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Stakeholder Perception Audit of Offsite Construction Innovation within Zimbabwe's Steel Fabrication and Erection Sector

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Abstract

The researcher conducted a stakeholder perception audit of offsite construction innovation within Zimbabwe's steel fabrication and erection sector, focusing on Harare. The study sought to assess stakeholders' views on the current state, drivers, benefits and constraints of offsite construction innovation in an industry increasingly shaped by modernisation and sustainability imperatives. The study utilised twenty-seven in-depth interviews, three focus group discussions, four field observations and document analysis involving professionals in procurement, fabrication, assembly and delivery. The phenomenological design, interpretivism philosophy and qualitative paradigm were adopted. The findings revealed a growing shift from conventional brick-and-mortar construction to prefabricated steel structures, especially in industrial and commercial projects. Stakeholders associated this transition with cost efficiency, shorter construction timelines and reduced on-site workload. However, the uptake of Industry 4.0 technologies such as Artificial Intelligence (AI), robotics and Building Information Modelling (BIM) remained slow due to conservative attitudes, limited awareness and skill gaps. The study also observed a gradual adoption of sustainable practices, including the use of eco-friendly materials and solar energy systems, largely driven by necessity rather than strategic choice. Participants further identified quality assurance, eco-efficiency and regulatory pressures as major influences on innovation. Offsite methods were perceived to enhance construction precision, minimise waste and improve long-term building performance. Nonetheless, outdated building by-laws, notably the 1976 Model Building Regulations, were considered major impediments to innovation. Additional barriers included inadequate technical training, resistance to change, consumer misconceptions, logistical constraints and financial limitations. The findings underscored the dual nature of Zimbabwe's offsite construction evolution marked by promising innovation potential yet constrained by structural, regulatory and cultural challenges. The study recommended policy reforms, investment in capacity building and enhanced stakeholder awareness to facilitate the sustainable growth of offsite construction innovation in Zimbabwe's steel fabrication and erection sector. The study also recommended other researcher to expand scope of inquiry towards other cities and towns in Zimbabwe for external validity.

Keywords: Offsite innovation, construction, steel fabrication.

Introduction

The construction sector significantly contributed to global environmental degradation given its reliance on orthodox and resource-intensive construction techniques. The brown-field on-site construction procedures were predominantly carbon-intensive, making the construction industry a major climate change driver. (Ugochukwu-Chioma, 2015). Elhacham *et al*., (2020)

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aver that humankind's ecological impact has become profound justifying the need for urgent structural social and economic transformations to match United Nations Sustainable Development Goals (SDGs). Consequently, construction innovation, principally offsite construction, represented a critical pathway to enhance construction industry sustainability, productivity and competitiveness. (De Vasconcelos, Cândido & Heineck, 2020; Loosemore, 2015). Offsite construction innovation involved the prefabrication and preassembly of building components in controlled environments, followed by on-site assembly (Gibbs, 2019). The practice resonated with the delivery of superior quality, faster construction turnarounds, minimal water and enhanced building ecological performance. (Ho *et al*., 2018; Akintoye *et al*., 2012). Within the Fourth Industrial Revolution (4IR) framework, digital technologies, smart materials and automation support offsite construction, offer transformative potential for urban infrastructure and smart city development. (Matamanda *et al*., 2022; Ojo-Fafore *et al*., 2021).

Background to the study

Offsite construction has gained significant international traction as in Australia, where Hum, Chong and Wang (2020) acknowledged fifty-nine sustainability-related stakeholder perceptions, including improved quality, affordability and environmental efficiency. Likewise, Wuni and Shen (2019) highlight cost savings, time efficiency and improved project performance as major innovation determinants. In the United States, Brissi and Debs (2023) identified a growing preference for off-site methods due to speed and sustainability among multi-family housing developers. Related studies, like Ferdous *et al*., (2019), Lacey *et al*. (2018)and Park *et al*. (2016), emphasised socio-economic and ecological benefits, including structural resilience, design flexibility and diminished environmental impact. There was a general preference for modular buildings given their capacity to withstand seismic activity, resisted high winds and adapted to rapid urbanisation within the steel erection and fabrication sector. (Zuo & Zha, 2017; Gunawardena, 2016). These benefits presented off-site steel framing as a compelling alternative to traditional brick-and-mortar systems, particularly in high-rise construction. (Thai, Ngo & Uy, 2020). Moreover, offsite construction methods decreased on-site labour, lower operational risks and ensured consistent quality. (Matamanda *et al*., 2022; Gibbs, 2019).

Nonetheless, global adoption of offsite construction was experiencing several constraints. In Chile, Ortega, Mersa and Arlacon (2023) observed that cultural conservatism; limited policy support and interoperability challenges hindered adoption of offsite innovation. In the UK, high costs, limited supplier capacity and consumer preference for orthodox homes slows adoption. (Agapiou, 2022). Likewise, in China, transaction costs, skilled labour shortages and logistical inhibitions impaired the uptake of prefabricated steel buildings (Liu *et al*., 2023; Wu *et al*., 2021). These challenges corresponded with the Transaction Cost Theory, in positing that concealed negotiation, coordination and compliance costs deter adoption decisions. (Li, Arditi & Wang, 2014).

