

# Innovative Blockchain Frameworks Driving ESG Impact in Real Estate

Mohd Azlan Ab. Jalil<sup>1</sup>, Noorsidi Aizuddin Mat Noor<sup>1,2,3\*</sup>, Nurul Saadah Lokman<sup>1</sup>, Farhana Diana Deris<sup>2</sup>

<sup>1</sup>Real Estate Department, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, Johor, Malaysia

<sup>2</sup>Centre for Real Estate Studies (UTM CRES), Institute for Smart Infrastructure and Innovative Construction (ISIIC), Universiti Teknologi Malaysia, Johor, Malaysia

<sup>3</sup>Mass Appraisal, Housing and Planning Research Group, Real Estate Department, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, Johor, Malaysia

<sup>4</sup>Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, Malaysia

DOI: <https://dx.doi.org/10.47772/IJRISS.2025.9010315>

Received: 18 January 2025; Accepted: 22 January 2025; Published: 21 February 2025

## ABSTRACT

This study presents a novel framework to enable a blockchain technology integration in the real estate sector from an Environmental, Social, and Governance (ESG) context, challenging the challenges of transparency, equity, and sustainability. As the sector is recognised as a critical stakeholder in sustainability, the research analyses whether blockchain could aid in streamlining operations, enhancing accountability in governance, and promoting equity in housing allocation. The data were collected with a mixed-method approach of qualitative interviews and quantitative surveys with 50 contributors who are real estate practitioners, blockchain experts, and ESG analysts. Key findings show that blockchain can be used to monitor carbon footprint, support fractional ownership, and create a trustless housing allocation system. Other governance improvements, through immutable records and real-time compliance tracking, were identified as key advances. Out of the real-life scenarios in a Malaysian context, there is land registry blockchain, green building certifications, and mostly all the technology is transformative. By providing actionable recommendations for regulators, industry leaders, and researchers, this research stresses the importance of regulatory, educational, and scalable solutions to bridge implementation gaps. This study lays a foundation for future work and practical applications of blockchain in sustainable real estate development by aligning blockchain's capabilities with ESG principles.

**Keywords:** Built Environment, Blockchain, Real Estate, ESG Framework, Sustainability

## INTRODUCTION

Global economic activity is greatly influenced by a sector that is particularly important—real estate—which accounts for a large share of gross domestic product (GDP) and impacts societal and environmental outcomes (United Nations, 2022). ESG dimensions (environmental sustainability, social equity, and governance accountability) are collectively affected by its operations. At the same time, urbanisation continues to accelerate and climate change becomes more extreme; the real estate industry has growing reasons to embed ESG principles into their practices (World Bank, 2023). Disruptive innovation: Blockchain technology, featuring its decentralised, secure, and tamper-proof architecture, is shaping ESG integration in real estate as a novel innovation. Blockchain provides a path of transparency and operational efficiency that unlocks breakthrough opportunities ranging from sustainable property governance to equitable rental allotment to ethical investment strategies (Swan, 2018; Nakamoto, 2008).

Yet, blockchain's introduction into real estate is relatively indolent, and even much slower in the realm of ESG applications where its promise is yet to be fully realised. Nowadays, blockchain technology has great promises, but the existing academic discussions tend to highlight its technical functionalities with limited considerations

of the complex challenges and possibilities of using it in supporting the real estate domain through ESG considerations (Wang et al., 2022).

One way that blockchain could revolutionise building operations, for instance, would be through the tracking of what constitutes a 'carbon footprint' to improve transparency in their tracking and provide immutable records of financial transactions to support ethical investment. Nevertheless, these applications are seldom elaborated upon in detail, and not particularly in a particular regional background such as Malaysia. Considering the country's determination in line with the United Nations Sustainable Development Goals (SDGs), Malaysia is a worthy case study of how the blockchain and ESG in real estate are intertwined in the context (Ministry of Environment and Water, Malaysia, 2023).

Traditionally, the governance models used by the real estate sector are becoming less and less able to deal with the challenges of the day, among them climate change, resource depletion, and social inequities. Real estate transactions are fraught with these limitations; inefficiencies, fraud, and uncarefulness characterise the work processes; there is a lack of inclusion in transactions highlighting a disconnect between the underlying principles of ESG objectives (Yadav & Singh, 2021). Environmental degradation resulting from unsuitable building practices still largely contributes towards Malaysia's carbon emissions, where building construction and use are responsible for more than 30 pct of the nation's greenhouse gas emissions (Department of Statistics Malaysia, 2023). Like housing allocation, social disparities in the property market are exacerbated by unequal distribution. Yet governance challenges, including impenetrable land title systems and corruption, compound the obstacles to achieving ESG goals, which require creative solutions to shore up transparency and accountability programs.

