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Beyond Operational Efficiency: Lean-Agile Practices and Social Sustainability Outcomes in Off-Site Construction

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ABSTRACT

Off-site construction (OSC) is increasingly adopted to improve efficiency in the building sector; however, its implications for social sustainability, particularly employee retention and safety, remain underexplored. Moving beyond efficiency-centred views, this study examines how Lean-Agile practices influence social sustainability outcomes in OSC firms. Anchored in Stakeholder Theory and Socio-Technical Systems (STS) theory, the study focuses on the effects of Value Stream Mapping (VSM) and Just-In-Time (JIT) practices on employee retention and safety. Survey data were collected from 180 professionals in OSC firms and analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The results show that both VSM and JIT have significant positive effects on employee retention and safety, with VSM exerting a stronger influence on retention. These findings suggest that Lean-Agile practices function not only as operational efficiency tools but also as enablers of social sustainability when embedded within coordinated work systems. The study contributes empirical evidence from a developing-economy context and offers practical insights for integrating Lean-Agile methodologies with workforce-centred objectives to promote safer and more socially sustainable off-site construction environments.

Keywords: *Lean-agile practices; social sustainability; off-site construction; value stream mapping; just-in-time; employee safety.*

1. INTRODUCTION

The construction industry has increasingly recognized the need for sustainability in recent times, especially in terms of social sustainability. In the contexts of the construction industry, social sustainability refers to the fair and equitable treatment of individuals and communities affected by construction activities, ensuring their participation, access to resources, and protection of their rights**.** It fosters community engagement, promotes social justice, and addresses stakeholders' diverse needs and aspirations (Eizenberg & Jabareen, 2017; Akhtar, Khan, Tahir, Ullah, & Waheed, 2024). Offsite construction (OSC) involves the manufacturing of elements, components, or modules in a factory before being pre-assembled, and installed on a construction site **(**Ofori-Kuragu,Osei-Kyei, & Wanigarathna, 2022)**.** However, integrating social sustainability principles within offsite construction remains under-explored, especially when aligned with the lean construction approach which has been explored under the environmental and economic dimension.

The use of offsite construction has shown to enhance construction project performance on multiple levels, including improved predictability, cut costs, shorter schedules, better quality, enhanced safety standards, reduced waste management, and lower demand for labor (O'Connor et al. 2013; Baldwin et al. 2009; Jaillon & Poon 2008; O'Connor et al. 2016; Uford, 2022). In fact, modular structures provide advantages because components can be prefabricated and mass produced, which

compounds the benefits of offsite construction, especially when the same module can be used for many structures (Tumbeva et al. 2021). Modular construction is being preferred which ensures timely delivery, also at good economic value in many countries (Sholanke, Opoko, Onakoya and Adigun, 2019). Lean construction emphasizes value creation through continuous improvement and the elimination of non-value-adding activities, directly impacting social sustainability by fostering safer work environments, better labor practices, and enhanced stakeholder collaboration (Ballard, 2021). Nonetheless, while lean and offsite construction independently demonstrate sustainability benefits, their combined impact on social sustainability dimensions such as employee safety and retention require further investigation.

Recent studies assert that social sustainability in construction projects is beyond compliance to proactive engagement with workforce welfare, diversity, and community integration (Zuo et al., 2022). The offsite construction technique offers potential to improve labor conditions compared to traditional onsite construction, which often suffers from fragmented workflows, safety hazards, and transient labor forces (Wang & Leite, 2023). Moreover, the lean approach's emphasis on collaboration and communication aligns with social sustainability goals by promoting transparency and shared responsibility among project participants (Koskela et al., 2020). Despite these positive indications, social sustainability in offsite construction within lean frameworks remains unresolved. Therefore, there is a critical need for empirical studies to assess how social sustainability considerations can be integrated into lean agile offsite construction practices to enhance social sustainability outcomes.

This study aims to address this gap by exploring the intersection between the subject matter. By investigating current practices and the perception of all stakeholders involved while contributing to the extant body of literature in regard to addressing sustainable construction practices.