Stakeholder perceptions of offsite construction innovation indicated a blend of interest and resistance across Africa. In Nigeria's Anambra State, Ezeokoli *et al*. (2023) opine that sustainable construction has been downplayed. This concurs with Awuzie *et al*., (2021), who highlight the centrality of limited accurate data, poverty, low urban investment, limited stakeholder interest, technophobia, entrenched colonial codes and knowledge deficits in inhibiting offsite construction innovation. Likewise, Chukwu and Anaele (2019) contend that sustainability is considered a complex and controversial concept, contributing to slow adoption. Similarly, Oke and Aigbavboa (2016) and Awuzie *et al*. (2021) provide corresponding evidence that, despite awareness of benefits, systemic barriers across government, professional institutionsand end-users impair offsite innovation in Nigeria. Rahimian *et al*. (2017) link the seventeen million housing deficits in Nigeria to high costs and slow construction, which suggests the potential for offsite innovation as an effective antidote, though negative client perceptions, inadequate infrastructure and lack of skills could affect the appetite for innovation.

Egypt displayed similar tendencies. Zolghadr *et al*. (2022) report low uptake of offsite housing attributed to higher costs, notwithstanding extensive product marketing. In Ghana, Eyiah-Botwe *et al*. (2021), growing demand for urban housing, though negative perceptions of offsite housing quality, limited government support, insufficient promotion and scarcity of skilled contractors impair adoption. Acheampong (2018) concurs that while engineers recognise inherent benefits, including lower costs, shorter construction timelines, efficiency gains and enhanced safety, negative perceptions, capital constraints and artisan skill gaps hinder adoption. South African studies indicate similar trends that limited incentives, social resistance, high upfront costs and lower awareness are significant offsite innovation barriers. (Kajji *et al*., 2020; Simpeh & Smallwood, 2018; Marcos & James, 2016). Likewise, Dosumu and Agbavboa (2021) agree that offsite innovation remains sluggish in South Africa even though the construction industry contributes 23% of greenhouse gas emissions.

Zimbabwe, with a population of approximately 16 million (ZIMSTATS, 2022), heavily relied on the construction sector to drive economic growth, employment and infrastructure development (Myers, 2013). The construction sector's growing economic importance is evident in its GDP contribution, which rose from 1.7% in 2009 to 2.9% in 2014 (Nyoni & Bonga, 2016). The Construction Industry Federation of Zimbabwe (CIFoZ, 2023) pinpoints the sector's role in the delivery and maintenance of critical infrastructure, including roads, bridges, utilities and housing. Regardless of its importance, Zimbabwe's construction sector contends with structural challenges that include general preference for conventional brownfield construction methods, reliance on concrete, clay and brick-and-mortar approaches, oftentimes contributing to cost overruns, delays and quality issues. (CIFoZ, 2023). Zimbabwe also remained highly vulnerable to climate change, including tropical cyclones such as Eline (2002), Gloria (2005) and Idai (2019), which damage poorly constructed buildings. (Meteorological Services Department, 2023; IPCC, 2021).

A Ministry of Housing and National Amenities (2023) publication posits that Zimbabwe contended with a two-million housing deficit, which exacerbates these challenges amidst rapid urbanisation and population growth of 2.14% per year. (ZIMSTATS, 2022; World Bank, 2020). Historical factors, comprising colonial-era housing policies and post-independence rural-to-urban migration, had intensified the crisis. (Muchadenyika, 2020; Potts, 2020). While government initiatives, including ZIMASSET, Vision 2030 and IDBZ-led housing projects, aim to address the housing deficit, implementation has been slow (IDBZ, 2023; Mananavire, 2019; ADB, 2019). Further outdated legal frameworks, including the 1976 Model Building Bylaws and negative user perceptions of prefabricated housing, impaired offsite innovation adoption. (Chigudu, 2021; CIFoZ, 2023; City of Harare Building Inspectorate, 2023). Construction firms like Grid Transmission, Brown Engineering, Agri Structures and Steel Horizon Structures have experimented with modular and steel-frame designs, but these remained marginal within the national construction ecosystem (CIFoZ, 2023). Small and medium enterprises dominated the sector, often lacking the capital and capacity to invest in innovation, reinforcing slow diffusion. (CIFoZ, 2023).