Blockchain technology presents a promising route to solve these problems. Building blockchain, the systems can work to improve the efficiency and reduce the amount of fraud and increase the transparency in real estate transactions (Swan, 2018). By early adopters of the blockchain in Malaysia, governance in the adaptation of land title registration and access to financing by low-income households has been proven potential (Zulkifli et al., 2021). Yet, those efforts have remained siloed and do not rely on a coherent framework that bridges blockchain's skills with ESG goals. Without such a framework, these solutions find themselves relegated to the small and incremental, limiting their scalability and significance to increased sustainability and social equity. Additionally, while the potential of blockchain to disrupt real estate operations has been recognised globally, empirical evidence of blockchain's full impact on ESG outcomes, particularly in emerging markets like Malaysia, is rare.

### **Intersection of Blockchain and Esg in Malaysia Real Estate**

The intersection of blockchain and ESG is fertile in the real estate sector in Malaysia. Amongst other initiatives is the adoption of blockchain in land title management by the Federal Land Development Authority (FELDA). Featuring the blockchain's transparency, this pilot project gets rid of fraudulent transactions and speeds up the land registration processes, decreasing administrative inefficiencies (Abdul Rahman et al., 2022). One such example is the combination of local property developers and technology firms to develop green building certifications tracked on the blockchain. Besides raising the marketability of sustainable properties, these certifications grant verifiable information on energy consumption and carbon emissions, consistent with Malaysia's Low Carbon Cities Framework (Ministry of Housing and Local Government, 2023). Further, blockchain-based crowdfunding platforms have become novel mechanisms of investment in affordable housing projects by permitting greater participation from individual investors and enhancing access to financial resources for developers (Hashim et al., 2023).

But these real-world applications show the possibility of how blockchain can solve ESG problems in the real estate space of Malaysia. But they also point out big gaps in implementation. Blockchain, on the one hand, is effective in making data more transparent, but its effectiveness is predicated on a strong regulatory framework and stakeholder collaboration. In addition, the high cost of blockchain adoption presents barriers for small and medium-sized enterprises (SMEs), which represent a significant portion of Malaysia's property market. Taking into account these challenges requires developing an extensive framework that links blockchain technology with ESG objectives based on Malaysia's time and limitations.

Several reasons make this research necessary. The first is to bridge a fundamental missing point by establishing

a well-rounded blockchain-stimulated framework for ESG-rooted real estate initiatives. To date, current studies mainly address technical aspects of blockchain or isolated applications, therefore leaving the rubric of ESG outcome achievement largely undiscovered (Wang et al., 2022). The proposed framework bridges this gap, offering useful insights for researchers and practitioners working to advance sustainable and just real estate practice.

Second, it is relevant and timely, as Malaysia rolls out its sustainability and digital transformation agenda. ESG goals (Ministry of Science, Technology and Innovation, 2023) are amongst the nation's strategic initiatives, such as the National Fourth Industrial Revolution Policy and the Malaysia Climate Action Council, underpinning the importance of such technology for achieving objectives. This research is in line with these priorities by examining how blockchain might raise transaction efficiency, transparency, and inclusivity in the real estate sector.

The research also has practical consequences for policymakers and industry stakeholders. The study identifies best practices and potential problems in blockchain adoption and offers actionable recommendations for how to support blockchain in real estate. In particular, these insights are relevant because emerging markets such as in Malaysia have limited resources, and regulatory complexity calls for context-specific solutions. By doing so, this research adds to global efforts in the real estate sector to line up the sector with sustainability objectives, a vital contribution to real estate ESG integration in operations.

### **Blockchain Technology in Real Estate**

Being decentralised, transparent, and immutable, blockchain technology has become a real estate game changer. Eliminating intermediaries, improving efficiency, and preventing fraud elevates property management's efficiency and is especially fitting for how traditional systems struggle with these prerequisites. Iansiti and Lakhani (2017) point out that blockchain's distributed ledger technology provides a secure, verifiable system for processing real estate transactions dramatically faster and with fewer errors occurring. Furthermore, Lemieux (2016) and Masis et al., (2017) views blockchain as evidence of an immovable record, data integrity, or as a vehicle for trust among the stakeholders. Here property transactions buy into a blockchain are tamper-proof, protecting against the risks of being forged documents and fraudulent claims.

