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The Impact of Lean Six Sigma on Organizational Sustainability

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ABSTRACT

This study explores the role of Lean Six Sigma (LSS) in enhancing organizational sustainability (OS), focusing on its impact across human, social, economic, and environmental dimensions. A quantitative approach was used, with a survey conducted among LSS Yellow Belt practitioners at a public university in Malaysia. The data were analyzed using statistical methods, including mean, p-value, and F-value, to identify patterns and relationships. The findings reveal that integrating human sustainability into the traditional Triple Bottom Line (TBL) framework is crucial for OS. The study shows that LSS positively impacts all sustainability dimensions: it supports social sustainability through continuous improvement and collaboration, drives economic sustainability through innovation and cost reduction, and promotes environmental sustainability through waste minimization and resource optimization. This research contributes to the literature by highlighting the critical role of human sustainability within the TBL framework and demonstrating how LSS can enhance various aspects of OS. Organizations can improve employee well-being and overall sustainability by prioritizing human sustainability, gaining a competitive edge in the business environment.

1. Introduction

The integration of LSS within organizational frameworks represents a transformative evolution in contemporary management paradigms. Originating from the combined principles of Lean manufacturing and Six Sigma techniques pioneered by Toyota, LSS initially emerged as a means to optimize quality and streamline production processes. Over time, it has evolved into a versatile approach for organizational improvement, emphasizing the reduction of waste, the elimination of defects, and continually enhancing operational efficiency [1-2]. The foundational success of LSS in manufacturing settings quickly led to its adoption across diverse industries, from healthcare to finance, where it has demonstrated remarkable efficacy in driving performance improvement and

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cost reduction initiatives. However, while the impact of LSS on enhancing organizational efficiency and productivity is well-documented, its broader implication for OS remains an area ripe for scholarly exploration and inquiry.

OS embodies the capacity of the organization to satisfy present needs while safeguarding resources for future generations. It encapsulates a holistic perspective that transcends traditional success metrics, encompassing economic, social, environmental, and, increasingly, human sustainability dimensions [3]. Due to a growing awareness of environmental degradation, social inequality, and economic volatility, the imperative of OS has become more prominent in today's rapidly evolving global business landscape. Against this backdrop, organizations face the formidable challenge of balancing short-term profitability with long-term resilience and societal impact, necessitating a re-evaluation of their strategic priorities and operational practices.

Despite the burgeoning recognition of OS as a paramount concern for contemporary organizations, the nuanced relationship between LSS and OS remains relatively underexplored in academic literature. While existing research has acknowledged the potential of LSS to enhance organizational efficiency and reduce environmental waste, a notable gap exists in understanding how LSS intersects with broader sustainability objectives, particularly concerning integrating human sustainability within the conventional TBL framework [4]. This research endeavors to bridge this gap by delving into the intricate interplay between LSS OS dimensions, elucidating the pivotal factors influencing OS across social, economic, environmental, and human sustainability realms, and scrutinizing the transformative role of LSS in fostering sustainable organizational practices. Through a synthesis of theoretical insights, empirical inquiry, and robust statistical analysis, this research aims to furnish valuable insights into the multifaceted impact of LSS on OS, thereby contributing to a deeper understanding of sustainable management approaches in contemporary business contexts.

This paper proceeds as follows: Section 1 introduces LSS, OS, and the research problem. Section 2 offers a comprehensive literature review of LSS, OS, and the integration of human sustainability within the TBL framework. Section 3 outlines the research methodology, including data collection and statistical analysis techniques. Section 4 presents the findings of the study, followed by a discussion in Section 5. Lastly, Section 6 offers conclusions and recommendations based on the research findings.

2. Literature Review

2.1 Lean Six Sigma

Lean Manufacturing, pioneered by Toyota, aims to minimize waste, maximize efficiency, and enhance product quality. It prioritizes continuous improvement and customer value generation, focusing on eliminating various types of waste in production processes. Just-in-time production ensures products are produced and delivered only when needed, reducing costs. Lean principles have expanded beyond manufacturing to sectors like healthcare and education, promoting waste reduction and efficiency enhancement.

Six Sigma, developed by Motorola engineers, focuses on data-driven methodologies to reduce defects and improve process quality. It helps organizations identify the root causes of defects and implement effective solutions. Despite initial associations with manufacturing, Six Sigma has demonstrated applicability across diverse sectors, including hospitality, finance, and business. It addresses barriers like time management and resistance to change in hospitality, streamlines financial processes in finance, and integrates with corporate strategies in the business sector.

LSS represents a fusion of Lean Manufacturing and Six Sigma methodologies, each contributing distinct principles to the improvement process. Lean Manufacturing, originating from the Toyota

Production System, focuses on eliminating waste across all aspects of operations. On the other hand, Six Sigma, pioneered by Motorola, aims to identify and minimize defects by reducing process variability. LSS offers a systematic approach to process improvement, effectively addressing waste elimination and defect reduction simultaneously. By emphasizing waste minimization, defect reduction, and quality enhancement, LSS enhances productivity, efficiency, and profitability across various industries [2].

