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Sustainable Construction in Rural Areas: The Advantages of Integrated Building Systems for Affordable Housing

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ABSTRACT

The Industrialised Building System (IBS) offers a transformative approach to sustainable construction in rural areas. However, traditional construction methods have an inefficiency and environmental impact, which are particularly challenging in rural settings. Therefore, this research aims to identify the potential benefits of IBS in rural areas. This study employed a qualitative survey design to gather detailed information on implementing IBS. The research used purposive sampling to select 40 respondents from government organizations, consulting companies, and contractors (class G6 and above) involved in IBS projects in Kelantan. Data were collected using a structured interview protocol and analyzed using thematic analysis with ATLAST—ti software. The results indicate that IBS significantly reduces greenhouse gas emissions, improves material efficiency, shortens construction time, and lowers project costs. The empirical evidence demonstrates that IBS construction methods lead to lower greenhouse gas emissions, higher quality and uniformity in construction components, and reduced on-site waste through controlled manufacturing processes. These advantages are crucial for sustainable construction in rural areas, where challenges such as limited access to skilled labor and materials often exist. Implementing IBS can thus provide more affordable, efficient, and environmentally friendly housing solutions in rural communities. IBS addresses the inefficiencies of traditional construction and promotes sustainable practices, particularly in rural areas where these benefits are critically needed. The research contributes valuable insights to construction practitioners, policymakers, and industry stakeholders, encouraging the adoption of IBS to enhance resource efficiency and environmental sustainability. This study also adds to the body of knowledge on sustainable construction by empirically validating the benefits of IBS, providing a robust framework for future research and practical applications in the construction industry.

1.0 INTRODUCTION

The construction sector plays a vital role in developing a country by rapidly advancing the industry and constructing modern skyscrapers. Daripa, Jagannath. (2022) highlighted the importance of timely construction activities, noting that delays can increase cost and time. Therefore, adopting new construction methods and technologies can significantly improve productivity. One such method currently used is the Industrialised Building System (IBS). According to Zhou et al. (2019), IBS offers numerous benefits in construction, including reducing the number of general workers needed, high-quality control of each component through prefabrication, easy on-site installation, reduced construction waste, and enhanced safety compared to conventional methods. Implementing IBS in rural areas can significantly improve the accessibility and affordability of housing. With prefabrication and modular construction, IBS can reduce the time and cost of traditional building methods, making it an ideal solution for rural development (Zhou et al., 2019).

Despite similarities between conventional methods and IBS during housing construction, IBS demands greater cooperation among project members to manage crucial design constraints related to component transportation, installation logistics, permits, and inspection schedules. This necessitates a fundamental structural change in the industry, affecting the design and construction phases. The prefabrication process inherent in IBS ensures high-quality control, which is particularly beneficial in rural areas where access to skilled labor and quality materials may be limited. This can lead to more durable and sustainable housing solutions (CIDB, 2018). During the design phase, the IBS method requires the integration of architectural, civil, and structural (C&S), mechanical, and electrical (M&E) plans and workshop drawings to ensure effective design coordination. IBS components are manufactured in a factory in the construction phase and then sent to the construction site for assembly. This method fundamentally alters how projects are planned and executed, necessitating different strategies for supply chain management, planning, scheduling, handling, and purchasing materials (Mohamad Kamar and Hamid, 2011). The rapid assembly process of IBS components can greatly reduce construction time, which is crucial for meeting the urgent housing needs in rural areas. This efficiency can help address housing shortages more effectively (Rahman & Omar, 2018).

However, implementing IBS in rural areas presents several challenges that hinder its effectiveness. One primary issue is the logistical challenge of transporting prefabricated components to remote sites, as rural areas often have underdeveloped infrastructure, complicating the transportation and delivery of large building modules (Pan et al., 2008). Additionally, while IBS reduces the need for a large workforce, specialized skills are required to install and assemble prefabricated components. In rural areas, there is often a shortage of skilled labor trained in IBS methods, which can impede the efficiency of IBS projects (Kamar et al., 2012). High initial costs also pose a significant barrier, as the investment required for prefabrication facilities and transportation can be prohibitive in rural areas with limited financial resources (Gibb & Isack, 2003). Moreover, regulatory and permitting issues can hinder IBS implementation, with local building codes and regulations often not adapted to accommodate prefabricated construction methods, leading to delays and additional costs (Tam et al., 2007). Limited access to high-quality materials further exacerbates the problem, affecting the overall quality and durability of IBS construction in rural settings (Jaillon & Poon, 2014).