Statement of the problem

A preliminary literature review (Ferdous *et al*., 2019; Lacey *et al*., 2018; Zuo & Zha, 2017; Park *et al*., 2016; Zha *et al*., 2016; Boafo *et al*., 2016) indicates that steel-based offsite innovation studies remain marginal. Most studies have focused on other countries like China (Thai *et al*., 2020; Lai *et al*., 2020), the USA (Velamati, 2012)and Nigeria (Ezeokoli *et al*., 2023; Awuzie *et al*., 2021; Chukwu & Anaele, 2019), indicating a lack of context-specific research in Zimbabwe. Limited qualitative evidence exists regarding how stakeholders perceive offsite construction innovation, particularly in steel fabrication and erection. Conflicting cross-country data highlighted key benefits, including faster delivery, cost reduction and environmental efficiency, but cultural, financial, regulatory and perceptual factors constrain adoption. These inconsistencies underscored uncertainty around how Zimbabwean stakeholders perceived offsite construction innovation. The main study question was: What are the stakeholder perceptions of offsite construction innovation in Zimbabwe?

Research objectives

The study sought:
1. To explore stakeholder perceptions of the current state of offsite construction innovation adoption in Zimbabwe’s steel framing and erection sector
2. To examine perceived drivers of offsite construction innovation in Zimbabwe’s steel framing and erection sector
3. To establish the perceived benefits of offsite construction innovation within Zimbabwe’s steel framing and erection sector
4. To establish perceived innovation constraints in Zimbabwe’s steel framing and erection sector

Significance of the study

This study was significant from multiple fronts as it firstly contributed to the body of knowledge through addressing a critical knowledge gap in Zimbabwe, in which limited empirical evidence on stakeholder perceptions of construction innovation relative to offsite construction was evident. Several global studies (Zha *et al*., 2016; Ferdous *et al*., 2019; Thai *et al*., 2020) offered useful insights regarding the adoption of drivers, benefits and barriers in other countries like the USA and China, but their observations were not easily generalisable to Zimbabwe given different socio-economic, policy and industrial contexts. Thus, this study contributed to the global discourse on offsite construction adoption and filled a gap in local engineering and construction literature. In addition, the study’s findings could offer policymakers and regulators including the Ministry of Housing and National Amenities, the Construction Industry Federation of Zimbabwe (CIFoZ) and municipal building inspectorates, with empirical insights to inform the development of targeted policies, incentives and regulatory reforms to accelerate the adoption of sustainable and innovative construction techniques, in line with Zimbabwe’s Vision 2030 and UN Sustainable Development Goal nine on resilient infrastructure, inclusive industrialisation and innovation. The study could guide strategic decision-making, resource allocation and project planning to ensure more efficient, cost-effective and environmentally sustainable construction outcomes for industry practitioners.

Literature review

Various UK studies concurred that offsite manufacturing was a widely adopted construction practice championed by leading construction firms such as Ilk Homes, Bryden Wood, TopHat and Urban Splash. (Rausch *et al*., 2019; Gbadamosi *et al*., 2019; Wang *et al*., 2018; Offsite Hub, 2019). The state of play in the UK was that the housing construction sector involved some form of offsite manufacturing. (Griffin *et al*., 2016). Lord (2018) said that up to 98% of UK construction projects considered adopting offsite innovation between 2013 and 2016. On the same note, IPA (2016) opines that the UK government had established the National Infrastructure Delivery Plan and Pipeline starting in 2013, with projections up to 2021 meant to encourage construction industry adoption of offsite innovation and technology in general. Fionta and Tithiochta (2023) note that in Ireland, the roadmap towards public housing service delivery was premised on the adoption of modern construction methods that encompassed offsite innovation. Arif *et al.* (2012) concurred that the rapid growth of the Indian construction sector had compelled most industry players to adopt alternative construction techniques. Ngunyen *et al*. (2023) indicated that the government encouraged offsite innovation as part of its long-term digital plans for the construction sector between 2020 and 2025 in terms of the Ministry of Construction 2030 Vision.

Most emerging economies demonstrated reluctance in adopting offsite innovation compared to developed countries. (Hang & Wang, 2018). The major barriers to offsite construction innovation encompassed limited government support, higher initial costs, lack of skilled artisans, lack of awareness and uncertainty of market demand post construction in Bangladesh. There was extensive reliance on traditional construction techniques in China. (Mao, Shen, Pan & Ye, 2015). A qualitative inquiry by Rahimian, Goulding, Akintolo and Kolo (2017) noted a very low level of offsite construction innovation in Nigeria even though the country was subject to a seventeen million housing deficit. The lower-level adoption was attributable to factors encompassing client resistance, negative end-user perceptions, skills shortage, lack of awareness, collaboration and training, as well as lack of central government support.

Moyo, Ormer and Chigara (2024) noted that in most developing countries, including Zimbabwe, there existed sustainable construction deficits. Chigwenya and Zhakata (2020) noted that in Zimbabwe, the adoption of green building technologies that encompassed offsite construction innovation was still limited, thereby limiting the contribution of the built environment to national sustainable development. Existing studies demonstrated general lethargy in technology adoption and sustainability orientations within the construction sector in Zimbabwe (CIFoZ, 2023; Zami, 2010; Chigudu, 2021). There were also no studies to the best knowledge of the researcher that alluded to the aspect of offsite construction innovation in Zimbabwe. This indicated the need to further interrogate the aspect in relation to the steel framing and fabrication sector in Zimbabwe.