Ali *et al*., [5] identified five critical success factors for successful organizational LSS implementation. These factors encompass the maturity level of LSS deployment, adequate resource allocation, comprehensive training programs, awareness of the significance of LSS, and strong management commitment. The presence and effectiveness of these factors significantly influence the outcomes of LSS implementation, directly impacting organizational performance. This underscores the widespread recognition and adoption of LSS as a powerful methodology for driving process improvements and achieving operational excellence.

Despite its origins in manufacturing, LSS has evolved beyond its initial application and has found relevance in diverse sectors, including healthcare, finance, banking, and government. Sreedharan and Raju [6] demonstrated that LSS principles can be effectively applied across various industries. For instance, Wang *et al*., [7] showcased the use of LSS in the finance and banking sector by developing a continuous improvement tool that enhanced a bank's competitiveness. Similarly, Yeh *et al*., [8] demonstrated the effectiveness of LSS in healthcare settings by implementing tools like the SIPOC flow chart, value stream map, and root cause analysis, resulting in improved process efficiency and significant cost savings. These examples underscore the versatility and impact of LSS methodologies beyond traditional manufacturing environments, highlighting its potential for driving organizational excellence across diverse industries.

2.2 Organizational Sustainability

OS refers to the operation of a business in a manner that aligns with societal expectations, ethical and legal standards, commercial demands, and public perceptions. It involves continuously pursuing economic viability, environmental responsibility, and social well-being to ensure long-term performance and success. Sustainable organizations adhere to the principles of sustainable development in their business activities, demonstrating a commitment to environmental, social, and economic responsibility.

Sustainability is crucial for businesses shifting to sustainable models. Dhanda and Shrotryia [9] provide a conceptual perspective on corporate sustainability and sustainable business models. They emphasize the challenge of defining sustainability in a way that aligns with specific business contexts. The study explores the evolution of corporate sustainability and the transition from compliance and philanthropy to gaining a competitive edge through sustainability. It highlights the emergence of sustainable business models and identifies research gaps. The study confirms the role of sustainability in facilitating the transformation of traditional business models into sustainable ones and provides valuable insights for organizations seeking to embrace sustainability.

CIPD [10] defines business sustainability as improving the economic, environmental, and social systems in which the company operates. This means organizations striving for sustainability should focus on all three elements equally. Colbert and Kurucz [11] also support this idea, stating that sustainability involves paying attention to economic, social, and environmental performance simultaneously, which is related to the concept of the TBL framework.

Human sustainability has also been considered in OS. Kola-Olusanya *et al*., [12] stated that human resource development is key to sustainability by integrating and orientating sustainability practices

in developing human capital. This can facilitate corporate sustainability and pro-environmental practices, leading to sustainable resource use and intellectual capital development. Also, Massaro *et al*., [13] show that human sustainability directly and significantly impacts an ability to innovate, fostering creativity and intellectual capital in the long run, thus being significant for corporate performance.

2.3 Four Elements of Sustainability

Introduced by John Elkington in 1994, the TBL concept integrates people, planet, and profit to assess business sustainability, challenging the previous focus solely on economic factors [14]. Widely adopted since its inception, TBL underscores the importance of considering social and environmental dimensions alongside economic ones. Although traditional TBL frameworks may lack adaptability, incorporating human development dimensions can enhance their comprehensiveness. Complementing sustainability initiatives, LSS improves efficiency, reduces waste, and enhances quality, impacting economic sustainability through cost reduction and productivity, social sustainability through teamwork and communication, and environmental sustainability through waste and energy use reduction [15]. In evaluating the relationship between LSS and sustainability, various aspects, including human, social, economic, and environmental factors, are considered, with human sustainability as the foundational element influencing social, economic, and environmental sustainability. Often overshadowed in TBL-focused studies, human sustainability emerges as a cornerstone, driving progress across all sustainability dimensions through collective efforts. Table 1 summarizes the four elements of organizational sustainability.

2.3.1 Human sustainability

Human sustainability encompasses maintaining and enhancing the knowledge, skills, and overall well-being of individuals, which are vital for OS and long-term success. It involves investing in health and education systems, providing access to services and nutrition, and fostering the development of knowledge and skills. From an OS perspective, human sustainability entails viewing the organization as part of society and promoting values prioritizing human capital and well-being among all involved in production and broader stakeholders [16]. This perspective recognizes the significant impacts organizational activities can have on communities, underscoring the importance of fostering skills and human capacity to support OS and societal well-being.

Linked closely to social sustainability within the TBL framework, human sustainability is considered foundational, recognizing human capital and well-being as the ultimate goals of sustainable development [17-19). Efforts to promote social, economic, and environmental sustainability will likely succeed over the long term, with a strong emphasis on human sustainability.

LSS offers several benefits for human sustainability, including enhancing decision-making skills, continuous learning, idea generation, problem-solving skills, and improving organizational competence levels [20-28]. LSS methodologies contribute significantly to strengthening human capital competency, thereby further supporting the overarching goal of human sustainability within organizations.

2.3.2 Social sustainability

Social sustainability revolves around the ability of the organization to address the needs of its employees and stakeholders while contributing to community and environmental well-being,

essential for OS and long-term prosperity. It emphasizes investments in services, relationships, and communities, focusing on fostering solid interpersonal connections, respect, and equal opportunities [29].

