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Research Article

Sustainability Assessment of Quality 4.0 Tools in Telecom Industry

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Abstract – The fourth industrial revolution, also commonly known as Industry 4.0, has brought about significant advancements in areas such as connection, mobility, analytics, scalability, and data, which have resulted in a complete transformation of the service and manufacturing industry. Quality 4.0 is an approach that integrates technology and data into quality management systems while also retaining traditional methods. This approach enhances value by facilitating modifications through culture, leadership, and collaboration. This paper aims to evaluate the sustainability and effectiveness of Quality 4.0 tools in the telecom industry by utilizing advanced Multi-Criteria Decision-Making (MCDM) techniques. The study seeks to analyze the impact of Quality 4.0 tools on both the quality management system and the overall sustainability of a telecom company through a combination of quantitative and qualitative data collection methods. The study has identified four crucial parameters of sustainability that significantly impact the sustainability evaluation of Quality 4.0 tools. It is focused on the telecom industry, specifically within the quality department, and identifies three potential tools for Quality 4.0 that are considered alternatives within the MCDM method. To effectively evaluate the effectiveness of these tools, the study utilizes the Analytic Hierarchy Process (AHP) techniques of MCDM. The results of this study provide a comprehensive overall ranking of the alternative tools, while a sensitivity analysis based on sustainability criteria demonstrates that the ranking of the alternatives can change based on specific sustainability factors. This groundbreaking research sheds invaluable light on the sustainability and effectiveness of Quality 4.0 hybrid tools in the telecom industry, providing valuable insights and practical recommendations for organizations considering their adoption.

Keywords – Quality 4.0, Telecommunication 4.0, Sustainability, MCDM, Telecom Industry

I. INTRODUCTION

Industry 4.0 has transformed the service and manufacturing industry, leading to Quality 4.0, which incorporates digitalization into quality management. Quality 4.0 enables organizations to leverage data analytics, machine learning, and artificial intelligence to optimize operations and enhance performance. By adopting Quality 4.0, quality teams can quickly identify quality issues, implement corrective actions, and improve collaboration across teams. Quality 4.0 enhances organizational performance, innovation, and business models, making it essential for quality leaders to adopt it [1]. Quality 4.0 belongs to an innovative quality management tactic that utilizes Industry 4.0 technologies, incorporation, and digitalization [2]. Quality 4.0 is the integration of technology and data into quality managing systems

without swapping traditional methods. It enhances value by facilitating modifications through culture, leadership, and collaboration. Quality 4.0 is the latest approach being used by modern businesses to compete effectively in the market and achieve success in the fourth industrial revolution. Despite being the newest buzzword in both academia and business, there is a lack of relevant analysis on how it will impact organizational adoption [3]. The evolution of Quality 4.0 has been identified as having four stages by the American Society for Quality. Quality 1.0, in the late 1700s and early 1800s, focused on scaling up production through measurements and inspection. Quality 2.0, in the late 1800s, measured productivity and enabled mass production. Quality 3.0, in the 1960s, emphasized customer satisfaction and digitization. Quality 4.0, the current stage, focuses on the digitalization of quality work from the perspective of Industry 4.0, emphasizing enterprise efficiency, performance, innovation, and new business models [4].

II. Problem and Objectives

The rapid growth of Quality 4.0 in the telecom industry presents both opportunities and challenges. Despite their potential benefits, the sustainability of these tools remains uncertain, requiring an assessment of their impact on the environment, economic viability, and technical feasibility. This study aims to address this gap by utilizing Multi-Criteria Decision Making (MCDM) techniques to evaluate the sustainability of Quality 4.0 tools in the telecom industry.

- To identify the impact of Quality 4.0 in the telecommunication industry.
- To find the relationship between Quality 4.0, and Sustainability.

III. Literature Review

A. *Quality 4.0 Dimensions and Tools*

The Quality 4.0 model integrates OT (operational technology) and IT (information technology) through digital transformation. The successful adoption of Quality 4.0 relies on key enablers such as advanced technologies, big data capabilities, skilled workforce, collaboration, and leadership support [2]. The dimensions of Quality 4.0 include Strategic Leadership, Quality Culture, Customer Centricity, Quality Management System, Compliance, Competence, Data Governance, Advanced Analytics, New Age Technologies, Collaboration, and Innovations. A review of literature and expert opinions led to the identification of twelve dimensions or axes of Quality 4.0 [1]. These axes were prioritized using the analytic hierarchy process (AHP) technique [5], which has concluded that the 12 dimensions of Quality 4.0 have a positive effect on organizational performance, agility, and sustainability. Although technology is crucial, traditional quality elements such as leadership, culture, customer focus, systems, compliance, competence, analytical thinking, and data-driven decision-making are also necessary for successful transformation. To achieve Quality 4.0, several key tools are being utilized by businesses. These tools include data science and statistics, enabling technologies, big data, blockchain, (AI), (ML), neural networks, and deep learning. Data science and statistics play a vital role by providing insights through predictions, trend analysis, and problem-solving models. The enabling technologies, including IoT and cloud computing, offer a platform to streamline processes and improve connectivity. Big data offers a setup to control and analyze vast quantities of data, while blockchain provides a secure environment for transactions. AI and ML are applied for decision-making and information streaming, while neural networks and deep learning provide advanced pattern recognition capabilities. All these tools work together to create a culture of quality, trust, and excellence in organizations [6].

