. Accordingly, this study pursues three interrelated objectives: (1) to describe patterns of actor collaboration and

power relations among the East Kalimantan Provincial Government, BPD Kaltimara, the IKN Authority, private contractors, and local communities; (2) to examine adaptive coordination mechanisms developed to manage governance fragmentation and regulatory uncertainty; and (3) to evaluate intermediate outcomes reflected in institutional trust, financial commitment, stakeholder alignment, and project readiness. Fieldwork was conducted in IKN and Samarinda between February and July 2025 through in-depth interviews, focus group discussions, participatory observations, and documentary analysis. These approaches provide a comprehensive empirical basis for understanding how asymmetric collaborative governance operates within Indonesia's decentralized development context and contribute to broader theoretical discussions on hybrid governance and quasi-PPP implementation

MATERIALS AND METHODS

Conceptual materials and literature foundation

Public-Private Partnerships (PPPs) have become a central strategy in Indonesia's infrastructure development, particularly as a response to fiscal constraints and the need for enhanced managerial efficiency. Within the 2020–2024 National Medium-Term Development Plan (RPJMN), the Indonesian government explicitly identified PPPs as a key mechanism to bridge the infrastructure financing gap, recognizing that the state budget (APBN) could only meet approximately 37 percent of total national infrastructure needs. The regulatory foundation for PPP implementation is outlined in Presidential

Regulation No. 38 of 2015, which establishes technical guidelines emphasizing value for money and efficiency throughout the project lifecycle. The PPP process in Indonesia consists of four major stages: planning, preparation, transaction, and implementation, each involving activities such as feasibility studies, business case development, partner selection, contract negotiation, and performance monitoring. Successful implementation of PPPs depends heavily on the quality of governance, both in contractual and relational dimensions. Well-structured contracts minimize opportunistic behavior and enhance sustainability, while fair risk-sharing mechanisms improve project viability (Wang et al., 2024; Maqbool & Sridhar, 2024). Despite their advantages, conventional PPPs are not always well-suited to Indonesia's complex and decentralized governance landscape. This has led to the emergence of the Quasi-Public-Private Partnership (Quasi-PPP) model, a hybrid form involving semi-public entities such as state-owned enterprises (SOEs), regionally owned enterprises (BUMDs), and public financial institutions. The Quasi-PPP model offers greater flexibility in risk management, financing mechanisms, and local legitimacy. Conceptually, this model draws upon three theoretical foundations. First, hybrid organization theory explains that such entities combine market and state logics in ownership, mission, and management. Second, incomplete contract theory suggests that under high uncertainty, the state should retain residual control over critical infrastructure projects. Third, state capitalism theory (Mazzucato, 2018; Musacchio & Lazzarini, 2014) argues that the state should actively lead the development of strategic sectors and long-term economic transformation. In both PPP and Quasi-PPP contexts, governance requires a shift toward more collaborative and participatory approaches. The collaborative governance framework (Ansell & Torfing, 2022) and the New Public Governance paradigm (Osborne, 2010) highlight the importance of social legitimacy, cross-sectoral participation, and collective decision-making. Collaborative governance engages public institutions and non-state stakeholders in deliberative, consensus-oriented processes (Ansell & Gash, 2008), supported by inclusive institutional design, facilitative leadership, and trust building. While early models often assume equality among actors, later studies (Emerson et al., 2012) indicate that collaboration can remain effective even under power imbalances,

as long as mutual dependence, complementary resources, and shared accountability exist. To address the limitations of conventional collaboration models, this study adopts the Asymmetric Collaborative Governance (ACG) framework, which views power and resource asymmetry as strategic assets rather than barriers. The ACG framework consists of five interrelated principles: Complementary Asymmetry, which leverages differences in actor capacity as collaborative assets; Adaptive Coordination, which tailors coordination mechanisms to dynamic power relations; Shared Value Creation, which emphasizes collective value rather than equal contributions; Flexible Accountability, which adjusts accountability systems according to actor roles and capacities; and Iterative Trust Building, which nurtures trust through incremental engagement and small wins. This theoretical framework forms the foundation for the study's research design and guides the operationalization of its key analytical constructs.

Research design and methodological approach

This study employed a descriptive qualitative design with an exploratory orientation to gain an in-depth understanding of the Quasi-PPP model implementation in the BPD Kaltimara headquarters project within the IKN development context. The approach was framed within an interpretive naturalistic paradigm (Babbie, 2014), which views social reality as constructed through actors' perceptions, negotiations, and interactions. This paradigm enables a deeper understanding of governance processes as they unfold in natural settings, shaped by institutional contexts and stakeholder interpretations. The study was structured around three specific objectives aligned with the theoretical framework and data collection design. The first objective was to describe collaboration patterns, including the roles, responsibilities, and power relations among the East Kalimantan Provincial Government, BPD Kaltimara, the IKN Authority, private contractors, and local communities. The second objective was to assess the adaptive coordination mechanisms used by stakeholders to address regulatory uncertainty, governance fragmentation, and the absence of formal risk-sharing instruments. The third objective was to evaluate the intermediate results achieved in terms of institutional trust, financial commitment, stakeholder alignment, and project readiness. These objectives

correspond directly to three of the ACG framework's key principles Complementary Asymmetry (Objective 1), Adaptive Coordination (Objective 2), and Iterative Trust Building combined with Shared Value Creation (Objective 3).

Research context and site selection

Fieldwork was conducted in two main locations: the IKN development area in East Kalimantan and the city of Samarinda, the provincial capital. These sites were purposively selected for their strategic importance in understanding multi-level governance and cross-sector collaboration. The IKN site represents a greenfield area where regulatory frameworks and governance structures are still evolving, offering a unique opportunity to observe institutional emergence and adaptive arrangements. Samarinda, as the base of provincial administration and the location of BPD Kaltimara's headquarters, provided access to key decision-makers and documentary evidence. The study covered the planning and pre-construction phases between February and July 2025, enabling observation of early-stage collaboration dynamics and trust-building processes under regulatory uncertainty. The BPD Kaltimara headquarters project was chosen as a concrete example of Quasi-PPP implementation. Its architectural design, which integrates traditional Rumah Betang elements and local vegetation, reflects the place-based governance approach central to the study's conceptual framework and embodies the fusion of cultural identity with modern infrastructure requirements.

Data collection methods and operationalization

Four integrated data collection techniques were used to address the research objectives and operationalize the constructs of the ACG framework: in-depth interviews, trust index assessment, focus group discussion (FGD), participatory observation, and documentary analysis. In-depth interviews were conducted with ten purposively selected informants representing diverse stakeholder groups, including BPD executives, provincial officials, consultants, community leaders, MSME actors, environmental activists, academics, residents near the IKN site, and religious leaders. Conducted between February and March 2025, interviews lasted between 45 and 90 minutes and followed semi-structured protocols, allowing for both consistency and flexibility. Questions

focused on each informant's role, perception of collaboration, conflict resolution mechanisms, and trust relationships. All interviews were audio-recorded with informed consent and transcribed verbatim. Institutional trust was measured during interviews using a 5-point Likert scale ranging from 1 (no trust) to 5 (complete trust). Respondents rated their confidence in each actor's commitment and capability. The average trust score between the provincial government and BPD Kaltimara was indicating high confidence, while the trust score between the IKN Authority and local partners was reflecting lower levels of communication and coordination. Quantitative results were supported by qualitative evidence on trust-building and institutional reliability. An FGD held on 5 July 2025 brought together eight representatives from regional government, BPD Kaltimara, private contractors, NGOs, indigenous communities, and academia. Facilitated by an independent moderator, the FGD served as a forum for open deliberation, allowing the articulation of differing views, negotiation of meaning, and potential consensus-building. The discussion was recorded and summarized to validate interview findings and assess levels of stakeholder alignment. Participatory observation involved direct attendance at coordination meetings, site visits, and informal interactions among project stakeholders. Field notes documented verbal and non-verbal communication, decision-making processes, and contextual details. Observation of the Tim Percepatan IKN Kaltim meetings revealed adaptive coordination practices, including the use of three scenario-based planning models (optimistic, realistic, and pessimistic) to manage regulatory uncertainty. Documentary analysis encompassed policy documents such as Law No. 3 of 2022 on the Capital City of the Archipelago, the IKN blueprint, BPD Kaltimara's financial statements (2024–2025), architectural designs, environmental impact assessments, and meeting records. Financial data analysis revealed that the BPD Kaltimara headquarters project had a total investment commitment of IDR 85 billion, financed entirely (100 percent) from internal capital, with 8 percent of the bank's annual capital budget reallocated to support the project.

Data analysis procedures

Data were analyzed following the interactive model of [Miles, Huberman, and Saldaña \(2014\)](#),

consisting of data condensation, data display, and conclusion drawing. During data condensation, interview transcripts and field notes were reviewed, coded, and categorized according to themes aligned with the research objectives. Coding was performed by multiple researchers to ensure reliability, and both explicit and latent meanings were identified. Data display involved organizing findings into thematic matrices, actor relationship maps, and process diagrams to clarify collaboration patterns, power dynamics, and coordination mechanisms. Conclusion drawing and verification entailed synthesizing empirical findings in relation to the ACG framework and verifying interpretations through member checking and peer discussions.

Validity and trustworthiness

To ensure methodological rigor, the study employed triangulation across methods, sources, investigators, and theories. Method triangulation combined interviews, FGDs, observations, and document analysis to cross-validate findings. Source triangulation incorporated perspectives from various actors to minimize bias. Investigator triangulation involved independent coding by multiple researchers, followed by consensus-building. Theoretical triangulation integrated the Quasi-PPP model, ACG theory, collaborative governance, and place-based development perspectives to provide a multidimensional interpretation. Trustworthiness was further assured through the four criteria proposed by Lincoln and Guba (1985). Credibility was enhanced through prolonged field engagement over five months, triangulation, and member checking. Transferability was ensured through rich contextual description, allowing readers to assess relevance to other cases. Dependability was supported by transparent documentation of data collection, coding procedures, and audit trails. Confirmability was achieved through evidence-based interpretation, inclusion of direct quotations, and reflexive awareness of the researcher's influence on the research process.

RESULT AND FINDINGS

Overview of Key Findings

This study analyzed the implementation of the BPD Kaltimara Headquarters project in Indonesia's New Capital (IKN) as a pioneering quasi-public-private partnership (quasi-PPP) within a decentralized and

polycentric governance environment. The research addressed three main objectives: (1) to describe actor collaboration patterns and power relations among key stakeholders; (2) to assess adaptive coordination mechanisms employed to navigate regulatory uncertainty and fragmented governance; and (3) to evaluate intermediate outcomes particularly institutional trust, financial commitment, stakeholder alignment, and project readiness despite the absence of formal site designation by the IKN Authority. The findings reveal that the partnership achieved significant institutional progress despite lacking conventional PPP instruments such as government guarantees, standardized contracts, or formalized risk-sharing frameworks. Instead, progress was enabled by asymmetric but complementary collaboration grounded in the five principles of Asymmetric Collaborative Governance (ACG). Quantitatively, the partnership recorded measurable institutional trust with a 5-point Likert mean of 4.2 (SD = 0.6) for the provincial government-BPD relationship and 3.1 (SD = 0.8) for the IKN Authority partnership relationship. BPD Kaltimara demonstrated a strong commitment by self-financing 100% of the IDR 85 billion total investment, equivalent to 8% of its annual capital budget, without dependence on the state (APBN) or regional (APBD) budgets. The project also achieved 100% completion of technical designs and environmental assessments, alongside full institutional alignment and strong community endorsement through public consultation.

The BPD Kaltimara project represents a distinctive quasi-PPP arrangement that deviates from traditional PPP frameworks defined by open bidding, contractual formality, and structured risk sharing (Presidential Regulation No. 38/2015). The partnership was established through a direct assignment from the Governor of East Kalimantan to BPD Kaltimara, emphasizing political strategy and regional participation rather than purely commercial logic. This model carries symbolic significance by strengthening subnational fiscal autonomy and regional visibility in Indonesia's national development agenda. From a financial perspective, the project's IDR 85 billion investment was fully financed through BPD's internal capital budgeting. The provincial government's contribution focused on political endorsement, land access, and regulatory facilitation. BPD targeted a 12% annual return on investment through fee-

Table 1: Summary of quantitative institutional indicators: characteristics of the quasi-PPP model

Indicator	Measurement	Result	Interpretation
Institutional Trust (Prov. Gov.–BPD)	Likert Mean (1–5)	4.2 (SD=0.6)	High confidence and collaboration quality
Institutional Trust (IKN Authority–Partnership)	Likert Mean (1–5)	3.1 (SD=0.8)	Moderate trust; limited coordination with central authority
Financial Commitment	% of total cost self-financed	100% (IDR 85B)	Full internal capital funding by BPD
Annual Budget allocation	% of annual capital budget	8%	Reflects strategic prioritization
Technical Readiness	Design & AMDAL completion	100%	The project is ready for the construction phase

based financial services and credit expansion. Such an arrangement reflects a deliberate asymmetric risk configuration, where BPD assumed full financial exposure while the government provided institutional legitimacy an approach consistent with state capitalism theory (Mazzucato, 2018; Musacchio & Lazzarini, 2014). Interviews revealed that the partnership's resilience stemmed from a 15-year history of collaboration between BPD and the provincial government, creating a foundation of trust and social capital that transcended project boundaries. This hybrid institutional architecture merged financial capital (BPD), political legitimacy (provincial government), and technical expertise (consultants), illustrating Complementary Asymmetry, where differences in capacity are mobilized as collaborative assets rather than constraints.

Patterns of asymmetric collaborative governance

The partnership involved four key actor groups: (1) the East Kalimantan Provincial Government, (2) BPD Kaltimara, (3) the IKN Authority, and (4) third-party contractors and consultants. Each actor occupied unequal yet interdependent roles. The provincial government served as facilitator and strategic broker, leveraging political authority and coordination capacity. BPD acted as both investor and implementer, bearing total financial responsibility. The IKN Authority retained legal control over land and master plan compliance, while contractors provided specialized technical input. This structure faced a persistent regulatory vacuum; the IKN Authority had yet to define the formal participation of subnational actors such as BUMDs. As a result, implementation relied on horizontal coordination networks rather than hierar-

chical directives. Informal mechanisms emerged to fill institutional voids, reflecting *Adaptive Coordination* in practice. Rather than being designed ex ante, these collaborative structures evolved organically in response to governance gaps consistent with *collaborative governance theory* (Ansell & Gash, 2008; Osborne, 2010) and the *adaptive governance* approach (Folke et al., 2005).

Mechanisms of adaptive coordination

A key innovation was the formation of the Tim Percepatan IKN Kaltim (IKN Acceleration Task Force), an informal yet functional institution comprising representatives from the Provincial Secretariat, Bappeda, BPD Kaltimara, and occasionally the IKN Authority. The task force met monthly to address coordination bottlenecks, monitor progress, and advocate for policies at higher levels of government. This practice aligns with Adaptive Governance Theory, where local institutions compensate for gaps in formal regulation (Ansell & Torfing, 2022). To mitigate uncertainty regarding land designation, the task force developed three planning scenarios: Optimistic (A), Realistic (B), and Pessimistic (C), each with differentiated timelines, budget strategies, and contingency actions. Scenario planning allowed actors to maintain project readiness despite prolonged delays, operationalizing flexibility central to the ACG framework. Architectural design decisions also reflected adaptive and place-based coordination. The building integrates traditional *Rumah Betang* elements, representing the institution's collective leadership, while passive cooling systems and landscape-sensitive design align with ecological sustainability principles. These choices embody Shared Value Creation, combining technical functionality,

Table 2: Mapping of ACG principles and empirical manifestations

ACG Principle	Empirical Manifestation	Supporting Evidence
Complementary Asymmetry	Integration of financial, political, and technical capacities	BPD as investor; province as regulator; consultants as technical experts
Adaptive Coordination	Informal coordination via <i>Tim Percepatan IKN Kaltim</i>	Monthly meetings; scenario-based planning
Shared Value Creation	Culturally grounded and community-endorsed design	Integration of <i>Rumah Betang</i> architecture; participatory consultation
Flexible Accountability	Resource allocation based on situational needs	8% capital budget reallocation; informal progress monitoring
Iterative Trust Building	Continuity of collaboration and demonstrated reliability	15-year history of joint projects; sustained trust index above 3.5

cultural symbolism, and social acceptance (Barca et al., 2012; Beatley, 2012).