LSS offers various benefits, such as enhancing employee satisfaction, promoting inclusivity and diversity, and reducing workplace injuries and illnesses [30-31]. LSS facilitates a sustainable future for employees, customers, and stakeholders by improving processes and efficiency. For instance, it can streamline customer service processes in retail, enhance healthcare services by minimizing errors, and contribute to social sustainability in the construction industry through comprehensive frameworks like that proposed by Taherkhani [32]. Guzmán-Pérez *et al*., [33] emphasize the importance of measuring the monetary impact of social sustainability, suggesting that LSS can provide insights into strategic sustainability management, stakeholder outcomes, and value creation. LSS enables knowledge sharing, collaboration, strong leadership, effective communication, teamwork, and meeting customer needs, thereby driving social sustainability and ultimately impacting OS positively [34-41].

2.3.3 Economic sustainability

Economic sustainability refers to the ability of the organization to maintain financial stability in the long term, which is crucial for OS and lasting success. LSS offers numerous benefits for economic sustainability, including developing new projects, cost-saving improvements, productivity enhancements by eliminating inefficiencies, and sustaining the economy of the company by attracting and retaining customers [3,42-48].

By identifying and eliminating waste, LSS helps organizations reduce costs, enhance efficiency, and improve quality, increasing profits, market share, and financial strength. For example, a manufacturing company can use LSS to cut production waste, thus lowering costs and boosting profitability [49-50]. Similarly, a retail company can streamline its supply chain to reduce costs and enhance customer service [28]. Additionally, LSS aids healthcare organizations in reducing medical errors, improving patient safety, and cutting costs [51-52]. By leveraging LSS for economic sustainability, organizations pave the way for a more sustainable future.

2.3.4 Environmental sustainability

Environmental sustainability involves maintaining and enhancing the health and resilience of the natural world, which is crucial for OS and long-term success. Cherrafi *et al*., [53] demonstrate how LSS can reduce energy consumption in production processes, leading to environmental benefits and cost savings. Adeyeri *et al*., [54] apply LSS to minimize waste during shipping in an agricultural packaging factory, with similar positive outcomes. Healthcare organizations benefit from LSS by reducing medical waste generation, aiding the environment, and cost management [55-56]. Integrating Green and LSS strategies, as suggested by Mishra [57], optimizes resources and reduces costs while achieving social, environmental, and economic performance goals. Sreedharan *et al*., [47] highlight the effectiveness of combining LSS and green supply chain management (GSCM) in overcoming public sector challenges and improving processes, emphasizing the need for a customer-centric and sustainable approach in response to growing demands. LSS promotes environmental sustainability through various practices such as incorporating environmental considerations in daily tasks, recycling waste, prioritizing sustainability practices, creating eco-friendlier work environments, and raising awareness, ultimately contributing to a greener and more sustainable future [48, 52,58-61].

Table 1
Summary of organizational sustainability

Sustainability Element	Definition & Key Aspects	LSS Contribution	References
Human Sustainability	Maintaining and enhancing knowledge, skills, and well-being, investing in health, education, and services for long-term success.	Enhances decision-making, continuous learning, problem-solving, competence development, and organizational human capital.	16-28
Social Sustainability	Addressing the needs of employees and stakeholders, fostering strong relationships, respect, inclusivity, and equal opportunities.	Improves employee satisfaction, inclusivity, workplace safety, customer service, leadership, teamwork, and stakeholder engagement.	29-41
Economic Sustainability	Ensuring long-term financial stability, cost-saving, and productivity enhancements.	Reduces costs, eliminates inefficiencies, enhances market competitiveness, and improves profitability.	5, 28, 42-43,45-53
Environmental Sustainability	Ensuring the resilience and health of the environment by minimizing waste, energy consumption, and pollution.	Reduces energy and resource waste, promotes green supply chain management, and enhances sustainability initiatives.	47-48, 52-61

2.4 Literature Findings

The literature findings underscore the critical importance of addressing the research gap surrounding the explicit relationship between human sustainability, environmental stewardship, social equity, economic prosperity, and LSS within organizational contexts. Despite the acknowledged significance of these dimensions, the lack of comprehensive understanding hinders efforts to advance sustainability management, inform policy decisions, and promote ethical business practices. Closing this gap is essential for elucidating how these interconnected dimensions collectively contribute to OS.

As an integral component of OS, human sustainability encompasses factors such as employee well-being, diversity and inclusion, talent development, and employee engagement. Research indicates that organizations prioritizing human sustainability demonstrate higher employee satisfaction, retention, and productivity levels, improving organizational performance and competitiveness. Furthermore, fostering a culture of learning and development through initiatives like LSS training programs enhances employee skills and capabilities, contributing to long-term organizational resilience [62].

Environmental sustainability emphasizes the responsible stewardship of natural resources, reduction of ecological footprint, and mitigation of environmental impacts. Integrating LSS principles into environmental sustainability initiatives enables organizations to identify and eliminate waste, optimize resource utilization, and minimize environmental pollution. For instance, LSS methodologies such as Define-Measure-Analyze-Improve-Control (DMAIC) provide systematic frameworks for identifying environmental inefficiencies, implementing corrective actions, and monitoring performance metrics to drive continuous improvement in sustainability outcomes.