2. CONCEPTUAL REVIEW

Just-In-Time Inventory Management

Just-in-time (JIT) refers to a process that ensures supplies are available in time and at the right place, at the right quality as well as quantity as demanded (Ballard and Howell, 2010). The management strategy for inventory is that of just-in-time, which ensures that raw material orders made by suppliers are put in line with production dates. This is one inventory control strategy used by companies to improve and save more money in terms of waste, as goods are received when the company requires them in the process of production, thus reducing the amount of inventory. To apply this approach, producers will have to make accurate estimates of demand. Just-in-time (JIT) is the brainchild of Toyota, Japan. It is a production philosophy, and it uses the continuous improvement concept as a way of identifying wastes and diminishing them (Bashar and Hasin, 2019). JIT aims to minimize inefficiencies and waste by only allowing the cases of acquiring the inventory when absolutely required during the production processes (Hussein and Zayed, 2021).

JIT is founded on six ideas. These can be the pull system, wastes eradication, workflow, quality management, interaction with suppliers, and senior management engagement (Pheng and Chuan, 2001). There is no need to have huge stocks under the pull method since the commodities can only be supplied when authorized requests from the demand side are being made. The idea of waste removal aims at identifying and eliminating waste that cannot add value to the end product. Thus, the principle of the pull system is highlighted with the application of the waste elimination concept, as it views inventories as a waste process. The idea of smooth flow of work attempts to follow a workflow that is continuous, as JIT tends to push towards zero hold-up. The idea of a smooth working process can never be applied when the material received is of low quality as determined by the entire concept of quality management. The focus of a long-term customer-supplier relationship is set earlier to the benefit of both parties involved in it so that the delivery of supplies needed comes in good time, in the right quality and quantity (Mfon and Uford, 2022). The positive aspects of JIT can never be realized without the engagement of top management and the participation of the employees in the process. They include cutting down the inventory, minimizing the cost of procurement, improving the aspect of market competence, establishing the long-term connection with the suppliers, and the forecast (Akintoye, 1995;

Hussein et al., 2021).JIT will minimize inventory challenges at different stages of the offsite construction supply chain by taking into consideration inventory management. Hashmi, Amirah, Yusof, and Zaliha, (2021); Rashid, Rasheed, Rahi, and Amirah, (2024), stated that proper inventory management has a notable effect on performance. An effective system of inventory control, especially in highly populated urban places, decreases the social impacts on the surrounding areas, like noise and traffic jams, hence enhancing the social welfare of the people living around the construction sites.

Value Stream Mapping

Value is the quality of a service or product as measured by a final consumer. Value stream mapping (VSM) is an imperative lean manufacturing and construction process-improvement tool. Value Stream Mapping is a significant generic tool of lean as it presents the current condition and the future condition of a process to an organization. Value stream mapping in lean practice is applicable to enhance communication and cooperation between the team members, therefore, makes it useful in any industry. VSM positively influences process ratio, TAKT time, inventory level, lead time and bottlenecks. The proposed innovation also enhanced consumer satisfaction through quality attainment, reduction of costs, and ability to deliver products in time (Jasti, Kota, and Sangwan, 2020). It allows visualization of multiple process levels, aids in waste identification and origin identification, and provides a uniform language for discussing manufacturing processes. By displaying product, material, and the flow of information, with the aid of eliminating non value-adding procedures while focusing on steps that create value. It facilitates communication between departments and improves processes. The VSM is also a basis to identify and take development and implementation strategies (Chen, Guo and Xue, 2023). The methods of VSM allow to observe the production process, as well as the environmental wastes that systematically happened, which reveals the possibility to improve the issue that remains invisible to the production control staff. This map can increase overall equipment performance, the efficiency of the manufacturing system, and communication (Al Najjar and Alsyouf, 2000; McKie,Jones, Miles, and Jones, 2021; Pech and Vaněček, 2018). One of the ways in which a value stream map can be applicable is to establish strategic orientations and make superior decisions (Gunduz, and Fahmi Naser, 2017; Haritha, Adamu, Prachi, Raut, and Ibrahim, 2025). Wu and Pheng (2011) are of the view that value stream map in the precast manufacturing is essential in the achievement of sustainability goals. As argued by Yu et al. (2009), it is possible that the work/ product flow and not single jobs would be exposed to value streaming processes so that the delay encountered by a conflict between the pre-planned schedule and the actual schedule of the building complex process would be minimized. VSM can be analyzed to improve utilization of raw materials, low environmental effects, solid waste generation to be disposed of at the landfill, as well as better problems of the society that are linked to the current threats to the health and safety of the employees (Lee, Gholami, Saman, Ngadiman, Zakuan, Mahmood and Omain, 2021).