This mapping illustrates how the five operational principles of the Asymmetric Collaborative Governance (ACG) framework were empirically manifested in the BPD Kaltimara–IKN partnership. Rather than functioning as abstract theoretical constructs, each principle was observable through specific institutional mechanisms and behavioral practices that collectively shaped project outcomes. Complementary Asymmetry was expressed through the integration of financial, political, and technical capacities among actors with unequal resources, transforming structural inequality into a source of collaborative advantage. Adaptive Coordination emerged through the establishment of the *Tim Percepatan IKN Kaltim* as an informal governance platform that compensated for regulatory gaps and facilitated scenario-based planning under uncertainty. Shared Value Creation was evident in the incorporation of local cultural and architectural elements that strengthened social legitimacy and public acceptance. Flexible Accountability enabled continuous progress through context-sensitive adjustments to resource allocation and role performance, while Iterative Trust Building was reinforced through a 15-year history of prior cooperation and consistent inter-organizational reliability. Collectively, these manifestations demonstrate that asymmetry, when strategically managed, can generate institutional synergy and sustained collaboration even in complex, decentralized governance environments

Resilience and sustainability factors

Despite the lack of fiscal guarantees and formal PPP safeguards, the partnership displayed remarkable institutional resilience. Five interconnected factors were identified as critical to sustaining collaboration:

(1) institutional trust, (2) complementary capabilities, (3) shared strategic interests, (4) flexible resource mobilization, and (5) organizational learning.

Five key factors sustained the BPD Kaltimara–IKN partnership under regulatory uncertainty. Institutional trust rooted in long-term collaboration ensured continuous engagement, while complementary capabilities and shared strategic interests created interdependence and a unified direction. Flexible resource mobilization through budget and personnel adjustments maintained project momentum, and continuous learning and adaptation strengthened responsiveness and overall institutional resilience

Challenges, dependencies, and mitigation strategies
Although construction has yet to begin due to the IKN Authority's pending site confirmation, the partnership achieved full technical and financial readiness. This distinction between institutional progress and physical progress highlights that effective collaboration can generate measurable outcomes even before project execution.

The challenges summarized above illustrate the multi-dimensional dependencies that shape the progress of the BPD Kaltimara–IKN partnership. Regulatory uncertainty remains the most critical constraint, driven by delays in land allocation, complex zoning requirements, and overlapping authority between central and regional institutions. These issues highlight the structural dependence on the IKN Authority and reflect broader limitations within Indonesia's multi-level governance system. To mitigate these barriers, the partnership employed proactive political engagement, legal risk reviews, and scenario-based planning that maintained organizational readiness despite regulatory stagnation. Financial risks, although moderate, emerged from the absence of state guar-

Table 3: *Institutional resilience factors and outcomes*

Factor	Operational Mechanism	Outcome
Institutional Trust	Long-term collaboration and social capital	Sustained partnership engagement under uncertainty
Complementary Capabilities	Distinct yet interdependent competencies	Mutual dependence and joint problem-solving
Shared Strategic Interests	Convergence of political, financial, and symbolic goals	Collective motivation and partnership cohesion
Flexible Resource Mobilization	Reallocation of capital and personnel	Maintained project momentum and readiness
Learning and Adaptation	Continuous procedural and strategic reflection	Adaptive capacity and resilience to delays

Table 4: *Challenges and mitigation strategies in the BPD Kaltimtura project*

Challenge Category	Specific Issues	Impact	Mitigation Strategy	Effectiveness
Regulatory Uncertainty	Land and zoning delays; AMDAL complexity	High	Scenario planning, political lobbying, and legal review	Moderate
Financial Risk	No state guarantees; market volatility	Moderate	Conservative budgeting; revenue diversification	High
Coordination Complexity	Multi-level governance fragmentation	Moderate	Monthly task force meetings; clear role definition	High
Social Acceptance	Community concerns; cultural sensitivity	Low	Public consultation; CSR programs; cultural integration	Under active management

antees and volatile market conditions. BPD addressed these challenges through conservative budgeting and diversification of revenue streams, ensuring financial sustainability and capital liquidity. Coordination complexity, arising from fragmented institutional mandates and informal communication channels, was effectively reduced through monthly task force meetings and the establishment of clear role definitions, which strengthened alignment and reduced transaction costs. Meanwhile, social acceptance challenges, though relatively low, were managed through participatory consultations, CSR initiatives, and the integration of local culture into the building's architectural design. Collectively, these mitigation strategies demonstrate that adaptive coordination, transparency, and stakeholder engagement can sustain trust and collaborative momentum even when formal regulatory clarity has not yet been achieved

Synthesis and theoretical implications

Overall, the implementation of the BPD Kaltimtura quasi-PPP provides empirical evidence that asymmetric governance models, when anchored in

complementary capacities and adaptive coordination, can produce sustainable institutional outcomes even under incomplete regulatory regimes. The case operationalizes the ACG framework in a real-world context and extends collaborative governance theory by demonstrating how informal, trust-based mechanisms can substitute for formalized contractual structures. These findings contribute to PPP and governance literature by showing that asymmetry can be productive when actors share long-term strategic interests, cultivate institutional trust, and apply adaptive learning to navigate uncertainty. This insight holds particular relevance for decentralized governance systems and emerging economies undertaking large-scale, multi-level development projects such as Indonesia's IKN initiative

Discussion

The findings of this study affirm that the implementation of the BPD Kaltimtura Head Office project in Ibu Kota Nusantara (IKN) exemplifies a distinctive form of quasi-public-private partnership (quasi-PPP). This model emerged from a combination of regional po-

litical mandates, institutional capacity, and cross-sectoral collaboration. Unlike formal PPP schemes characterized by standardized regulation and contractual risk-sharing mechanisms, this quasi-PPP displayed flexibility and adaptability while remaining shaped by asymmetries in power, resources, and risk distribution among actors. The governance configuration that materialized in this project aligns with the concept of *asymmetric collaborative governance*, a model of collaboration that remains functional and productive despite unequal actor capacities and contributions. The East Kalimantan Provincial Government served as a policy broker and strategic facilitator, mediating the interests of BPD Kaltimara, the IKN Authority, and third-party actors through informal and adaptive coordination mechanisms. This pattern reflects the *Collaborative Governance Framework* (Ansell & Gash, 2008), which emphasizes trust, mutual commitment, and facilitative leadership as key enablers of multi-actor collaboration. Meanwhile, BPD Kaltimara acted as the core implementer, bearing full financial responsibility without fiscal support from either national or regional budgets. Drawing on *First Mover Advantage theory* (Lieberman & Montgomery, 1988), BPD's early engagement in IKN demonstrates strategic positioning to establish institutional influence before the formalization of regional governance structures. This proactive stance signals both financial risk tolerance and a symbolic assertion of regional ownership within a national strategic agenda. It also resonates with *Resource Dependency Theory* (Hillman et al., 2009), which suggests that resource dominance enhances bargaining power. However, in this case, financial strength was leveraged not for control but to accelerate collaboration and reinforce regional legitimacy within the IKN project. Despite these advances, the partnership remains constrained by regulatory ambiguity, particularly from the IKN Authority, which has yet to finalize project site designation and clarify the legal scope of regional participation. This dependency on a single regulatory decision has placed all stakeholders, including those fully prepared technically and financially, into a conditional holding pattern. Such conditions mirror the *coordination gaps* described in *Adaptive Governance Theory* (Ansell & Torfing, 2022; Folke et al., 2005), where local institutions compensate for absent top-down directives through informal arrangements and proactive role assumption. Third-party contractors and consultants, while tech-

nically prepared, operate under conditional readiness until regulatory confirmation is obtained. Their function extends beyond construction execution; they act as co-producers of public value by embedding cultural and sustainability principles into architectural design. Yet, delays in formal contracts and site approval have created latent costs and reduced efficiency within the collaboration network. From a financial perspective, the project's structure, where BPD assumes the entirety of investment risk, highlights the limitations of the quasi-PPP model when compared to classical PPP frameworks. As emphasized by Li et al. (2024), sustainable PPPs typically rely on proportional risk-sharing between the public and private sectors. The absence of such mechanisms exposes BPD to prolonged investment recovery periods and potential liquidity pressures. Without regulatory support or macro-level fiscal guarantees, the project's long-term financial sustainability may face challenges. Nonetheless, the partnership benefits from strong political and social legitimacy rooted in government endorsement and community support. Local stakeholders view the project as a symbol of regional participation in national development, generating optimism, reinforcing political legitimacy, and stimulating local economic activity. This represents a form of social license to operate, where legitimacy derives from public acceptance rather than regulatory authorization, supported by information transparency, consultation, and responsiveness to community expectations. These findings align with the place-based governance approach (Barca et al., 2012), emphasizing that local identity and social cohesion enhance project legitimacy and success. Through the lens of New Public Governance (NPG) (Osborne, 2010), the project illustrates a transition from hierarchical to networked governance characterized by flexible role distribution, multi-actor interdependence, and trust as central drivers of collaboration. Although formal governance structures for IKN remain incomplete, regional governments, BUMDs, the IKN Authority, private sector partners, and local communities each contribute distinct but complementary roles within a semi-formal collaborative framework. The sustainability of this partnership ultimately depends on the institutionalization of coordination mechanisms, including formalized forums, shared incentive systems, milestone-based contracts, and measurable performance indicators. Theoretically, these findings reinforce the relevance

of the *Asymmetric Collaborative Governance (ACG)* model as an analytical framework for understanding strategic development partnerships in Indonesia. The model operationalizes five core principles: Complementary Asymmetry, Adaptive Coordination, Shared Value Creation, Flexible Accountability, and Iterative Trust Building, which were empirically demonstrated in this study. The BPD Kaltimara IKN project thus provides a compelling example of how a quasi-PPP configuration rooted in institutional flexibility and local commitment can function effectively within unstable, multi-level governance systems. As such, it offers both conceptual insight and practical guidance for designing adaptive, trust-based governance frameworks in similarly complex regulatory and political environments

CONCLUSION

This study examined the implementation of the BPD Kaltimara headquarters project in Indonesia's New Capital (IKN) as a pioneering quasi-public-private partnership (quasi-PPP) in a decentralized governance context. It aimed to describe actor collaboration patterns, assess adaptive coordination under regulatory uncertainty, and evaluate institutional trust, financial commitment, and project readiness. The findings demonstrate that this quasi-PPP represents a distinct institutional configuration departing from conventional PPP frameworks, yet capable of achieving substantial institutional progress despite regulatory and coordination constraints. The partnership was characterized by resource and authority asymmetries among the East Kalimantan Provincial Government, BPD Kaltimara, the IKN Authority, and private contractors. Rather than hindering collaboration, these asymmetries functioned as strategic assets when aligned with the five principles of *Asymmetric Collaborative Governance (ACG)*: Complementary Asymmetry, Adaptive Coordination, Shared Value Creation, Flexible Accountability, and Iterative Trust Building. The provincial government played a facilitative and legitimizing role, while BPD Kaltimara acted as the primary investor, committing IDR 85 billion (8% of its annual capital budget) without state or regional fiscal guarantees. This configuration generated structural interdependence and mutual incentives, illustrating how asymmetric collaboration can produce cohesive institutional arrangements. Trust indices of (provincial government–BPD) and (IKN Authority–partnership)

indicate substantial but differentiated confidence among actors. These results are consistent with collaborative governance thresholds identified by [Ansell and Gash \(2008\)](#), confirming that cooperation can remain effective despite power imbalances when built on long-term mutual reliability ([Emerson et al., 2012](#)). The partnership also operationalized Adaptive Coordination through the Tim Percepatan IKN Kaltim task force, which mitigated uncertainty via scenario-based planning and informal coordination consistent with adaptive governance literature ([Folke et al., 2005](#); [Ansell & Torfing, 2022](#)). Comparatively, these findings diverge from conventional PPP models emphasizing proportional risk sharing and contractual safeguards ([Li et al., 2024](#); [Maqbool & Sridhar, 2024](#)). Instead, the quasi-PPP configuration aligns more closely with the principles of state capitalism ([Mazzucato, 2018](#); [Musacchio & Lazzarini, 2014](#)), in which public-sector institutions assume strategic investment leadership. This study thus demonstrates that relational trust and institutional complementarity can substitute for formal risk-allocation mechanisms in decentralized governance environments, contrasting with [Maqbool and Sridhar's \(2023\)](#) assertion that contractual safeguards are prerequisites for PPP sustainability. These results reinforce the New Public Governance perspective ([Osborne, 2010](#)), showing that institutional relationships and adaptive learning may sustain complex partnerships even when formal regulatory structures remain incomplete. The study's theoretical contribution lies in validating the ACG framework as a practical analytical lens for understanding asymmetric governance in emerging economies. Empirically, it provides evidence that subnational institutions can drive national strategic initiatives through complementary capacities, flexible coordination, and iterative trust building. Practically, the findings suggest that contextually designed quasi-PPP models can enhance legitimacy, resilience, and innovation in decentralized development settings. While the study is limited to a single pre-construction case, its insights offer direction for future comparative and longitudinal research exploring whether such institutional arrangements can sustain effectiveness through project implementation and operation phases. Ultimately, the BPD Kaltimara IKN partnership illustrates that asymmetry, when strategically managed, can serve as a foundation for adaptive, legitimate, and enduring collaboration in complex governance systems

AUTHOR CONTRIBUTIONS

Elca Maradona conceptualized the research framework, led the data analysis, and drafted the main sections of the manuscript. Bonaventura Ngarawula contributed to the theoretical formulation of the Asymmetric Collaborative Governance (ACG) model, conducted literature synthesis, and supported data interpretation. Tommy Hariyanto coordinated field data collection, validated empirical findings through stakeholder consultations, and contributed to the final revision and editing of the manuscript. All authors discussed the results, reviewed the manuscript critically for intellectual content, and approved the final version for submission

ACKNOWLEDGEMENT

The authors thank the East Kalimantan Provincial Government, the IKN Authority, and BPD Kaltimarta for their support and cooperation.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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PUBLISHER NOTE

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ABBREVIATIONS (NOMENCLATURE)

AMDAL	<i>Analisis Mengenai Dampak Lingkungan</i> (Environmental Impact Assessment)
APBD	<i>Anggaran Pendapatan dan Belanja Daerah</i> (Regional Government Budget)
APBN	<i>Anggaran Pendapatan dan Belanja Negara</i> (State Government Budget)
Bappeda	Badan Perencanaan Pembangunan Daerah (Regional Development Planning Agency)
BPD	Bank Pembangunan Daerah (Regional Development Bank)
BUMD	Badan Usaha Milik Daerah (Regionally-Owned Enterprise)
FGD	Focus Group Discussion
IIGF	Indonesian Infrastructure Guarantee Fund
IKN	<i>Ibu Kota Nusantara</i> (Nusantara Capital City – Indonesia's New Capital)
MSME	Micro, Small, and Medium Enterprise
NPG	New Public Governance
PPP	Public–Private Partnership
Quasi–PPP	Quasi–Public–Private Partnership (Hybrid PPP model involving regional actors or state-owned entities)
RPJMN	<i>Rencana Pembangunan Jangka Menengah Nasional</i> (National Medium-Term Development Plan)
SOE	State-Owned Enterprise
SPV	Special Purpose Vehicle
VGF	Viability Gap Fund

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HOW TO CITE THIS ARTICLE

Maradona, E.; Ngarawula, B.; Hariyanto, T., (2026). *Asymmetric collaborative governance in Indonesia's new capital: A quasi-public-private partnership approach to regional financial institution engagement*. *Int. J. Hum. Capital. Urban Manage.*, 11(3): 591 - 604.

DOI: [10.22034/IJHCUM.2026.03.10](https://doi.org/10.22034/IJHCUM.2026.03.10)

URL: https://www.ijhcum.net/article_732110.html



International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: <http://www.ijhcum.net/>

CASE STUDY

Reconfiguring waste governance for a resilient circular economy

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ARTICLE INFO

Article History:

Received 17 August 2025

Revised 10 October 2025

Accepted 15 February 2026

Keywords:

Circular economy; Decentralized waste management; Institutional reform; Refuse-derived fuel; Zero waste governance

ABSTRACT

BACKGROUND AND OBJECTIVES: Decentralized waste governance in resource-constrained regions presents complex challenges where infrastructural expansion alone does not guarantee systemic resilience. Banyumas Regency, Indonesia, provides a critical case: following the abrupt landfill closure in 2018, the local government launched the “Sumpah Beruang” program, which initially reduced landfill-bound waste by over 90 percent. However, persistent inefficiencies such as underutilized facilities, stockpiled refuse-derived fuel, and declining digital engagement exposed governance and market fragilities. This study aims to evaluate the effectiveness of Banyumas’s Zero Waste strategy by examining its institutional adaptability, financial resilience, and stakeholder dynamics, while situating its relevance within broader circular economy transitions in decentralized settings.