In real estate, blockchain applications become globally viable tools to transform the sector. Implementation of blockchain in land registry systems in Sweden has reduced transaction time from months to days and removed fraud risks (Wouda & Opdenakker, 2019). Likewise, in Singapore, the Digital Economy Framework for Action utilises blockchain to improve property market transparency and facilitate fewer inefficiencies while maintaining stakeholders' confidence (Singapore Infocomm Media Development Authority, 2023). Even these advancements are poorly adopted in the Malaysian real estate sector. Pilot projects, such as Penang's blockchain-based land registry initiative, seem promising, but there is no unified framework that includes ESG principles (Penang Institute, 2021).

### **Blockchain and ESG Dimensions: A Comprehensive Analysis**

It explores how blockchain technology strengthens Environmental, Social, and Governance (ESG) practices by increasing transparency, accountability, and innovation to foster sustainable growth and smart decisions in all industries.

### **Environmental Contributions of Blockchain Technology**

Real estate offers enormous environmental sustainability potential using blockchain technology. Blockchain can be a tool by which energy-efficient property management systems monitor and optimise real-time energy consumption. According to Tapscott and Tapscott (2016), energy-efficient practices like dynamic lighting and temperature control in green buildings can be automated by blockchain-enabled smart contracts. Secondly, tokenisation on the blockchain of green assets ensures transparency in the environmental compliance, allowing the stakeholders to check the adherence to the sustainability standards. Consequently, blockchain technology is used to monitor renewable energy usage and carbon emissions with platforms such as Power Ledger,

---

encouraging accountability in energy consumption (Power Ledger, 2023; Ho et al., 2024).

Continuing that line of thought, another obvious application of blockchain in real estate is carbon tracking. The carbon footprints of a property, from construction to operation, can be recorded and tracked by smart contracts for stakeholders to identify associated improvement opportunities. For instance, early use of blockchain in Europe has shown that it can be applied to trace emissions through the supply chain (European Blockchain Partnership, 2022). Nevertheless, applications of these methodologies in urbanising nations such as Malaysia, where environmental degradation, especially at the urban interface, is significant, remain underexplored. Green building certification programs in Malaysia, such as the Green Building Index (GBI), could be bolstered with the integration of blockchain.

### **Blockchain Applications and Social Equity**

ESG and social equity walk hand in hand, and blockchain technology has the potential to tackle disparity in the allocation of property and resources. Zhang et al. (2020) point out the potential of blockchain to democratise property ownership through fractional models permitting people to invest in real estate with smaller initial capital outlays. This innovation could also solve Malaysia's housing affordability crisis, in which about 20% of urban households live in substandard housing (World Bank, 2022). Blockchain-based platforms reduce entry barriers and can pave the way towards broader access to property ownership and social inclusivity.

Blockchain can also add transparency and fairness into resource distribution, for example, into housing allocation processes. They use, for instance, blockchain-enabled systems to block favouritism and corruption in public housing projects so that the resources should go to deserving beneficiaries. Gupta et al. (2023) have used pilot programs in India to show how blockchain can streamline affordable housing distribution by reducing administrative delays and bringing equal access for all stakeholders in the process. Integrating blockchain into the People's Housing Programme (PPR), a housing development programme in Malaysia, may help to address social inequality with the help of public trust.

### **Blockchain Technology, Governance Accountability**

ESG at its core revolves around governance, and blockchain has no equal in the opportunities to bring increased transparency and accountability to the real estate business. Lemieux (2016) highlights the unique feature of blockchain, that is, the ability to generate immutable records that create trust between the involved stakeholders. This is especially important in real estate transactions, where opaque decision-making processes tend to erode stakeholder confidence. Transparent ledgers established through blockchain-based platforms can lower the risk of corruption and keep the affairs fair.

The Dominica's: e-Residency Programme has incorporated blockchain technology in order to efficiently and transparently streamline administrative processes as well as increase efficiency in governance (Estonia, 2022). Despite Malaysia's efforts to develop blockchain in the land administration area, like the Penang pilot program, the efforts are not aligned with an overarching ESG focus (Penang Institute, 2021). Improving stakeholder confidence and operational efficiency in Malaysia's real estate sector can potentially be developed by creating a blockchain framework that incorporates governance accountability with ESG principles.

### **Blockchain Adoption and Institutional Theory**

The adoption of blockchain for ESG integration in real estate can be explained by institutional theory, a robust framework. Based on this theory, it is proposed that pressure from regulatory, normative, and cultural cognitive forces drives the adoption of innovative practices (DiMaggio & Powell, 1983). On a real estate aspect of this, regulatory pressures like ESG compliance standards and governance standards compel stakeholders to basically adopt blockchain to achieve the ESG objectives. Additional pressures, such as normative pressures, are pushing toward blockchain adoption: industry best practices and stakeholder expectations. Societal values and sustainability priorities combine to create cultural pressures that are also crucial.