Resistance to change is another critical issue, as traditional building practices are deeply ingrained in rural areas, and stakeholders may be hesitant to adopt IBS without a clear understanding of its benefits (Blismas & Wakefield, 2009). Efficient supply chain management is crucial for IBS projects, yet rural areas often face challenges such as unreliable suppliers and transportation networks, leading to delays and increased costs (Goodier & Gibb, 2007). While IBS can lead to long-term cost savings, the economic viability of such projects in rural areas is often questioned due to high upfront costs and logistical challenges, particularly in low-income communities (Rahman & Omar, 2006). Technological constraints also pose a significant barrier, as adopting IBS requires advanced technological infrastructure for prefabrication and assembly, often lacking in rural areas (Pan et al., 2012). Addressing these challenges requires a multifaceted approach, including investment in infrastructure, training programs for local labor, regulatory reforms, and awareness campaigns to promote the benefits of IBS. By tackling these issues, the potential of IBS to revolutionize rural construction and provide sustainable, affordable housing can be fully realized.

Supporting this perspective, Akadiri and Olomolaiye (2012) emphasize the importance of resource efficiency and waste reduction in sustainable construction practices. The use of IBS aligns with these principles by ensuring efficient material use and minimizing on-site waste. Moreover, integrating sustainable materials and technologies in IBS projects aligns with the broader goals of sustainable development (Tam et al., 2007). Given the advantages and challenges identified, it is crucial to explore the potential of IBS for affordable housing in rural areas. The primary aim of this paper is to evaluate the implementation of IBS in rural construction projects and identify its potential benefits. Data for this study was gathered through in-depth interview sessions with key stakeholders, including government officials, contractors, and industry experts involved in rural development. The study seeks to enhance our understanding of how IBS can be leveraged to improve construction efficiency, reduce environmental impact, and address the significant housing shortages in rural settings. By analyzing these insights, the research aims to provide practical strategies and a comprehensive framework for the effective implementation of IBS in rural areas, contributing meaningfully to the discourse on sustainable construction practices.

2.0 METHODOLOGY

This study employed a qualitative research design to explore the potential of implementing the IBS in affordable housing construction projects in rural areas. In the Malaysian context, rural areas are defined by their lower population density, underdeveloped infrastructure, and heavy reliance on primary industries such as agriculture, forestry, and fishing. These regions often lack access to essential infrastructure and services, including clean water, electricity, and modern transportation networks. The Malaysian government’s Rural Development Policy is designed to address these disparities by improving infrastructure, enhancing income opportunities, and fostering sustainable development to attract and retain residents, particularly the younger population (Department of Statistics Malaysia, n.d.; FFTC Agricultural Policy Platform, n.d.).

The qualitative approach was selected to facilitate the collection of detailed, descriptive information without exerting control over the respondents, thus allowing for an in-depth understanding of their perspectives. A structured interview protocol was developed and used to gather the necessary data. This instrument was chosen for its effectiveness in capturing respondents' opinions and explanations, which align with the study's objectives. The interview protocol was comprehensive, consisting of five parts: demographics, introductory questions, transition questions, essential questions, and closing questions. This structure ensured that the interviews systematically covered all relevant aspects of the research topic.

The study utilized purposive sampling, a technique recommended by Creswell, J. W., & Poth, C. N. (2016). for its ability to provide purposeful selection from diverse backgrounds, also known as "maximum variation sampling." This method enabled the collection of comprehensive and meaningful data. The sample comprised 40 respondents from government organizations, consulting companies, and contractors (class G6 and above) who were actively involved in IBS construction projects specifically within the rural areas of Kelantan. In Kelantan, specific areas like Gua Musang, Jeli, and parts of Tanah Merah are recognized as rural. These areas are particularly challenged by limited infrastructure, making them ideal for studying the implementation of sustainable construction methods such as the Industrialised Building System (IBS). This research specifically targets respondents who have been actively involved in construction projects within these rural settings. These respondents were selected to provide a comprehensive perspective on the implementation of IBS in these rural settings, ensuring that the study captured the unique challenges and opportunities presented by the region's infrastructure and development needs. This diverse sampling strategy ensured a broad range of insights and experiences related to IBS implementation.