METHODS: A convergent mixed-methods approach was applied, combining policy content analysis, institutional scoring, and financial benchmarking. Primary data were obtained through 20 semi-structured interviews with government officials, waste operators, community-based waste groups, and industrial off-takers. Secondary data included facility operations, household surveys, and municipal records. Comparative benchmarking with international refuse-derived fuel systems and institutional frameworks was undertaken. Triangulation ensured validity across qualitative narratives, operational statistics, and economic indicators.

FINDINGS: Results show significant upstream-midstream trade-offs. While landfill diversion exceeded 90%, facility utilization averaged only 58.25%, and over 160,000 tons of refuse-derived fuel remained unsold due to unstable quality and limited market absorption. This paradox underscores the fragility of end-of-pipe solutions in circular economy contexts. Institutional assessment revealed the local public service agency governance model scored substantially higher (4.35/5) compared to the technical implementation unit system (2.7/5), suggesting improved fiscal autonomy and partnership flexibility. Stakeholder mapping highlighted asymmetrical power: cement factories and the state electricity company dominate refuse-derived fuel markets, while community-based waste management groups and households remain marginal actors. Financial analysis showed revenue dependency on household fees (more than 85%), leaving the system vulnerable to non-compliance. Scenario modeling indicated that refuse-derived fuel co-firing could reduce up to 140,000 tons of carbon dioxide equivalent annually, representing United States Dollar 0.7–1.4 million in potential climate finance revenue if integrated with global carbon markets.

CONCLUSION: The study reveals that transforming the current technical implementation unit model into a public service agency significantly enhances fiscal autonomy and stakeholder coordination. We propose an integrated framework combining institutional reform, digital citizen engagement, and climate finance instruments. As a single case study focused on Banyumas Regency, the findings may have limited generalizability to regions with different governance or market contexts.

DOI: [10.22034/IJHCUM.2026.03.11](https://doi.org/10.22034/IJHCUM.2026.03.11)

		
NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
41	3	2

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the “Show Article.”

INTRODUCTION

Waste management remains a pressing global challenge, particularly in developing countries where rapid urbanization and population growth drive escalating waste volumes (Kumari and Raghubanshi, 2023; Alam et al., 2022; Nik Hasan and Panghao, 2025). The World Bank projects that global municipal solid waste will rise from 2.01 billion tons in 2016 to 3.40 billion tons by 2050, with over 90% of this increase occurring in low- and middle-income nations (Nartey and Nyarko, 2020; Kaza et al., 2018). In Southeast Asia, Indonesia ranks among the largest waste producers, struggling with limited processing infrastructure, weak regulatory enforcement, and low public participation in waste segregation (Pariatamby et al., 2020). These systemic issues highlight the need for governance innovation and circular economy integration, especially in decentralized regions (Dagnaw et al., 2025; Wang et al., 2021). Emerging evidence shows that sustainable waste systems require diversified utilization pathways Santoso et al., (2023) demonstrated that valorizing organic waste through black soldier fly cultivation not only reduces pollution but also generates high sustainability scores across economic and ecological dimensions. Such findings underline that circular waste management must go beyond end-of-pipe approaches like RDF to achieve resilience. A particularly illustrative case is Banyumas

Regency, Central Java, where the sudden closure of its only landfill in 2018 triggered a regional waste crisis (Diyanto and Warsono, 2020). The local government responded with the “Sumpah Beruang” as Sulap Sampah Berubah Jadi Uang (turning waste into money) initiative, emphasizing source-level sorting, organic waste valorization, and local recycling industries (Rosyidah, 2023). Initially, landfill-bound waste declined by over 90%, earning Banyumas recognition as a national model alongside Surabaya and Balikpapan (Muslihudin et al., 2023). However, subsequent performance deterioration marked by reduced digital engagement, stockpiled RDF, and policy discontinuity exposed governance and market fragilities (Indiahono, 2021; Fitrianingrum and Surjasatyo, 2023). These dynamics make Banyumas an ideal site for examining how institutional adaptability and financial mechanisms shape circular waste transitions in decentralized contexts. Existing studies on Indonesia’s waste governance often emphasize technical or behavioral aspects while overlooking institutional and financial interdependencies (Yusriadi et al., 2023; Anastasia et al., 2020). This study fills that gap by adopting an integrative sustainability framework linking policy, market, and institutional dimensions. Specifically, the research aims to: (i) *To evaluate the effectiveness of Banyumas’s Zero Waste policy in reducing landfill dependency and improving system performance;*(ii)



Fig. 1: Site location of the study in the Banyumas district

To assess institutional and financial resilience by comparing governance frameworks, technical implementation unit (UPT) vs. local public service agency (BLUD) and analyzing income diversification, operational funding, and market viability; (iii). To formulate strategic pathways for long-term sustainability through multi-stakeholder coordination and integration with global climate finance mechanisms. The scientific novelty of this research lies in its integration of institutional reform and fiscal resilience analysis within a circular economy framework at the subnational level, an analytical combination that has been rarely explored in previous waste governance literature. By linking governance adaptability, financial sustainability, and stakeholder participation, this study provides a new empirical basis for understanding systemic resilience in decentralized waste management systems. Similar integrative approaches combining digital innovation and circular resource flows have been demonstrated in the construction sector, where Building Information Modeling (BIM) frameworks are used to optimize material reuse and minimize demolition waste (Andriyani *et al.*, 2024). Position-

ing Banyumas within the broader circular economy transition allows this study to illustrate how governance flexibility, fiscal innovation, and citizen engagement interact to advance sustainable waste reforms in resource-constrained settings. The findings also offer practical insights for replicating resilient waste governance models across other decentralized municipalities in Indonesia and the wider Global South. To achieve these objectives, the research survey was conducted in the Banyumas District Center and the Directorate of Environment, Maritime, Natural Resources, and Nuclear Policy, National Research and Innovation Agency, Indonesia, Java, between July and October 2024.

MATERIALS AND METHODS

Research design and justification

This study employs a convergent mixed-methods design that synthesizes qualitative inquiry and quantitative metrics to comprehensively assess the sustainability of the zero-waste strategy in Banyumas Regency (Fig. 1). Given the multifaceted nature of the research objectives, ranging from institutional governance to technological

Table 1: Integrated solid waste management facility (TPSTs) at the Banyumas district

No	TPSTs name	Capacity (t/day)	Personnel (person)	Waste generated (t/day)	Household
1	Soka Negara	5	20	5-6	974
2	Kedung Gede	9	25	9	730
3	Sumpiuh	10	31	10	1,008
4	Patik Raja	15	38	15	2,972
5	Karangklesem	8	19	4-5	1,342
6	Mugi Resik	9	15	3	1,681
7	Cilongok	3	23	2	N/A
8	Bawa Berkah	10	29	8	1,404
9	Rawalo	8	19	2	1,087
10	Tipar Kidul	9	32	12	980
11	Arca Satria	10	4	4	1,010
12	Kamandaka	7	10	2	8,000
13	Migunami	8	15	6	956
14	Sejahtera	6	14	6	1,258
15	Sapu Resik	5	10	5	1,200
16	Cemara	1	4	1	530
17	Brayan	7	18	7	1,000
18	Gempar Jaya	8	12	4	1,160
19	Mandari	5	20	5	1,300

Source: (Ismail *et al.*, 2025)

feasibility, this approach facilitates the triangulation of policy insights, stakeholder narratives, and operational data (Rana and Chimoriya, 2025). The integration of both methods enhances analytical rigor by aligning contextual understanding with empirical validation, allowing for deeper exploration of institutional transitions (UPT to BLUD), financial resilience, and technology-market alignment. Field immersion and iterative data validation were employed to ensure both policy relevance and scientific reliability (Shah and Corley, 2006).

Data sources and collection

Primary data were collected through 20 semi-structured interviews with local government officials, waste management operators, community-based waste management groups (KSMs), and private partners, including Corporate Social Responsibility (CSR) affiliated industries. Respondent selection was carried out using a purposive sampling approach to ensure data validity and representativeness across stakeholder groups. This study specifically selected participants

who are actively engaged, skilled, and well-informed about the waste management system in Banyumas Regency. Focus Group Discussions (FGDs) were conducted to review and validate survey data, involving six experts with at least five years of experience in comprehensive waste management, including plant operators, plant managers, waste management specialists, and entrepreneurs. This rigorous selection process ensured that only qualified and knowledgeable participants contributed to the qualitative analysis, thereby enhancing the reliability and credibility of the findings. Secondary data were obtained from the Banyumas Environmental Agency (DLH), the National Waste Management Information System (SIPSN), and financial statements from selected 3R Waste Management Station (TPS3R) and Integrated Solid Waste Management Facility (TPST). A household survey involving 150 respondents was conducted to evaluate service coverage, community participation in waste segregation, and willingness to pay. Survey design followed best practices in environmental behavior research

Table 2: The results of the index of sustainability for every element and Associated accuracy requirements (Source: [Ismail et al., 2025](#))

Dimension	Index (%)	SQR	R ² Stress
Environmental	47.17	0.9339	0.230
Social	52.12	0.9346	0.245
Economy	55.27	0.9344	0.246
Technology	54.44	0.9354	0.223
Institutional	45.10	0.9247	0.263
Average	50.82		

([Stern, 2000](#)). Waste banks are vital in managing and redistributing recyclable materials that have financial significance. However, many households fail to sort or process their waste properly, and due to inefficiencies in the KSMs that are responsible for handling unprocessed waste, large quantities bypass the midstream stage and are sent directly to landfills. This interferes with the structured waste disposal process, compelling landfills to accept waste that ought to have been processed earlier. While the mixed-methods design and purposive sampling ensured data depth and contextual relevance, the survey sample may not fully represent the entire population of Banyumas Regency. Consequently, the findings should be interpreted as indicative rather than statistically generalizable, emphasizing analytical insight over population-level inference.

To support these KSMs, the Banyumas government constructed more than TPSTs to accommodate unprocessed residual waste ([Table 1](#)). It displays each station's installed processing capacity, workforce size, and waste input per day, along with the number of households served. These statistics reveal heterogeneity in coverage and performance, forming the empirical base for institutional benchmarking and resource allocation analysis.

Analytical strategy

The analytical framework is structured around four thematic pillars: policy effectiveness, institutional flexibility, financial sustainability, and technological viability.

1. Policy effectiveness was analyzed through qualitative content analysis of regulations, mayoral decrees, and Standard Operating Procedures (SOPs). Documents were coded thematically using NVivo to identify

gaps between policy design and field implementation.

2. Institutional performance was assessed using a structured scoring model across eight criteria: legal mandate, financial autonomy, operational flexibility, human resources, accountability, stakeholder coordination, responsiveness, and sustainability orientation. Each criterion was scored from 1 (very weak) to 5 (very strong), with a comparative analysis between UPT and BLUD formats.
3. Financial viability was examined using Cost-Benefit Analysis (CBA) and revenue source ratios. Operational expenditures (e.g., fuel, labor, maintenance) were compared against income from user fees, recyclable product sales, and CSR subsidies.
4. Technological benchmarking was conducted by comparing Banyumas's RDF systems with national and international models (e.g., Surabaya, Kamikatsu, Germany). Metrics included moisture control, storage efficiency, equipment durability, and off-take stability.

[Table 2](#) presents the sustainability index scores across five dimensions: environmental, social, economic, technological, and institutional. The indices were computed using the Multidimensional Scaling (MDS) approach with Rapfish software, incorporating expert validation. The inclusion of structured query report (SQR) and coefficient of determination (R²) stress values ensures the robustness of dimensional mapping ([Ismail et al., 2025](#)).

Validity and replicability

Data triangulation enhanced the validity of this study by cross-referencing interview data with

documentary evidence and direct observations. Thematic interpretations were validated through member-checking involving ten key informants, ensuring that the analysis accurately reflected stakeholder perspectives (Birt *et al.*, 2016). Reliability was strengthened through the use of multiple independent coders for institutional scoring and the deployment of pre-tested survey instruments. A comprehensive audit trail, including coding manuals and detailed documentation of analytical procedures, is maintained and available upon request to facilitate methodological transparency and replication. This rigorous approach reinforces the credibility and reproducibility of the findings, aligning with established standards in sustainability policy evaluation.

RESULTS AND DISCUSSION

Effectiveness of an integrated waste management system

The effectiveness of Banyumas Regency's Zero Waste strategy was assessed by analyzing its integrated waste management system across three principal levels: upstream, midstream, and downstream. At the upstream level, household waste segregation is promoted through community-based waste bank programs and digital platforms such as Jeknyong, which facilitates the collection of recyclables, and Salinmas, which manages organic waste streams. These initiatives, jointly administered by BUMD, were designed to promote household-level waste sorting and reduce landfill burden. However, in practice, programs such as Waste Bank, Jeknyong, and Salinmas have yet to reach massive implementation due to persistent behavioral and mindset barriers within the community. Consequently, the significant reduction in daily waste deliveries to the TPA landfill from 143 truckloads in 2018 to just 14 in 2022 is not primarily attributable to upstream household waste segregation. Instead, this reduction has been largely driven by midstream interventions, particularly the operational role of TPS3R and TPST facilities, which serve as the primary nodes for waste sorting and processing. These facilities have absorbed the bulk of municipal waste, effectively diverting it from final disposal and underscoring the pivotal role of infrastructure over behavioral change in the system's current effectiveness. (Suyanto and Lestari 2024). Midstream waste processing in Banyumas is carried

out at 29 TPS3R and 10 TPST units, where solid waste undergoes both manual and mechanical sorting. Manual sorting targets high-value recyclable materials such as Polyethylene terephthalate (PET) bottles, cans, Polipropilena (PP) cups, and cardboard, while separating residual waste that cannot be further recycled or processed into RDF. Mechanical sorting involves the use of shredders that divide waste into two main streams: combustible materials, primarily paper and plastic which are processed into RDF for use in cement kilns; and organic pulp, previously utilized for Black Soldier Fly (BSF) maggot cultivation but now entirely directed toward RDF production with organic content exceeding 95%, specifically for coal cofiring at power plants. These midstream operations significantly reduce the volume of waste requiring final disposal. Downstream, residuals that cannot be processed at the TPS3R or TPST level are incinerated at the BLE landfill. This facility also incorporates a buffer management system to handle surges in waste volume or interruptions in upstream and midstream processing (Muslihudin *et al.* 2023). The ideal model, as illustrated in the provided image (Fig. 2), was designed to ensure that waste is sorted, processed, and disposed of efficiently, thereby minimizing the burden on TPA. Nevertheless, the practical execution of this system has run into various operational inefficiencies, mainly caused by limitations in infrastructure and alterations in policy that followed changes in regional governance. Fig. 2 illustrates Banyumas's integrated Zero Waste system architecture. This three-tiered model consists of: (1) upstream sorting via households and digital platforms, (2) midstream processing at TPS3R/TPST units for recyclables and RDF, and (3) downstream incineration and final residue handling at the BLE landfill.