In particular, the Malaysian real estate sector matches the importance of institutional theory since regulatory

frameworks such as the National Affordable Housing Policy and Green Building Index drive sustainability efforts (Ministry of Housing and Local Government Malaysia, 2023). Nevertheless, the lack of unity of these initiatives requires a single alignment framework that combines blockchain and ESG principles. Based on the institutional theory, this research helps to develop the understanding of the drivers and barriers to blockchain adoption and a structured approach to ESG integration.

### **A unified blockchain ESG framework is needed.**

Although blockchain is showcased to be applied in all the dimensions of ESG, the framework is lacking a unified metaverse that links these various dimensions together. In their study, Wang et al. (2022) point to the fact that most of the studies leave the holistic implications of blockchain on ESG factors aside. The gap highlighted in this study highlights that there is a need for research that brings blockchain technology and ESG principles for real estate together. This study proposes to fill the void by proposing a comprehensive framework with practical, sustainable, and inclusive real estate development strategies.

Besides that, the fragmented nature of blockchain initiatives in Malaysia stressed a need for a unified framework. Pilot projects show the technology's promise, but isolated implementation means the technology is not scalable or impactful (Penang Institute, 2021). Through the development of a blockchain-ESG framework that aligns with global sustainability goals and local regulatory constraints in the Malaysian real estate sector, this research proposes avenues to fill this gap.

Blockchain technology also provides great promise to resolve ESG challenges in real estate by improving transparency, efficiency, and accountability. Existing literature offers considerable insight into blockchain applications, and its encyclopedism has afforded an often narrow, if nonetheless valuable, focus on their intersection with ESG dimensions. Based on institutional theory, this research develops a unified framework that provides a 'first to solve' construct to alleviate the limitations of fragmented initiatives and provides actionable strategies for stakeholders. This study thus supports advancing sustainable real estate practices in Malaysia and elsewhere through alignment of blockchain capabilities to ESG goals.

## **METHODOLOGY**

This study to fully explore the intersection of blockchain technology in the real estate sector with ESG principles. This approach was motivated by the complexity of the research subject that demanded both numerical data on trends as well as in-depth qualitative insights on the underlying motivations and contextual factors. Hence, perspectives from multiple stakeholder groups were needed that included real estate professionals, blockchain experts, and ESG analysts in order to develop a robust framework for blockchain-enabled ESG integration.

The mixed-methods approach was implemented in two sequential phases: First was an initial qualitative phase that consisted of semi-structured interviews followed by the quantitative phase using structured questionnaires. Triangulation was performed in this design so that data gathered through interviews could be used to inform the questionnaire design, thereby increasing the relevance and depth of findings. This structured integration of qualitative and quantitative data also allowed common themes to be identified and the statistical validation for the qualitative perspectives.

Participants with ESG compliance-related domain expertise as well as real estate and blockchain technology domain expertise were purposively sampled for participation in desk research activities. A total of 50 respondents participated in the study, categorised into three groups: And 20 real estate professionals, 15 blockchain experts, and 15 ESG analysts. By providing a balanced representation of perspectives, this distribution allowed for the ability to study blockchain's many facets of impact on ESG in the real estate space.

Criteria for participant selection included professional experience in at least three consecutive years in the appropriate field; being involved in projects/research related to blockchain or ESG; and familiarity with the real estate industry. Emails and professional networks were used for sending invitations with a response rate of 70%. Table 1 summarises the sample demographics, showing the diversity of respondent backgrounds, gender, and years of experience..

Table 1 Participant Demographics

Category	Number of Participants	Gender (M/F)	Avg. Years of Experience
Real Estate Professionals	20	12/8	8
Blockchain Experts	15	10/5	6
ESG Analysts	15	9/6	7
<b>Total</b>	<b>50</b>	<b>31/19</b>	<b>7</b>

### Data Collection Methods

Data collection was over a period of two months; data collection was divided between qualitative and quantitative phases. The qualitative phase consisted of 15 semi-structured interviews from among 5 from different stakeholder interviews. In an effort to understand perceptions that blockchain was applicable to ESG principles, challenges with implementation, and potential benefits for the real estate sector, these interviews were conducted. We used a standardised interview guide over these key topics: governance transparency, environmental sustainability, and social equity. Each interview took place between 30–45 minutes, and the audio was recorded for accuracy. After this, thematic analysis was applied for unique patterns to appear, called insights.

Quantitative phase: Using all 50 respondents, structured questionnaires were administered. The questionnaire comprised three sections: Likert scale items asking how effective someone found blockchain in achieving ESG goals, along with demographic details and other open-ended questions about additional comments. A survey platform was used for the electronically distributed questionnaire, with weekly reminders to nonrespondents. Forty-five completed questionnaires were received with a response rate of 90%. In Table 2, we present summary statistics for the responses to the questionnaire.

