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FROM REACTIVE REPORTING TO REGENERATIVE CONTROL: RETHINKING CONSTRUCTION PROGRESS MONITORING IN SRI LANKA THROUGH IOT ENABLED REAL-TIME PRACTICES

T.M.A.Y.B. Malvila[1], R.M.H.R. Bandara[2] and M. Thayaparan[3]

ABSTRACT

Construction progress monitoring remains a critical yet underperforming function in the Sri Lankan construction industry, where continued reliance on manual and semi-digital methods results in reactive reporting systems that do not align with the continuous feedback mechanisms required for regenerative construction. This study examines current progress monitoring practices in Sri Lanka and explores how IoT-enabled real-time monitoring can support a transition from reactive reporting toward regenerative control. A qualitative research approach was adopted, using semi-structured interviews with sixteen experts from the construction and information technology sectors. The collected data were analysed using qualitative content analysis based on predefined thematic categories derived from the literature. The findings indicate that progress monitoring remains largely manual, while IoT adoption is limited to fragmented applications including drone photogrammetry, RFID-based labour tracking, and barcode-based material monitoring. Major barriers include high investment costs, unreliable connectivity, limited digital literacy, and the absence of clear regulatory frameworks. The findings further reveal that these barriers are closely connected to broader structural realities within the Sri Lankan construction industry, particularly government-dominated procurement systems, economic instability, and limited institutional readiness for digital transformation. Nevertheless, considerable opportunities exist for IoT to support proactive resource management, reduce rework, and enable continuous optimisation in line with regenerative construction principles. The study contributes empirical evidence from a developing country context and reframes IoT-enabled monitoring as a socio-technical mechanism for regenerative control rather than merely automated reporting.

Keywords: *Construction Progress Monitoring; Internet of Things (IoT); Real-time Monitoring; Regenerative Control.*

[1] Undergraduate, Department of Building Economics, University of Moratuwa, Sri Lanka, malvilatmyb.21@uom.lk
[2] Temporary Instructor, Department of Building Economics, University of Moratuwa, Sri Lanka, bandararmhr.20@uom.lk
[3] Professor, Department of Building Economics, University of Moratuwa, Sri Lanka, mthayaparan@uom.lk

1. INTRODUCTION

The construction industry plays a significant role in the global economy, making a substantial contribution to the Gross Domestic Product (GDP) and generating extensive employment opportunities, particular in developing countries including Sri Lanka (Silva et al., 2025). Construction projects are inherently complex, requiring the coordination of multiple stakeholders, substantial resources, and intricate scheduling process. The time, cost, and quality control of a project lifecycle are important during the construction progress monitoring (Shamsollahi et al., 2022). Regenerative construction extends beyond traditional sustainability by focusing on adaptive systems that continuously optimise resource use while minimising long-term environmental impacts. Therefore, accurate progress monitoring is essential to support adaptive decision-making and continuous system improvement (Sertyesilisik, 2016).

Despite global technological advancements, construction progress monitoring still relies heavily on traditional manual methods including site inspections, daily progress reports, and scheduled site visits (Rehman et al., 2023). These time-consuming data collection procedure and periodic assessments are becoming increasingly inadequate for the complex demands of modern projects (Omar, 2018). Manual reporting often results in delayed communication, subjective assessments, and overlaps in data collection which slow down corrective actions (Rehman et al., 2023; Shamsollahi et al., 2022). In a regenerative context, where continuous resource optimization and minimal environmental impact are key objectives, delayed and reactive reporting systems become highly detrimental, as these practices often lead to increased rework, material waste, and cost overruns (Pal et al., 2023).

To bridge the gap between reactive reporting and proactive control, industry 4.0 technologies, particularly the Internet of Things (IoT), have emerged as important transformative enabler (Naji et al., 2024). The concept of the IoT, first introduced by Kevin Ashton in 1999, refers to a network of sensors, devices and software that can collect and exchange data automatically without human intervention (Ashton, 2009). In construction IoT applications supports a shift from periodic oversight to continuous project control by enabling real-time progress tracking, predictive maintenance, and more efficient resource management across all project phases (Khan et al., 2024).