Employee Safety

In high-risk fields such as manufacturing, oil and gas, and construction, it is particularly important to have good safety practices, as an accident or unsafe situation can cause huge financial losses, regulatory fines, and a damaged reputation (Henke & Jacques Bughin, 2016, Onukwulu et al., 2021; Uford, et al., 2022). The aim of these protocols is to minimize risks through formulation of comprehensive accident, injury and occupational disease prevention policies, processes and systems. The safety processes generally consist of risk analysis, safety training, emergency warning and frequent checking of workplaces. Moreover, employee engagement in safety programs, establishment of safety culture, and abidance to local and international regulations are critical parts of a complete health and safety program (Ebrahim, Battilana, & Mair, 2014; Soni & Krishnan, 2014; Basiru, Ejiofor, Onukwulu, & Attah, 2023).

The traditional on-site procedures compared to the off-site construction procedure tends to be a safer advantage (Killingsworth, Mehany, and Ladhari, 2020). OSC provides a significant improvements in safety plans and risk assessments as opposed to the traditional on site building practices where construction work is being done in a more controlled environment (Killingsworth et al., 2020), with

less exposure to bad weather conditions and extremes temperature, it also provides a conducive work environment, better understanding of the task at hand, the hazards involved, no need to work at heights, cases of risky activities being checked, and the level of manpower is reduced on-site when executing a project (Killingsworth et al., 2020; Fard, Terouhid, Kibert and Hakim, 2017). The nature and value of the physical work environment are assumed to influence how workers interact, execute their roles as well as their mental, physical, and emotional states (Oyetunji, 2014; Falola, Oludayo, Igbinoba, Salau, & Borishade, 2018).

An essential component of ensuring safety standards in OSC is the safety knowledge and skills that employees acquire through structured safety training (Vithanage, Sing, Davis, 2021; Fardi, Terouhid, Kibert, and Hakim, 2017). Because of this, training programs that are tailored to the needs of employees are thought to be essential to establishing a secure work environment. Through safety education and training, this is possible to better the safety behavior of employees hence eliminating the risky human behavior caused by poor technique of work and errors (Al-Hussein, 2019; Liu, Ye, Feng, 2019; Li, et al., 2019; Ikuma, Nahmens, and Aghazadeh, 2014; Ikuma, Nahmens, and James, 2011; Vithanage, Sing, and Davis, 2021). Moreover, lean methods are employed in the design and planning of OSC workplaces to enhance safety. This is essential in offsite construction projects where machines perform the majority of the operations. To find the solutions and address the issues of safety in OSC, massive collaboration between employees and stakeholders will improve the coordination and communication (Vithanage et al., 2021).

Employee Retention

Retention of employees was traditionally ignored during the planning of organizations in the early 20th century (Slade et al., 2022). Maintaining personnel has become a priority of corporate leaders as a strategic objective (Auger et al., 2022). Modern retention methods, as Auger et al. (2022) state, adopt the diverse approach. There were several policies employed by the leaders of the organization to make them gain and maintain high personnel (Slatten et al., 2021). Employee retention is the ability of an organization to maintain employees and reduce the number of voluntary turnovers (Sharma, 2021). Employee retention is a tactical and an active method of engaging and motivating employees to want to stay in the firm. In order to decrease staff turnover intentionally,

Setyaningrum et al. (2023) state that to decrease the turnover intention, it is necessary to improve the employee engagement in the employment. In the studies (Smith et al., 2017; Johnson & Thompson, 2018), a high turnover rate leads to resource wastage and increased costs of training and hiring new employees. When workers feel valued and connected to the firm's mission, they are more likely to remain invested (Etim & Uford, 2019; Smith & Martinez, 2020). Maintaining skilled workers has become a big concern to organisations worldwide. The need to maintain good and talented employees in the workplace is a debilitating concern within the corporate operating environment of every industry in the emerged and the emerging economies (Adeniji Osibanjo, Salau, Falola, Igbinoba, Ohunakin, and Ogueyungbo, 2019). Employee retention is crucial in the construction sector due to the project's complexity and challenges caused by many causes (Park et al., 2021).

