NTU Journal for Administrative and Human Sciences (Special Issue): 146-163
DOI: https://doi.org/10.56286/ICSDT2025

IRAQI Academic Scientific Journals

JAHS NTU

P-ISSN: 2789-1240 E-ISSN:2789-1259

NTU Journal for Administrative and Human Sciences

Available online at: https://journals.ntu.edu.iq/index.php/NTU-JMS/index

Strategic Engineering Techniques and Their role in Activating The Sustainable Lean Manufacturing System /A Diagnostic and Analytical study of the opinions of a sample of employees in the General Company for Industrial Cement Industry/Badush Factory

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Article Informations

Received: 15-03- 2025,
Accepted: 30-04-2025,
Published online : 01-03-2026

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Key Words:
keyword1, strategic Engineering
keyword2, sustainable
lean manufacturing

A B S T R A C T

This study aims to examine the relationship and impact between the dimensions of strategic engineering and sustainable lean manufacturing. The research was conducted at the General Company for Cement Industry / Badoush Cement Expansion Plant, based on a sample of (213) department managers, division officials, and engineers. A questionnaire was used as the primary instrument for data collection, and the data were analyzed using advanced statistical techniques through SPSS and AMOS software. The theoretical framework focused on strategic engineering and sustainable lean manufacturing, while the empirical framework tested the correlation and causal relationships between the study variables. The findings indicate that the company demonstrates a strong orientation toward adopting strategic engineering practices, which significantly enhance sustainable manufacturing agility. Moreover, the results highlight the importance of achieving high levels of manufacturing flexibility while integrating environmental considerations, thereby improving the company's ability to meet customer requirements, ensure production continuity, and effectively respond to future environmental and market changes.

1 Introduction

In today's highly competitive and dynamic industrial landscape, organizations are increasingly compelled to adopt advanced strategies that enhance both operational efficiency and environmental sustainability. Strategic engineering emerges as a pivotal approach that integrates long-term planning with innovative design and technological adaptation, enabling firms to align their engineering functions with overall business goals. Simultaneously, sustainable lean manufacturing systems have gained significant attention for their ability to eliminate waste, optimize resources, and reduce environmental impact without compromising productivity or quality.The convergence of strategic engineering and sustainable lean manufacturing presents a promising framework for achieving holistic organizational excellence. By embedding sustainability principles into lean methodologies, industries can not only streamline their processes but also fulfill their social and ecological responsibilities. This research explores the interplay between strategic engineering and sustainable lean manufacturing systems, examining how their integration can drive value creation, foster innovation, and support long-term growth in a rapidly evolving global market.

2 Study methodology:

2.1 The research problem:

Keeping pace with the rapid changes and developments in the contemporary industrial environment requires a new direction for work that responds to these changes, as existing companies today must adopt advanced technologies in the field of manufacturing that enable them to adapt, survive and grow in the industrial environment and overcome their competitors from companies working with them in the same environment, as the intensification of competition and the changes occurring in the market require these companies to adopt contemporary and sustainable methods and techniques that enable them to eliminate or reduce the gap between them and competing companies with modern technology, taking into account the challenges of sustainable environmental performance, as strategic engineering is one of these methods that has proven its success in different situations as a global methodology with strength that is in line with the environments of administrative and strategic systems engineering by focusing on all the necessary tactics to solve problems and work to follow them up immediately. Accordingly, through the researchers' review of the company's departments and laboratories, it became clear that there is no interest by the company's management in strategic engineering and its dimensions, despite its availability in a form that is unclear due to the company's management's lack of knowledge of the explicit meaning of this concept, which contributes to enhancing Sustainable manufacturing agility, and increasing its efficiency and effectiveness... which prompted the researchers to address this topic in some detail... Therefore, the researchers sought to define the research problem within its specific and indicative paths by raising a number of questions that lie in:

1. Do managers in (General Company for Cement Industry/ Badoush Factory) have a clear vision of strategic engineering?
2. Is there a correlation between the dimensions of strategic engineering and the sustainable lean manufacturing system in the researched field?
3. Is there an impact of strategic engineering on the sustainable lean manufacturing system?