Table 2 Summary Statistics of Quantitative Responses

Statement	Mean Score (1-5)	SD	% Agree (4-5)
Blockchain improves transparency in real estate transactions.	4.6	0.7	92%
Blockchain enhances environmental compliance monitoring.	4.3	0.8	85%
Blockchain facilitates equitable housing distribution.	4.0	0.9	78%
Blockchain reduces governance inefficiencies.	4.5	0.6	88%

### Data Analysis Techniques

Thematic analysis was undertaken using a six-step approach of familiarising with the data, coding, theme identification, reviewing themes, defining themes, and writing up results. Qualitative data were organised and managed using the NVivo software for consistency and traceability of themes. Key themes around governance transparency, environmental tracking, and social inclusivity, along with their subthemes like regulatory hurdles and technological literacy.

Descriptive and inferential statistical methods were utilised in quantitative data analysis. Demographic information and Likert scale responses were summarised in descriptive statistics, and t-tests were used to test for differences in perceptions of the stakeholder groups. The results of the t-tests for differences in perceptions of blockchain’s utility are presented in Table 3, indicating statistically significant differences between the three groups.

Table 3 T-Test Results for Stakeholder Perceptions

Comparison	t-Statistic	p-Value	Significance (p < 0.05)
Real Estate vs. Blockchain	2.45	0.02	Significant
Blockchain vs. ESG Analysts	1.98	0.05	Significant
Real Estate vs. ESG Analysts	1.56	0.13	Not Significant

### Ethical Considerations

Ethical considerations were an integral part of this study: ensuring participant confidentiality, informed consent, and data integrity. Before data collection, all participants were informed about the study’s purposes, methodology, and use of data. Participants gave informed consent electronically, with withdrawal at any time without penalty. Anonymised responses maintained data confidentiality and protected digital recordings and transcripts. The study was conducted after ethical approval was obtained from the relevant institutional review board.

Finally, the mixed-methods approach is thus useful for making sense of how blockchain can become incorporated within ESG frameworks of real estate. The use of qualitative and quantitative techniques combined to generate depth and breadth in the findings, which were based on well-sampled, rigorously controlled procedures. This methodology provides an excellent foundation for tackling the research tasks herein and extending the knowledge in the field as a whole.

## FINDINGS AND IMPLICATIONS

### Environmental Impact on Resource Tracking and Sustainability

The study has shown great potential for blockchain technology in strengthening environmental sustainability in real estate by accurately tracking and managing resources. With its ability to monitor in real time energy consumption and a carbon footprint, Blockchain makes it possible for the property owners and the managers to embark on data-driven strategies in order to minimise the environmental impact. An instance of this is integrating smart contracts with blockchain to automatically optimise energy in buildings without waste. However, respondents were quick to point out the use case of blockchain for driving green certifications like the Green Building Index (GBI) by maintaining transparency in the certification of the environmental compliance data.

Moreover, the use of blockchain can be used to incentivise people to engage in sustainable practices with tokenised rewards when the energy efficiency targets are met. About 80 percent of respondents considered this application as a valuable tool for encouraging environmentally responsible behaviour among stakeholders. The perceptions of respondents to blockchain’s environmental benefits are summarised in Table 4.

Table 4 Perceived Environmental Benefits of Blockchain in Real Estate

Benefit	% of Respondents
Energy consumption monitoring	85%
Carbon footprint tracking	82%
Green certification facilitation	78%
Incentives for sustainability practices	80%

The findings suggest the potential in blockchain in environmental sustainability but also present challenges. Therefore, certain blockchain systems, such as Proof of Work (PoW), may undermine efforts for sustainability by consuming high energy. The paper suggests that adopting energy-efficient blockchain protocols such as Proof

of Stake (PoS) can ameliorate this problem. Additionally, the technological interoperability challenges that must be resolved when integrating blockchain with IoT devices are that they maximise environmental benefits.

**Social Equity: Inclusive Housing Solutions and Transparency**

Our results show that blockchain technology is significantly tied to social equity in real estate by driving transparency and inclusivity. It showed that blockchain-based fractional ownership models lower property investment entry barriers, expanding eligibility for property investment participation. About 70 percent of respondents underscored how blockchain shapes the solutions to create inclusive housing, for example, in the form of affordable housing projects. On one hand, blockchain provides the transparent allocation records of housing distribution to facilitate fairness without corruption and favouritism in public housing programs.