Social equity and community engagement are also essential components of OS, reflecting a commitment of the organization to ethical and responsible business practices. LSS methodologies promote stakeholder engagement, participatory decision-making, and collaborative problem-solving, fostering stronger relationships with employees, customers, suppliers, and local communities. By incorporating social considerations into LSS projects, organizations can address

community needs, support social justice initiatives, and enhance their reputation as responsible corporate citizens.

Economic sustainability underscores the importance of achieving financial stability, profitability, and long-term growth while balancing the interests of stakeholders. LSS contributes to economic sustainability by driving cost savings, revenue generation, and operational efficiency improvements. Through process optimization, waste reduction, and quality improvement initiatives, LSS enables organizations to enhance their competitive position, capture market opportunities, and sustain profitability in dynamic business environments.

Closing the research gap on the explicit relationship between human sustainability, three elements of TBL (environmental, social, and economic sustainability) and LSS are critical for developing integrated management strategies that promote organizational resilience and contribute to OS. By exploring the synergies among these dimensions, researchers can provide valuable insights into effective approaches for addressing complex sustainability challenges and driving positive outcomes for organizations and society.

3. Methodology

The research methodology is structured to address the objectives of the study systematically. Beginning with a thorough literature review, the study aims to define the significance of human sustainability within the TBL framework and explore how LSS influences OS across various sustainability dimensions. Through this phase, insights from existing literature on LSS, OS, and the integration of human sustainability into sustainability frameworks will be gathered, providing a solid foundation for subsequent stages.

Following the literature review, the questionnaire design phase will translate research objectives into survey questions, ensuring alignment with the focus of the study.

The research utilized a Likert scale ranging from 1 to 5 (1: Strongly Disagree, 2: Disagree, 3: Neither disagree nor agree, 4: Agree, 5: Strongly Agree). Respondents will rate their agreement with statements regarding the impact of LSS on sustainability elements, including human, social, economic, and environmental dimensions. Table 2 represents the construction of the questionnaires. Feedback from LSS experts will be incorporated to refine the questionnaire, which will then be administered to LSS practitioners, particularly those with LSS Yellow Belt certification. This phase aims to collect first-hand perspectives on the impact of LSS on sustainability elements, including human, social, economic, and environmental dimensions.

The survey phase will involve distributing the questionnaire to LSS Yellow Belt-certified students at a public university in Malaysia (here forth known as USM) via digital platforms like WhatsApp and Facebook. Efforts will be made to encourage participation and ensure a representative sample size. Once collected, responses will be subjected to thorough analysis using statistical methods.

In the result analysis phase, statistical techniques such as calculating mean and standard deviation for Likert scale responses and conducting tests like p-value and F-value in ANOVA will be employed. These analyzes will help determine the perceived importance of human sustainability within the TBL framework and assess the impact of LSS on sustainability across various dimensions. Through rigorous data analysis, the study aims to provide actionable insights that contribute to understanding sustainability in organizations and the role of LSS in promoting sustainable practices.

Table 2
The construction of the questionnaires

No	The Significance of the Four Elements of Sustainability
1	Human sustainability refers to maintaining and improving knowledge, skills, and overall well-being, which is important for OS and long-term success.
2	Social sustainability refers to the ability of an organization to meet the needs of its employees and other stakeholders while also contributing to the well-being of the community and the environment, which is important for OS and long-term success.
3	Economic sustainability refers to the ability of an organization to maintain its financial health over the long term, which is important for OS and long-term success.
4	Environmental sustainability refers to maintaining and improving the health and resilience of the natural world, which is important for OS and long-term success.
No	LSS on Human Sustainability
1	LSS has impacted your decision-making in your personal or professional life [H1]
2	LSS has helped you apply continuous learning to improve your work performance [H2]
3	LSS has impacted your ability to generate ideas in your personal or professional life [H3]
4	LSS has impacted your ability to solve problems systematically [H4]
5	LSS has impacted your competence level in the organization [H5]
No	LSS on Social Sustainability
1	LSS enables me to share the LSS knowledge with my co-workers in the organization [S1]
2	LSS helps you effectively lead your team members [S2]
3	LSS enabled you to communicate effectively with top management, suppliers, clients, and customers (stakeholders) [S3]
4	LSS helped you work effectively in teams as a leader or team member [S4]
5	LSS helped you deliver customer needs effectively [S5]
No	LSS on Economic Sustainability
1	LSS helped you develop new projects and improve cost savings [EC1]
2	LSS enabled you to save company costs by becoming an instructor for internal LSS training [EC2]
3	LSS helped you generate income for the organization through external training/consultants [EC3]
4	LSS enabled you to improve productivity by eliminating inefficiencies in their processes [EC4]
5	LSS enabled you to sustain the economy of the company by attracting more new customers [EC5]
No	LSS on Environmental Sustainability
1	LSS helped you emphasize environmental factors within your daily work [EN1]
2	LSS helped you identify ways to recycle waste or by-products in your organization [EN2]
3	LSS helped you prioritize environmental sustainability even if it required additional costs in your organization [EN3]
4	LSS helped you encourage your co-workers to work in a greener environment [EN4]
5	LSS helped you to be more aware of environmental sustainability in the organization [EN5]

3.1 The Population of the Respondents

The population of the respondents for the survey comprises 216 students who have completed the LSS Yellow Belt training program over the ten waves conducted in collaboration between Company A and USM since 2013. This comprehensive program incorporates theoretical and practical learning approaches, covering essential topics such as Lean Enterprise Overview, Aligning the Organization, Fundamentals of Problem Solving, Basic Statistics, and Lean Management Systems. Additionally, students are required to undertake a Plan-Do-Check-Act (PDCA) project as part of their certification process, integrating their learning into real-world applications. Upon completing the program, participants receive LSS Yellow Belt certification, equipping them with the skills to contribute effectively to organizational improvement initiatives.