The interview data were analyzed using thematic analysis, a qualitative method that systematically identifies, analyzes, and reports patterns (themes) within the data. This method was chosen for its ability to provide a comprehensive and nuanced understanding of the complex issues surrounding the implementation of the Industrialised Building System (IBS) in rural construction projects. To enhance the rigor and clarity of the analysis, ATLAS.ti software was employed, which is well-regarded for its advanced features that facilitate theory development, including the construction of conceptual diagrams that visually illustrate relationships between key ideas.

The use of ATLAS.ti in construction research has been well-documented, demonstrating its effectiveness in generating significant theoretical contributions and enhancing analytical depth. For instance, Zairul (2021) utilized ATLAS.ti to conduct a thematic review of IBS publications in Malaysia, identifying patterns and trends that are crucial for the future of IBS research. Similarly, Batra (2021) applied ATLAS.ti to identify barriers and challenges in implementing public-private partnerships in housing, highlighting the software’s capacity to manage complex qualitative data. Hajirasouli et al. (2022) employed ATLAS.ti in their study on augmented reality in construction, developing conceptual frameworks that contributed to the understanding of technology adoption in the industry. Additionally, Saf’a et al. (2023) utilized ATLAS.ti to explore the readiness and challenges of implementing Building Information Modelling (BIM) in the construction industry, further showcasing the software's utility in construction research.

3.0 RESULT AND DISCUSSION

Adopting the IBS in rural construction projects offers numerous advantages that align with the principles of sustainable development. Through a comprehensive analysis of qualitative data, this paper elucidates the multifaceted benefits of IBS for affordable housing in rural settings (refer to the conceptual model provided).

3.1. Environmental Sustainability and Efficiency

Implementing the Industrialised Building System (IBS) enhances environmental sustainability by significantly optimizing energy use. A key aspect of this optimization is the integration of renewable energy sources, such as solar panels and geothermal heat, into IBS designs. One respondent noted, "The use of solar energy as a clean renewable resource aligns with IBS practices" (Respondent 24). This integration aligns with the theory of sustainable building practices, which underscores the importance of incorporating renewable energy technologies to reduce operational energy consumption and lower greenhouse gas emissions (Zhou et al., 2019).

The empirical data collected strongly support the theory of sustainable building practices. Respondents consistently highlighted the benefits of integrating renewable energy sources within IBS projects, noting that "The integration of renewable energy sources like solar panels into IBS designs supports sustainable building practices" (Respondent 15). Additionally, respondents emphasized that "Renewable energy integration in IBS buildings can reduce reliance on fossil fuels" (Respondent 26) and that "The incorporation of renewable energy solutions is a key feature of sustainable IBS construction" (Respondent 10). These insights reinforce the theoretical foundation that the practical application of renewable energy technologies in IBS improves energy efficiency and advances broader sustainability objectives. Integrating renewable energy technologies into IBS projects can markedly reduce their environmental footprint, corroborating the theoretical claim that sustainable building practices are crucial for long-term environmental health.

Furthermore, the empirical evidence provides detailed insights into the practical application of these theoretical principles. For example, using solar energy and geothermal heat within IBS designs exemplifies how renewable energy integration can enhance energy efficiency and sustainability. These practices reduce the dependence on fossil fuels, decrease greenhouse gas emissions, and contribute to a more sustainable built environment. Integrating renewable energy technologies within IBS designs is critical to enhancing energy efficiency and environmental sustainability. The empirical data strongly aligns with the theoretical framework of sustainable building practices, demonstrating that the practical application of these technologies in IBS projects reduces operational energy consumption and advances broader sustainability objectives. This alignment highlights the tangible benefits of incorporating renewable energy in IBS projects, reinforcing the importance of adopting sustainable building practices for long-term environmental health.

3.1.1. Carbon Footprint Reduction

The Industrialised Building System (IBS) significantly reduces the overall carbon footprint of construction projects through its controlled manufacturing processes. Respondents noted that "IBS construction methods lead to lower greenhouse gas emissions during the building process" (Respondent 37). This observation aligns with the findings of Li et al. (2019), who assert that prefabrication techniques commonly employed in IBS significantly decrease emissions compared to traditional construction methods due to the reduced need for transportation and on-site activities. Empirical data further support this theoretical perspective, highlighting that "The project uses geothermal heat for energy which has a low carbon footprint" (Respondent 17) and emphasizing efforts in "reducing emissions and finding solutions to pull CO2 out of the atmosphere" (Respondent 7). The relationship between the theoretical framework of sustainable construction and the empirical data gathered is robust. Akadiri and Olomolaiye's (2012) theoretical framework underscores the critical importance of resource efficiency and waste reduction in achieving environmental sustainability. The empirical evidence provided by respondents substantiates this theory, demonstrating that the practical implementation of IBS effectively minimizes environmental impact.