Each level plays a pivotal role in diverting waste from landfills, but recent findings show declining effectiveness at the source and technological stagnation midstream, underscoring the importance of synchronized system governance and adaptive institutional support. This study assessed the effectiveness of Banyumas Regency's Zero Waste strategy by examining its integrated waste management system, which operates across upstream, midstream, and downstream levels. System performance has shown signs of regression after 2023, attributed to political transitions and a decline in user engagement

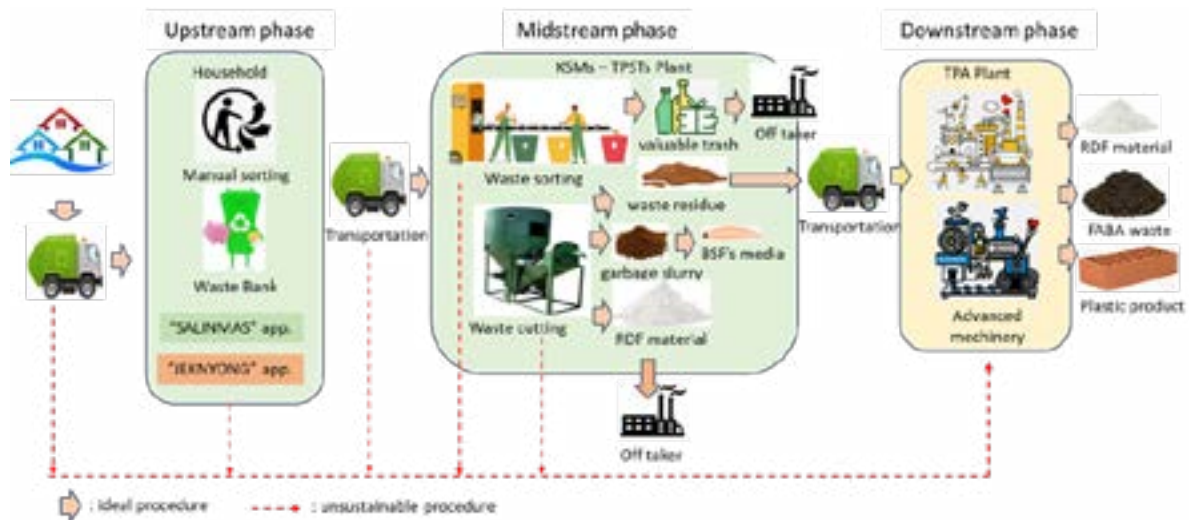


Fig. 2: Diagram of waste management at the Banyumas district

Source: (Ismail et al. 2025)

with digital tools (Suyanto and Lestari, 2024). Digital infrastructure lacks real-time tracking, incentive mechanisms, and user-centered interfaces, which limit household engagement. Similar lessons were observed in Surabaya and Seoul, where the absence of user rewards and infrastructure maintenance led to a breakdown in community participation (Wong, 2022). The sustainability of Banyumas's model depends on reinforcing digital incentives (e.g., gamification, rebates), upgrading household waste infrastructure (dual bins, QR-coding), and reactivating civil society campaigns. For a sustainable rebound, improvements are needed in upstream engagement. These include intensive community campaigns, gamified digital incentives (e.g., reward points or user fee reductions), and standardized household infrastructure such as dual-compartment bins and QR-coded containers for traceability. Prior research in emerging economies shows that source-level sorting supported by economic incentives significantly improves waste diversion and household compliance (Godfrey et al., 2019). Without reinforcement at this level, Banyumas risks reversing its progress and overloading its downstream facilities. Similar patterns were observed in Surabaya, where citizen disengagement led to sharp declines in segregated waste supply. These findings confirm that policy design alone is insufficient without stable institutional incentives and behavioral reinforcement. Thus, while the integrated model showed early promise,

its sustainability hinges on system-wide coherence and long-term stakeholder commitment.

Operational gap in TPS3R and TPST utilization

Banyumas Regency's waste management system faces a significant operational imbalance in its TPS3R and TPST units. Although 39 facilities (29 TPS3R and 10 TPST) possess an installed capacity of 416 tons per day, only 242 tons are processed daily, equating to a utilization rate of just 58.25% (Budhijanto et al., 2024). The finding of a low utilization rate (58.25%) should be understood not merely as a technical limitation, but as a reflection of the failure of institutional integration and community behavior in a decentralized system. This data confirms that infrastructure availability does not automatically guarantee effectiveness if it is not accompanied by adaptive governance and socio-economic incentives. Thus, the gap between installed capacity and actual usage reflects a misalignment between the logic of technocratic planning and the reality of citizen participation, a problem also frequently encountered in circular economy studies in developing countries. This structural inefficiency undermines the overall success of the waste reduction targets and risks overwhelming downstream facilities. The underutilization stems from two primary issues. First, a low percentage of households have subscribed to regular waste services, with many still relying on informal or illegal dumping. Second,

there is a chronic shortfall in operational funding for fuel, equipment maintenance, and worker compensation (Siagian *et al.*, 2019). Equipment such as *gibrig* machines, three-wheeled motor transporters, and conveyor systems often remain out of service for extended periods due to delayed or insufficient maintenance budgets. These constraints severely limit service coverage, particularly in high-density areas that remain underserved. Addressing existing gaps in waste management requires the concurrent application of both technical and social strategies. On the technical front, key interventions include increasing the frequency of waste collection, expanding transport fleets, and integrating customer monitoring systems via mobile applications. Provision of equipment renewal subsidies and operational training for KSM personnel can enhance the operational efficiency of existing facilities. Social strategies should focus on incentivizing community participation through mechanisms such as discounted service fees for new users and referral programs. These approaches, successfully demonstrated in cities like Surabaya and Balikpapan, have been shown to improve public engagement in waste management systems. From a financial sustainability perspective, 88.31% of TPS3R/TPST revenues come from household service fees, with only 11.69% derived from the sale of recyclables, 94% of which is from low-value scrap (Budhijanto *et al.*, 2024). Such heavy reliance on fees renders the system vulnerable to income fluctuations caused by fee resistance or non-compliance. International standards suggest that no more than 60–70% of revenue should be fee-based, with the remainder sourced from product sales, sectoral subsidies, and CSR programs (Kaza *et al.*, 2018). Strengthening Banyumas's financial model requires a reoriented business strategy that supports long-term viability. Establishing regional recycling hubs has the potential to improve economies of scale and enhance negotiating power with material off-takers. Diversification of revenue streams can be achieved by producing value-added outputs such as organic compost, solid fertilizers, and RDF briquettes. Although certain operational limitations persist, Banyumas possesses considerable latent capacity, including an extensive network of KSM organizations and robust local market demand. Institutional reforms that facilitate public-private partnerships, offer fiscal incentives for recycling initiatives, and

align CSR efforts can accelerate the transition toward a resilient and sustainable waste management ecosystem.

Technological and market constraints of RDF

In the midstream phase of Banyumas Regency's waste management system, the production of RDF yields two distinct products: approximately 60,000 tons of RDF derived from combustible materials such as plastic and paper, primarily intended for cement factories; and around 106,000 tons of RDF made from organic waste pulp, aimed at power plant operators. However, field data reveal serious bottlenecks in the downstream distribution and market absorption of these products. This finding is also connected to the dynamics of biomass co-firing in coal-fired power plants. Febijanto *et al.* (2024) emphasized that although sawdust co-firing at a ratio of 11.8% reduced global warming potential by nearly 20% and significantly lowered acidification and eutrophication impacts, it simultaneously caused substantial increases in land use and ozone depletion indicators. Thus, while RDF may be positioned as a coal substitute, its deployment requires a comprehensive life-cycle evaluation to ensure long-term sustainability. Two key factors underlie this stagnation. First, product quality remains unstable, most notably the moisture content of RDF, which frequently exceeds the 25% threshold acceptable to the cement industry in Central Java. Second, operational inconsistency among off-takers, including shutdowns due to overcapacity or routine maintenance, has limited regular procurement. The paradox between the achievement of reducing waste to landfill by more than 90% and the reality of RDF stockpiles illustrates a crucial policy trade-off. While emergency interventions successfully reduced the flow of waste to landfills, the intermediate solution of RDF actually created a new burden in the form of stocks that were not absorbed by the market. This contradiction demonstrates the limitations of end-of-pipe strategies in the context of a circular economy and strengthens the argument that sustainability transitions require synchronization between technical policies, market readiness, and multi-level governance coordination. Beyond main partners like the cement industry and electricity company, Banyumas has yet to establish active commercialization pipelines with alternative buyers, such as lightweight brick manu-

facturers, mineral processors, and biomass energy firms across Central Java. Our field data indicate that more than 160,000 tonnes of RDF remain stockpiled in Banyumas, with key quality constraints including high moisture (frequently above 25%), inconsistent particle size, and storage degradation that limit market absorption. Based on these conditions and the local market structure, several realistic alternatives merit consideration: (1) Immediate quality remediation through high-throughput shredding, forced-air drying, and covered storage to meet current industrial fuel standards; (2) Densification (briquetting or pelletizing) to stabilize calorific value and logistics, making RDF usable in industrial boilers, tile and brick manufacturing, and small energy plants; (3) Biological valorization of the organic-rich fraction by reintroducing BSF cultivation, composting, or anaerobic digestion to recover value as animal feed, fertilizer, or biogas; (4) Product diversification for construction use, converting mixed RDF streams into lightweight aggregates or composite bricks; and (5) Thermal conversion via gasification or pyrolysis for producing syngas and biochar. A staged approach is recommended, beginning with quality improvement and pilot-scale trials for densified fuels and construction materials (short-term), while simultaneously diverting the organic fraction for biological utilization and evaluating advanced thermal options (medium- to long-term). Each pathway should be tested with standardized quality control and environmental monitoring to assess absorption capacity, costs, and sustainability performance before wider adoption. This integrated strategy aligns with the broader objectives of Banyumas's circular waste governance framework, allowing unused RDF stocks to be reintegrated into productive value chains while mitigating environmental and storage risks.

Environmental risks in residue combustion

The final stage of Banyumas Regency's waste management chain, residue combustion at the Environmental Learning-based Landfill Facility (BLE landfill), faces serious environmental and education challenges. Field evaluations revealed significant mechanical damage in several incinerator units, including broken seals, frayed steel slings, and cracked refractory walls. These failures have led to the uncontrolled escape of smoke and flames, not through the designated chimney but from structural gaps and loose joints. The resulting emission leakage causes pungent odors,

visible air pollution, and acute health risks for both workers and surrounding residents. This condition violates the Best Available Techniques (BAT) principles outlined by the European Commission (Afgan, 2010), which demand high combustion efficiency and stringent emission control. Similar findings by Alao *et al.* (2022) show that uncontrolled incineration generates high levels of dioxins and fine particulate matter, both of which are known to exacerbate respiratory diseases and degrade ambient air quality. Preventing recurrent damage and enhancing combustion efficiency requires a dual approach that combines technical upgrades with managerial reform. Technically, preventive maintenance should be institutionalized within SOPs, incorporating scheduled inspections of thermal seals, slings, and heat-resistant linings using advanced thermal and pressure sensors. Recalibration of ventilation systems is necessary to ensure that emissions are directed exclusively through the designated chimney. Installation of early-warning systems equipped with high-temperature sensors can provide real-time detection of structural vulnerabilities or overheating, thereby mitigating operational risks and extending equipment lifespan (de Titto and Savino, 2019). On the managerial side, the adoption of a total productive maintenance (TPM) framework is highly recommended. This approach entails digital recordkeeping of equipment performance, maintenance intervals, and operational anomalies, with routine audits to ensure continuous improvement. Transitioning the current management structure from a UPT to a BLUD would provide greater flexibility in budgeting and procurement, enabling timely repair and replacement of critical components without bureaucratic delay (Ismail *et al.*, 2025). The implementation of safe and efficient thermal technologies is a vital element of Banyumas's broader green economy strategy. Not only does it minimize residual landfill waste, but it also significantly reduces long-term air pollution risks. In line with (Wilson *et al.*, 2015), investing in robust emission control infrastructure and institutional capacity will determine the environmental integrity and public health safety of Banyumas's waste-to-energy framework.

Institutional reform and multi-stakeholder partnership strategy

A critical structural bottleneck in Banyumas Regency's current waste management system is the

institutional framework, which remains embedded within a UPT under the Environmental Agency. While the UPT model provides legal legitimacy and bureaucratic integration, it is ill-suited for dynamic public service delivery. It lacks budgetary flexibility, inhibits efficient investment, and constrains partnership-building with private and civil society actors. This study's institutional assessment, based on eight core indicators of financial autonomy, operational efficiency, service quality, investment readiness, accountability, HR management, environmental sustainability, and regulatory compliance, revealed that the BLUD model scored 4.35 compared to UPT's 2.7 (Ismail *et al.*, 2025). Technically, transforming into a BLUD would enable more autonomous financial management, allowing revenues to be sourced not only from service charges but also from product sales (e.g., recyclables, RDF, BBJP), consultancy services, and waste management training programs. Crucially, BLUD status would empower local waste management operators, especially at BLE and TPST units, to hire professional staff outside the rigid ASN framework under performance-based contracts. This is particularly important given the need for responsive and technically proficient personnel to manage technologies such as RDF systems, digital waste banking, and RDF production. Moreover, BLUD entities are allowed to directly sign contracts with industrial off-takers, CSR partners, and research institutions without having to navigate cumbersome public procurement rules. The efficacy of this approach has already been demonstrated in Surabaya's wastewater management BLUD and the Bali Urban Waste Project (World Bank, 2021), both of which benefited from streamlined decision-making, agile budget execution, and enhanced institutional accountability. Actor analysis reveals a power asymmetry in Banyumas waste management. The cement industry and PLN (State Electricity Company) act as dominant stakeholders with strong bargaining power in determining the price and quality of RDF, while KSMs (Citizens' Association) and the community are marginal stakeholders, financially and technically vulnerable. Shifting to a BLUD model has the potential to reduce this inequality by opening up space for direct contracts and flexible fund management, but also carries the risk of resistance from the local bureaucracy and political elite. Therefore, the power dynamics between actors need to be explicitly mapped to formu-

late a balanced collaborative strategy. Realizing the full potential of an improved institutional framework requires the establishment of a multi-stakeholder platform to coordinate the diverse actors engaged in Banyumas's circular waste economy. The proposed FSSB would bring together stakeholders, including local government representatives, KSMs, BUMD, major off-takers such as cement and electric company, and CSR contributors. Oversight of the platform would be assigned to the forthcoming BLUD, with facilitation by Bappeda. The forum is envisioned to serve three core functions: integrated strategic planning, collaborative negotiation for project financing, and systematic monitoring of zero waste program targets. The platform could also serve as a clearing house for RDF commercialization, establishing long-term off-take agreements and providing legal support for contract enforcement. In addition, it would facilitate stakeholder capacity-building and promote policy alignment between district-level authorities and provincial or national sustainability agendas. Beyond local coordination, the future of Banyumas's waste system depends on its ability to access international climate and green infrastructure funding. Global opportunities are increasingly available in the wake of climate transition imperatives. Banyumas should prepare comprehensive proposals for funding from the Global Environment Facility (GEF), Climate Investment Funds (CIF), or the Green Climate Fund (GCF). These proposals must demonstrate a clear emissions baseline, projected carbon reductions (in tons carbon dioxide equivalent (CO₂-eq)), and measurable co-benefits such as community inclusion and economic resilience. To strengthen the argument for climate finance, quantitative estimates are essential. Based on projections for RDF co-firing at a coal-fired power plant, every 100,000 tons of RDF absorbed can replace approximately 70,000 tons of coal, with a potential emission reduction of approximately 140,000 tons of CO₂-eq per year. Converted to the voluntary carbon market value (USD 5–10/ton), the potential funding reaches USD 0.7–1.4 million per year. The financial relevance of this pathway becomes clearer when linked to the urgency of mitigating individual and institutional carbon footprints. Haryanto *et al.* (2025) reported that employees at a national research institution in Indonesia had an average carbon footprint of 7.42 tons CO₂-eq per year, significantly higher than the national average. These findings



Fig. 3: Strategic pathways for strengthening zero waste governance

underscore the magnitude of emissions from institutional and consumption-related activities, further strengthening the argument that emission reductions projected through RDF co-firing hold strategic value not only for accessing climate finance but also for mobilizing institution-based mitigation actions. This figure demonstrates that the climate finance mechanism is not merely a normative option, but a concrete opportunity that can support the financial sustainability of the Zero Waste system in Banyumas. Eligible projects may include expanded RDF capacity to substitute coal, organic waste diversion programs, or digitized citizen engagement platforms. Collaborations with environmental non-government organizations (NGOs), local universities (e.g., Universitas Jenderal Soedirman), and national research institutions like BRIN would be essential for preparing technically robust and scientifically validated submissions. Insti-

tutionalizing long-term sustainability goals requires the Banyumas local government to develop a Green Investment Plan for the 2025–2030 period. This strategic roadmap should map investment priorities within the waste sector while aligning financial flows with national emissions reduction commitments and the Sustainable Development Goals (SDGs). Formal registration of the plan with international donor networks such as ICLEI-Local Governments for Sustainability, along with integration into funding pipelines managed by the United Nations Development Programme (UNDP), GCF, or the World Bank, would enhance its visibility and funding viability.

The Fig. 3 illustrates the hierarchical structure of Banyumas's institutional reform strategy toward a resilient circular economy. It consists of three interlinked layers: (i). Institutional Reform (foundation): transitioning from the UPT model

to the BLUD framework to improve financial autonomy and governance flexibility; (ii) Financial Innovation (intermediate layer): promoting income diversification, CSR engagement, and access to climate finance to enhance fiscal sustainability; and (iii). Community Engagement and Digital Integration (top layer): leveraging public participation and digital platforms (e.g., *Beruang Apps*) to strengthen accountability, citizen inclusion, and behavioral transformation. Together, these layers form an integrated strategic pathway linking structural reform, financial sustainability, and social participation within Banyumas's circular waste management system.