3. METHODS AND MATERIALS

The research design was descriptive. The survey engaged participants from a selected construction firm in Lagos State, Nigeria, selecting a total of 331 employees as at the time of the research, which represents the population of the study. The construction industry was chosen for this research because of its peculiarity to the subject matter. Lagos State was selected for the location of this research because it is recognized as the central hub for construction activities in Nigeria. This study used the Taro Yamane formula (1967) to determine the appropriate sample size. Making use of the standard approximation formula, the resultant calculation has a 5% error tolerance and a 95% confidence level. The sample size for the study population was 180. The questionnaires were filled out online via Google Forms.

The study employed a simple random sampling technique to ensure a comprehensive

representation of the target population. It ensures an accurate representation of the subgroups within the population. Employees from various management levels and positions were selected for the study. This method ensured that each participant had an equal opportunity to be chosen to deliver educated and impartial replies. However, only individuals who were accessible and available at the time of data collection were conveniently sampled for this study. A quantitative approach was applied, using a questionnaire as the source of data collection. The questionnaire employed closed-ended questions to gather data. Section A of the survey encompassed the participants' biographical information, consisting of gender, age, educational background, job role, and tenure within the organisation. Conversely, section B are inquiries about the independent variable Lean agile practice and its impact on the dependent variable of social dimension. The study made use of a scale of five items, with response options ranging from strongly agree to strongly disagree, 4(Strongly Agree) 3(Agree), 2(Disagree), 1(strongly Disagree), and 0 (undecided). This study aims to gather the viewpoints and insights of employees from the chosen offsite construction firm regarding the impact of lean agile practices on social sustainability.

Ethical issues were addressed, allowing respondents to be anonymous, with the assurance of discontinuing at any level of participation without explaining their decisions to opt out. Participants were assured that data provided would be confidential. The respondents were not vulnerable and consented to participate in the survey without compulsion. In order to establish the content and construct validity of the research instruments, the measurement tool was reviewed by supervisors who possess expertise in the relevant field of study. Cronbach Alpha was also utilized to test the hypotheses and validate variables. The collected data were analysed using Structural Equation Modeling-Partial Least Squares (SEM-PLS) approach to deduct the relationships between lean agile practice and social sustainability of offsite construction firms in Lagos, Nigeria.

4. RESULT AND DISCUSSION

Table 1. Descriptive Statistics

Construct Code	Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness
JIT1	2.297	2	1	7	1.075	1.126	0.900
JIT2	2.416	2	1	6	1.185	0.06	0.748
JIT3	2.226	2	1	5	1.092	-0.224	0.704
JIT4	2.262	2	1	5	1.061	-0.693	0.494
VSM1	2.470	2	1	5	1.175	-0.559	0.593
VSM2	2.498	2	1	6	1.164	-0.411	0.485
VSM3	2.409	2	1	5	1.217	-0.677	0.544
VSM4	2.272	2	1	6	1.100	0.031	0.745
ER1	2.659	2	1	6	1.251	-0.476	0.512
ER2	2.606	2	1	7	1.198	0.649	0.798
ER3	2.609	3	1	6	1.165	-0.373	0.404
ER4	2.530	2	1	7	1.294	-0.225	0.675
ES1	2.323	2	1	5	1.079	-0.025	0.671
ES2	2.498	2	1	6	1.227	-0.081	0.690
ES3	2.423	2	1	7	1.239	1.009	1.042
ES4	2.470	2	1	7	1.182	0.556	0.807
ES5	2.341	2	1	6	1.168	0.362	0.912

I nflation Factor (VIF). The VIF values range from 1.076 to 1.702, all well below the conservative threshold of 3.0, indicating no multicollinearity concerns among the indicators, and confirming the structural model is stable and free from redundancy issues.

Overall, the measurement model demonstrates strong psychometric properties, confirming the reliability and validity of the constructs used to assess Lean-Agile Practices (JIT and VSM), Employee Retention, and Employee Safety in the context of off-site construction firms in Lagos. The results provide confidence in the adequacy of the measurement instruments for subsequent structural model analysis and hypothesis testing.