B. *Telecommunication 4.0*

Quality 4.0 tools used in the telecom sector, such as IPV6, 5g, IOT, sensors, and cloud computing. The Fourth Industrial Revolution 4.0 merges digital and physical technologies, but also creates challenges in the telecoms sector, including declining quality and changing customer expectations. Organizations must collaborate with stakeholders, show flexibility, and foster innovation to successfully manage these challenges and remain competitive [7]. The telecommunications industry is rapidly evolving with new innovations, competition, and regulations. Organizations must adapt quickly to remain competitive in this constantly changing environment. Telecommunication 4.0 is characterized by smart and connected technologies, such as IoT, AI, quantum computing, and 3D printing. IoT and linked gadgets are having a wide range of effects on businesses, government agencies, and everyday people. Ahead of schedule 5G and Multi-Access Edge Computing (MEC) is intended to provide IoT use cases with extremely low latency. The considerable impact of

digital technology on the sector is what propels Industry 4.0. To maintain their competitive advantages, businesses must evolve to offer services that enhance the consumer experience. Innovations like integrating vertical and horizontal capabilities and co-creating with clients and partners are crucial for Industry 4.0. ICT plays a vital role, but research on new business models for ICT skills transformation is scarce. Further investigation is necessary to develop innovative business models that will drive Industry 4.0's success [8].

C. *Quality 4.0 and Sustainability*

Quality 4.0 is instrumental in the pursuit of the 17 sustainable development goals established by the United Nations in 2015, which aim to overcome global challenges such as poverty, environmental degradation, prosperity, and peace. The EFQM 2020 model is a comprehensive business model that incorporates sustainability principles and shares characteristics with Industry 4.0 [9]. It emphasizes transformation and improves organizational performance and offers an integrated business excellence framework for Quality 4.0. The model has links with Industry 4.0, but its generic and non-prescriptive nature does not specifically reference the nine Industry 4.0 pillars and lacks links to direction, organizational culture, and leadership [10]. In brief, Quality 4.0 (Q4.0) is a combination of quality management and improvement models with technology in the context of Industry 4.0 and digital transformation. It aims to enhance critical competencies and factors for organizational success. Quality 4.0 and the UN's Sustainable Development Goals are linked as they both aim to promote long-term well-being.

IV. METHODS AND MATERIALS

In the study's first phase, a comprehensive literature review was conducted to gather information about Quality 4.0, its dimensions, tools, and the relationship between Q4.0 and sustainability. To assess the sustainability of Q4.0 tools in the telecom industry using the Analytic Hierarchy Process technique, the QC department of a telecom company has been chosen as a case study, which utilizes advanced technologies for quality control and assurance processes. The important parameters and alternatives have been identified in phase two of the research methodology. The QC department of a telecom company uses special tools for QC and QA such as ISDP (Integrated Service Delivery Platform), ITSC (IT Service Center), and RNO (Radio Network Optimization), supported by Quality 4.0 tools on the backend, to enhance their quality management processes. The above-mentioned tools were considered as alternatives in the AHP technique. The functions of these Quality

4.0 tools include document management, inspection management, CAPA management, training management, complaint management, and maintenance. The study aims to evaluate the sustainability of these tools based on economic, social, technological, and environmental criteria through a case study approach.

A. *Data Collection and Analysis*

To assess the sustainability of Q4.0 tools in the telecom industry using the Analytic Hierarchy Process technique, the QC department of a telecom company has been chosen as a case study, which utilizes advanced technologies for quality control and assurance processes. The important parameters and alternatives have been identified in phase two of the research methodology. The QC department of a telecom company uses special tools for QC and QA such as ISDP (Integrated Service Delivery Platform), ITSC (IT Service Center), and RNO (Radio Network Optimization), supported by Quality 4.0 tools on the backend, to enhance their quality management processes. The above-mentioned tools were considered as alternatives in the AHP technique. The functions of these Quality 4.0 tools include document management, inspection management, CAPA management, training management, complaint management, and maintenance. The study aims to evaluate the sustainability of these tools based on economic, social, technological, and environmental criteria through a case study approach. Data were collected through the administration of questionnaires and physical interviews with experts from the QC department of the telecom company. Expert Choice software was used to analyze the collected data.