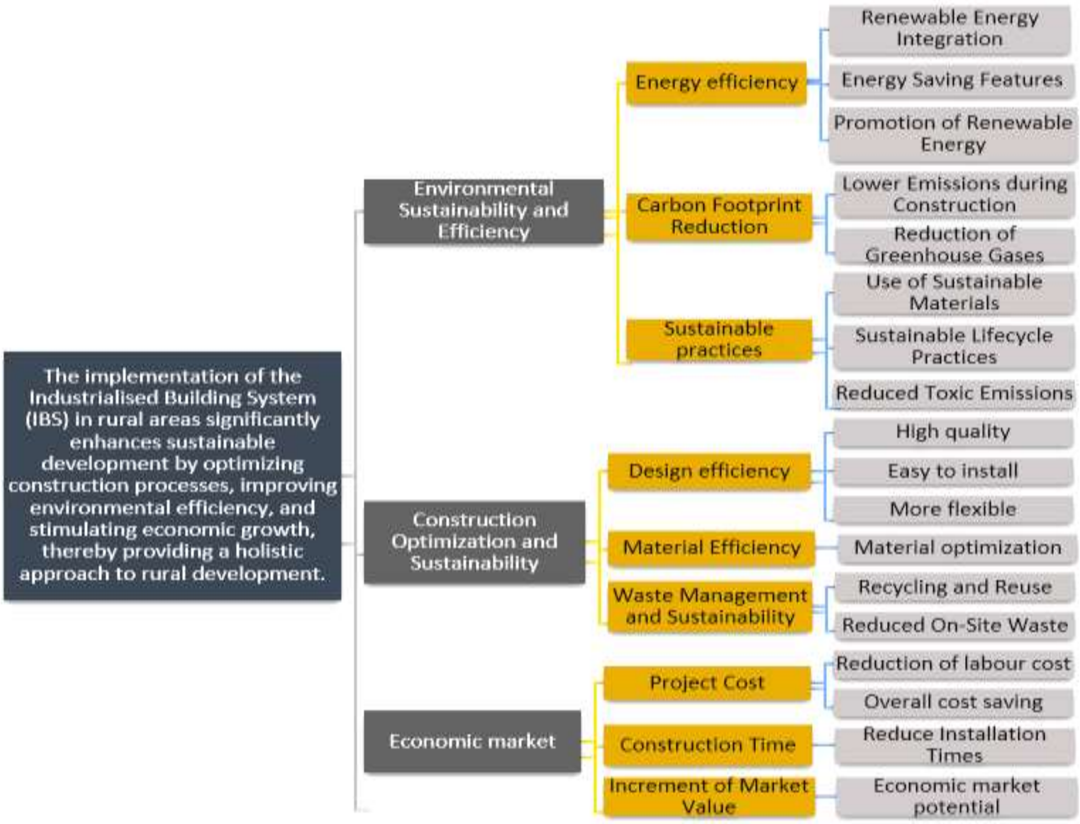

Figure 1. Grounded Theory Framework.

By incorporating recycled and renewable materials, IBS projects conserve natural resources and significantly reduce their environmental footprint. Respondents noted that "IBS supports the use of recycled and renewable materials promoting lower environmental impact" (Respondent 29) and "the use of sustainable materials in IBS reduces the overall environmental footprint" (Respondent 11). This empirical evidence reinforces the theoretical assertion that sustainable construction practices are essential for long-term environmental health. Furthermore, the use of geothermal energy and efforts to reduce CO2 emissions exemplify how IBS projects can integrate sustainable practices to achieve significant carbon footprint reductions. By utilizing low-carbon energy sources and focusing on emission reduction strategies, IBS projects align with the theoretical principles of sustainable construction, emphasizing the necessity of reducing greenhouse gas emissions.

The controlled manufacturing processes and integration of renewable materials in IBS significantly contribute to reducing the carbon footprint of construction projects. The empirical data strongly supports the theoretical framework of sustainable construction, demonstrating that IBS practices effectively minimize environmental impact through resource efficiency and waste reduction. This alignment underscores the importance of adopting sustainable construction practices for long-term environmental health and highlights the practical benefits of using IBS to achieve substantial carbon footprint reductions.