4. Results

4.1 Demographic Result

The target respondents included 216 individuals. Upon closure of the questionnaire link, 122 respondents completed the questionnaire. This corresponds to a response rate of 56.48% of the total target respondents. The response rate of over 50% is considered excellent (SurveyPlanet, 2023), indicating a substantial representation of the viewpoints of the respondents. All responses were valid, and no rejections or incorrect answers were observed. Figure 1 shows the variation in the number of respondents in different waves of the LSS Yellow Belt. Waves 9 and 10 had the highest participation, with 24 participants each, followed by Wave 8, with 20 participants. This may be because participants from these waves are still students at USM and are easily accessible for data collection. In contrast, Wave 5 and Wave 2 had the lowest response rate, with only 4 participants each. Figure 2 illustrates the diversity of job titles within the respondent pool. Engineers constituted the most significant demographic, comprising 53 individuals, while students represented a substantial segment with 48 participants. Managers constituted a smaller subset, with 13 respondents. Furthermore, the sample included two unemployed individuals, and four respondents categorized as "Others." Additionally, two respondents identified themselves as Graduate Trainees.

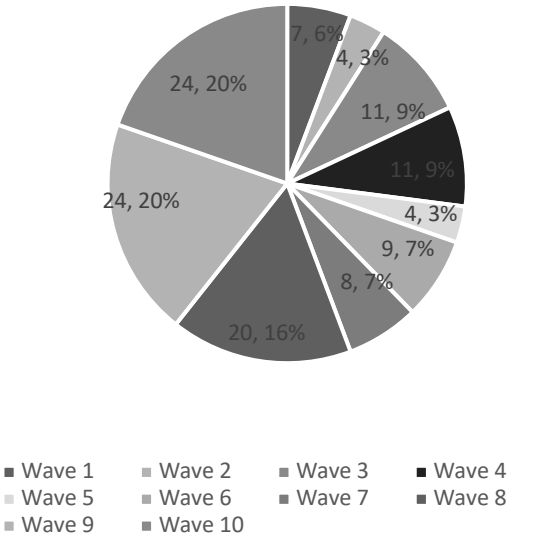

Fig. 1. Percentage of respondents according to wave

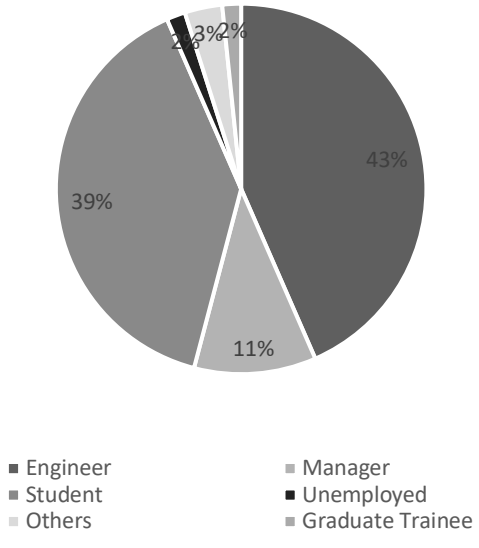

Fig. 2. Job title of the respondent

4.2 The Significance of the Four Sustainability Elements to OS

The significance of the four elements of sustainability (human, social, economic, and environmental) to OS is presented in Figure 3. Human sustainability emerges as particularly influential, with a high mean value of 4.48 and a low standard deviation of 0.66, indicating strong consensus among respondents. The remarkably high F-value of 1238 underscores the substantial variation between groups, affirming the critical role of human sustainability in fostering OS. Economic sustainability also demonstrates a strong relationship with OS, supported by a mean value of 4.42 and a standard deviation of 0.69. The substantial F-value of 1029 further accentuates the importance of economic sustainability in driving organizational success and stability. Similarly, environmental sustainability exhibits a robust association with OS, with a mean value of 4.42 and a standard deviation of 0.75. The F-value of 885 highlights the significance of environmental sustainability in ensuring long-term organizational viability. While social sustainability shows a slightly lower mean value of 4.41, the p-value of 0.00 indicates a statistically significant relationship with OS. However, the relatively high F-value of

954 suggests notable variation between groups, emphasizing the importance of further exploring and enhancing social sustainability to drive organizational success.