Table 3: Structural Equation Model Results (Test of Hypothesis)

Hypothesis	R	Path Coefficient (β)	P-value	T-value	Decision
H_{O1}: Value Stream Mapping →Employee Retention	0.73	0.377	0.000	5.351	Significant & Supported
H_{O2}: Value Stream Mapping →Employee Safety	0.51	0.255	0.000	3.425	Significant & supported
H_{O3}: Just-In-Time →Employee Retention	0.63	0.144	0.017	2.115	Significant & Supported
H_{O4}: Just-In-Time →Employee Safety	0.69	0.211	0.003	2.791	Significant & Supported

The structural model results in Table 3 and Figure 1 provide evidence of statistically significant relationships between Lean-Agile Practices specifically Value Stream Mapping (VSM) and Just-In-Time (JIT) and the dimensions of Employee Retention and Employee Safety, which represent critical aspects of social sustainability in off-site construction firms.

For Hypothesis 1 (H01), the path coefficient from Value Stream Mapping to Employee Retention is $\beta = 0.377$, with a highly significant p-value = 0.000 and a t-value = 5.351, exceeding the recommended minimum t-value of 1.96 for significance at the 5% level. The associated R value of 0.73 indicates that the model explains a substantial portion of variance in employee retention. Based on these results, H01 is supported, confirming that VSM positively and significantly influences employee retention.

Hypothesis 2 (H02) tested the effect of Value Stream Mapping on Employee Safety, yielding a path coefficient of $\beta = 0.255$, with a p-value = 0.000 and a t-value = 3.425, which is statistically significant. The R value = 0.51 reflects moderate explanatory power for employee safety. These results support H02, demonstrating that VSM significantly enhances employee safety in the off-site construction context.

Hypothesis 3 (H03) examined the relationship between Just-In-Time practices and Employee Retention, with a path coefficient of β = 0.144, p-value = 0.017, and a t-value = 2.115, all exceeding the required thresholds for statistical significance. The R value = 0.63 indicates considerable explained variance in employee retention. Thus, H03 is supported, indicating that JIT practices have a positive and significant effect on employee retention, though the magnitude of the effect is relatively modest compared to VSM.

Finally, Hypothesis 4 (H04) assessed the impact of Just-In-Time practices on Employee Safety, yielding a path coefficient of β = 0.211, with a p-value = 0.003 and a t-value = 2.791, both meeting criteria for statistical significance. The model explains 69% (R = 0.69) of the variance in employee safety. Consequently, H04 is supported, showing that JIT contributes positively to improving safety outcomes among employees.

These results collectively affirm that Lean-Agile Practices, particularly Value Stream Mapping and Just-In-Time approaches, play a significant role in advancing social sustainability outcomes, namely employee retention and safety, within off-site construction firms in Lagos.