3.1.2. Waste Management and Sustainability

The Industrialised Building System (IBS) significantly contributes to environmental sustainability by minimizing construction waste generated on-site. Respondents highlighted that "IBS minimizes construction waste generated on-site" (Respondent 21) and "the controlled manufacturing processes of IBS help in reducing on-site waste" (Respondent 18). "Reduced on-site waste is a significant environmental benefit of IBS" (Respondent 29).

This aligns with the theoretical framework provided by Tam et al. (2007), which indicates that prefabricated construction methods generate less waste and promote higher recycling rates than conventional construction. The design of IBS components further enhances sustainability by allowing for efficient recycling and reuse. Respondents noted that "IBS facilitates easier recycling and reuse of materials at the end of the building's life" (Respondent 38), and "the design of IBS components allows for efficient recycling and reuse"

(Respondent 31). This underscores the key benefits of IBS construction regarding waste management and material reuse. Tam et al.'s (2007) theoretical foundation emphasizes the efficiency of prefabrication in reducing waste and facilitating higher recycling rates. The empirical evidence collected in this study supports this theory, demonstrating that IBS's controlled manufacturing processes and design for recycling and reuse effectively minimize on-site waste. IBS projects can significantly reduce their environmental impact by integrating controlled manufacturing processes and facilitating recycling and reuse.

Respondents' feedback substantiates the theoretical assertion that sustainable construction practices, particularly those involving prefabrication, are essential for long-term environmental sustainability. For instance, the controlled environment of IBS manufacturing leads to precise material usage, thereby reducing waste. This precision in material use minimizes environmental impact and contributes to cost efficiency, as less material is wasted during construction. The Industrialised Building System (IBS) enhances waste management and sustainability in construction by minimizing on-site waste and promoting recycling and reuse of materials. The empirical data strongly support the theoretical framework provided by Tam et al. (2007), demonstrating that prefabrication techniques inherent in IBS effectively reduce waste and increase recycling rates. This alignment underscores the critical role of sustainable construction practices in minimizing environmental impact and highlights the practical advantages of IBS in achieving long-term sustainability goals.

3.2. Construction Optimization and Sustainability

3.2.1. Design Efficiency

Implementing the Industrialised Building System (IBS) significantly enhances construction efficiency through improved design. IBS designs are recognized for their durability and uniformity, which reduce the likelihood of construction errors and ensure high-quality outcomes. As noted by respondents, "The IBS design is more durable and uniform for each component produced" (Respondent 19). Additionally, respondents highlighted that "IBS ensures high quality and uniformity in construction components" and "The controlled manufacturing environment of IBS leads to higher quality construction" (Respondent 35).

These observations support the theory of lean construction, which emphasizes minimizing variability, standardizing processes, and ensuring high-quality outcomes (Koskela, 1992). Lean construction principles advocate streamlining construction processes to reduce waste, enhance quality, and increase efficiency. This theoretical framework aligns closely with the empirical evidence gathered from respondents. These observations support the theory of lean construction, which emphasizes minimizing variability, standardizing processes, and ensuring high-quality outcomes (Koskela, 1992). Lean construction principles advocate streamlining construction processes to reduce waste, enhance quality, and increase efficiency. This theoretical framework aligns closely with the empirical evidence gathered from respondents.

The feedback from respondents substantiates the theoretical foundations of lean construction. The durability and uniformity of IBS designs and the controlled manufacturing processes demonstrate the practical application of lean construction principles. IBS projects can significantly enhance construction quality and efficiency by integrating standardized and controlled manufacturing processes.

The empirical data indicate that using IBS results in high-quality construction components, reduced variability, and minimized construction errors. This supports the theoretical assertion that lean construction practices are essential for achieving high-quality outcomes and minimizing waste. The controlled environment in which IBS components are manufactured ensures consistent quality, aligning with Koskela's (1992) emphasis on standardization and quality control.

Implementing IBS significantly enhances construction's design efficiency by integrating standardized and controlled manufacturing processes. The empirical data align with the theoretical principles of lean construction, demonstrating that IBS practices lead to high-quality, durable, and uniform construction outcomes. This alignment underscores the critical role of lean construction practices in achieving superior construction quality and efficiency. The practical advantages of IBS, as highlighted by the empirical evidence, showcase the tangible benefits of adopting these efficient design practices in construction projects.