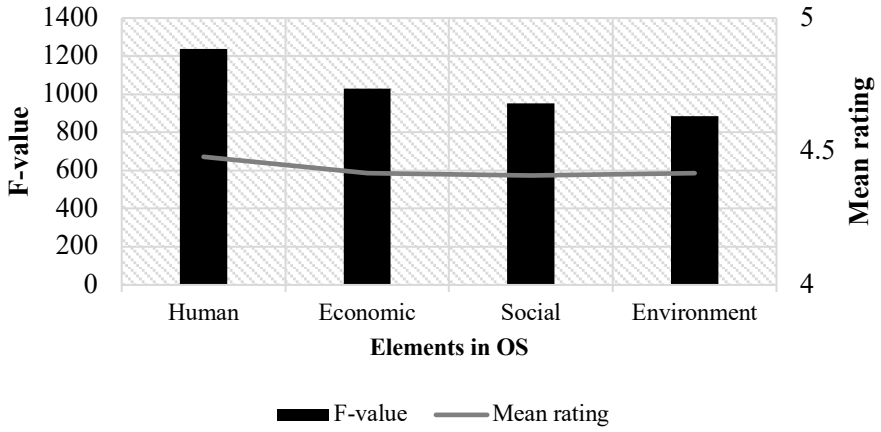

Fig. 3. The elements of sustainability in terms of F-value and mean rating

4.3 Significance Impacts of LSS on OS

4.3.1 Significance impact of LSS on human sustainability

The analysis of the responses reveals significant impacts of LSS on human sustainability to OS, as shown in Figure 4. Participants strongly agreed that LSS knowledge enhances decision-making skills ($X \pm \sigma = 4.37 \pm 0.74$, p-value = 0.00, F-value = 833), promotes continuous learning and knowledge acquisition ($X \pm \sigma = 4.45 \pm 0.66$, p-value = 0.00, F-value = 1190), fosters idea generation and innovation ($X \pm \sigma = 4.35 \pm 0.74$, p-value = 0.00, F-value = 820), improves effective problem-solving abilities ($X \pm \sigma = 4.43 \pm 0.76$, p-value = 0.00, F-value = 859), and contributes to a high level of competence and expertise ($X \pm \sigma = 4.31 \pm 0.76$, p-value = 0.00, F-value = 723). These results indicate that LSS is significantly related to human sustainability and should be integrated to measure OS effectively.

4.3.2 Significance impact of LSS on social sustainability

The findings demonstrate that LSS significantly impacts social sustainability within organizations, as shown in Figure 4. Participants strongly agreed that LSS knowledge promotes knowledge sharing and collaboration among team members ($X \pm \sigma = 4.14 \pm 0.80$, p-value = 0.00, F-value = 500), facilitates strong leadership for guiding sustainable practices ($X \pm \sigma = 4.27 \pm 0.77$, p-value = 0.00, F-value = 661), enables effective communication within the organization ($X \pm \sigma = 4.22 \pm 0.79$, p-value = 0.00, F-value = 586), enhances teamwork and cooperation for achieving common goals ($X \pm \sigma = 4.31 \pm 0.77$, p-value = 0.00, F-value = 703), and ensures meeting customer needs and expectations ($X \pm \sigma = 4.23 \pm 0.79$, p-value = 0.00, F-value = 590). These results indicate that LSS positively influences social sustainability and contributes to the OS.

4.3.3 Significance impact of LSS on economic sustainability

The analysis reveals that LSS knowledge significantly impacts economic sustainability within organizations, as shown in Figure 4. Participants strongly agreed that LSS contributes to the development of new projects and cost savings ($X \pm \sigma = 4.25 \pm 0.82$, p-value = 0.00, F-value = 572), enables cost reduction and financial savings ($X \pm \sigma = 3.92 \pm 1.00$, p-value = 0.00, F-value = 207), facilitates the generation of income and revenue ($X \pm \sigma = 3.66 \pm 1.10$, p-value = 0.00, F-value = 86),

increases productivity and efficiency (X ± σ = 4.36 ± 0.69, p-value = 0.00, F-value = 940), and attracts new customers to sustain the economy of the company (X ± σ = 4.00 ± 0.91, p-value = 0.00, F-value = 297). These results indicate that LSS positively influences economic sustainability and contributes to the OS.

4.3.4 Impact of LSS on environmental sustainability

The findings suggest that LSS significantly impacts environmental sustainability within organizations, as shown in Figure 4. Participants strongly agreed that LSS knowledge emphasizes environmental factors and considerations (X ± σ = 4.18 ± 0.76, p-value = 0.00 and F-value = 590), promotes recycling waste or by-products (X ± σ = 4.14 ± 0.82, p-value = 0.00 and F-value = 475), prioritizes environmental sustainability practices (X ± σ = 4.12 ± 0.87, p-value = 0.00 and F-value = 408), contributes to creating a greener work environment (X ± σ = 4.14 ± 0.83, p-value = 0.00 and F-value = 463), and increases awareness and commitment to environmental sustainability (X ± σ = 4.18 ± 0.84, p-value = 0.00 and F-value = 478). These results indicate that LSS knowledge positively influences environmental sustainability and contributes to the OS.