CONCLUSION

This study evaluated the effectiveness of Banyumas's Zero Waste policy through a multidimensional lens encompassing institutional, financial, technological, and social aspects. The findings demonstrate that Banyumas achieved significant landfill reduction and community-based circular practices but continues to face structural challenges related to RDF market absorption, governance continuity, and declining public engagement. The transition toward a BLUD model provides a promising framework for improving institutional and financial resilience; however, sustained progress depends on consistent policy alignment and stakeholder coordination across governance levels. To strengthen the clarity and practical relevance of this study, specific recommendations are now formulated for each level of governance:

- i. Local government level (district and municipal): prioritize the institutionalization of the BLUD model to ensure stable budgeting, transparent financial management, and professionalized waste service operations. Strengthen community engagement by reactivating digital platforms such as *Beruang Apps* with reward-based participation schemes and periodic outreach.
- ii. Provincial and regional level: facilitate market linkages for RDF and recyclable materials through regional cooperation, joint procurement schemes, and technology standardization among waste processing facilities. Provide technical assistance to municipalities transitioning toward integrated circular systems.
- iii. National level: align local zero waste initiatives with broader circular economy and climate

financing frameworks under national policy. Establish fiscal incentives and grant-based support mechanisms that reward verified reductions in landfill dependency and measurable improvements in recycling performance.

To ensure the effective implementation of these recommendations, a multi-tier monitoring system is proposed. At the local level, routine performance tracking should be integrated into the *Beruang Apps* dashboard to record waste diversion rates, financial transparency, and citizen participation. At the provincial level, coordination forums led by the Environmental Agency can conduct semi-annual evaluations, while at the national level, the Ministry of Environment and Forestry should integrate these local reports into the *SIPSN* database to enable benchmarking and inter-regional learning. This structure supports adaptive management by linking data-driven evaluation with policy feedback loops across governance levels. Implementing the proposed model may face several risks, including institutional resistance to administrative reform, financial dependency on local government budgets, and fluctuating market demand for RDF and recyclables. There is also the possibility of declining community participation if incentive mechanisms are not sustained. To mitigate these risks, the study recommends phased implementation supported by stakeholder consultation, diversification of funding sources through public-private partnerships, and continuous public engagement supported by transparent digital reporting systems. These multi-level recommendations ensure that Banyumas's experience contributes not only to local innovation but also to Indonesia's broader waste governance reform. The study highlights that sustainable transitions require synchronized action between institutional reform, financial innovation, and citizen participation, supported by adaptive governance mechanisms and continuous intergovernmental learning. This study is limited to a single case in Banyumas Regency, which may affect the generalizability of its findings to other regions. In addition, the reliance on stakeholder interviews and institutional records may introduce contextual bias. Future research should include longitudinal or cross-regional comparisons to enhance external validity.

AUTHOR CONTRIBUTIONS

A.D. Santoso prepared the manuscript, and critically analyzed the manuscript's crucial substantive

value; M.A. Kholiq critically analyzed the manuscript's crucial substantive value; S.D.R. Pahri performed recognition of data and handed material and operational support; I. Setiawati supervised manuscript preparation; E. Avianti prepared the manuscript and performed critical revisions; T.G. Franzisca performed recognition of data; Sarkiwan performed data curation; Diyono performed experimental operation; Suprpto analyzed the manuscript's crucial substantive value; A. Lusia performed recognition of data, and A. Wiratmoko performed recognition of data.

ACKNOWLEDGEMENT

The authors are grateful to the Deputy Chairman for Development Policy at the National Research and Innovation Agency (BRIN) of Indonesia for the support the instrumental in facilitating survey activities, FGDs, and obtaining necessary research permits. The authors would like to thank the editors and anonymous reviewers for their constructive feedback

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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PUBLISHER NOTE

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ABBREVIATIONS (NOMENCLATURE)

%	Percent
BAT	Best available techniques
BIM	Building Information Modeling
BSF	Black soldier fly
BLUD	Badan layanan umum daerah (local public service agency)
CO ₂ -eq	carbon dioxide equivalent
CIF	Climate investment funds
CBS	Cost-benefit analysis
CSR	Corporate social responsibility
DLH	Dinas Lingkungan Hidup (local environmental agency)
GEF	Global Environment Facility
GCF	Green Climate Fund
KSMs	Community-based waste management groups
MDS	Multidimensional scaling
NGOs	Non-government organizations
PP	Polipropilena
PET	Polyethylene terephthalate
RDF	Refuse-derived fuel
R ²	Coefficient of determination
SDGs	Sustainable Development Goals
SOPs	Standard operational procedures
SQR	Structured query report

SIPSN	National Waste Management Information System
TMP	Total productive maintenance
TPSTs	Integrated solid waste management facility
TPS3R	3R Waste management station
TPA	Tempat pembuangan akhir (the final disposal site)
UNDP	United Nations Development Programme
UPT	Unit pelaksana teknis (the technical implementation unit)

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HOW TO CITE THIS ARTICLE

Santoso, A.D.; Kholiq, M.A.; Pahri, S.D.R.; Setiawati, I.; Avianti, E.; Franzisca, T.G.; Sarkiwan, S.; Diyono, D.; Lusia, A.; Suprpto, S.; Wiratmoko, A., (2026). Reconfiguring waste governance for a resilientcircular economy. *Int. J. Hum. Capital. Urban Manage.*, 11(3): 605 - 620.

DOI: 10.22034/IJHCUM.2026.03.11

URL: https://www.ijhcum.net/article_734476.html



International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: <http://www.ijhcum.net/>

REVIEW PAPER

The application of a gamification approach in promoting citizen engagement in Tehran's urban policy-making process

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ARTICLE INFO

Article History:

Received 27 August 2025

Revised 12 November 2025

Accepted 19 May 2026

Keywords:

Citizen Participation; Gamification; Smart Governance; Tehran Urban Management; Urban Policy-making

ABSTRACT

Contemporary urban centers, including Tehran, the capital of Iran, are grappling with complex challenges such as institutional fragmentation, data scarcity, and a decline in citizen engagement, which underscore the need for innovative approaches to urban governance. This article explores the potential of gamification—the application of game design elements in non-game contexts—as a strategic tool to enhance citizen participation in Tehran's urban policymaking and management processes. By leveraging elements such as points, competition, progress levels, and rewards, gamification can transform traditional, often opaque and formal, policymaking into a more appealing, transparent, and accessible experience for a broader public. The primary objective of this study is to elucidate the foundational concepts of gamification, analyze its impact on the quality of urban policy decisions and implementation, and propose practical, context-specific strategies for its successful application in Tehran. Through a detailed examination of successful global case studies, including CityScopeAR in the United States, ParmoSense in Japan, and Game.UP in Germany and Austria, this research analyzes the potential for local adaptation and alignment of these approaches with Tehran's unique socio-cultural needs and existing infrastructure. The findings suggest that a well-designed gamification framework can not only significantly increase citizen participation rates but also generate valuable data for evidence-based policymaking, foster a stronger sense of community belonging, and empower citizens to assume a more proactive role in shaping their city's future. Ultimately, this research provides a comprehensive and actionable set of recommendations for Tehran's urban management to strengthen smart and participatory governance in the Iranian capital.

DOI: [10.22034/IJHCUM.2026.03.12](https://doi.org/10.22034/IJHCUM.2026.03.12)



NUMBER OF REFERENCES

109



NUMBER OF FIGURES

6



NUMBER OF TABLES

2

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Note: Discussion period for this manuscript open until October 1, 2026 on IJHCUM website at the "Show Article."

INTRODUCTION

Urban governance is undergoing a fundamental transformation globally, driven by the increasing complexity of urban issues, the rise of new information technologies, and growing citizen demands for active involvement in decision-making processes (Tappert et al., 2024; Chamoso et al., 2020). Traditional top-down, non-transparent policymaking models are no longer sufficient to meet the dynamic needs of modern cities. In this context, meaningful citizen participation has emerged as a cornerstone of good urban governance, essential for enhancing the effectiveness of policies, ensuring spatial justice, and establishing institutional legitimacy (Alhassan, 2025; Arnstein, 1969; Fung, 2006). Despite the clear benefits, engaging citizens in a meaningful and sustained manner remains a significant challenge (Choo et al., 2023). This is particularly true in large metropolitan areas like Tehran, where institutional inconsistencies, data scarcity, and a lack of public trust can hinder effective collaboration. Recognizing this, urban policymakers are seeking innovative tools to bridge the gap between citizens and the government (Alshahrani, 2025). One of the most promising and novel approaches is gamification. Gamification uses the engaging and motivating aspects of games—such as points, rewards, leaderboards, and challenges—to encourage voluntary and creative participation in non-game contexts (Tóbiás and Boros, 2025; Deterding et al., 2011; Hamari et al., 2014). In the urban context, gamification can serve as a powerful interactive tool for a wide range of applications, from urban planning and waste management to sustainable transportation and civic education (Venturi et al., 2025; Sgueo, 2019; Thiel, 2016). By making complex and formal processes more enjoyable and accessible, gamification has the potential to fundamentally change the relationship between citizens and their city's management (Fig. 1). Figure 1 provides a bibliometric visualization illustrating the weighted value and interconnectedness of “gamification,” “play,” and “serious games” within the broader interactive digital landscape. This visualization serves to contextualize the core concept of the study by demonstrating its central position and strong linkage to related concepts like “virtual reality,” “crowdsourcing,” and “behavior change,” thus justifying the selection of gamification as the innovative tool under investigation. This manuscript aims to address a critical gap in the

existing literature on urban gamification, specifically concerning its practical application in the context of developing countries. While successful examples exist in smart cities worldwide, the approach has not yet been widely adopted or formally established in Iran's urban management framework, particularly in Tehran. Therefore, the paper will propose practical, context-specific strategies for its successful application in Tehran. The study has been carried out as a literature review and comparative case study with a focus on Tehran, without a specific date mentioned. This manuscript seeks to bridge this gap by:

- Analyzing and evaluating successful international experiences of gamification in urban policymaking.
- Analyzing the specific context and challenges of implementing gamification in Tehran's urban management.
- Developing practical and context-specific recommendations for implementing this approach in the Iranian capital.

Theoretical foundation: Review of gamification and its application in urban settings

To provide a robust analytical foundation, this framework is structured around the concept of Motivational Affordances, which posits that the success of gamification is contingent upon the design elements' ability to fulfill users' psychological needs for competence, autonomy, and relatedness (Hamari et al., 2014). This perspective moves beyond simple feature enumeration (e.g., points and badges) to analyze the underlying mechanisms that drive sustained behavioral change and civic engagement. To understand how gamification can be applied to urban policymaking, it is crucial to first define its core concepts and distinguish it from related terms:

Defining gamification, play, and games

The most widely accepted definition of gamification refers to “the use of game design elements in non-game contexts” (Fox et al., 2022; Deterding et al., 2011). Its main objective is to motivate and engage users, promote learning, or encourage specific behaviors by leveraging the inherent fun and motivational aspects of games (Kapp, 2012; Zichermann and Cunningham, 2011; Werbach and Hunter, 2012). This is distinct from play, which is a spontaneous and flexible activity often driven by intrinsic motivation (Lebed, 2020; Pellegrini,

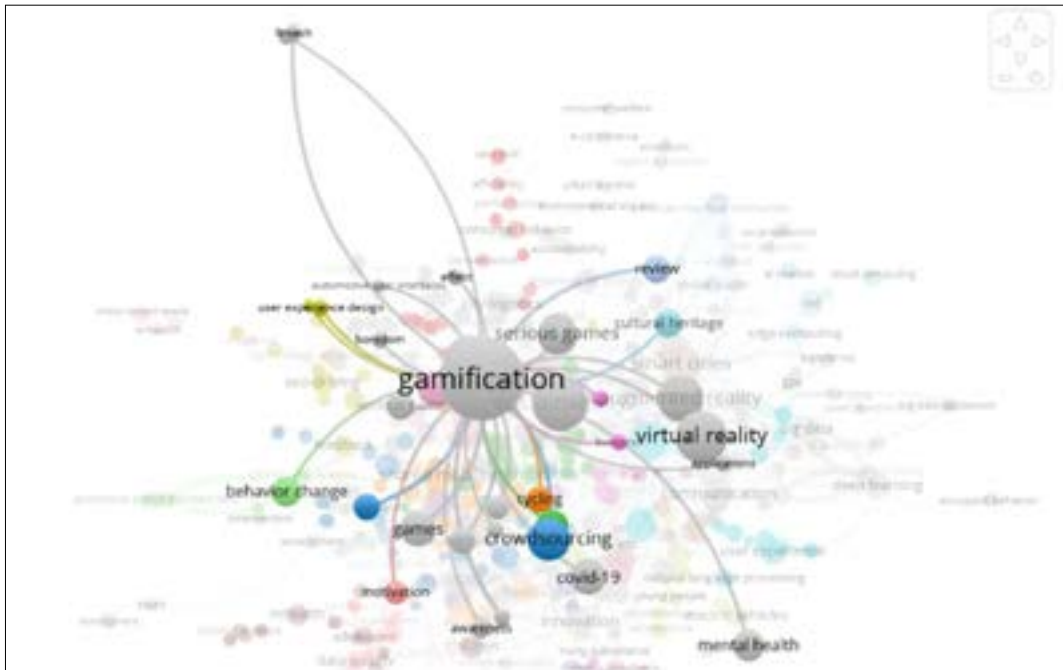


Fig. 1: A demonstration of the weighted value of gamification, play, and serious games in the field of civic engagement

2010; Buijs-Spanjers *et al.*, 2019), and a game, which is a structured activity with explicit rules and goals (Lebed, 2020; Pellegrini, 2010; Buijs-Spanjers *et al.*, 2019; Frasca, 2009). Think of the difference between children playing freely in a playground (play) and a structured game like soccer or SimCity (game). Gamification strategically borrows specific elements from game design, such as points, badges, leaderboards, challenges, and rewards (Huotari and Hamari, 2017; Zichermann and Cunningham, 2011), to influence behavior and improve user experience in various domains, including education, healthcare, and business (Parra-González *et al.*, 2021; Kasurinen and Knutas, 2018). Importantly, gamification is not about creating a full-fledged game; rather, it's about applying these mechanics to enhance motivation in non-game activities (Ryan and Deci, 2000; Seaborn and Fels, 2015).

Types of games

Categorizing games based on their underlying mechanisms and objectives is instructive because different genres lend themselves to various planning challenges. Games can be categorized into various genres (Buijs-Spanjers *et al.*, 2019; Mora *et al.*, 2017; Bharathi *et al.*, 2016; Seaborn and Fels, 2015) based

on their gameplay mechanics and objectives (Fig. 2):

- Action Games: These games emphasize physical challenges, including hand-eye coordination and reaction time (Michael and Chen, 2005; Zyda, 2005; Frasca, 2009; Djaouti *et al.*, 2011).
- Adventure Games: They focus on storytelling, exploration, and solving puzzles (Michael and Chen, 2005; Koster, 2013; Lebed, 2020). For urban planning applications, their exploratory nature can be beneficial.
- Role-Playing Games (RPGs): These allow players to take on the roles of characters in a narrative setting and make choices that affect the game's outcome (Caillois, 2001; Michael and Chen, 2005; Steinkuehler, 2012; Lebed, 2020). RPGs are particularly relevant for fostering social empathy, allowing participants to experience the city from different perspectives, which directly supports enhancing participatory policymaking.
- Simulation Games: These mimic real-world activities such as city building or flight simulation (Michael and Chen, 2005; Zyda, 2005). Along with Strategy Games, they can effectively model the complex trade-offs of city management.



Fig. 2: Types of game genres based on gameplay mechanisms and objectives

- Strategy Games: These require players to use decision-making skills to achieve goals, often involving resource management and tactical planning (Michael and Chen, 2005; Koster, 2013; Djaouti et al., 2011). Complex participatory processes often draw upon the logic of Simulation and Strategy Games to model urban challenges.
- Sports and Racing Games: These simulate physical sports competitions or car races (Michael and Chen, 2005; Bharathi et al., 2016; Pellegrini, 2010).
- Puzzle Games: These challenge players with problem-solving tasks (Koster, 2013; Michael and Chen, 2005; Frasca, 2009; Pellegrini, 2010; Djaouti et al., 2011).