3.2.2. Material Efficiency

The precision in material usage associated with IBS reduces overuse and minimizes waste, leading to cost savings and environmental benefits. One respondent explained, "IBS ensures precise material usage reducing overuse and minimizing waste during construction" (Respondent 24). "Material efficiency in IBS construction leads to lower overall material costs" (Respondent 15). "Efficient use of materials is a core principle of IBS" (Respondent 39). Jaillon and Poon (2014) support this perspective, noting that prefabrication allows for better control over material quantities, thus reducing waste and improving material efficiency. The theoretical foundation provided by Jaillon and Poon (2014) emphasizes the importance of material efficiency in achieving sustainability. The respondents' feedback supports this theory, demonstrating that IBS's precision in material usage and reduction of waste align with sustainable construction principles.

By integrating precise material usage practices, IBS projects can significantly enhance material efficiency, leading to cost savings and environmental benefits. This empirical evidence supports the theoretical assertion that sustainable construction practices, particularly those involving prefabrication, are essential for long-term resource conservation and cost efficiency. The codings derived from the data provides concrete examples of how these theoretical principles are operationalized in IBS projects, highlighting the practical advantages of these efficient material practices.

Integrating precise material usage within IBS aligns with the theoretical framework's emphasis on reducing waste and improving material efficiency through controlled construction processes. This alignment underscores the importance of adopting sustainable construction practices for material efficiency and cost savings. The codings illustrate how the theoretical principles are implemented in practice, showcasing the tangible benefits of adopting IBS in construction projects.

3.2.3. Construction Time

IBS significantly reduces construction time due to the pre-manufacturing of components, with the added benefit of being less affected by weather conditions. A respondent noted, "IBS can reduce construction time because panel installation is easier and assisted by additional machines" (Respondent 3). Another respondent echoed this sentiment, who stated, "Simpler and simpler designs speed up construction. This method is less affected by rainy weather" (Respondent 4). Additionally, another respondent explained, "Saving time and construction period of the project occurs with more careful planning before the site work is done" (Respondent 10). This aligns with the theory of time compression in construction, which suggests that prefabrication can significantly shorten construction timelines by allowing simultaneous off-site manufacturing and on-site preparation (Eastman et al., 2011).

Eastman et al. (2011) emphasize the efficiency gains from prefabrication techniques, which allow for simultaneous off-site manufacturing and on-site preparation, thus reducing construction time. The respondents' feedback supports this theory, demonstrating that IBS's pre-manufacturing processes and weather-resilient designs align with the principles of time compression in construction.

IBS projects can significantly reduce construction timelines by integrating pre-manufacturing techniques and efficient planning. This empirical evidence supports the theoretical assertion that prefabrication and careful project planning are essential for achieving faster construction. The codings derived from the data provide concrete examples of how these theoretical principles are operationalized in IBS projects, highlighting the practical advantages of these time-saving practices.

Integrating reduced construction time and weather-resilient designs within IBS aligns with the theoretical framework's emphasis on leveraging prefabrication to accelerate construction schedules. This alignment underscores the importance of adopting efficient construction practices to achieve shorter timelines and maintain project schedules despite weather disruptions. The codings illustrate how the theoretical principles are implemented in practice, showcasing the tangible benefits of adopting IBS in construction projects.

3.3. Economic Market Potential

3.3.1. Project Cost

The economic advantages of IBS in rural construction projects are significant, offering cost savings, market growth, and enhanced economic development. IBS reduces labor and material costs, making construction more affordable and accessible in rural areas. For example, respondents indicated that "IBS projects can save higher overall project costs due to the use of less labor" (Respondent 32). This is corroborated by Rahman and Omar (2006), who found that IBS can lead to substantial cost reductions through the decreased need for skilled labor and shorter construction times. "The use of IBS components such as paneled systems and additional machinery can reduce the number of workers required at the site by up to fifty percent compared to using bricks"

(Respondent 21). "The overall cost of IBS is cheaper because it can reduce the cost of construction site workers" (Respondent 30). "In terms of cost savings, large-scale IBS projects can save higher overall project costs due to using less labor" (Respondent 23).