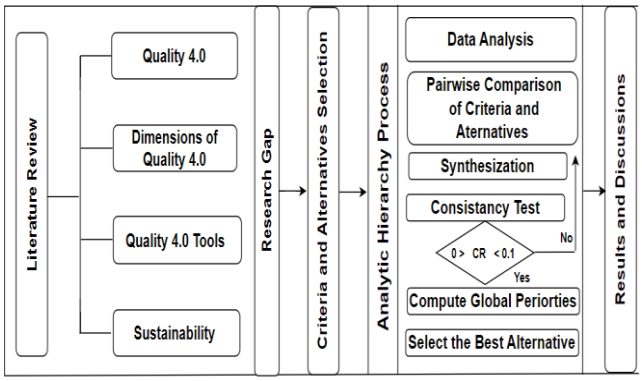

Fig. 1 Research Methodology

V. Results

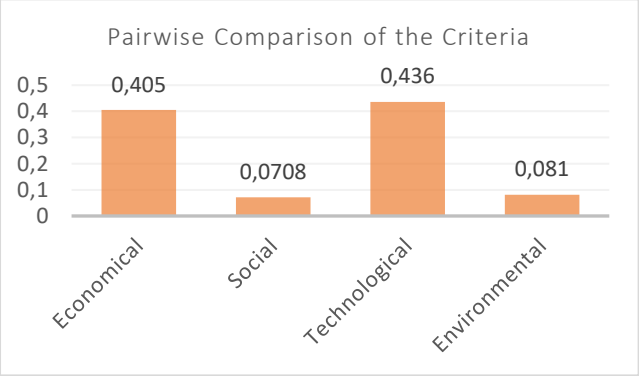

Fig. 2 Pairwise Comparison of the Criteria

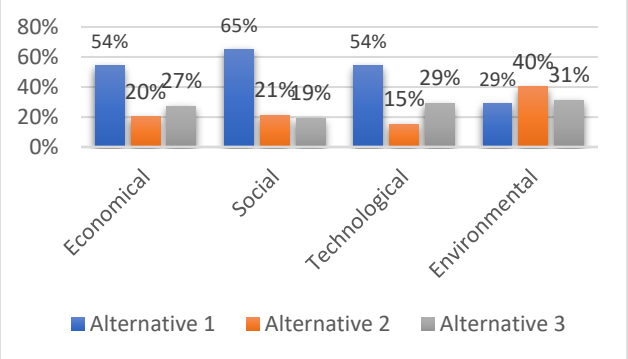

Fig. 3. Sensitivity Analysis of the Criteria and Alternatives

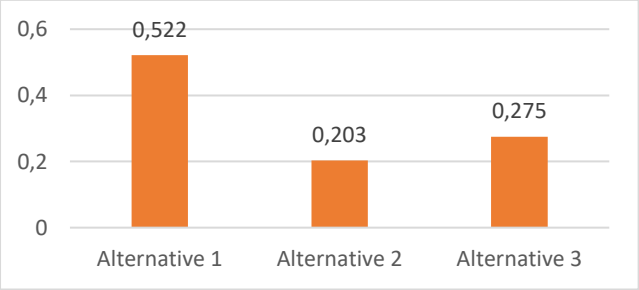

Fig. 4. Ranking of Alternatives w.r.t Goal

VI. Discussion

According to the results presented in Figure 2, the research objective aimed to rank the four main criteria of sustainability. The technological criterion was ranked the highest, with a score of 0.436, and was considered the most important criterion. The economical criterion was ranked second with a score of 0.405, followed by the environmental criterion with a score of 0.081, and the social criterion with a score of 0.078. The inconsistency judgment was found to be 0.00402, which is lower than the acceptable threshold of 0.10. The sensitivity analysis of alternatives based on criteria was conducted, as shown in Figure 4. The analysis was done based on four criteria, namely economical, social, technological, and environmental. The results indicate that the alternatives remained unchanged in terms of the first three criteria. However, when the environmental criterion was analyzed, the alternatives changed. Alternative 2 came out on top with a score of 40%, followed by Alternative 3 with 31%, while Alternative 1 was ranked at the bottom with a score of 29%. Based on the results shown in Figure 4, Alternative 1 was considered the most important alternative among the three, with a score of 0.522, meeting the research objective. Alternative 3 was ranked second with a score of 0.275, and Alternative 2 was ranked third with a score of 0.203. The inconsistency judgment was found to be 0.01, which is below the acceptable limit of 0.10.

VII. Conclusion

The study assessed the sustainability of Quality 4.0 tools in the telecom industry, considering economical, social, technological, and environmental factors. It evaluated three tools, with Integrated Service Delivery Platform (ISDP) performing the best. The study emphasized the relationship between Quality 4.0 and United Nations' Sustainable Development Goals, particularly Goal 8 (Decent Work and Economic Growth) and Goal 9 (Industry, Innovation, and Infrastructure). The research provides insights for stakeholders to adopt sustainable practices and contribute to economic growth, employment, industrialization, infrastructure, and innovation.

Acknowledgment

The heading of the Acknowledgment section and the References section must not be numbered

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