The application of these genres to urban settings is typically realized through serious games. Serious games are a specialized subset of games designed for non-entertainment purposes, which provide the content-rich platforms often leveraged by urban gamification strategies (Oliveira et al., 2024).

Urban gamification

Urban gamification integrates principles of game design—such as reward systems, interactive visualization, and scenario development—into urban planning practices to strengthen citizen engagement and enhance planning processes (Muehlhaus et al., 2023; Sgueo, 2019; Chamoso et al., 2020). Research identifies gamification as an approach that renders planning more attractive and educational, while empowering citizens by redistributing decision-making processes (Kavouras et al., 2025; Iulia et al., 2020; Devisch et al., 2016). In a more specific sense, urban gamification refers to the application of game design elements within urban environments, processes, systems, and challenges (Yao et al., 2025; Naranjo-Zolotov et al., 2019). Such elements are mobilized within urban governance frameworks to promote civic participation and support urban management (Muehlhaus et al., 2023; Romano et al., 2022; Sgueo, 2019). The scope of this concept is broad, encompassing urban problem-solving, planning scenarios, political interaction, and information dissemination (Sergeyeva et al., 2019; Iulia et al., 2020). Gamification features

may include the use of sensors, data collection mechanisms, and interactive technologies designed to foster more efficient and inclusive cities (Sgueo, 2019; Papaioannou *et al.*, 2018). These activities influence how citizens perceive, interpret, and interact with their urban surroundings (Thibault, 2019). Applications also extend into education, where virtual reality systems are employed to assess motivational, social, and spatial competencies in architecture and urban design curricula (Cho and Suh, 2023; Fonseca *et al.*, 2017). Overall, urban gamification constitutes a rapidly expanding field with diverse applications across urban management, civic participation, and education (Miao *et al.*, 2022; Hassan and Hamari, 2020). Within the framework of this research, the focus lies on employing gamification elements in urban planning processes to increase citizen participation, collect feedback, facilitate co-creation, raise public awareness of urban issues, and encourage pro-social and environmentally responsible behaviors.

Key characteristics of urban gamification

Several core attributes have been identified for different forms of urban gamification, including:

- Integration with place: Linking digital interactions to urban spaces or planning proposals (e.g., location-based tasks, AR overlays) (Sengupta *et al.*, 2020; Gnat *et al.*, 2016).
- Civic purpose: Aimed at public outcomes such as improved planning, social capital, or civic literacy (Park and Fujii, 2023; Al-Kodmany, 2020).
- Data production for planning: Generating spatial and preference data from citizens to inform decisions (Kavouras *et al.*, 2023; Poplin *et al.*, 2017).
- Addressing complexity: Simplifying issues like budgeting or zoning trade-offs for wider audiences (Mora *et al.*, 2017).
- Collective action: Encouraging collaboration among citizens and planners (Gordon and Manosevitch, 2011).

Additional features of urban gamification may include:

- Real-time interaction: Immediate feedback to urban actions.
- Contextual alignment: Adapting game elements to local cultural and social contexts.

Key typologies of gamification

Gamification can be categorized in several ways. Two prominent typologies are:

- Structural vs. Content Gamification (Kapp, 2012; Werbach and Hunter, 2012; Seaborn and Fels, 2015; Mora *et al.*, 2017; Fraternali and Gonzalez, 2019):
 - A) Structural gamification applies game elements to an existing process or content without changing the content itself. For instance, awarding points for completing a survey or attending a workshop (Fig. 3).
 - B) Content gamification, on the other hand, modifies the content itself to make it more game-like, such as presenting a planning scenario as a story-driven quest where citizens' choices have visible consequences within a game-like environment.
- Meaningful Gamification: This approach criticizes the over-reliance on superficial rewards like points and badges. Meaningful gamification, as proposed by Nicholson (2015), focuses on fostering intrinsic motivation by incorporating deeper mechanics such as reflection, narrative, meaningful choices, and social interaction. This approach is particularly relevant for civic engagement, where intrinsic motivation is a key driver (Zhou *et al.*, 2025; Nicholson, 2015; Seaborn and Fels, 2015).

Urban gamification and its evolution

Urban gamification specifically applies game design principles to urban planning, processes, and systems to increase citizen participation. It is described as a method that makes urban planning more engaging and educational, while empowering citizens by redistributing decision-making processes. The evolution of urban gamification can be broadly categorized into three phases (Fig. 4):

- Early conceptualization (pre-2015): This period saw the use of analog board games and physical simulation tools to engage stakeholders in complex urban planning concepts (Reinart and Poplin, 2014; Poplin, 2011; de Heer *et al.*, 2010; Mayer, 2009; Arnstein, 1969).
- Technology integration (2015-2018): With advancements in technology, urban gamification began to integrate digital platforms, mobile applications, and location-based services. This phase focused on promoting sustainable urban

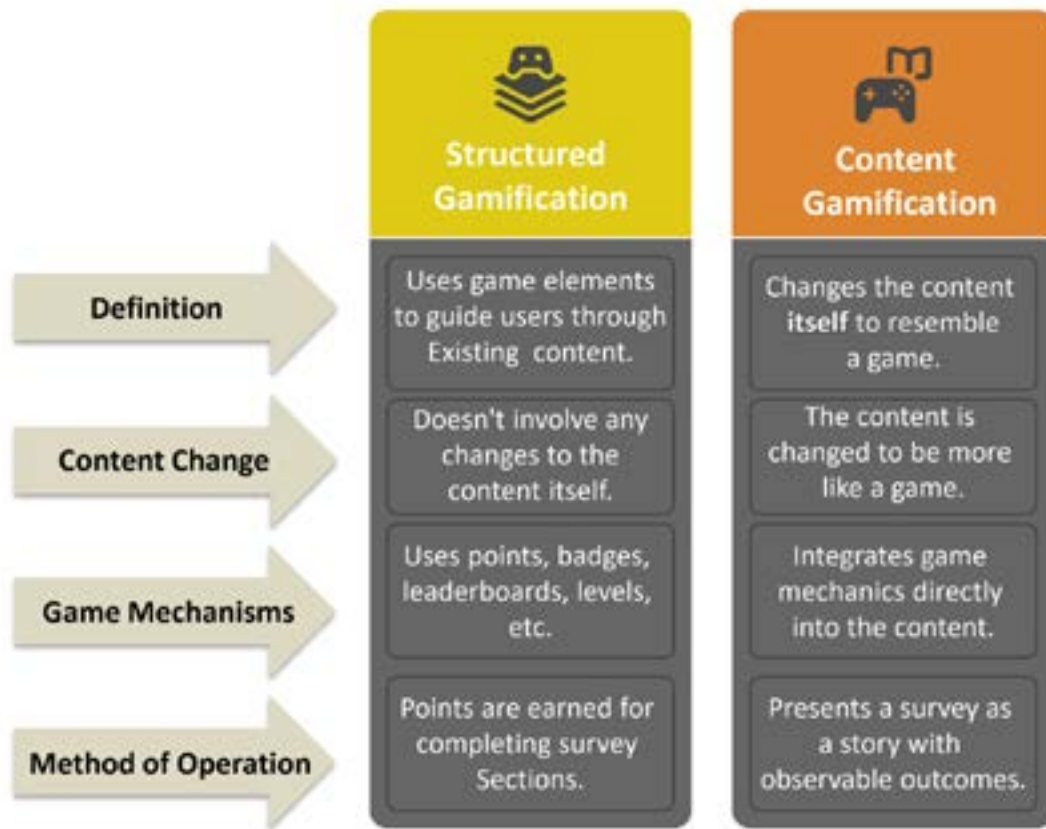


Fig. 3: Structured gamification vs. content gamification

mobility and accessibility mapping (Kawanaka et al., 2020; Pajarito and Gould, 2017; Thiel and Fröhlich, 2016; Prandi et al., 2015; Kazhamiakin et al., 2015).

- Contemporary applications (2019-present): The most recent phase has seen a diversification of applications, incorporating AI and pandemic response tools to address emerging challenges in smart cities. This includes using gamification for public health initiatives, environmental sustainability, and smart city projects (Zhou et al., 2024; Guerra et al., 2024; Nourian et al., 2024; Lifelo and Ding, 2024; Özden et al., 2023; Bijlani, 2023; Muehlhaus et al., 2023; Cavada, 2023; Thibault and Baer, 2021; Thibault, 2020; García-Retuerta and Corchado, 2022).

These approaches demonstrate that urban gamification has evolved from a focus on efficiency to a more inclusive, citizen-centric approach.

Methodology

This research employs a qualitative approach with an analytical and comparative nature. This methodological choice is best suited for the study's objective, as a systematic review and cross-case comparison provide the necessary rigor to synthesize diverse global implementation strategies and extract transferable design principles for a novel policy context (Oliveira et al., 2024). Specifically, the methodology of the present study is based on documentary analysis and comparative case studies. The main objective is to analyze successful global experiences in the application of gamification in urban management and policymaking, and then to adapt and localize the key findings to the specific characteristics and needs of the Tehran metropolis. The research steps are as follows (Fig. 5):

1. *Literature review and theoretical foundations:*
This initial step involved a systematic search

Features	Early Conceptualization (Before 2015)	Technology Integration (2015-2018)	Contemporary Applications (2019-Present)
Key Innovations	Analog Games, Participatory Approaches	Mobile Applications, Location-based Services	Integration of Artificial Intelligence (AI), All-in-one Response Tools
Main Applications	Urban Planning, Civic Engagement	Sustainable Mobility, Accessibility Mapping	Public Health, Smart City Initiatives
Influencing Factors	Physical Limitations, High Interaction Potential	Increased Data Collection Capabilities, Real-time Interactions	Adaptability to Challenges, Large-scale Implementation

Fig. 4: Evolution of urban gamification

of indexed academic databases (ISI Web of Science and Scopus) to establish a robust theoretical framework defining “gamification,” “serious games,” and “citizen participation” in the urban context, which informed the analytical categories for the case study analysis.

2. *Selection and analysis of global case studies:*

Based on the research objective and the breadth of application, a purposeful sample of 13 successful international experiences in urban gamification was selected and analyzed comparatively. The comparative analysis followed a structured protocol, examining each case across key analytical dimensions: Key Technology/Tool, Gamification Elements, Kind of Participation, Subjective Domain, and Target Groups. These experiences were chosen from various parts of the world, including the USA (CityScopeAR), Japan (ParmoSense), Germany and Austria (Game.UP), and Spain (Smart Recycling App). The criteria for selecting these cases were the success of the projects in achieving their predetermined goals, the innovativeness of the approach, and the broadness of their application scope.

3. *Adaptation and localization:* This critical qualitative step involved thematic synthesis of the cross-case findings to identify the core mechanisms (e.g., real-time feedback, narrative-driven missions) that satisfied key motivational affordances (competence, autonomy,

relatedness). Subsequently, considering the current situation and the specific challenges of urban management in Tehran (such as data scarcity, weak participation, and institutional fragmentation), an operational framework was developed to localize and implement these experiences within the cultural and institutional context of Iran.

4. *Proposal of operational solutions:* Finally, based on the localized framework, a set of practical proposals and tangible projects for applying gamification in various domains of Tehran’s urban policymaking and management (including citizen reporting, participatory budgeting, collaborative urban design, and neighborhood competitions) was presented.

This analytical and comparative methodology allows for the extraction of successful mechanisms and principles from global experiences, enabling the development of a practical and operational model to address specific problems related to citizen participation in Tehran.

Findings

A global perspective: comparative analysis of gamification in urban policy

The global application of gamification in urban policymaking offers a rich and diverse set of examples, each tailored to its specific institutional, social, and cultural context. This section presents the synthesized analytical findings from the thirteen



Fig. 5: Mind map- study implications of urban gamification research

comparative case studies (see Appendix for detailed tables). This section provides an analytical overview of thirteen successful international experiences, drawing from the provided document to identify key trends, mechanisms, and outcomes that can inform a framework for Tehran. The analysis is presented in a comparative table format in the original document, which is summarized here to highlight its key findings.

Synthesis of global experiences

The cross-case analysis demonstrates that successful urban gamification is fundamentally a strategic mechanism for fostering citizen self-determination, rather than a mere mechanism for gathering attention (Hamari et al., 2014). The analyzed case studies, ranging from North America and Europe to Asia, reveal that gamification is not merely a tool for attention-grabbing but a strategic mechanism for redefining the relationship between citizens and public policy (see Devisch et al., 2016; Klamert and Münster, 2017; Prilenska, 2019). These projects have been implemented across a wide range of thematic areas, including urban design, participatory budgeting (see Baiocchi and Ganuza, 2014), waste management, sustainable transportation, and civic education. A key takeaway is the impressive diversity in the type of participation fostered by these projects. Some, like *Game4City* in Barcelona (Redondo et al., 2020; Game4City Consortium, 2020), defined participation as an educational experience to engage younger generations with urban design concepts. Others, such as *Budget Games* in San Jose (Every Voice Engaged Foundation, 2018), treated participation as

a means for citizens to make real, impactful decisions on policy, where their resource allocation choices directly influenced the local budgeting process. Meanwhile, projects like *FixMyStreet* in the UK (FixMyStreet Pro, 2023; mySociety, 2021) provided a model for everyday, on-the-ground participation, empowering citizens to act as observers and reporters of urban infrastructure issues. The common and critical thread in these successful experiences is the strategic use of core gamification elements—points, real-time feedback, social competition, badges, missions, and tangible or social rewards—to cultivate sustained motivation and a sense of genuine ‘impact’ in citizens, thereby fostering long-term trust and engagement (see Werbach and Hunter, 2012; Zichermann and Cunningham, 2011; Deterding et al., 2011; Seaborn and Fels, 2015). Furthermore, the analysis shows a convergence in the macroscopic outcomes (see Sgueo, 2019; Vanolo, 2018; Deterding et al., 2011; Buijs-Spanjers et al., 2019; Hamari et al., 2014) of these projects. Nearly all were successful in increasing real participation, improving public awareness, modifying individual and collective behaviors, and regenerating a sense of civic responsibility. Projects integrated with data-driven infrastructure, such as *ParmoSense* in Japan (Arakawa and Matsuda, 2021; Kawanaka et al., 2020) and *Smart Recycling App* in Spain (Briones et al., 2018; Chamoso et al., 2018), were also able to generate valuable local data on citizen preferences and action patterns, which served as a basis for evidence-based policymaking (Table 1). This global transition from passive, bureaucratic models to interactive, people-centered, and responsive structures (Devisch

et al., 2016; Ampatzidou *et al.*, 2018; Gordon and Baldwin-Philippi, 2014; Thibault, 2020) is a crucial lesson for cities like Tehran, which face challenges

of public distrust, limited participation, and lack of transparency.

Discussion: Localizing gamification for Tehran's

Table 1: A comparative analysis of 13 global experiences in applying gamification to urban policy-making and management from a participatory perspective.

Project Title and City/Country #1				
CityScopeAR in Cambridge, USA				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Interactive Crowdsourcing	Urban Design and Spatial Modeling	Augmented Reality, Physical Block, Real-time Analysis	Real-time Feedback, Team Challenge, Multi-level Scenarios	Citizens, Students, Urban Managers
Achievements:				
Enhanced Spatial Understanding; Improved Feedback Quality; Policy Testing				
Reference: (Landa Oregi <i>et al.</i> , 2025; MIT Media Lab, 2019; Noyman <i>et al.</i> , 2019; Alonso <i>et al.</i> , 2018)				
Localizability in Tehran:				
Very high – Suitable for participatory education in urban neighborhoods.				
Project Title and City/Country #2				
ParmoSense in Osaka, Japan				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Voluntary Environmental Measurement Participation	Environmental Monitoring, Urban Data Collection	Mobile Application, Participatory Sensors	Scoring, Daily Mission, Competitive Leaderboard	General Citizens, Elderly, Schools
Achievements:				
Increasing Data Coverage; Enhancing Environmental Awareness; Validated Data				
Reference: (Arakawa and Matsuda, 2021; Kawanaka <i>et al.</i> , 2020)				
Localizability in Tehran:				
High – Applicable for strengthening grassroots environmental data collection.				
Project Title and City/Country #3				
Game.UP in Germany and Austria				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Decision-making Simulation	Urban Planning, Interactive Design	Digital Platform, Virtual Reality, Cognitive Assessment	Rewards, Mission, Instant Feedback, Data Modeling	Students, Citizens, Decision-makers
Achievements:				
Enhanced Qualitative Participation; Understanding Causal Relationships; Policy Transparency				
Reference: (Muehlhaus <i>et al.</i> , 2023; Gordon and Manosevitch, 2011)				
Localizability in Tehran:				
Medium to High – Very useful for local plans.				