What’s more, blockchain allows for decentralised financing, like tokenised real estate, which democratises property ownership. An overview of respondents’ perceptions of the social equity contributions made by blockchain is provided in Table 5.

Table 5 Perceived Social Equity Contributions of Blockchain in Real Estate

Contribution	% of Respondents
Transparent housing allocation	72%
Fractional ownership opportunities	70%
Democratization of property ownership	68%
Reduction of entry barriers	73%

Though blockchain improves social equity, the finding shows the need for accessibility and digital literacy. Blockchain-based solutions may not always reach the marginalised groups who generally lack access to technology or know about it. Educational initiatives, as well as infrastructure development on a targeted scope for equitable access to blockchain-enabled platforms, are required to address this gap.

**Governance Improvements: Transparency and Accountability are a plus.**

Being able to conduct any transaction on a blockchain diminishes a lot of the governance problems that the real estate industry faces today, mostly because of the level of transparency, accountability, and trust the blockchain provides among all the stakeholders. Blockchain’s immutable records minimise opportunities for fraud by offering a secure and verifiable trail of transactions, the study found. A staggering 85% of participants affirmed that blockchain enhances real-time tracking of compliance with ESG standards.

Blockchain makes it possible for stakeholders to engage in the governance process in an open manner. One such example is the use of blockchain-based voting systems in projects such as real estate projects to incorporate and utilise the various inputs of the stakeholders in core project decisions. In Table 6, we present respondents’ perceived governance-related benefits.

Table 6 Perceived Governance Benefits of Blockchain in Real Estate

Benefit	% of Respondents
Immutable records	88%
Fraud prevention	86%
Real-time compliance tracking	85%
Transparent decision-making	80%



Blockchain boosts governance, but so do the findings that emphasise the importance of regulatory alignment. Without the presence of standards for blockchain regulation, the adoption might face hurdles, especially since Malaysia has not yet developed its real estate governance framework. There are guidelines that have to be implemented to make it more seamlessly integrated into addition.

### **Operational Efficiency and Cost Reduction**

This study makes an important contribution to the literature by demonstrating that blockchain potentially increases operational efficiency and reduces transaction costs in the real estate transaction market. This is done without the use of intermediaries and automates processes using smart contracts, which removes activities such as property registration, ownership passing, and lease management. Respondents stated that this would significantly reduce the transaction times and transaction costs, especially in large-scale real estate projects.

Considering that blockchain directly facilitates the formation of a unified platform for the data sharing among the stakeholders, blockchain has a crucial role in boosting operational efficiency. For instance, collaborating on a real estate developer's project and monitoring the project performance using the blockchain avoids duplication of effort within ESG analysts and real estate developers. This is identified from this study as a key enabler for scaled blockchain adoption in real estate.

### **Filling the Knowledge Implementation Gaps**

The lessons learnt from this study are important for blockchain's role in ESG integration in real estate. While the technology is undoubtedly promising, there are a number of knowledge gaps when it comes to blockchain's potential uses, most notably the ability of stakeholders to comprehend blockchain beyond cryptocurrency. The respondents stressed the importance of educational programs and capacity-building programs to bridge gaps and speed up adoption.

The study also indicated that blockchain implementation may be most successful when worked on collaboratively among policymakers, industry stakeholders, and technology providers. Matching blockchain steps with national ESG initiatives, e.g., Malaysia's Green Technology Master Plan, should increase impact. It also highlights that pilot projects on ESG use cases, including carbon tracking or affordable housing, can be useful in enabling the scaling of blockchain solutions

### **Opportunities for Policy and Regulatory Development**

The findings stress the important role of policy and regulatory policy in the mainstream adoption of blockchain in real estate. Many respondents said that clear regulations for blockchain-enabled ESG projects are typically absent, which discourages investment. A cohesive policy framework that covers data privacy, interoperability, and discussion that surrounds standardisation would go far towards adoption.

Moreover, in the case of tax breaks and grants to green real estate projects, it could also be an incentive to get them in these blockchains. Blockchain can also work to help businesses meet goals to achieve business sustainability (ESG) by collaborating with international organisations to move their laws to world standards, e.g., the United Nations' Sustainable Development Goals (SDGs).

### **Transforming Real Estate Through Blockchain-Driven ESG Integration**

But what blockchain technology brings to the real estate market is transformational; it is the first time that such technology can tackle environmental sustainability, social equity, and governance challenges. The increased centrality of real estate within ESG objectives on a global scale, this study offers a robust method for harnessing the power of blockchain in transforming these possible impacts. The framework aligns blockchain functionalities with real estate-orientated ESG requirements and provides actionable solutions for real-world applications. Utilising the title's ambitions to build on existing knowledge, this research not only adheres to the title's goals but also provides critical groundwork for further exploration into blockchain potentially redefining how ESG integration occurs.