The theoretical foundation provided by Alawag, Alaloul, Liew, Al-Bared, Wan Abdullah Zawawi, and Ammad (2021) and Omar (2006) emphasizes the importance of reducing labor and material costs to achieve economic sustainability in construction projects. The respondents' feedback supports this theory, demonstrating that IBS's prefabrication processes and efficient use of resources align with cost efficiency principles. IBS projects can significantly enhance economic sustainability by integrating labor and material cost reduction strategies. This empirical evidence supports the theoretical assertion that optimizing construction processes through prefabrication and standardization leads to substantial cost savings. The codings derived from the data provide concrete examples of how these theoretical principles are operationalized in IBS projects, highlighting the practical advantages of these cost-efficient practices.

Integrating labor and material cost reduction within IBS aligns with the theoretical framework's emphasis on achieving economic sustainability through efficient construction methods. This alignment underscores the importance of adopting cost-efficient construction practices to enhance affordability and accessibility in rural construction projects. The codings illustrate how the theoretical principles are implemented in practice, showcasing the tangible benefits of adopting IBS in construction projects.

3.3.2. Increment of Market Value

The future economic market for IBS is expected to rise, driven by government support and industry adoption. One respondent mentioned, "The future economic market is expected to rise following the recommendations for IBS" (Respondent 28). Goodier and Gibb (2007) argue that the prefabrication sector is poised for expansion due to increasing recognition of its benefits. "The government needs to give encouragement to industry players to further develop the construction sector based on this IBS" (Respondent 23). "IBS will have a growing market and demand if the government makes its use mandatory in government and private projects" (Respondent 14).

Furthermore, adopting IBS can stimulate economic development by attracting investment and enhancing the local economy. "IBS will have a growing market and demand if the government makes its use mandatory in government and private projects" (Respondent 13). This observation aligns with Kamar et al. (2010), who suggest that regulatory frameworks and government incentives can significantly boost the adoption of IBS and drive market growth.

The relationship between the theoretical framework of market growth in construction and the empirical data reveals a strong alignment. The theoretical foundation provided by Goodier and Gibb (2007) and Kamar et al. (2010) emphasizes the importance of government support, regulatory frameworks, and industry adoption in driving market expansion. The respondents' feedback supports this theory, demonstrating that IBS's potential for market growth is contingent on these critical factors.

IBS projects can significantly enhance market value and stimulate economic development by integrating government support and fostering industry adoption. This empirical evidence supports the theoretical assertion that regulatory incentives and industry encouragement are essential for market growth in the construction sector. The codings derived from the data provide concrete examples of how these theoretical principles are operationalized in IBS projects, highlighting the practical advantages of these market expansion practices.

Integrating government support and market demand within IBS aligns with the theoretical framework's emphasis on driving market growth through regulatory frameworks and industry incentives. This alignment underscores the importance of supportive policies to enhance market value and stimulate economic development in the construction sector. The codings illustrate how the theoretical principles are implemented in practice, showcasing the tangible benefits of adopting IBS in construction projects.

4.0 CONCLUSION

The findings from this study highlight the diverse advantages of the Industrialised Building System (IBS) in fostering sustainable construction practices in rural areas. IBS significantly enhances environmental sustainability, economic efficiency, and overall construction quality by integrating renewable energy sources, optimizing material use, reducing construction time, and minimizing waste. The empirical data robustly supports the theoretical frameworks, showcasing the practical benefits of adopting IBS in rural construction projects. The study comprehensively explored how IBS can enhance environmental sustainability, economic efficiency, and construction quality. The findings reveal that IBS significantly reduces greenhouse gas emissions, improves material efficiency, shortens construction time, and lowers project costs. These results underscore the importance of IBS in promoting sustainable construction practices, particularly in rural areas where traditional construction methods may be less feasible.

This research provides valuable insights for construction practitioners, policymakers, and industry stakeholders. By highlighting the benefits of IBS, the study encourages the adoption of prefabrication techniques and sustainable practices in rural construction projects. This leads to more efficient use of resources, reduced environmental impact, and cost savings. Such practical guidance is essential for advancing sustainable construction practices within the industry. Moreover, this study contributes to the expanding body of knowledge on sustainable construction by empirically validating the theoretical benefits of IBS. The findings offer concrete examples of how IBS principles can be operationalized in practice, providing a robust framework for future research and practical applications in the construction industry. This alignment of empirical data with theoretical assertions reinforces the critical role of IBS in achieving sustainable development goals and underscores its potential to revolutionize construction practices, particularly in rural settings.

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