While global studies highlight the advantages of IoT in construction monitoring (Kim et al., 2025), developing economies continue to experience a significant gap between technological potential and practical implementation. The Sri Lankan construction industry remains relatively slow in adopting digital technologies due to low digital infrastructure, insufficient technical expertise, economic instability, fragmented subcontracting systems, financial constraints, and resistance to organisational transparency (Sendanayake et al., 2024). Current literature highlights a notable gap: the role of IoT-enabled real-time progress monitoring as an operational mechanism for regenerative construction within developing economies remains insufficiently explored. Existing studies largely focus on technical performance and automation capabilities in developed contexts, with limited attention given to the socio-economic, institutional, and procurement realities that shape technology adoption in financially constrained construction environments.

Therefore, this paper investigates current construction progress monitoring in Sri Lanka and examines how IoT-enabled real-time monitoring can support a transition from reactive reporting to regenerative control. Although numerous studies highlight the technical capabilities of IoT for automated monitoring, limited empirical research has explored how these technologies can transform traditional progress monitoring practices to support regenerative construction principles in developing economies. Furthermore, limited studies have critically examined how government procurement systems, financial instability, institutional culture, and regulatory environments influence the feasibility of IoT-enabled regenerative control in developing construction industries such as Sri Lank.

2. LITERATURE REVIEW

2.1 TRADITIONAL CONSTRUCTION PROGRESS MONITORING PRACTICES

Construction progress monitoring serves as a fundamental project management function aimed at tracking task completion and optimizing resource allocation over time (Rehman et al., 2023). Traditionally, document-based, labour-intensive task procedures including handwritten site reports, physical site visits, and photographic evidence have been relied on in this required process (Rehman et al., 2023). To evaluate performance, project managers typically utilize foundational visual tools including Gantt charts, s-curve, and milestone schedules to compare planned baselines against actual site execution (Suvvari & Saxena, 2024). Furthermore, Earned Value Management (EVM) is often incorporated into traditional project management practices to provide a quantitative evaluation of scope, cost, and schedule performance (Alvarez et al., 2022).

Despite their long-standing use, these conventional techniques rely largely on human observation and manual data collection, resulting in significant delays in identifying operational deviations (Gamil et al., 2023). This time-consuming nature of manual data collection places a considerable burden on site supervisors and produces subjective reporting that ultimately compromise data reliability (Gamil et al., 2023). Because the data collection and communication processes are periodic rather than continuous, a significant time lag arises between actual site events and the distribution of progress updates (Samsami, 2024). These delayed reporting mechanisms also make the project management teams unable to institute proactive interventions, resulting in issues being addressed only after escalation (Omar, 2018). As modern infrastructure initiatives increase in scale and complexity, the inefficiencies of these static, paper-based systems become increasingly difficult to mitigate (Khan et al., 2024). The dynamic and highly competitive nature of modern construction demands a level of operational agility that static reporting methods are unable to provide (Alaloul et al., 2022).

When used independently, traditional monitoring methods are rarely connected to digital scheduling or cost control systems, leading to fragmented project management (Dilaksha et al., 2024). The lack of geometric accuracy and the difficulty in directly comparing actual site conditions with planned models further reduce the reliability of visual estimations (Dilaksha et al., 2024). Traditional monitoring approaches rely heavily on manual observation and periodic reporting, which creates significant delays between site activities and management awareness. Ultimately, traditional monitoring is incompatible with regenerative construction goals, which demand continuous optimization and dynamic responsiveness to environmental constraints(Rehman et al., 2023).

2.2 REAL-TIME PROGRESS MONITORING AND IOT IN CONSTRUCTION

To address the profound limitations of manual tracking, the construction sector is transitioning toward real-time progress monitoring through the integration of digital, automated frameworks (Qureshi et al., 2023). This transformation is largely driven by the IoT, which links physical site elements with digital systems to create intelligent, data-driven environments (Qureshi et al., 2023). The deployment of wireless sensor networks (WSNs) forms the fundamental perception layer that monitors site conditions automatically transmit data (Hudda & Haribabu, 2025). Modern automated monitoring integrates diverse sensor technologies, including Ultra-Wideband (UWB) and Bluetooth Low Energy (BLE) for precise indoor localisation, and Radio Frequency Identification (RFID) tags placed on construction materials to monitor delivery and installation progress without manual input (Aziz & Koo, 2025).

The real value of these integration lies in their ability to maintain continuous data flows rather than simply adoption technology (Kozlovska et al., 2021). Continuous data capture from distributed IoT networks eliminates the information latency that traditionally hinders project coordination and decision-making (Musarat et al., 2024). Automated status updates generated by these systems enable site planners to compare actual work progress with 4D scheduling models more efficiently (Liu et al., 2025).