Research Methodology

The study adopted the interpretivism philosophy and a qualitative paradigm in capturing nuanced, context-specific insights from experienced professionals regarding stakeholder perceptions of offsite construction innovation in Harare's steel fabrication and erection sector. The study was based in Harare, the capital city of Zimbabwe, which was characterised by high offsite construction innovation participants. The study targeted construction professionals with direct involvement in offsite construction innovation, ensuring informed and reliable perspectives. It employed a purposive sampling strategy to select twenty-seven key informants for in-depth interviews and twenty-five participants for three focus group discussions (FGDs), representing design and planning, construction and installation, supervision and quality control segments. Sampling ensured representation across age, gender, education and experience.

The study adopted multiple data generation techniques, including in-depth semi-structured interviews targeting twenty-seven key informants, including architects, engineers, builders, supervisors and quality controllers for methodological rigour and methodological triangulation. Open-ended questions targeted participants' experiences, opinions and perceptions regarding offsite construction innovation. Interviews were conducted at participants' convenience and recorded with consent in line with propositions by Maxwell (2019) and Kumar (2015). Three Focus Group Discussions (FGDs) targeted business owners, architects and builders. Each group comprised between eight and nine participants to explore collective perspectives and generate additional insights. Observations complemented as the researcher conducted non-participant observations at offsite construction sites to document practices, behaviours physical settings and observations provided contextual understanding and corroborated primary data. (Yin, 2014; Creswell, 2013). Secondary data, including industry reports, policy documents and corporate records, were analysed to complement primary data and strengthen methodological triangulation. (Maxwell, 2019).

The generated data were transcribed, coded and thematically analysed using a manual analytic process premised on frequency of occurrence and relevance to research objectives and the study findings were presented as narratives supported by verbatim quotes, tables and figures to ensure rich, context-sensitive interpretation. The researcher ensured trustworthiness through member checking (where the participants verified interview transcripts for accuracy), prolonged engagement (based on multiple interactions with participants to enhance credibility), triangulation (methodological and data triangulation to reduce bias), thick descriptions (to capture detailed participant narratives and provide contextual depth) and fostering relational trust (through transparency, informed consent and ethical practices to reinforce data authenticity). The study embraced various ethical considerations, including ethical approval, confidentiality, anonymity, voluntary participation and the right to withdraw. Objectivity and fairness were maintained throughout data collection and analysis.

Participant biodata

The study leveraged twenty-seven key informants aged twenty-five to sixty-seven years, predominantly male (78%), mostly holding first degrees (56%) and with extensive sector experience (fifteen years, 67%), in terms of the participant profile. Participants spanned design and planning (35%), construction and installation (35%), supervision (17%) and quality control (13%) roles. The twenty-five FGD participants included business owners (32%), architects (32%) builders (36%) and most were over forty years (64%), male (64%), holding degrees (68%) and with over fifteen years' experience (80%). The participant profiles ensured rich, credible and sector-specific insights into offsite construction innovation. See Table 1 below for participant biodata.

Table 1: Participant biodata

Interview participant Code	Age (years)	Sex (M, F)	Highest level of education	Work experience	Designation

KI01	25	F	Degree	below 5 years	Structural engineer
KI02	62	M	Degree	Over 15 years	Rigger
KI03	50	M	Degree	Over 15 years	Draughtsman
KI04	45	M	Diploma	Over 15 years	Quantity surveyor
KI05	58	M	Diploma	Over 15 years	Construction supervisor
KI06	52	M	Degree	Over 15 years	Gang leader
KI07	40	M	Master's degree	Over 15 years	Electrical engineer
KI08	49	M	Master's degree	Over 15 years	Quality controller
KI09	29	M	Master's degree	Over 15 years	Structural engineer
KI10	54	F	Degree	Over 15 years	Draughtsman
KI11	37	M	Diploma	11- 15 year	Rigger
KI12	59	M	Degree	Below 5 years	Electrical engineer
KI13	62	M	Degree	6 to 10 years	Builder
KI14	55	M	Master's degree	Over 15 years	Architect
KI15	42	F	Diploma	Over 15 years	Architect
KI16	28	M	Master's degree	Over 15 years	Architect
KI17	44	M	Degree	Over 15 years	Carpenter
KI18	42	F	Degree	Over 15 years	Construction supervisor
KI19	37	M	Degree	Over 15 years	Construction supervisor
KI20	39	M	Degree	11-15 years	Carpenter
KI21	57	M	Degree	Below 5 years	Electrical engineer
KI22	67	F	Degree	Below 5 years	Structural engineer
KI23	57	M	Degree	11- 15 years	Quality controller
KI24	57	M	Degree	Over 15 years	Quality controller
KI25	54	M	Degree	Over 15 years	Diesel Plant Fitter
KI26	50	F	Degree	Over 15 years	Electrical engineer
KI27	29	M	Degree	11-15 years	Rigger

Source: Author (2025)

Results and discussion

The generated data were transcribed, coded and thematically analysed using a manual analytic process premised on frequency of occurrence and relevance. The results produced thirteen themes as indicated below.

