



A ROADMAP FOR ENABLING SMART MANUFACTURING IN SRI LANKAN SMES THROUGH INDUSTRIAL INTERNET OF THINGS (IOT) TECHNOLOGIES

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The Fourth Industrial Revolution (Industry 4.0) has transformed global manufacturing through the integration of digital technologies such as the Industrial Internet of Things (IoT), artificial intelligence, and data analytics. For Sri Lanka, where Small and Medium Enterprises (SMEs) contribute significantly to the economy, adopting IoT presents both an opportunity and a challenge. Despite accounting for over 50% of the national GDP and employing nearly half the workforce, Sri Lankan SMEs, particularly in sectors like textiles and food processing, face barriers to digital transformation, including limited technical skills, financial constraints, and inadequate infrastructure. This study proposes a structured, phased roadmap to enable IoT adoption among Sri Lankan SMEs, tailored to the country's unique socio-economic and industrial landscape. The research employs a qualitative approach, supported by literature reviews, case studies from developing economies, and expert insights. A pilot survey of 25 SME managers revealed low awareness but high interest in IoT technologies. Targeted awareness workshops and modular training programs significantly improved understanding and skills, with competency levels increasing by 55% post-training. Pilot installations of low-cost IoT sensors demonstrated tangible benefits, including a 20% reduction in machine downtime and 12% improvement in energy efficiency. The study underscores the importance of a National IoT Strategy aligned with Sri Lanka's digital policy, along with financial incentives, sector-specific IoT starter kits, and regional innovation hubs. Public-private partnerships and industry-academia collaboration are identified as key enablers for sustainable IoT integration. The roadmap emphasises inclusivity, recommending targeted efforts to involve women and marginalised communities in the digital workforce. With coordinated efforts and strategic interventions, Sri Lankan SMEs can transition to smart manufacturing, enhancing competitiveness and contributing to equitable economic growth. The proposed framework also offers a replicable model for other developing nations pursuing inclusive digital transformation.

Keywords: Industrial Internet of Things (IoT), Smart Manufacturing, Small and Medium Enterprises (SMEs), Digital Transformation, Inclusive Growth

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INTRODUCTION

The Fourth Industrial Revolution (Industry 4.0) has redefined global manufacturing paradigms through the integration of digital technologies such as the Industrial Internet of Things (IoT), artificial intelligence (AI), and big data analytics (Ashima et al., 2021; Soori, Arezoo, & Dastres, 2023). The IoT enables interconnected devices to collect, transmit, and analyse data in real-time, transforming traditional production systems into intelligent, adaptive, and efficient operations. Sri Lanka's manufacturing sector, largely dominated by Small and Medium Enterprises (SMEs), stands to gain significantly from IoT adoption. However, challenges such as financial constraints, technical skill gaps, and inadequate infrastructure hinder their digital transformation (Ghosh & Vinod, 2020).

SMEs in Sri Lanka contribute approximately 52% to the national Gross Domestic Product (GDP) and employ over 45% of the labour (Sharini Kulasinghe, Han, Hoshino, Rathi, & Lambert, 2018), with key sectors including textiles, food processing, rubber manufacturing, and electronics. Despite this significance, these enterprises lag in technology adoption, often relying on outdated machinery and manual processes (Karunaratne, 2021). This digital divide risks marginalising local manufacturers in the global marketplace. Hence, this study aims to develop a comprehensive and phased roadmap for IoT integration within Sri Lankan SMEs, tailored to the country's unique socio-economic and industrial landscape. By aligning technological capabilities with local constraints and opportunities, the roadmap aims to provide practical, scalable solutions that foster inclusive and sustainable growth.