Consequently, this continuous feedback loop enables the early detection of discrepancies allowing supervisors to identify minor deviations long before they manifest as critical path delays (Radman et al., 2025). Edge computing further enhances this functionality by processing sensor data directly at the source, thereby reducing bandwidth strain and delivering near real-time alerts to site personnel (Musarat et al., 2024). Furthermore, machine learning algorithms are increasingly applied to this sensor data to convert raw site information into predictive insights on potential cost overruns and schedule delays (Marengo, 2024). These technologies enable continuous visibility of construction activities, allowing project managers to identify deviations earlier than traditional monitoring methods (Musarat et al., 2024).

2.3 PROGRESS MONITORING AS AN ENABLER OF REGENERATIVE CONSTRUCTION

The concept of regenerative construction extends beyond basic sustainability by actively focusing on systems that renew resources and minimize long-term ecological impacts throughout the building lifecycle (Alqahtani et al., 2024). Unlike conventional sustainability approaches that primarily focus on reducing negative environmental impacts, regenerative construction seeks to create adaptive systems capable of restoring ecological balance, optimising long-term resource efficiency, and generating continuous environmental and operational value throughout the project lifecycle (Oyefusi et al., 2024). Therefore, achieving regenerative construction objectives requires project execution to become more data-driven, adaptive, and supported by continuous feedback mechanisms (Maqbool et al., 2023). Real-time progress monitoring plays a key role in enabling this shift by providing accurate and timely information that helps improve material use and labour efficiency on construction sites (Althoey et al., 2024). Automated tracking of materials via IoT directly improves supply chain visibility, which is a critical factor in reducing unnecessary material waste and preventing over-ordering on complex projects (Liu et al., 2025).

Promoting circular economy practices on construction sites requires clear and real-time visibility of reusable materials to reduce unnecessary waste and support resource recovery processes (Liu et al., 2025). Furthermore, continuous monitoring facilitates better resource utilization by allowing managers to analyse live usage data and instantly divert idle equipment to areas with higher operational demand (Soleymani et al., 2022). This level of site visibility supports adaptive planning, allowing construction teams to adjust short-term schedules quickly in response to unexpected disruptions (Radman et al., 2025). By combining real-time environmental sensors with progress tracking, quality control becomes a proactive process, helping to reduce defective work and minimize the need for carbon-intensive rework (Hong & Guo, 2025).

Reducing rework directly lowers overall environmental impact by avoiding the repeated use of raw materials, heavy machinery fuel, and human effort (Munianday et al., 2024). Using IoT telematics to implement predictive maintenance for heavy machinery helps prevent unexpected breakdowns, allowing construction activities to proceed more efficiently and sustainably (Althoey et al., 2024). Additionally, monitoring temporary works and site energy consumption via smart metering allows for precise demand profiling, ensuring that power usage is minimized without hindering daily productivity (Hong & Guo, 2025).

Integrating lean logistic with IoT data streams supports regenerative practices by reducing site bottlenecks and enabling smoother coordination between different trade contractors (Liu et al., 2025). Consequently, the economic benefit of reducing delays and waste intersect perfectly with environmental responsibility, creating a strong case for adopting digital technologies (Ghosh et al., 2021). Regenerative construction therefore depends heavily on real-time visibility, continuous learning, and adaptive decision-making processes capable of responding dynamically to changing site conditions (Sertyesilisik, 2016). Within this context, IoT-enabled monitoring systems can operationalise regenerative principles by enabling continuous feedback loops, proactive interventions, predictive resource allocation, and minimisation of waste generation throughout the project lifecycle (Mahmud, 2025). Although global applications demonstrate significant benefits, considerable economic, technical, and cultural barriers still hinder the integration of this advanced system in many regions (Massoud et al., 2025). Developing economies face unique challenges, including fragmented supply chain and unreliable digital infrastructure, which make the smooth adoption of these regenerative technologies more difficult (Waqar et al., 2024).

In addition to these technical constraints, institutional factors such as limited regulatory frameworks, fragmented procurement systems, financial instability, and low organisational readiness further influence the feasibility of regenerative digital transformation within developing construction contexts. Despite the recognised potential of real-time monitoring technologies, limited empirical studies have examined how such systems can operationalise regenerative construction principles in developing construction contexts.