Project Title and City/Country #4				
Digital Co-Design in the UK				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Digital Co-creation	Participatory Urban Design, Digital Governance	Web-based Platform, Scoring System	Levels of Participation, Real-time Feedback, Ranking	General Citizens, Consultants, Urban Institutions
Achievements: Enhanced Participation Rate; Reduced Cost; Design Creativity				
Reference: (Ng et al., 2024 ; Kavouras et al., 2023 ; Ampatzidou et al., 2018 ; Gordon and Schirra, 2011)				
Localizability in Tehran: Very high – Suitable for low-cost and participatory virtual sessions.				
Project Title and City/Country #5				
Participatory Chinatown in Boston, USA				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Interactive Role-playing	Neighborhood Planning, Social Empathy	Three-dimensional Narrative Game	Narrative-driven, Mission, Role-playing, Team Collaboration	Immigrants, Low-income Groups, Local Residents
Achievements: Fostering Empathy; Participation of Marginalized Groups; Participatory Data Analysis				
Reference: (Gordon and Baldwin-Philippi, 2014 ; Engagement Game Lab, 2010 ; Shareable, 2010)				
Localizability in Tehran: High – Implementable in deteriorated and multicultural contexts.				
Project Title and City/Country #6				
Unlimited Cities in Rennes, France				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Visual Scenario Building	Participatory Urban Design	Visual Web and Mobile Platform	Visualisation, Sharing, Liking and Voting	Local Residents, Users with Low Literacy, Youth
Achievements: Enhanced Visual Literacy; Multiplied Participation; Input for Detailed Design				
Reference: (Poplin, 2014)				
Localizability in Tehran: Very high – Suitable for underprivileged urban areas.				

Project Title and City/Country #7				
Game4City in Barcelona, Spain				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Educational – Experiential Participation	Urban Design Education, Youth Participation	3D Simulation, Virtual Reality	Points, Team Competition, Educational Levels, Rewards	Students, University Students, Teachers
Achievements: Enhanced Spatial Literacy; Fostering Responsibility; Sustainable Participation				
Reference: (Redondo et al., 2020 ; Game4City Consortium, 2020 ; Fonseca et al., 2017)				
Locaizability in Tehran: Very high – It is implementable for participatory education in schools.				
Project Title and City/Country #8				
GreenApes in Italy (Florence, Rome)				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Behavior-based Environmental Participation	Environmental Sustainability, Civic Behavior Change	Mobile Application, Reward System	Points, Badges, Challenges, Tangible Rewards	General Citizens, Organizations, Local Businesses
Achievements: Reduced Energy Consumption; Increased Environmental Awareness; Stakeholder Engagement				
Reference: (GreenApes, 2021 ; Sgueo, 2019)				
Locaizability in Tehran: Very high – Compatible with Tehran's environmental policies.				
Project Title and City/Country #9				
Smart Recycling App in Barcelona and Seville, Spain				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Behavioral – Committed	Urban Waste Management	QR Code, Smart Bins	Points, Leaderboard, Badges, Instant Feedback	Households, Schools, Recycling Companies
Achievements: Enhanced Sorting Rate, Family Education, Data-driven Decision-making				
Reference: (Briones et al., 2018 ; Aguiar Castillo et al., 2018 ; Chamoso et al., 2018)				
Locaizability in Tehran: Very high – Implementable with local applications.				
Project Title and City/Country #10				
Budget Games in San Jose, USA				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Participatory Budgeting	Local Financial Resource Allocation	Role-playing Game, Group Facilitation	Notional Budget, Prioritization, Negotiation	Neighborhood Residents, Minorities, Urban Managers

Achievements:				
Increased Public Trust; Preference Analysis; Budgetary Transparency				
Reference: (Every Voice Engaged Foundation, 2018 ; Baiochi and Ganuza, 2014)				
Localizability in Tehran:				
Very high – A practical model for district budgeting.				
Project Title and City/Country #11				
FixMyStreet in the UK				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Reporting Urban Issues	Civil Oversight, Urban Infrastructure	Mobile Application, Interactive Map	Points, Badges, Feedback, Neighborhood Competition	General Citizens, Youth, Schools
Achievements:				
Increased Reporting; Enhanced Responsiveness; Urban Monitoring Index				
Reference: (FixMyStreet Pro, 2023 ; mySociety, 2021)				
Localizability in Tehran:				
Very high – Developed for the 137 system.				
Project Title and City/Country #12				
EcoCrowd in Germany				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Green Crowdfunding	Environment, Neighborhood Micro-projects	Digital Platform, Participation Profile	Badges, Group Challenges, Results Feedback	Green Citizens, Environmental Institutions
Achievements:				
Enhanced Motivation; Implementation of Grassroots Projects; Policy-makers' Use of Data				
Reference: (EcoCrowd, 2023 ; Resek et al., 2022 ; OECD, 2020 ; Sgueo, 2019)				
Localizability in Tehran:				
High – Suitable for neighborhood-based innovation ecosystems.				
Project Title and City/Country #13				
Urban Treasure Hunt in Helsinki, Finland				
Kind of Participation	Subjective Domain	Key Technology/ Tool	Gamification Elements	Target Groups
Place-based Cultural Participation	Urban Identity, Public Spaces	Map-based Application, GPS, Content Creation	Points, Missions, Team Competition, Participatory Content	Youth, Tourists, Schools, Low-identity Neighborhoods
Achievements:				
Interaction with Spaces; Local Content; Intergenerational Participation				
Reference: (City of Helsinki, 2020 ; Thiel and Fröhlich, 2016)				
Localizability in Tehran:				
Very high – Suitable for the revitalization of historic and forgotten neighborhoods.				

urban management

The present studies demonstrate that gamification, as a novel strategy, holds significant potential for increasing citizen participation in urban policymaking processes. However, its effectiveness is influenced by several factors, including the *mechanisms employed* (such as scoring, challenges, or immersive technologies), the *individual characteristics of participants* (such as age and intrinsic motivations), and the *implementation context*. In some cases, gamification has meaningfully increased participation (such as the 32.2% increase in the study by Briones *et al.*, 2018) and has even yielded tangible results like improved recycling rates. Conversely, it may have a limited impact on groups already interested in urban issues or may even diminish their intrinsic motivation. A key takeaway is that *gamification is not a comprehensive solution on its own*; it should be considered as part of a *multifaceted approach* to urban engagement. The careful design of mechanisms with the target audience in mind, continuous monitoring of results, and integration with other participatory tools can mitigate challenges such as “tokenistic activity with no policy impact” or “age segmentation”. Furthermore, future research should increasingly focus on the *link between gamified participation and tangible changes in urban policies* to fill the existing gap in the literature. Ultimately, the success of this strategy requires a balance between game-like appeal and the depth of civic participation. A comprehensive review of successful international experiences in using gamification to enhance citizen participation in urban policymaking reveals the immense potential and diverse approaches of this innovative tool. Projects like CityScopeAR in Cambridge, which facilitated the understanding of complex urban concepts through 3D visualization and augmented reality, and ParmoSense in Japan, which enabled collective participation in environmental monitoring through gamification, demonstrate their power. Game.UP in Germany and Austria transformed decision-making simulation into an engaging experience, while Game4City in Spain focused on educating the younger generation in urban design. Similarly, examples such as the Smart Recycling App in Spain and GreenApes in Italy proved gamification’s ability to drive sustainable environmental behaviors. Projects like Budget Games in San Jose and FixMyStreet in the UK also showed how urban budgeting and problem reporting can

be transformed into interactive and trust-building processes. Finally, EcoCrowd in Germany, with its green crowdfunding model, and Urban Treasure Hunt in Finland, with its location-based discovery of urban identity, revealed new dimensions of participation. Despite differences in scale, subject area, and technical complexity, each of these experiences shared a common goal: to establish a deeper and more motivational connection between citizens and urban management. Inspired by these achievements and considering the local capacities, specific needs, and existing regulations in Tehran, , the following table presents proposed operational applications for the capital’s urban management. These applications are designed to align with Tehran’s urban ecosystem and to leverage the full potential of gamification to promote active citizen participation (Table 2). This table also outlines the impact of each proposed application on Tehran’s policymaking at the end of each entry. It should be noted that in the next chapter, these operational examples will be proposed in greater detail for implementation within Tehran’s urban management framework.

The localization framework for Tehran must, therefore, target the specific urban challenges—institutional fragmentation, data scarcity, and low public trust—by deploying gamification models that foster transparency and reward tangible civic action. The localization strategy is structured across key functional areas of urban management:

1. Data-Driven Environmental Monitoring and Citizen Reporting:

To address Tehran’s documented challenge of data scarcity and environmental pollution, the application of sensory-based gamification is proposed, mirroring the success of ParmoSense in Japan. This approach, titled the “Tehran-Sanj” Project, would leverage mobile applications and portable sensors (distributed via neighborhood centers) to enable citizens to crowdsource real-time data on noise, air quality, and temperature. The use of Missions/Challenges and Leaderboards, derived from ParmoSense, satisfies the competence and relatedness needs by providing immediate feedback on contributions and promoting healthy social competition. The reliable, high-volume data generated would provide Tehran’s urban managers with a crucial evidence base

Table 2: Global gamification experiences and proposed applications in Tehran's urban policy-making

Global Experience Title	Mechanism Type	Key Technology or Tool
CityScopeAR	3D Visualization, Missions/Challenges, Social Interaction, Points, and Leaderboards	Augmented Reality, Physical Block, Real-time Analysis
Proposed Applications in Tehran's Urban Policy-making based on this Game: Smart Workshops "My Tehran, My Design" A proposal to create interactive workshops in neighborhood houses or cultural centers using <i>smart tables</i> (similar to CityScopeAR), where citizens can model various neighborhood development scenarios with <i>physical blocks</i> (such as the placement of green spaces, parking, and land uses) and observe their impact <i>in real-time</i> through <i>augmented reality</i>. This tool is particularly applicable for **urban regeneration** projects or the renovation of deteriorated urban fabrics.		
Influence on Policy-making	Democratization of the planning process by enhancing spatial understanding and increasing the participation of non-specialists in urban design. Enhancing the quality of feedback and enabling the testing of policies before actual implementation, which leads to improved decision-making.	
Global Experience Title	Mechanism Type	Key Technology or Tool
ParmoSense	Missions/Challenges, Points and Leaderboards, Rewards/Incentives	Mobile Application, Participatory Sensors
Proposed Applications in Tehran's Urban Policy-making based on this Game: "Tehran-Sanj" Project So that citizens can use smartphone sensors or small portable sensors (e.g., distributed in cultural centers or neighborhood houses) to record and send data on temperature, humidity, noise pollution, light, and air quality from different parts of the city. This data can assist in the continuous monitoring of the urban environment and serve as a basis for environmental policies (e.g., the placement of new green spaces and noise pollution reduction programs).		
Influence on Policy-making	Provision of timely and accurate data for environmental policies (e.g., the placement of new green spaces and noise pollution reduction programs). Democratization of urban monitoring and enhanced environmental awareness among citizens, which can lead to participatory policy-making.	
Global Experience Title	Mechanism Type	Key Technology or Tool
Game.UP	3D Visualization, Missions/Challenges, Points and Leaderboards, Rewards/Incentives	Digital Platform, Virtual Reality, Cognitive Assessment
Proposed Applications in Tehran's Urban Policy-making based on this Game: "Tehran Online Urban Design" Project A proposal to create a digital simulation platform (similar to Game.UP) where citizens can virtually experience various urban planning schemes (such as land use changes, new traffic plans, and public space development). They can observe the consequences of their decisions on indicators like density, accessibility, environmental quality, and citizen satisfaction, and then submit their suggestions to decision-makers. This platform could also be used in the municipality's online consultative meetings.		
Influence on Policy-making	Democratization of the planning process through decision-making simulation and online citizen participation. Enhanced skills for collective thinking and submitting more informed suggestions to decision-makers.	

Global Experience Title	Mechanism Type	Key Technology or Tool
Digital Co-Design	Missions/Challenges, Points and Leaderboards, Rewards/Incentives, Social Interaction	Web-based Platform, Scoring System
Proposed Applications in Tehran's Urban Policy-making based on this Game: "Tehran Co-Design Studio" Project A proposal to create a web and mobile-based platform (similar to <i>Digital Co-Design</i>) where citizens can participate in different stages of urban design (from the ideation phase to the final design selection). The platform can provide tools for uploading photos, drawing simple designs, and sharing ideas, while encouraging creative participation through a scoring system and instant feedback. This tool is particularly applicable for the redesign of squares, parks, or urban facades.		
	<i>Enhanced participation</i> in certain areas and fostering co-creation between citizens and urban designers. <i>Improving the quality of crowdsourced feedback</i> and reducing the operational costs of consultative meetings.	
Global Experience Title	Mechanism Type	Key Technology or Tool
Participatory Chinatown	3D Visualization, Missions/Challenges, Social Interaction	Three-dimensional Narrative Game
Proposed Applications in Tehran's Urban Policy-making based on this Game: "My Neighborhood Game" Project This project involves developing three-dimensional role-playing games (<i>3D RPGs</i>) focused on Tehran's historic or deteriorated neighborhoods (e.g., southern Tehran neighborhoods, Harandi neighborhood, etc.). In these games, citizens take on the roles of fictional residents and experience daily challenges, such as finding housing, employment, and access to services. These games can be used in in-person sessions with vulnerable groups (e.g., immigrants, seniors) to help policy-makers better understand their needs and problems, and to design more empathetic policies.		
Influence on Policy-making	<i>Potential for participatory policy-making</i> with a better understanding of the needs and problems of vulnerable and marginalized groups. <i>Increased empathy and public trust</i> in local policy-making processes.	
Global Experience Title	Mechanism Type	Key Technology or Tool
Unlimited Cities	3D Visualization, Missions/Challenges, Social Interaction, Points and Leaderboards	Visual Web and Mobile Platform
Proposed Applications in Tehran's Urban Policy-making based on this Game: "My Neighborhood Vision" Project This project involves creating a visual application (similar to <i>Unlimited Cities</i>) where citizens can take photos of public spaces in their neighborhood and then use <i>pre-designed elements</i> (trees, urban furniture, facade color schemes) to create their desired future image of that space. These images can be shared on the platform, and through <i>public voting</i>, the best visions can be identified to serve as the basis for public space beautification and redesign projects.		
Influence on Policy-making	<i>Democratization of the planning process</i> with the participation of various social groups in urban visioning. <i>Incorporating citizens' tastes and preferences</i> into detailed design and the redesign of public spaces.	

Global Experience Title	Mechanism Type	Key Technology or Tool
Game4City	3D Visualization, Missions/Challenges, Points and Leaderboards, Rewards/Incentives	3D Simulation, Virtual Reality
Proposed Applications in Tehran's Urban Policy-making based on this Game: "Future Urban Planners" Project This project involves the development of 3D games and simulation environments (similar to Game4City) in collaboration with the Ministry of Education, neighborhood houses, and cultural centers to teach urban design and spatial planning concepts to students and non-specialists. These games could include challenges such as designing a sustainable park, managing traffic at an intersection, or placing service centers in a neighborhood.		
Influence on Policy-making	Enhanced spatial and planning literacy among youth, which leads to their conscious and responsible participation in future policy-making. Creation of a usable idea bank for urban designers and institutions.	
Global Experience Title	Mechanism Type	Key Technology or Tool
GreenApes	Points and Leaderboards, Rewards/Incentives, Missions/Challenges, Social Interaction	Mobile Application, Reward System
Proposed Applications in Tehran's Urban Policy-making based on this Game: "Green Tehran Companion" Project This project proposes the development of an application similar to GreenApes that encourages citizens to adopt sustainable environmental behaviors such as cycling, walking, waste sorting, and reducing energy and water consumption. Through scoring, digital badges, and tangible rewards (e.g., discounts from green businesses, free tickets to municipal environmental events), the application can promote behavioral change and help achieve the goals of Green Tehran.		
Influence on Policy-making	Increased behavior-based environmental participation and assisting in the achievement of "Green Tehran" goals and urban sustainability policies. Provision of citizens' behavioral data for data-driven policies in the environmental domain.	
Global Experience Title	Mechanism Type	Key Technology or Tool
Smart Recycling App	Points and Leaderboards, Rewards/Incentives, Missions/Challenges	QR Code, Smart Bin
Proposed Applications in Tehran's Urban Policy-making based on this Game: "Tehran Zero-Waste (Smart Recycling)" Project This project proposes the implementation of a system similar to Smart Recycling App in pilot areas of Tehran, in collaboration with the Waste Management Organization. Citizens can earn points by recording their waste sorting (e.g., by scanning the QR code on sorted waste bags or smart bins). These points can be converted into discounts on water bills, metro/bus ticket card top-ups, or shopping coupons from Shahrvand stores. This application directly helps increase the rate of waste sorting at the source.		
Influence on Policy-making	Increased waste sorting rate at the source and improved urban waste management policies. Fostering a cultural and behavioral transformation among citizens in the environmental domain through behavioral-committed participation.	