Table 2: Themes and sub themes

Theme	Sub-Theme	Source
1. Prefabrication	a. Steel structures b. Prefabricated designs	Interviews, FGD, observation, document analysis
2. Digitalisation	a. Slow industry 4.0 adoption	Interviews, FGD, observation, document analysis
3. Sustainability	b. Eco-friendly materials c. Renewable energy systems	Interviews, FGD, observation, document analysis
4. Necessity	a. Cost efficiency b. Speed c. COVID-19 d. Population growth	Interviews, FGD, observation, document analysis
5. Regulatory pressure	a. Policy alignment b. Compliance standards	Interviews, FGD, observation, document analysis
6. Market demand	a. Client preferences b. Competition c. Reputation	Interviews, FGD, observation, document analysis
7. Quality	a. Quality control b. Precision c. Building performance	Interviews, FGD, observation, document analysis
8. Eco-efficiency	a. Reduced waste b. Energy efficiency in design	Interviews, FGD, observation, document analysis
9. Regulatory lag	a. Outdated bylaws b. Archaic Codes c. Regulations	Interviews, FGD, observation, document analysis
10. Knowledge gaps	a. Lack of skills b. Resistance to change c. Limited knowledge	Interviews, FGD, observation, document analysis
11. End-user awareness	a. Misconceptions b. Cultural preferences	Interviews, FGD, observation, document analysis
12. Resource limitations	a. Limited infrastructure b. Financial constraints c. Bureaucratic hurdles	Interviews, FGD, observation, document analysis
13. Procurement Challenges	a. Supply chain issues	Interviews, FGD, observation, document analysis

Source: Primary data (2025)

Prefabricated designs

Stakeholders in Harare's steel fabrication and erection sector stressed rapid modernisation through prefabricated designs and steel structures, alongside gradual adoption of Industry 4.0 technologies and sustainability practices. One participant emphasised widespread offsite innovation adoption in industrial buildings:

- **KI-11**: *"We have moved into that age where almost every industrial building is being made out of steel and I think we are around 100% adoption and I have not designed any industrial building in the past five years that is entirely brick and mortar; most have been composite structures thereby indicating the preference for offsite innovation particularly in relation to industrial buildings."*

Another confirmed the sector's transition from traditional construction:

- **KI-19**: *"There has been a significant movement towards innovation adoption in the steel fabrication and erection sector in Zimbabwe considering the transition from brick-and-mortar structures towards a general preference for prefabricated designs."*

Digitalisation

However, the adoption of Industry 4.0 technologies remained slow, as noted by one participant:

- **KI-15**: *"New technologies like AI are still new and the challenge within our market is that people are conservative they take time to respond to new ideas as they are used to existing systems, they are deeply embedded in a culture and there are multiple hurdles to fight the systems."*

Sustainability

The stakeholders perceived a gradual but noticeable movement toward green building practices, solar energy adoption and sustainable material use in Zimbabwe's steel fabrication and erection sector. One participant pointed to growth in momentum, indicating that half of the construction industry had gone green and that eco-friendly practices had slowly gained traction, as the following shows.

- **KI-16**- *"Almost half of the construction industry has gone green and it's about time! Eco-friendly and sustainable practices are slowly gaining momentum in the sector?"*

Another participant supported the claim indicating that the steel structures were easy to set up and dismantle indicating convenience drivers of adoption and sustainability outcomes relative to lower demobilisation costs as the following claim indicated.

- **KI-21**- *"The sector has really done a bit towards the adoption of sustainability practices and if you consider steel structures which are easy to dismantle and move with little environmental disturbance.*

These findings concurred with Matamanda *et al*. (2022) and Chigwenya (2019), who noted that Zimbabwe's construction sector remained constrained by legacy practices, regulatory rigidity and conservative market culture, which slowed technological adoption. Conversely, the high adoption of steel and prefabricated designs reflected global trends, such as modular construction in the UK (Griffin *et al*., 2016; House of Lords, 2018) and Australia (Ferdous *et al*., 2019), where offsite innovation improved efficiency and safety. Sustainability adoption, though moderate at around 50%, resonated with emerging evidence that eco-friendly practices were gradually gaining traction in developing economies. (Moyo, Ormer, & Chigara, 2024). The overall stakeholder perception was that offsite innovation was transformative for industrial efficiency, yet its uptake remained uneven, highlighting a gap between traditional practices, technological innovation and sustainability integration in Zimbabwe's construction sector.

Necessity

The results indicated that necessity in terms of economic pressures, population growth and the COVID-19 pandemic compelled firms to adopt offsite methods to optimise resources and reduce construction timelines.