3. METHODOLOGY

This study adopted an exploratory qualitative research design to investigate the transition from reactive reporting to regenerative control through IoT-enabled real-time progress monitoring in Sri Lankan construction industry. A qualitative survey strategy was selected to systematically capture exploratory insights from professionals, as qualitative methods help researchers explore real situation, understand professional perspectives, and develop theoretical insights (Oranga & Matere, 2023). Data collection commenced with a literature review to build the strong theoretical foundation for the study (Snyder, 2019), followed by semi-structured interviews were chosen due to their flexibility, allowing for the collection of in-depth and detailed information, linking broader patterns to individual experiences (Littig, 2009). To ensure relevance and expertise, a non-probability sampling method, incorporating snowball sampling, was used to make the selection of respondents more effective, as it enables the selection of participants with relevant knowledge and experience (Vehovar et al., 2016). The sample comprised 16 experts, 8 from information technology (IT) sector and 8 from the construction industry, ensuring a balanced perspective between technological capabilities and site-level realities. The investigation specifically focused on current progress monitoring practices, the baseline awareness and use of IoT, perceived implementation challenges, and the potential opportunities for achieving regenerative outcomes. Interviews were conducted until data saturation was reached and no new themes or insights emerged. Each interview lasted approximately 30–45 minutes. Data saturation was assessed through continuous comparison of interview responses and coding patterns across both construction and IT professionals. Saturation was considered achieved when later interviews produced repetitive insights with no substantially new codes or perspectives emerging across the predefined thematic categories (Saunders et al., 2017). Finally, the collected qualitative data were analysed using directed qualitative content analysis informed by predefined thematic categories adapted from existing literature and interpreted using coding principles proposed by Braun and Clarke (2006) to identify meaningful patterns in the text. The analytical framework was deductively structured around four predefined themes identified from the literature review: current progress monitoring practices, challenges, opportunities, and regenerative implications while still allowing iterative interpretation of emerging expert insights during the coding process. This approach enabled the synthesis of multidisciplinary perspectives into cohesive and practice-focused conclusions.

Table 1: Profile of the experts

Expert Code	Sector	Designation	Experience
E1	Construction	Civil Engineer	22 years
E2	Construction	Quantity Surveyor	4 years
E3	Construction	Planning Engineer	14 years
E4	Construction	Project Manager	24 years
E5	Construction	Technical Officer	7 years
E6	Construction	Civil Engineer	28 years
E7	Construction	Civil Engineer	11 years
E8	Construction	Planning Engineer	6 years
E9	IT	IoT Engineer	11 years
E10	IT	IoT Engineer	8 years
E11	IT	Electronic Engineer	5 years
E12	IT	Software Engineer	14 years
E13	IT	Software Engineer	6 years

Expert Code	Sector	Designation	Experience
E14	IT	Telecommunication Engineer	5 years
E15	IT	IoT Engineer	9 years
E16	IT	Network Engineer	15 years

4. FINDINGS

4.1 CURRENT PROGRESS MONITORING PRACTICES IN SRI LANKA

Construction progress monitoring in Sri Lanka largely continues to rely on manual and semi-digital methods, with only selective adoption of advanced tools confined to a few organisations. The most widely practiced progress monitoring approaches are still based on traditional site documentation and regular reporting. Daily site visits and Daily Progress Reports (DPR) were identified by E1, E3, E4, E5, and E6 as standard practice, indicating that physical presence and manual recording remain the dominant means of capturing progress on Sri Lankan construction sites. Expert E1 confirmed that *"Site engineers and technical officers record daily work quantities in daily progress reports"*, illustrating the labour-intensive nature of this data collection process. Photographic documentation of completed works and inspection-based verification of major construction activities further reinforce the reliance on human observation as the primary means of progress assurance. Progress monitoring through periodic meetings was also confirmed by E1, E3, E4, and E7. Expert E7 elaborated that *"In most of the projects I have been involved in, progress monitoring is also reviewed during periodic progress meetings where the team discusses completed work, delays, and the activities planned for the next period"*.