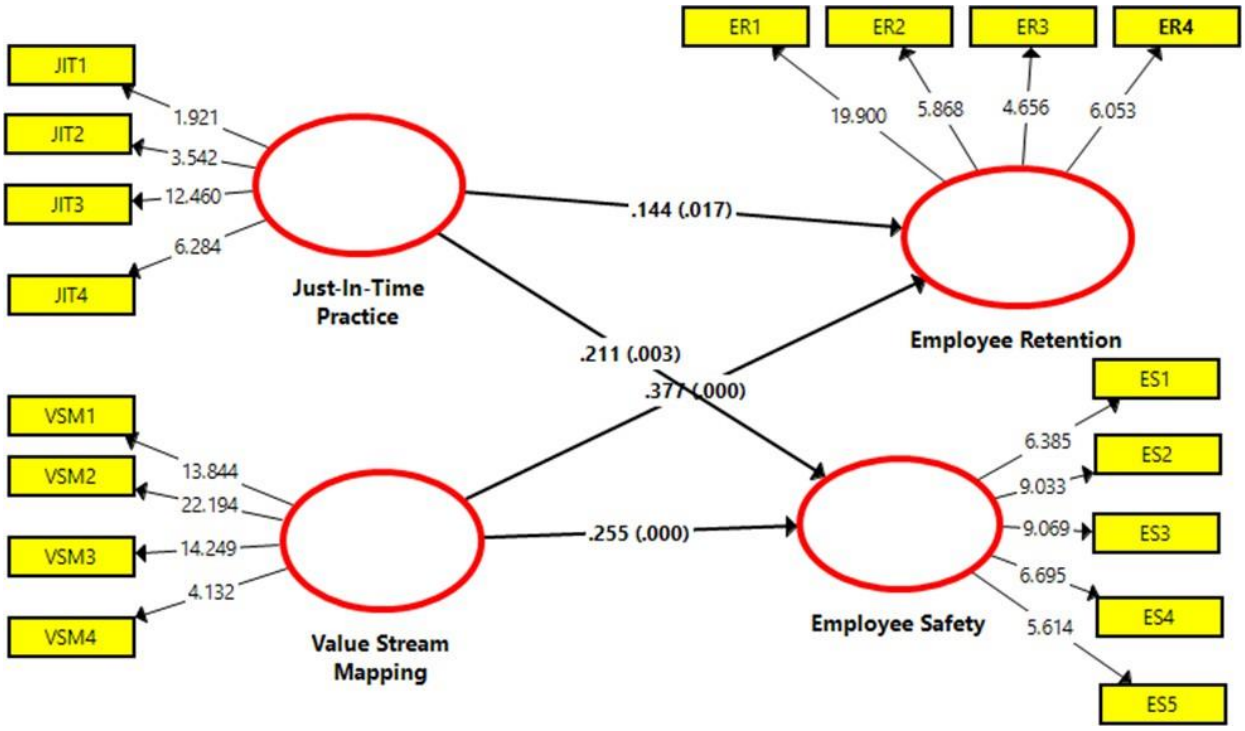

Figure 1: Structural Model Path Diagram

The results of this study reveal that Lean-Agile approach, specifically Value Stream Mapping (VSM) and Just-In-Time (JIT), have significant positive effects on social sustainability outcomes, particularly Employee Retention and Employee Safety, within off-site construction (OSC) firms in Lagos.

The findings support earlier research by Wu and Pheng (2011), who emphasized VSM's relevance in precast manufacturing for achieving sustainability goals, as well as Gholami et al. (2019) and Lee et al. (2021), who argued that VSM enhances productivity and safety while reducing waste. The positive influence of VSM on both employee retention and safety aligns with Grewal (2008) and Fontanini et al. (2013), who demonstrated that lean tools, particularly VSM, optimize workflow and contribute to a healthier work environment.

Similarly, the study confirms the work of Bashar and Hasin (2019) and Hussein and Zayed (2021) by demonstrating that JIT contributes significantly to reducing waste and fostering operational efficiency, which positively impacts employee retention and safety. This aligns with broader lean literature, such as Bajjou et al. (2017) and Li et al. (2019), which showed that lean practices reduce the root causes of accidents and create safer workspaces.

Moreover, the observed positive relationship between lean-agile practices and employee-centered outcomes expands on prior studies in OSC environments (Ahn et al., 2020; Fard et al., 2017) by empirically validating these relationships within the Lagos OSC context, a setting characterized by workforce informality, regulatory gaps, and urban pressures.

The results also affirm the theoretical foundation of this study, notably Stakeholder Theory and Socio-technical systems, by illustrating how lean-agile capabilities (internal resources) and enhanced stakeholder relations (employee welfare and safety) synergistically promote organizational resilience and social sustainability.

5. CONCLUSION AND RESEARCH IMPLICATIONS

This study investigated the effects of Lean-Agile practices, specifically Value Stream Mapping (VSM) and Just-In-Time (JIT), on the social sustainability of off-site construction (OSC) firms in Lagos, Nigeria, focusing on employee retention and safety. The findings demonstrate that Lean-Agile practices generate benefits that extend beyond operational efficiency to workforce-level outcomes. VSM exhibited a strong and significant positive influence on both employee retention and safety, indicating that improved process visibility, workflow standardisation, and waste reduction create more predictable and safer working environments. JIT practices also showed a significant, though comparatively weaker, positive effect, suggesting that disciplined material flow and timely deliveries can reduce site congestion and safety risks when appropriately managed. Together, the results highlight Lean-Agile practices as strategic enablers of social sustainability in OSC operations.

The study recommends that OSC firms institutionalise VSM with explicit social performance objectives and implement JIT alongside robust safety management systems. Policymakers and industry bodies should support Lean-Agile training programmes that incorporate social sustainability principles. Additionally, future OSC projects should integrate employee retention and safety metrics into project planning and performance evaluation frameworks to ensure balanced and sustainable outcomes.

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