- **KI-24:** *"The recent COVID-19 pandemic has been an incessant driver of construction innovation… I think the disease has been a reminder on the need to think differently through adoption of sustainability practices."*

- **FGD-01**: *"Limited building spaces have forced companies to think creatively leveraging offsite innovation to optimise space and resources."*

These results aligned with Gatheeshgar *et al*. (2021) and Assaad *et al*. (2022), who noted modular steel-framed buildings as cost-effective and rapid solutions during emergencies. Cost savings, access to funding and competitive advantage also supported findings by Wuni *et al*. (2023) and Alderton (2019).

Regarding faster delivery and better experience, the participants emphasised accelerated construction due to controlled environments and parallel processes:

- **KI-23:** *"Construction is now done in controlled environments where there is optimisation in terms of time."*

- **KI-21**: *"While the structure is being fabricated in the workshop, others could be busy pouring foundations."*

Zha *et al*. (2016), Ho *et al*. (2018) and Duc (2023) corroborate reduced timelines in offsite projects and Sun *et al*. (2020) highlight modular construction's efficiency in time-sensitive projects.

Participants also reported cost-effectiveness through optimised production cycles and reduced labour requirements:

- **FGD-01**: *"Using machinery to do most of the work cuts costs."*

- **KI-13**: *"Steel structures are cost-effective compared to brick constructions."*

Ho *et al*. (2018) and Hum *et al*. (2020) support modular construction as affordable, energy-efficient and sustainable.

Regulatory Pressure

Regulatory frameworks, government initiatives and advocacy by special interest groups pushed firms toward sustainable, offsite practices.

- **KI-16**: *"The construction sector has recently been under pressure from strict environment management regulations such as the [EMA] Act which punishes errant conduct towards the environment and encourages sustainable construction practices."*

- **KI-27**: *"There is room for the government…currently we have innovation hubs in universities. The scope is there it might just be an issue of the pace."*

These perceptions resonate with Thorpe *et al*. (2008) and Veselovska (2017), highlighting regulation and institutional support as critical innovation enablers. Zimbabwe contrasts with slower adoption in countries like the UK due to weaker policy enforcement. (CITB, 2017; KPMG, 2016).

Market Demand

Consumer access to information and growing demand for high-quality construction aesthetics further influenced offsite adoption.

- **FGD-01**: *"Now we have privileged access to information through mobile devices…we are now warming up to the idea given social media platforms where we can learn."*

- **FGD-02**: *"I think the aspect of quality…has driven higher adoption rates of offsite construction innovation. There is a notable difference in terms of aesthetics and quality because now we see the need to conform to standards…"*

These results aligned with Steinhardt and Manley (2016b) and Potts (2020), showing that informed consumers and skilled labour catalyse adoption. Zimbabwe's skilled workforce contrasts with skill deficits in some developed countries. (Green, 2019).

Need for Quality

Participants highlighted the need for quality motivated offsite innovation due to production in controlled environments, reducing on-site errors and improving monitoring opportunities:

- **KI-04**: *"Offsite innovation allows for improvement in quality control considering that modules are produced in controlled environment to reduce on-site errors."*

- **KI-10:** *"It's easy to run quality assurance indoors as opposed to externally."*

These findings aligned with Matamanda *et al*. (2022) and Hum *et al*. (2020), who noted that offsite construction enhances quality control, reduces defects and limits on-site work. Ferdous *et al*. (2019) and Larcey *et al*. (2018) similarly report improved construction quality and efficiency through prefabrication. (Ngo *et al*., 2020; Steinhardt & Manley, 2016).

Offsite methods enabled precise adherence to engineering specifications, standardised measurementsand reduced defects:

- **FGD-02**: *"Offsite innovation promotes accurate and precise construction as building components are constructed to match engineering specifications."*

- **KI-17**: *"There is a sense of standardisation in relation to steel structures, which can be constructed to match specific measurements."*

Consistent with Awuzi *et al*. (2021), prefabrication ensures precision, reduces variability and enhances client satisfaction.

Durability, versatility, health and safety of offsite-constructed buildings were perceived benefits:

- **KI-08**: *"Structures are durable as long as competent artisans make them."*

- **KI-20**: *"Steel structures withstand natural disasters like earthquakes if foundations are properly done."*

- **KI-12**: *"Simulation software ensures durability and quality certification."*

KPMG (2016) and Acheampong (2018) supported the safety and durability benefits, while Arif & Goulding (2013) noted potential perception challenges in prefabricated houses. Offsite innovation reduced dust, noise and improves health and safety. (Housing Today, 2020; House of Lords, 2018; House of Commons, 2019a).