A secondary layer of semi-digital practices, mainly involving spreadsheet applications and scheduling software, was commonly observed among the experts. Excel-based reporting and monitoring emerged as the most adopted digital practice, highlighted by E1, E2, E3, E4, E5, E6, E7, and E8, where site records are transferred into spreadsheet files for tracking and reporting purposes. Expert E8 provided a detailed account of this workflow, noting that *"I send out blank Excel templates to the site execution team every Thursday. They fill in the percentage completion for each activity and send it back to me on Friday. Over the weekend, I cleaned that data and input it into P6 to update the schedule"*. Expert E5 further noted that *"some companies use shared Excel files or Google Sheets where daily quantities are entered instead of maintaining only paper records"*. Schedule-based monitoring using Microsoft Project or Primavera P6 was confirmed by E1, E3, E4, E6, and E8, with E3 elaborating that *"we usually develop detailed schedules using Primavera or MS Project, including activity sequencing, resource allocation, and milestones"*.

More advanced digital monitoring tools were also identified, although their use was limited to a smaller number of organisations. Dashboard-based systems were reported by E2, E4, and E8, while ERP-based monitoring platforms were mentioned by E1 and E2. E2 stated *"In some advanced companies, progress is monitored through mobile applications that directly update a centralised ERP system"*. E4 reinforced this. Drone-based aerial monitoring of construction progress was identified by E2, E3, E5, and E6 as an emerging practice. Despite these emerging applications, E1 emphasized the overall situation by stating that *"progress monitoring in Sri Lanka remains a semi-digital* *process, heavily dependent on human reporting and documentation"*. These findings indicate that construction progress monitoring in Sri Lanka remains largely reactive, with limited capability to detect deviations in real time.

4.2 LEVEL OF IOT ADOPTION FOR REAL-TIME PROGRESS MONITORING

IoT adoption within Sri Lankan construction remains low to moderate, with existing applications largely confined to planning support, safety monitoring, and asset tracking rather than real-time progress control. The most identified IoT-related devices were used for workforce and safety management. E2 and E7 mentioned the use of fingerprint scanners and site-wide CCTV systems. E7 noted that *"We use fingerprint scanners for our direct labour attendance, so we know exactly how many of our own guys are on site"*. These systems can be considered IoT-based because they collect and transmit real-time workforce data through connected digital devices. E6 described the use of weekly drone photogrammetry surveys for earthwork verification. RFID-based labour monitoring systems were cited by E2 and E6. Expert E6 noted that *"some projects have begun experimenting with RFID-based labour monitoring systems, where RFID tags attached to workers' helmets"*, are used to track workforce activity, indicating early experimentation with automated technologies.

The most structured IoT implementation identified was reported by E2, who deployed a barcode-based tracking system in which *"Each precast module had a barcode, and progress was tracked using sensors and mobile applications integrated into a central ERP system"*, demonstrating that sensor-driven automated data capture is technically feasible within the local context but remains confined to isolated project applications. E8 confirmed that *"The visualization is digital, but the data feed is totally manual"*, indicating that although some digital tools are used, real-time IoT-based progress monitoring is still largely absent in Sri Lankan construction projects. While several emerging digital tools were identified, their implementation remains fragmented and insufficient to establish a fully automated monitoring system. These findings suggest that Sri Lanka is positioned at an early experimental stage of IoT adoption, where isolated applications exist but systemic, project-wide deployment has yet to emerge. Understanding why this gap persists requires examining the barriers that constrain broader implementation.

4.3 BARRIERS TO IOT IMPLEMENTATION

The implementation of IoT-enabled real-time progress monitoring in Sri Lanka is constrained by several interconnected barriers spanning financial, technical, infrastructural, and cultural dimensions. The high cost of investment was among the most prominent, with Expert E6 noting that *"Convincing a board of directors to spend millions of rupees on sensors when they are struggling to secure letters of credit for steel is very difficult"*, a concern reinforced by E3 who confirmed that *"Many organisations hesitate to invest in technology without immediate visible returns"*. Poor network connectivity was equally critical, with E7 warning that *"In a concrete high-rise under construction, getting a stable internet signal is very difficult because concrete walls block the signal"*. A similar challenge was also noted by E2, who experienced that reliable internet connectivity was unavailable even on the upper floors of a 30-storey project. Resistance to change extended into deliberate avoidance of transparency, as E8 observed that *"Some project managers prefer the manual system because it allows them to adjust the numbers* *and conceal small delays",* while E6 highlighted that *"A lot of imported IoT devices are not built for Sri Lankan site conditions and will break within a week"*. Limited awareness at decision-maker level further compounds adoption, with E10 noting that *"Many organisations hesitate because they are not sure how quickly IoT adoption will generate measurable benefits"*. These challenges, collectively confirmed across both construction and IT professionals, are comprehensively summarised in the following table.