METHODOLOGY

The research utilises a qualitative methodology supported by secondary data, case studies, and expert opinions of IoT implementations in developing economies. The study involves a comprehensive literature review on global IoT adoption frameworks and SME digital readiness (McKinsey & Company, 2019; UNIDO, 2021). The study identifies common barriers and enabling factors and synthesises them into a strategic four-phase roadmap. These phases include awareness building, capacity development, infrastructure deployment, and policy support. (Müller, Buliga, & Voigt, 2018)



Additionally, a pilot survey involving 25 SME managers across sectors such as textiles and food manufacturing was conducted to validate the roadmap's applicability and gather comprehension into readiness levels and technology perception. Sector-specific examples from textiles and food processing are used to validate the applicability of proposed interventions.

RESULTS AND DISCUSSION

Survey results indicated that 68% of SME managers had limited or no knowledge of IoT, but 84% expressed interest once the benefits were explained. Workshops and seminars significantly improved understanding, with 90% of participants indicating increased confidence in exploring IoT. A pilot awareness workshop led to the formulation of two cross-sector pilot collaborations.

Only 24% of surveyed SMEs had staff with basic data analytics or digital skills. Customised modular training programs were developed and tested with a sample group. Post-training assessments showed a 55% increase in competency scores related to IoT operations. Feedback from participants emphasised the need for more practical sessions and sector-specific content.

Pilot installations of low-cost sensors (e.g., temperature, vibration, and energy meters) in two textile SMEs revealed a 20% reduction in machine downtime and a 12% increase in energy efficiency over a three-month monitoring period. These SMEs used open-source cloud analytics platforms integrated with basic Enterprise Resource Planning (ERP) systems. The findings confirm that even minimal investment in IoT infrastructure can yield measurable productivity improvements (Soori et al., 2023). Interviews with stakeholders emphasised the need for financial incentives. Based on simulated projections, a 30% government co-funding scheme for IoT implementation could reduce payback periods for SMEs from 3.5 years to under 2 years. Stakeholders also highlighted the importance of regional IoT hubs to support SMEs in rural areas. Public-private partnerships emerged as key drivers for scalable, cost-effective ecosystem development.

Use cases such as predictive maintenance and real-time analytics have demonstrated tangible productivity gains. For example, predictive maintenance in a rubber processing SME led to a 17% decrease in unplanned stoppages and improved delivery timelines by 10%. Real-time dashboards enabled better production planning and inventory control. Automation and sensor integration also contributed to safer work environments by enabling early fault detection.



CONCLUSIONS/RECOMMENDATIONS

The research confirms that IoT adoption in Sri Lankan SMEs is both feasible and impactful when guided by a structured and inclusive strategy. The phased roadmap, encompassing awareness building, capacity development, infrastructure deployment, and policy support, addresses both technological and socio-economic barriers, offering a holistic path forward.

Key recommendations emerging from the study emphasise the need for a holistic and inclusive approach to foster IoT adoption among Sri Lankan SMEs. First, the establishment of a dedicated National IoT Strategy for SMEs under the Ministry of Industries, aligned with the broader national digital policy, is essential to provide clear direction and institutional support (UNIDO, 2021; McKinsey & Company, 2019). Financial mechanisms such as tax incentives, matching grants, and subsidised loans should be introduced to alleviate the high initial costs associated with IoT implementation. To accelerate hands-on adoption, sector-specific IoT starter kits and demonstration centres can play a pivotal role in showcasing real-world applications tailored to industry needs. Additionally, strong collaboration between industry and academia is crucial for aligning educational curricula with the evolving demands of smart manufacturing, while also fostering research and development. Regional innovation hubs and mobile laboratories should be launched to support SMEs in underserved rural areas, ensuring that the benefits of digital transformation are equitably distributed. Finally, the strategy must promote gender and social inclusion by actively involving women and marginalised communities in IoT training programs and leadership roles, thereby ensuring a diverse and sustainable digital workforce.

The study also advocates continuous monitoring of implementation outcomes and the iterative refinement of the roadmap based on feedback and emerging technologies. With coordinated efforts from policymakers, industry leaders, and technology providers, Sri Lankan SMEs can transition from low-tech producers to high-value manufacturers equipped to compete in global Industry 4.0 supply chains. The proposed roadmap offers a model for other developing countries aiming to modernise their SME sectors through inclusive digital transformation.

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