Finally, blockchain integration for ESG in real estate, especially environmental sustainability, social equity, and governance accountability, is being transformed by the analytical findings. The technology has a number of benefits, but accessibility, regulatory uncertainty, and digital literacy all need to be overcome in order to fully realise the technology's potential. The study's findings yield actionable outcomes for stakeholders, from policymakers and industry leaders to technology developers, who should collaborate to pursue targeted strategies.

Taking a step further, this research complements the existing literature on blockchain applications in and around real estate and ESG by providing a roadmap for future research. This also points to the vital importance of contextualising blockchain adoption around certain regional and sectoral challenges and that its adoption will be in line with broader sustainability goals.

## CONCLUSION

So, one compelling use case example from the real world—Malaysia in particular—is actually how blockchain can potentially solve the affordable housing crisis. The primary problem with housing affordability is that it has been an ongoing and, at the same time, ineffective struggle in Malaysia, as the effects of corrupt and opaque housing allocation procedures, along with poor decision-making related to public housing policies, have worked against its social equity goals. This study proposes the framework, and it provides a solution towards transparent housing allocation via utilising blockchain. By putting everything in a blockchain-based system, an immutable record of housing applications can be built so that allocations stand a fair and transparent chance. Verification of eligibility criteria can also be automated by smart contracts, making it infeasible otherwise, which tremendously eliminates administrative inefficiencies and favouritism.

It is particularly relevant to Malaysia's attempt to put into practice the Shared Prosperity Vision 2030, which prioritises equitable growth and the inclusion of all. By utilising blockchain, the government and developers can monitor if housing projects are meeting sustainability and equity goals, not only to assist in the distribution of affordable housing projects but also to ensure they are environmentally sustainable. For instance, allowing for blockchain to be used alongside Malaysia's Green Building Index (GBI) might entice developers to design affordable housing that is energy efficient and bridge the gap between social equity and environmental sustainability.

## Features for Future Research and Practical Applications

The framework provided in this paper acts as a foundational resource for future research in blockchain-enabled ESG integration in numerous other industries beyond just real estate. The methodology and findings provide researchers with a roadmap for further research into blockchain applications in other fields, including agriculture, supply chain management, and energy. For instance, the proposed framework can be expanded on and use advanced blockchain protocols such as Proof of Stake (PoS) to increase environmental sustainability or hybrid blockchain for scalability.

This study provides actionable insights that can benefit practitioners in the real estate business. The framework can be used by real estate developers and property managers to incorporate the blockchain in their operations that include resource tracking as well as governance transparency. This research also offers potential insights for policymakers in designing regulatory frameworks both to foster adaptation and guard against misuse of blockchain. For instance, Malaysia's policymakers might implement this framework as an incentive for blockchain-induced green real estate projects, such as tax benefits or grants for energy-efficient buildings.

## Challenges and Scalability Targets

The study calls out the importance of implementation challenges while the framework proves blockchain's transformative potential. Therefore, digital literacy becomes one of the major challenges in Malaysia, particularly for a marginalised population that is most in need of blockchain-enabled equitable housing solutions. Future research should aim towards the development of modalities of targeted education and training programs that fill this gap, allowing the paradigm of blockchain solutions to be available to all.

The other important issue is scalability. While blockchain is rapidly being adopted, it is important for systems to scale its use without impacting the efficiency and sustainability of said systems beyond a certain scale. Based on this study, it can serve as an initial examination into blockchain architectures with scalability that aligns with ESG objectives. Future research on hybrid systems incorporating blockchain with other fast-emerging technologies, such as artificial intelligence (AI) and the Internet of Things (IoT), could help boost scalability and functionality.

### **Blockchain Innovation to Advancing Malaysia's ESG Goals**

Based on the findings and the proposed framework, this study closely relates to Malaysia's national sustainability goals as presented in the Green Technology Master Plan as well as the Twelfth Malaysia Plan. The study offers a practical roadmap to integrating blockchain with ESG objectives by offering a structured approach. For example, blockchain utilities such as carbon tracking could augment Malaysia's efforts in reducing greenhouse gas emissions, while tokenising real estate solutions aims to democratise the ownership of properties to mirror Shared Prosperity Vision 2030.

The research also points out the importance of collaboration from government, the industry, and academia to promote blockchain adoption. While progress on ESG was wide and varied across the real estate sector, pilot projects around a specific ESG application, such as affordable housing or blockchain-based carbon tracking, could be a way to learn lessons for scaling solutions. With Malaysia's vibrant technology ecosystem and proactive government policies, this makes it an ideal testing ground for such initiatives.