Table 2: Barriers to IoT implementation for real-time progress monitoring in Sri Lanka

Barrier	Experts Who Agreed
High initial investment and financial constraints	E1, E2, E3, E4, E6, E9, E10, E11, E14, E15, E16
Limited technical knowledge and expertise among construction professionals	E1, E2, E3, E4, E5, E9, E10, E15
Resistance to change and conservative industry culture	E1, E2, E3, E4, E5, E6, E7, E8, E9
Poor or unreliable internet connectivity on construction sites	E1, E2, E3, E7, E9, E10, E11, E13, E14, E15, E16
Difficulty integrating IoT with management existing systems	E3, E4, E8, E12
Data privacy and cybersecurity concerns	E8, E12, E13, E14
Lack of clear industry standards and guidelines for IoT adoption	E3, E9, E12, E14, E16
Limited awareness of the practical benefits of IoT technologies	E1, E3, E9, E14, E15
Device durability and harsh site conditions	E5, E6, E9, E11, E15

4.4 OPPORTUNITIES FOR REGENERATIVE CONTROL

Collectively, these barriers reveal that the challenge of IoT adoption in Sri Lanka is not merely technical but is deeply embedded in the financial constraints, cultural resistance, and institutional gaps that characterise the broader construction environment. Despite these constraints, the experts also identified a range of practical opportunities through which IoT-enabled monitoring could begin to support regenerative construction outcomes. IoT-enabled real-time monitoring can help move the Sri Lankan construction industry from reactive reporting to regenerative control by supporting continuous feedback, better decision-making, improved resource management, and waste reduction. E3 highlighted this potential by stating that *"IoT allows automatic data capture, which can directly support planning and decision-making",* indicating a shift from periodic, manual updates toward more continuous and system-driven monitoring. Moreover, Expert E1 confirmed that *"When deviations from the plan are identified early, corrective actions can be taken before costs increase"*, highlighting how real-time data creates the feedback loops essential to regenerative control rather than reactive intervention.

A key opportunity highlighted by several experts was the potential to reduce resource waste and idle time by enabling real-time visibility of labour, materials, and equipment on site. Expert E6 explained that *"If I can see on a dashboard that the cement trucks haven't left the plant, I can instantly reassign my masonry gang to another task before the day is wasted"*. Similarly, E7 noted that tracking material consumption can prevent over-ordering and reduce waste, while E2 added that RFID-based material tracking *"Reduces wastage and prevents disputes regarding material quantities"*, further linking automated monitoring to measurable reductions in unnecessary resource consumption.

Furthermore, IoT offers significant opportunities for proactive quality control, central to minimising the rework that regenerative construction seeks to eliminate. Expert E5 noted that *"Sensors can monitor curing conditions in real time, helping us decide when to remove formwork or proceed with the next activity safely"*, while E6 reinforced this by describing how embedded concrete temperature sensors allow formwork to be stripped the moment required strength is reached, *"Rather than waiting a conservative 7 or 14 days just to be safe"*. These capabilities collectively represent the transition from a reactive, document-driven industry toward a regenerative, data-driven construction ecosystem.

5. DISCUSSION

The findings of this study show that construction progress monitoring in Sri Lanka is still largely reactive, relying heavily on manual data collection, periodic reporting, and human judgement. As identified in both the literature review and expert interviews, progress monitoring practices remain dependent on daily site inspections, spreadsheet-based reporting, and periodic progress meetings. These findings are consistent with Rehman et al. (2023) and Samsami (2024), who highlighted that traditional monitoring systems create delays between actual site events and management awareness. Such delays limit the ability to implement proactive interventions and contribute to rework, material waste, resource inefficiencies, and schedule overruns, all of which contradict regenerative construction principles that depend on continuous optimisation and adaptive decision-making.

According to the literature review and expert findings, IoT technologies offer a clear pathway to transform this reactive monitoring system into a more adaptive and regenerative process through sensor-driven data capture, RFID tracking, drone photogrammetry, and BIM-integrated monitoring platforms. However, the findings indicate that IoT implementation within Sri Lankan construction projects remains fragmented and limited to isolated applications including barcode-based material tracking, drone-assisted earthwork verification, and RFID-based labour monitoring. These findings suggest that Sri Lanka currently remains at an early experimental stage of IoT adoption where digital technologies are used selectively rather than systematically integrated into project-wide progress monitoring frameworks.