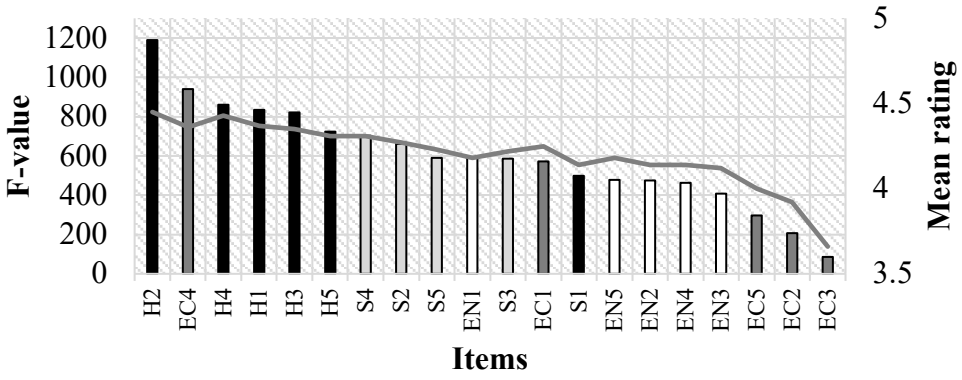

Fig. 4. The four elements of OS in terms of F-value and mean rating

5. Discussions

5.1 The Impact of LSS on the Human Sustainability of OS

Sir Richard Branson has several famous quotes saying, “Business success is all about people, people, people. Whatever industry a company is in, its employees are its biggest competitive advantage” and “Take care of your employees, and they will take care of your business” (Branson, 2011). The quotes can be interpreted as the most critical human factor in business. The quotes are consistent with a study by Campbell *et al*., [63] that claimed that paying attention to people is necessary for business practice to be fully effective and sustained. It concludes that people are the key to successful business operations, and many businesses have failed because they failed to recognize the importance of the human element. When the people mentioned are dedicated and loyal to organizations, the organizations can thrive in the long run. According to a survey of 216 business leaders, Ortega-Parra [64] emphasizes the importance of human-oriented values in enhancing employee commitment and demonstrating their significant impact on organizational dedication. Consequently, it is evident that most of the respondents in this study strongly support the notion that human sustainability, encompassing the maintenance and enhancement of people's knowledge, skills, and overall well-being, is crucial for OS and long-term success.

Within the framework of LSS, employees are empowered to make informed decisions and solve problems systematically using methodologies like PDCA and DMAIC. For instance, LSS enables individuals to apply continuous learning to enhance their work performance, generate innovative ideas, and solve problems efficiently, thus contributing to human sustainability while driving operational excellence. Moreover, LSS fosters a culture of continuous improvement and teamwork, promoting collaboration and innovation across the organization.

The impact of LSS extends beyond individual development to encompass broader organizational outcomes. By integrating LSS with a focus on human sustainability, organizations create environments that value collaboration, innovation, and excellence. Employees are encouraged to share LSS knowledge, lead effectively using PDCA and DMAIC methodologies, communicate with stakeholders, and deliver customer needs efficiently. For example, organizations can leverage LSS tools like value stream mapping and root cause analysis to identify inefficiencies and streamline processes, enhancing productivity and customer satisfaction. Through structured training programs and certification pathways such as Yellow Belt, Green Belt, and Black Belt, LSS elevates competence levels across the organization, ensuring that employees possess the skills needed to drive continuous improvement and operational excellence. Ultimately, the synergy between LSS and human sustainability reinforces the notion that investing in people is not just a moral imperative but also a strategic imperative for achieving long-term organizational success and sustainability.

5.2 The Impact of LSS on TBL of OS

The impact of LSS on the TBL of OS is multifaceted, encompassing social, economic, and environmental dimensions. Socially, LSS promotes a collaborative work culture by fostering knowledge sharing, leadership development, effective communication, and teamwork. For instance, LSS enables individuals to share their LSS knowledge with their co-workers, empowering them to disseminate best practices and drive continuous improvement initiatives collectively. This collaborative approach not only enhances the overall expertise within the organization but also strengthens interpersonal relationships and encourages a culture of mutual support and learning. LSS also helps individuals effectively lead their team members by providing them with the tools and methodologies to inspire and guide their teams toward achieving common goals. By implementing techniques such as Gemba walks, where team members and leaders observe operations firsthand, LSS promotes collaboration and aligns goals among stakeholders. This leadership development aspect of LSS improves organizational practices and fosters a sense of ownership and accountability among team members, leading to more effective problem-solving and decision-making processes.
LSS empowers individuals to communicate effectively with top management, suppliers, clients, and customers (stakeholders), enabling them to articulate their ideas, concerns, and solutions clearly and persuasively. Value stream mapping highlights value-added activities, enhances team dynamics, and facilitates effective problem-solving. By equipping individuals with the skills and confidence to engage with stakeholders at all levels, LSS strengthens relationships and promotes transparency and trust within and with external partners. In addition to social sustainability, LSS facilitates effective teamwork by equipping individuals with the skills and techniques to collaborate efficiently as leaders or team members, thereby enhancing productivity and morale within the organization. By implementing methodologies such as PDCA and DMAIC, LSS cultivates problem-solving capabilities and nurtures a culture of innovation and adaptability—essential for thriving in competitive landscapes. Integrating LSS practices focusing on human sustainability creates a work environment that values employee growth and contributions to operational excellence. LSS assists individuals in delivering customer needs effectively by enabling them to identify and promptly address customer

requirements, thereby fostering customer satisfaction and loyalty. By emphasizing the importance of understanding and meeting customer needs, LSS ensures that organizational processes are aligned with customer expectations, leading to improved products and services and enhanced competitiveness in the market.