Ecological Efficiency

The stakeholders also perceived that offsite innovation reduced material waste through precise estimation and controlled manufacturing:

- **FGD-02**: *"Precise material estimation reduces excess materials and associated chaos."*

- **KI-10**: *"Efficiency in manufacturing leads to less scrap and optimal material usage."*

The stakeholders also perceived that innovative design features, such as reflective paints and translucent roofs, reduced energy consumption:

- **FGD-01**: *"Roofs are partly galvanised and translucent, reducing energy bills."*

- **KI-14**: *"Offsite innovation promotes energy efficiency."*

Umah and Khamidi (2012), Ho *et al*. (2018), Sutrisna *et al*. (2023)and Simpeh & Smallhood (2018) highlight offsite construction's sustainability, lower carbon footprint and material conservation. Matamanda *et al*. (2022) and Gee *et al*. (2020) emphasise energy efficiency and reduced environmental impact.

The participant perceptions indicated that offsite innovation in Zimbabwe suffered from several constraints, including regulatory constraints, economic limitations, skill and knowledge deficits, low end-user awareness, resource constraints and procurement issues.

Regulatory Lag

The participants perceived those outdated by-laws and building codes restricted the adoption of offsite construction methods:

- **KI-14**: *"Outdated codes such as the 1976 Model Building By-laws restrict adoption of modern technologies and methods including offsite innovation."*

- **KI-26**: *"Currently we don't have the by-laws to support steel fabrication because the 1976 laws fail to accommodate such innovations."*

Previous studies (Ugochukwu-Chioma, 2020; Gibb, 2019) highlighted regulatory rigidity as a global barrier to offsite construction, emphasising the need for legal reform to enable innovation adoption.

Knowledge Gaps

The results indicated that shortage of skilled labour also limited effective implementation.

- **FGD-02**: *"Due to massive migration of construction sector artisans, skilled labor is in short supply leading to innovation challenges."*

- **KI-27**: *"Offsite innovation is a practice that started in developed countries… we do not have sufficient knowledge as artisans."*

A lack of awareness about offsite methods among professionals restricts adoption.

- **KI-23**: *"Industry leaders seem to be in the dark regarding offsite innovation and the industry is missing out on a world of opportunity."*

- **KI-05**: *"…we haven't taken much advances in terms of how steel structures are being done…"*

Traditional mindsets and fear of risk also hampered uptake.

- **KI-15**: *"The construction sector… is difficult to address this traditional mindset to adopt new technologies like offsite innovation."*

- **KI-20**: *"There is personal risk to office bearers in terms of losing their jobs so they may not support the adoption of offsite innovation."*

Studies by Gibb (2019) and Li *et al*. (2018) underscored the role of skills shortages, limited knowledge and resistance to change as critical barriers to offsite construction adoption.

End-user Awareness

Low end-user awareness and misconceptions in terms of limited client knowledge and cultural preferences restrict demand for offsite innovation.

- **FGD-01**: *"There is a lot of confusion about what offsite innovation can really do… some think it's only for big corporations."*

- **KI-21**: *"People are afraid of experimenting with their hard-earned money."*

Sun *et al*. (2020) noted that low awareness and misconceptions among clients can significantly slow the adoption of innovative construction practices, highlighting the importance of education and engagement.

Resource limitations

Inadequate fabrication infrastructure and transport facilities impede innovation in the sector as well.

- **KI-19**: *"The challenges are also related to transport models where at times it's difficult to transport modules constructed elsewhere."*

- **KI-23**: *"The transportation sector is not ready to accommodate changes in steel construction. Our Lorries normally carry 12-metre lengths…"*

Financial constraints and macroeconomic challenges impeded investment in offsite innovation.

- **KI-01**: *"Economic sanctions have destroyed the appetite for construction in general… Construction is happening, but if there were no sanctions, there would be a boom in construction and offsite innovation."*

- **KI-06**: *"Most technologies have to be bought from outside which means you have to pay in foreign currency…"*

As Darko *et al*. (2017) noted, economic instability and limited access to financing remained key inhibitors of construction innovation, particularly in developing economies.

Additionally, lack of funding reduces capacity to adopt innovations.

- **KI-17**: *"Banks are still warming up to funding innovation, but the uptake is still slow."*

Weak institutional (government) backing also constrains implementation.

- **KI-10**: *"There is no will on the part of the government… the culture is very bureaucratic."*

- **KI-18**: *"The government has not provided funding towards offsite innovation. I have not come across anything like that."*

Darko *et al*. (2017) and Gibb (2019) indicated that resource limitations, including financial, infrastructural and institutional support, were persistent barriers to offsite construction adoption globally.

Procurement challenges

Procurement challenges were also noted relative to the difficulty of accessing quality materials that limited construction efficiency.

- **FGD-01**: *"There are procurement challenges in relation to access to steel limiting our capacity to secure usable materials as an industry."*
- **FGD-03**: *"There is basically no local supplier of ideal steel products, so the majority import their material and this increases the cost of imports."*

As Li *et al*. (2018) highlight, procurement inefficiencies and supply-chain limitations reduce the feasibility of offsite construction in emerging economies.