The study further reveals that barriers to IoT implementation are not purely technological but strongly connected to broader structural and institutional realities within the Sri Lankan construction industry. Key challenges identified by the experts include high initial investment costs, poor internet connectivity, limited technical expertise, resistance to organisational transparency, and harsh site conditions affecting device durability. These findings align with previous studies conducted within developing economies, which emphasise that financial instability, inadequate infrastructure, and fragmented industry practices significantly hinder Industry 4.0 adoption (Waqar et al., 2024). Importantly, the findings indicate that digital transformation in construction should be understood as a socio-technical and institutional challenge rather than simply a technological transition.

The dominance of government-funded projects within Sri Lanka further shapes the feasibility of IoT implementation. The government functions not only as the primary regulator but also as the largest client and procurement authority within the construction sector. Consequently, decisions regarding digital adoption are heavily influenced by procurement systems, contract conditions, reimbursement structures, and regulatory requirements established through public projects. Several experts highlighted that contractors facing financial hardship are unlikely to independently invest in expensive IoT infrastructure without client-driven requirements or financial support mechanisms. Therefore, large-scale adoption is unlikely unless procurement reforms, reimbursable digital implementation costs, and government-supported pilot initiatives are introduced.

Despite these constraints, the findings demonstrate considerable opportunities for IoT-enabled monitoring to support regenerative construction outcomes. Experts identified that real-time visibility of labour, materials, and equipment can improve resource allocation, reduce idle time, minimise material waste, and support proactive quality control. These findings support the argument of Liu et al. (2025) that continuous monitoring enhances operational efficiency and enables more adaptive construction management practices. Furthermore, IoT-enabled feedback systems allow early identification of deviations and facilitate corrective action before delays escalate into major operational and environmental inefficiencies. Consequently, this study contributes to the emerging regenerative construction discourse by demonstrating how IoT-enabled real-time monitoring can function as an operational mechanism for continuous feedback, adaptive decision-making, and resource optimisation within developing construction contexts.

6. CONCLUSIONS

This study examined current construction progress monitoring practices in Sri Lanka and explored how IoT-enabled real-time monitoring can support a transition from reactive reporting toward regenerative control. The findings reveal that construction progress monitoring within Sri Lanka remains heavily dependent on manual and semi-digital methods including daily site inspections, spreadsheet-based reporting, and periodic progress meetings. These traditional practices continue to create delays in information flow, subjective assessments, fragmented communication, and limited ability to implement proactive interventions. Such limitations are fundamentally incompatible with regenerative construction principles, which require continuous feedback, adaptive decision-making, and resource optimisation throughout the project lifecycle.

The study further identified that IoT adoption within Sri Lankan construction projects remains limited and fragmented, with only selective applications such as RFID-based labour tracking, drone photogrammetry, barcode-based material tracking, and ERP-integrated monitoring systems being implemented in isolated cases. Although the experts acknowledged the significant potential of IoT technologies to improve real-time visibility, reduce waste, minimise rework, and enhance operational efficiency, implementation is constrained by several interconnected barriers. These include high investment costs, unreliable internet connectivity, limited digital literacy, resistance to organisational transparency, lack of interoperability standards, cybersecurity concerns, and poor institutional readiness. The findings additionally highlight that these barriers are deeply embedded within the broader structural realities of the Sri Lankan construction industry, particularly government-dominated procurement systems, financial instability, and fragmented subcontracting practices.

The study recommends that future digital transformation initiatives should move beyond isolated technological experimentation and focus on collaborative implementation strategies supported by procurement reforms, public sector pilot projects, reimbursable digital implementation mechanisms, and stronger institutional support. Greater emphasis should also be placed on improving digital literacy, cybersecurity governance, interoperability standards, and regulatory frameworks to support sustainable IoT integration within the construction sector.

This study contributes to knowledge by extending the emerging discourse on regenerative construction through the conceptualisation of IoT-enabled real-time progress monitoring as a regenerative control mechanism rather than merely an automated reporting tool. Furthermore, the study contributes empirical evidence from a developing country context that remains underrepresented within existing Industry 4.0 and construction digitalisation literature, highlighting the importance of socio-technical, institutional, and economic realities in shaping the feasibility of regenerative digital transformation.

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