Global Experience Title	Mechanism Type	Key Technology or Tool
Budget Games	Missions/Challenges, Social Interaction, Points and Leaderboards	Role-playing, Group Facilitation
Proposed Applications in Tehran's Urban Policy-making based on this Game: "Neighborhood Budget Game" Project This project proposes holding gamified workshops (similar to <i>Budget Games</i>) in each municipal district, with the participation of citizens, neighborhood managers, and experts. In these workshops, citizen teams with a specific <i>virtual budget</i> would decide on and negotiate the <i>prioritization of local projects</i> (e.g., improving lighting, creating playgrounds, and repairing sidewalks). The results of these games can be used as important <i>grassroots inputs</i> in the annual budgeting process of Tehran's municipal districts and neighborhoods.		
Influence on Policy-making	<i>A significant increase in public participation</i> in the urban budgeting process and enhanced budgetary transparency. <i>The inclusion of grassroots priorities</i> in the allocation of real resources and strengthening public trust in urban management institutions.	
Global Experience Title	Mechanism Type	Key Technology or Tool
FixMyStreet	Points and Leaderboards, Rewards/Incentives, Missions/Challenges	Mobile Application, Interactive Map
Proposed Applications in Tehran's Urban Policy-making based on this Game: "Smart Tehran 137" Project This project involves upgrading the Tehran Municipality's <i>137 system</i> by adding <i>gamification elements</i> similar to FixMyStreet. Citizens can earn points by reporting urban issues (potholes, broken streetlights, accumulated waste) in the "My Tehran" or "137" application. These points, along with <i>badges</i> (e.g., "The City's Eye," "Cleanliness Champion"), <i>neighborhood leaderboards</i>, and <i>instant feedback</i> on the status of their reports, would increase participation and support <i>qualitative monitoring of urban infrastructure</i>.		
Influence on Policy-making	<i>Increased citizen reporting</i>, improved responsiveness of municipal institutions, and enhanced transparency of their performance. <i>Assisting in the qualitative monitoring of urban infrastructures</i> and identifying priorities for repair and maintenance.	
Global Experience Title	Mechanism Type	Key Technology or Tool
EcoCrowd	Rewards/Incentives, Points and Leaderboards, Missions/Challenges, Social Interaction	Digital Platform, Participation Profile
Proposed Applications in Tehran's Urban Policy-making based on this Game: "Tehran Green Partnership Platform" Project This project involves creating a <i>crowdfunding platform</i> with a <i>gamification approach</i> for small-scale <i>environmental and neighborhood-based projects</i> in Tehran. Citizens can earn points and badges by financially supporting projects such as creating urban gardens, installing solar water heaters in public spaces, or waste sorting education campaigns. This platform can collaborate with <i>non-governmental organizations</i> and <i>neighborhood councils</i> to help attract small-scale grassroots investments for sustainable urban projects.		
Influence on Policy-making	<i>Fostering social capacity</i> for implementing small-scale projects with long-term environmental impact. <i>Creation of a digital ecosystem</i> to democratize environmental policy-making and to use participatory data in policy-making reports.	

Global Experience Title	Mechanism Type	Key Technology or Tool
Urban Treasure Hunt	Missions/Challenges, Points and Leaderboards, Rewards/Incentives, Social Interaction	Map-based Application, GPS, Content Creation
Proposed Applications in Tehran's Urban Policy-making based on this Game: "Tehran's Hidden Treasures" Project This project involves designing a <i>map-based application</i> (similar to <i>Urban Treasure Hunt</i>) to help discover and introduce public spaces, lesser-known historical sites, and cultural attractions in Tehran's neighborhoods. By visiting these locations and completing related missions (e.g., taking photos, answering historical questions, talking to residents, and creating text/image content), citizens can earn points and badges. This platform can help increase the sense of belonging to the neighborhood, promote local tourism, and collect <i>qualitative data</i> on urban spaces.		
Influence on Policy-making	<i>Increased sense of belonging to the neighborhood</i> and enhanced social, historical, and identity-based understanding of urban spaces. <i>The creation of grassroots content</i> about places that can serve as input for urban redesign and beautification projects.	

for environmental policy-making, directly addressing the need for empirical policy input.

2. Participatory Budgeting and Resource Allocation:

The localization of participatory budgeting, inspired by Budget Games and the narrative-driven mechanics of Participatory Chinatown, is essential for strengthening citizens' sense of autonomy in financial decision-making. A Tehran Budget Challenge could use an iterative process that awards points for trade-off decisions, simplifying complex municipal finances while satisfying the need for competence and meaningful choice (Nicholson, 2015).

3. Collaborative Urban Design and Spatial Planning:

For complex spatial planning, the CityScopeAR model is highly localized into "Tehran my design" workshops. These interactive workshops utilize smart tables where citizens model scenarios using physical blocks augmented with real-time data feedback (Landa Oregi et al., 2025), which directly satisfies the need for competence in design, a core challenge in traditional, non-visual public consultation.

4. Fostering Social Empathy and Community Cohesion:

To address social fragmentation, a role-playing gamification model similar to Participatory Chinatown is proposed. The "Tehran

Storyteller" Project would use narrative-driven missions to place users in the roles of marginalized residents, fostering empathy and collecting valuable qualitative data on housing, transport, and service access. This strategy addresses the psychological need for relatedness and contributes to a more socially just policy outcome.

5. Educational and Public Awareness Campaigns: Leveraging the educational success of Game4City and Unlimited Cities, a mobile-web platform focused on urban issues is proposed for Tehran's youth. The use of educational levels, team competition, and visual scenario-building will enhance spatial literacy and civic responsibility, moving participation from a formal requirement to an intrinsically motivated, enjoyable educational experience.

Applying gamification to Tehran's urban management

Based on the analysis of global experiences, this section proposes a comprehensive framework for implementing gamification in Tehran. This framework, designed as a continuous cycle, ensures that the proposed solutions are grounded in theory, guided by practical strategies, and manifest as tangible projects. The framework is structured as a continuous and complementary cycle, moving from theoretical methods to practical strategies and culminating in concrete operational examples.

The implementation cycle

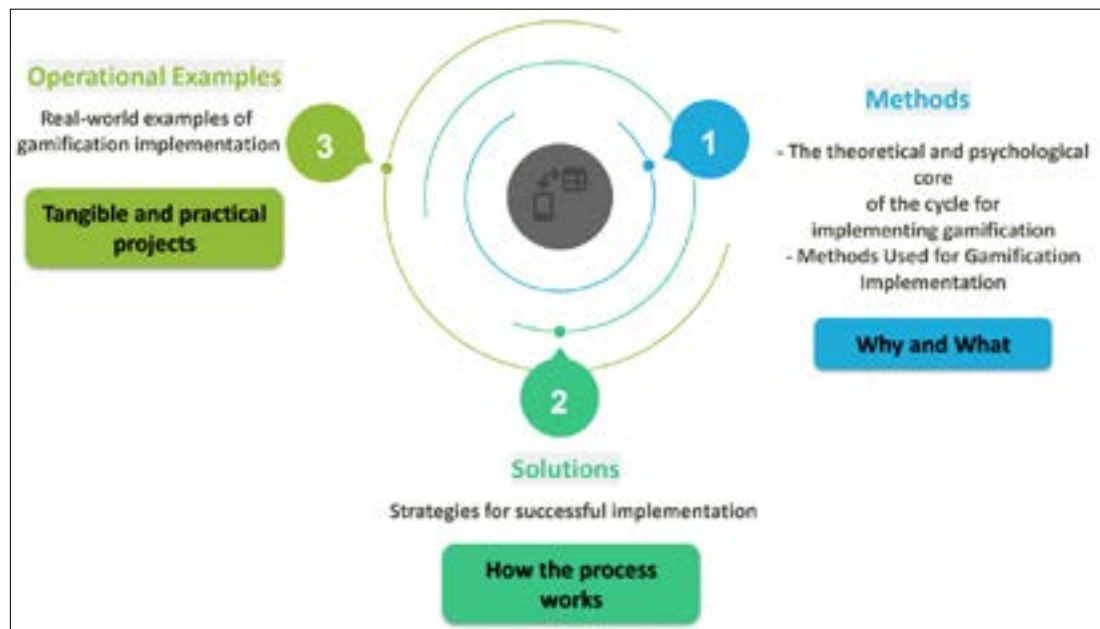


Fig. 6: The gamification implementation cycle; from methodologies to operational examples

1. *Methods* ("Why" and "What"): This is the theoretical and psychological core of the cycle. It defines the core objectives of gamification, which include:

- Increasing motivation and interest through points and rewards.
- Facilitating and making participation more engaging with challenges and storytelling.
- Enhancing learning and awareness through educational content and simulations.
- Strengthening a sense of belonging and social cooperation through teamwork and virtual communities.

2. *Strategies* ("How"): This layer provides the practical roadmap and infrastructure for implementation. Key strategies include:

- Creating an integrated, gamified platform for citizen participation.
- Defining clear goals and target audiences to make activities more focused.
- Designing balanced and appropriate game mechanics.
- Ensuring transparency and a continuous feedback loop to build public trust.
- Implementing pilot projects and a continuous improvement process.
- Providing training and public education to

prepare both citizens and officials.

- Securing cross-sector collaboration and organizational support to ensure sustainability.

3. *Operational examples* ("Manifestation"): This final layer provides tangible, real-world projects that apply the methods and strategies to Tehran's context. These examples are categorized into specific thematic areas to address different urban challenges (Fig. 6).

Proposed operational examples for Tehran

The following is a curated list of proposed gamification projects for Tehran, inspired by global best practices and adapted to the city's unique needs and opportunities. These proposals were designed to be directly applicable to Tehran's urban ecosystem, enhancing citizen participation across various domains:

1. Neighborhood Competition and Development

- "Our neighborhood, our idea" challenge:* A gamified competition between neighborhoods to propose the best ideas for local development, such as green space projects or waste management initiatives. Winning neighborhoods receive recognition and resources to implement their projects, with points awarded for participation, idea

quality, and project success.

- *“Neighborhood league”*: A continuous gamified system that ranks Tehran’s neighborhoods based on key performance indicators like cleanliness, participation in surveys, and local project completion. A public leaderboard would foster a sense of competitive spirit and civic pride.
- *“Model neighbor” initiative*: A point-based system to encourage positive social interactions and volunteerism in local communities. Points could be earned for activities like helping seniors or participating in local events, with a “Golden Neighbor” title awarded to the most active individuals each season.

2. Reporting and Creative Problem-Solving

- *“Smart Tehran 137” project*: An upgrade to the existing Tehran 137 municipal reporting system, similar to the UK’s FixMyStreet. Citizens would earn points and badges for reporting urban issues like potholes or broken streetlights. Additional points would be awarded upon resolution, and a real-time feedback loop would inform citizens of their report’s status, building trust and engagement.
- *“My Tehran, my painting” campaign*: A creative approach to problem-solving where citizens report urban blemishes (e.g., damaged walls) via an app and propose ideas for them to be turned into public art. The best ideas would be painted by local artists, and the original reporter would be recognized as a “Urban Art Patron”.

3. Participatory Budgeting

- *“Budget games” for neighborhoods*: A workshop-based gamified approach, similar to the US’s Budget Games, where citizen teams in each municipal district receive a virtual budget to allocate to local projects. The outcomes of these role-playing simulations would provide valuable, citizen-sourced input for the city’s annual budgeting process.

4. Policy and Urban Design Simulation

- *“Be Tehran’s mayor”*: A serious game or interactive workshop where users take on the role of mayor to experience the complexities of urban decision-making. This would increase civic literacy and provide policymakers with insights into citizen preferences.

- *“Future architects” project*: A simulation game, inspired by Game4City, to educate students and non-experts on urban planning concepts. Participants would be challenged to design a sustainable park, manage traffic, or site community centers within a virtual neighborhood.
- *“My neighborhood, my game” project*: A 3D role-playing game focused on historical or worn-out neighborhoods. Players would experience daily challenges faced by fictional residents, such as finding housing or accessing services, providing policymakers with a deeper, empathetic understanding of marginalized communities’ needs.

5. Co-creation and Participatory Design

- *“Tehran my design” workshops*: Interactive workshops using smart tables, similar to CityScopeAR, where citizens can use physical blocks to model different neighborhood development scenarios. Augmented reality would provide real-time feedback on the impact of their designs, making complex planning concepts accessible to everyone.
- *“My neighborhood’s vision” initiative*: An app, inspired by Unlimited Cities, that allows citizens to upload photos of public spaces and use design elements (e.g., trees, benches, colors) to create their desired future vision for that space. Public voting would select the best visions, which could inform real urban redesign projects.
- *“Tehran co-design studio”*: An online platform, similar to Digital Co-Design, where citizens can participate in various stages of urban design. The platform would include tools for uploading photos, sketching ideas, and providing feedback, with gamification elements like points to encourage creative participation.

CONCLUSION

This review article systematically explored the potential of a gamification approach to enhance citizen engagement within the urban policy-making and management processes of Tehran, the capital of Iran. By anchoring the analysis in the Motivational Affordances theory, the study moved beyond mere technological application to investigate how game design elements—such as real-time feedback,

social competition, and meaningful challenges—fulfill citizens' fundamental psychological needs for competence, autonomy, and relatedness. The comparative analysis of thirteen successful global case studies, including CityScopeAR, ParmoSense, and Game.UP, yielded a transferable framework, confirming that the success of urban gamification lies in its ability to transform opaque, formal policy procedures into intrinsically motivating, data-rich civic activities. These findings reveal a clear shift: effective gamification acts as a strategic intervention that increases the quality of participation by fostering spatial literacy, encouraging collaborative problem-solving, and providing municipal management with verified, high-resolution crowdsourced data. Crucially, the research synthesized these global insights into a localized, operational strategy tailored to Tehran's unique socio-cultural and administrative context. The proposed framework, which advocates for context-specific projects like the "Tehran-Sanj" Project for environmental monitoring and the "Tehran Storyteller" for social empathy, addresses Tehran's current challenges of institutional fragmentation and data scarcity. By prioritizing the mechanisms that facilitate citizen self-determination and tangible impact, these proposals are designed to increase public trust and transition participation from a formal requirement to a sustained, enjoyable civic commitment. In sum, this article provides a robust, evidence-based roadmap for Tehran's urban management to implement smart governance principles. The adoption of this gamification approach is not simply a modernization of tools, but a fundamental redesign of the civic-state relationship, promising a more inclusive, responsive, and ultimately, a more socially sustainable urban future for the metropolis. Future research should focus on the empirical testing and comparative evaluation of these localized project proposals.

AUTHOR CONTRIBUTIONS

M. Ghorbanian was responsible for the conception and design of the study, systematic literature review, analysis and synthesis of the reviewed studies, development of the proposed framework for gamification in urban management, and writing, revising, and finalizing the manuscript.

ACKNOWLEDGMENTS

This paper is derived from the City Knowledge Book (Danesh-E-Shahr in Persian), titled "The Application of a Gamification Approach in Promoting Citizen Engagement in Tehran's Urban Policy-Making Process". The author would like to express her sincere gratitude to the Center for Urban Studies and Planning, and the Deputy of Urban Policy and Governance, at the Municipality of Tehran, for their support.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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ABBREVIATIONS (NOMENCLATURE)

RPGs Role-Playing Games

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HOW TO CITE THIS ARTICLE

Ghorbanian, M., (2026). *The application of a gamification approach in promoting citizen engagement in Tehran's urban policy-making process*. *Int. J. Hum. Capital. Urban Manage.*, 11(4): 621 – 644.

DOI: 10.22034/IJHCUM.2026.03.12

URL: https://www.ijhcum.net/article_735870.html



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