Conclusion and Recommendations

The study findings revealed that offsite construction innovation in Zimbabwe was emerging**,** lagging global counterparts. While some firms began adopting innovative practices, uptake was fragmented and uneven**,** reflecting both enthusiasm among early adopters and scepticism among more conservative actors. Participants noted that the slow adoption of Industry 4.0 technologies risked constraining efficiency, productivity and competitiveness. Nonetheless, the growing integration of sustainability practices signalled a positive trend, offering opportunities to reduce the industry's carbon footprint. As the results suggested, greater awareness and cultural shifts were required to accelerate adoption. This aligned with the literature, which stresses that industry-wide awareness campaigns and capacity building were essential precursors for mainstreaming innovation (Gibb, 2019; Pan & Goodier, 2012).

Where adoption occurred, it was largely necessity-driven as participants emphasised that external shocks such as the COVID-19 pandemic catalysed innovation, compelling firms to rethink traditional practices. Other enablers included growing government support, collaborative efforts within the industry and access to imported steel. However, respondents cautioned that the range of drivers remained narrow, which explained the sector's lethargic uptake. These findings resonated with previous scholarship. (Li *et al*., 2018), which noted that while crises could accelerate adoption, sustained uptake requires structural incentives and long-term policy support.

Where adopted, offsite construction innovation yielded a broad spectrum of tangible benefits, including improved quality and reliability**,** greater cost-effectiveness and faster construction timelines, for enhanced project outcomes and client satisfaction. Additionally, offsite practices were linked to sustainability gains, supporting environmental conservation while reducing the sector's overall carbon footprint. These outcomes reinforced the triple bottom line impact on people, planet and profit, consistent with global findings by Darko *et al*. (2017) and Sun *et al*. (2020). The evidence suggests that further adoption could amplify these benefits across the construction value chain in Zimbabwe.

However, significant barriers persisted, limiting the expansion of offsite practices. The most prominent constraint was the absence of enabling regulatory frameworks, which created an uncertain environment for innovation. Participants also pointed to a skills deficit, with local capacity insufficient to meet sectoral needs, thereby necessitating reliance on imported expertise, particularly from China. Broader economic instability and fiscal challenges further dampened investment and innovation. These findings underscored the importance of addressing institutional, human capital and macroeconomic constraints if offsite construction innovation was to thrive. This was consistent with global literature, which highlighted the pivotal role of policy alignment and skills development in creating innovation-ready construction sectors. (Blismas & Wakefield, 2009; Pan *et al*., 2018).

Recommendations

In view of the above findings, the study proposed a set of targeted recommendations directed at key stakeholders to accelerate the adoption of offsite construction innovation in Zimbabwe's steel fabrication and erection sector.

Government of Zimbabwe

The participants implored the government to do the following:

1. Implementing targeted awareness campaigns to shift perceptions of steel as a durable and cost-effective long-term investment.
2. Collaborating with architects and designers to promote the aesthetics of steel structures through exhibitions, advertisements and demonstration projects.
3. Revising legislation and building bylaws to integrate modular and offsite construction methods, while streamlining approval processes.
4. Establishing a Major Projects Authority to oversee large-scale infrastructure delivery with innovation goals in mind.
5. Supporting the local steel industry through export quotas and diversified investments beyond Manhize and controlled imports that protected local manufacturing while enabling access to advanced technologies.
6. Providing financial incentives and training support, including sponsored exchange programmes for engineers and regulators to build expertise in offsite methods.

Professional industry bodies

Institutions like the Construction Industry Federation of Zimbabwe and the Zimbabwe Institute of Engineers should:

1. Promote knowledge dissemination through seminars, exhibitions and guest lectures at tertiary institutions.
2. Advocate for enabling policies via structured engagement with government and regulators.
3. Influence education by integrating industry-relevant offsite construction modules into curricula.
4. Facilitate study tours, exchange programmes and awards to display innovation and global best practices.

Universities and research institutions

Higher learning institutions to:

1. Embed practical, hands-on training in design software, fabrication and prototyping into engineering and architecture curricula.
2. Establish innovation hubs and partnerships with industry for collaborative research and technology transfer.

3. Support student-led research, commercialisation and early exposure to modern construction methods.
4. Collaborate with international universities to adapt globally proven technologies to local contexts.

Steel manufacturers and fabricators

Local manufacturers, including Manhize, to:

1. Invest in local production capacity and customised fabrication machinery to reduce reliance on imports.
2. Pursue technology partnerships and on-site training with international firms.
3. Expand product offerings to include aesthetic and functional steel solutions.
4. Collaborate with transport specialists to develop efficient logistics systems for modular steel units.
5. Engage communities through open plant tours and outreach to build public trust and awareness.

Future research

1. To expand the scope of inquiry to include other cities and regions across Zimbabwe to promote the generalisability of findings and allow for comparative insights into how different geographical contexts shape the adoption and diffusion of offsite construction innovation.

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