### **A setting a precedent of global blockchain and ESG integration**

Finally, this paper makes a contribution to deepening understanding of what blockchain could bring to support climate-positive integration in ESG through startups and developing countries and the path that should be explored in these efforts in other markets and other industries. This work offers a practical solution that addresses the important problems of transparency, accountability, and inclusivity and implements the framework for real-world applications. Rather, the research contextualises blockchain adoption to Malaysia's particular socio-economic and environmental landscape, presenting a model that can be applied to other nations that share the same issues.

Future research might continue in this intersection of blockchain and ESG by looking at current, emerging technologies, as well as innovative applications. The insights and lessons from this study provide a foundation to help researchers and practitioners advance es towards a more equitable and sustainable future, one in which all benefit from sustainable advancements in real estate and beyond.

## **ACKNOWLEDGEMENT**

Our lifetime gratitude exceeds the verbal expressions. First of all, the UTM Mass Appraisal, Housing and Planning Research Group members introduced us some wise pieces of advice when we developed the project and we highly appreciate them for their explaining. Secondly, we thank the anonymous reviewers for their comments, however any imperfections are ours and should not affect to these respected people's reputation.

## **REFERENCES**

1. DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, 48(2), 147-160.
2. European Blockchain Partnership. (2022). Blockchain and emissions tracking in Europe. Retrieved from <https://ec.europa.eu>
3. Gupta, S., Yadav, K., & Kumar, A. (2023). Blockchain in affordable housing: Case studies from India. *International Journal of Housing Policy*, 22(1), 15-29.
4. Ho, V. L. C., Yi, L. J., Noor, N. A. B. M., & Jalil, R. B. A. (2024). Assessing the Listed Property Companies Readiness Towards Environmental Social Governance Implementation in Malaysia. *International Journal of Research and Innovation in Social Science*, 8(7), 2514-2524.

5. Iansiti, M., & Lakhani, K. R. (2017). The truth about blockchain. *Harvard Business Review*, 95(1), 118-127.
6. Lemieux, V. L. (2016). Trusting records: Is Blockchain technology the answer? *Records Management Journal*, 26(2), 110-139.
7. Masis, N. N. S., Maimun, N. H. A., Noor, N. A. M., Yusoff, N. S. M., & Rahman, M. S. A. (2017). E-commerce in the Malaysian real estate agency industry. *International Journal of Real Estate Studies*, 11(5), 33-41.
8. Ministry of Housing and Local Government Malaysia. (2023). National Affordable Housing Policy. Retrieved from <https://www.kpkt.gov.my>
9. Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. Retrieved from <https://bitcoin.org/bitcoin.pdf>
10. Penang Institute. (2021). Blockchain in land registry pilot project. Retrieved from <https://penanginstitute.org>
11. Power Ledger. (2023). Blockchain solutions for energy management. Retrieved from <https://powerledger.io>
12. Singapore Infocomm Media Development Authority. (2023). Digital Economy Framework for Action. Retrieved from <https://imda.gov.sg>
13. Swan, M. (2015). *Blockchain: Blueprint for a new economy*. O'Reilly Media, Inc.
14. Tapscott, D., & Tapscott, A. (2016). *Blockchain revolution: How the technology behind bitcoin is changing money, business, and the world*. Portfolio Penguin.
15. UNEP. (2020). *Emissions gap report 2020*. United Nations Environment Programme.
16. Wang, F., Zhang, L., & Li, J. (2022). Blockchain and ESG integration: A systematic review. *Journal of Sustainable Real Estate*, 14(3), 45-60.
17. Wang, Y., Han, J., & Beynon-Davies, P. (2022). Understanding blockchain technology for future supply chains: A systematic literature review and research agenda. *Supply Chain Management*, 27(1), 55-75.
18. World Bank. (2022). *Malaysia: Affordable housing and urban inequality*. Retrieved from <https://worldbank.org>
19. Wouda, H., & Opendakker, R. (2019). Blockchain technology in commercial real estate transactions. *Journal of Property Investment & Finance*. <https://doi.org/10.1108/JPIF-06-2019-0085>.
20. Yadav, M., & Singh, A. (2021). Real estate sector and blockchain: A systematic review. *Journal of Real Estate Research*, 43(4), 1-22.
21. Zhang, L., Wang, X., & Hu, W. (2020). The impact of blockchain on the real estate industry: A systematic review. *Sustainability*, 12(9), 3568.
22. Zhang, Y., Wang, X., & Liu, Q. (2020). Blockchain-based fractional ownership models in real estate. *Journal of Property Investment & Finance*, 38(4), 267-281.