Economically, LSS serves as a catalyst for significant improvements in productivity within organizational settings. LSS methodologies such as PDCA and DMAIC enable individuals to identify bottlenecks, reduce cycle times, and enhance resource utilization by optimizing processes and eliminating inefficiencies. For instance, by applying Lean techniques like value stream mapping and 5S, organizations can pinpoint and eliminate non-value-added activities, resulting in smoother workflows and heightened productivity. LSS empowers individuals to spearhead initiatives to develop new projects and drive cost savings. Organizations can bolster their financial sustainability by implementing innovative solutions and best practices derived from LSS principles. For instance, individuals trained in LSS can lead efforts to streamline operations, reduce waste, and optimize resource allocation, thereby contributing to enhanced cost efficiency and resource utilization. LSS facilitates cost-saving endeavors by enabling individuals to be instructors for internal LSS training programs. By imparting their knowledge and expertise to colleagues, these individuals enhance organizational capabilities and generate cost savings by reducing the need for external training resources. LSS-trained personnel can leverage their skills to provide external training and consulting services to other organizations seeking to implement LSS practices, thereby generating additional income streams for their organization. Regarding revenue generation, LSS helps attract new customers, expand market reach, and secure sustained growth. By driving productivity enhancements and cost-saving initiatives, LSS enhances its competitiveness and ability to meet customer needs effectively. This, in turn, fosters customer satisfaction and loyalty, leading to increased sales and revenue opportunities over the long term.

From an environmental perspective, LSS is a driving force for promoting sustainable practices within organizations, thereby minimizing their ecological footprint. By integrating eco-friendly principles into daily operations, LSS facilitates adopting environmentally conscious practices to reduce waste and preserve natural resources. For instance, individuals with LSS knowledge can emphasize the environment in their daily job responsibilities. This may involve reducing energy consumption by optimizing equipment usage or implementing energy-efficient technologies. Additionally, LSS practitioners can contribute to sustainable transportation logistics by optimizing delivery routes, reducing fuel consumption, and lowering greenhouse gas emissions associated with transportation activities. LSS enables organizations to embrace sustainable manufacturing processes aimed at minimizing environmental impact. By leveraging tools like value stream mapping and root cause analysis, individuals can identify inefficiencies and waste sources within production processes. This, in turn, allows for targeted interventions to reduce resource consumption, minimize pollution, and optimize material usage. One illustrative example of LSS in action is the implementation of waste reduction and recycling initiatives within organizations. Through systematic analysis and problem-solving, LSS facilitates identifying opportunities for reusing materials, recycling waste products, and minimizing overall waste generation. Organizations can significantly reduce their environmental footprint by implementing strategies to reduce waste at its source while simultaneously realizing cost savings through more efficient resource utilization.

LSS enables individuals to prioritize environmental sustainability initiatives, even in cases where they may entail additional costs. For instance, by advocating for the adoption of greener practices and investing in eco-friendly technologies, LSS practitioners can drive organizational efforts towards sustainability goals. Despite potential initial investments, these environmentally friendly practices often yield long-term benefits regarding resource conservation, regulatory compliance, and

enhanced brand reputation. LSS fosters a culture of environmental responsibility within organizations by raising awareness and encouraging colleagues to participate actively in green initiatives. By promoting collaboration and engagement among employees, LSS cultivates a shared commitment to environmental stewardship and encourages adopting sustainable practices at all levels of the organization.

6. Conclusions

This study aimed to examine the correlation between LSS and OS by integrating human sustainability into the TBL sustainability dimensions, including social, economic, and environmental aspects. The study identified a research gap in the existing literature. It aimed to address it by exploring the significance of human sustainability within the context of OS, an area that has yet to be extensively explored. A survey conducted among LSS Yellow Belt practitioners at USM indicated a significant relationship between human, social, economic, and environmental sustainability and OS. The findings showed that LSS significantly influences OS across human, social, economic, and environmental elements.

This research contributes to the field by enhancing the understanding of the impact of LSS on OS and emphasizing the importance of incorporating human sustainability as a key component when measuring sustainability performance. The findings can benefit organizations seeking to enhance their sustainability practices through LSS and inform policymakers interested in promoting sustainable business practices. Additionally, scholars conducting research in LSS and OS can gain insights into the specific impacts of each element of sustainability, leading to a deeper understanding of sustainable practices for various stakeholders.

This study has limitations. The survey questionnaire was limited to LSS Yellow Belt practitioners from USM, which may have restricted the diversity of perspectives. Additionally, the use of closed-ended questions in the survey may have limited the depth of the data collected. Furthermore, challenges in contacting respondents and outdated contact information may have affected the response rate and introduced potential biases in the data. Future research in this field could expand the scope by including additional elements of sustainability and increasing the sample size to obtain a broader perspective. Moreover, focusing on LSS practitioners with higher belt levels could provide insights from experts in the field. Maintaining up-to-date contact information for future respondents is crucial to ensure effective communication and data collection. By addressing these recommendations, future research can contribute to a more comprehensive understanding of the relationship between LSS knowledge and OS.

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