2.2 **Hypothetical research plan:**

The hypothetical research plan was built in light of the contents of the research problem and its objectives, which clarifies or identifies the main variables and the influential relationships between them, as shown in Figure (1)

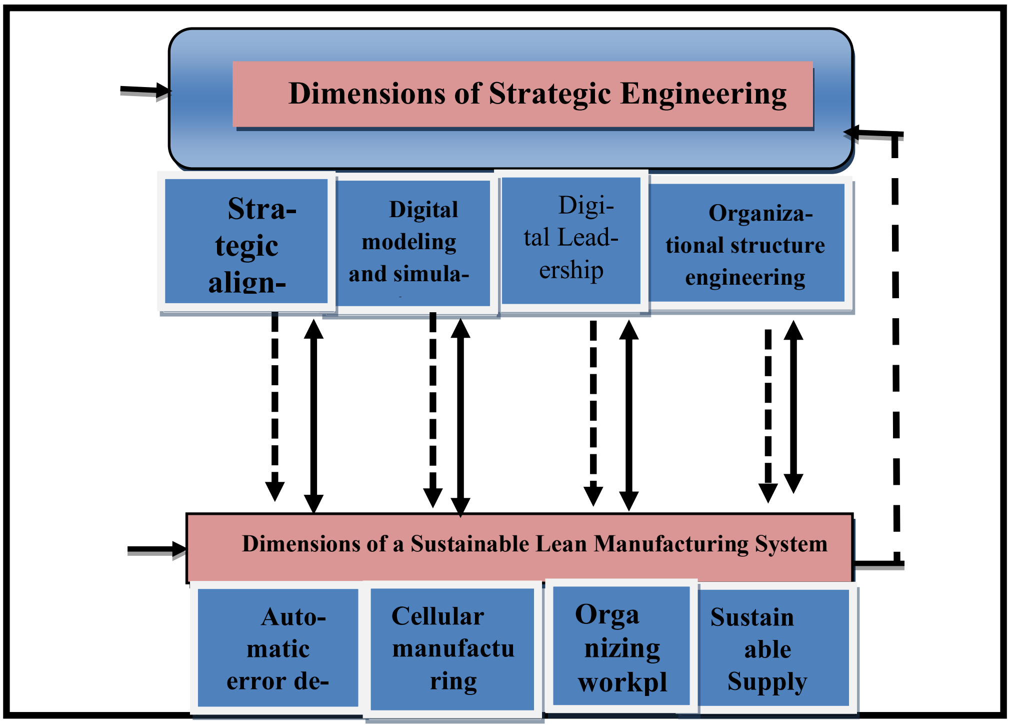


Fig. 1. Hypothetical Research Plan

Source: Prepared by the researchers

2.3 Research hypotheses: The current research is based on testing the validity of the following two main hypotheses:

First: There is a significant correlation between the dimensions of strategic engineering and the sustainable lean manufacturing system, and a number of the following sub-hypotheses emerge from the first main hypothesis:

1. There is a significant correlation between organizational structure engineering and the sustainable lean manufacturing system.
2. There is a significant correlation between digital leadership and the sustainable lean manufacturing system.
3. There is a significant correlation between digital modeling and simulation and the sustainable lean manufacturing system.
4. There is a significant correlation between strategic alignment and the sustainable lean manufacturing system.

Second: There is a significant effect of strategic engineering dimensions on the sustainable lean manufacturing system, and the second main hypothesis emanates from it the following sub-hypotheses:

1. There is a significant effect of organizational structure engineering on the sustainable lean manufacturing system.
2. There is a significant effect of the digital leadership dimension in the sustainable lean manufacturing system.
3. There is a significant effect of the digital modeling and simulation dimension in the sustainable lean manufacturing system.
4. There is a significant effect of the strategic alignment dimension and the sustainable lean manufacturing system

2.4 Research Methodology:

The researchers relied on the descriptive analytical method in their research, which included a desk and electronic survey in order to benefit from references and sources to build the theoretical framework of the research. The questionnaire form was also used to collect data from the researched field and it was statistically analyzed to test the research hypotheses.

Data collection methods and processing tools:

The researchers relied on the questionnaire form that was prepared based on the theoretical aspect of the research in addition to taking the opinions of a number of professors specialized in the field of the current research. The interview was also relied upon to collect data from working individuals, as the sample included a random group of individuals. The number of forms distributed was (223) forms, of which (213) forms were retrieved, so the response rate was (96%). The form included three main axes. The first axis included personal data of the individuals being researched and included (age, gender, academic achievement). As for the second axis, it included phrases related to strategic engineering, while the third axis included phrases related to the sustainable lean manufacturing system, as the five-point Likert scale was used to measure the variables and dimensions of the research.

3 Strategic Engineering:

3.1 The concept of strategic engineering and its definition:

The concept of strategic engineering is one of the contemporary concepts in the field of strategic thinking, as it is used in several fields, the most important of which is solving problems and making decisions more effectively,As[1] defined it a new system that defines strategy as a comprehensive and integrated approach to designing, using and developing new solutions in order to achieve effective results against risks, uncertainty, competitors, threats and within critical environments, as strategic engineering actually depends on the integrated use of innovative technologies such as (simulation and modeling) and (artificial intelligence and intelligent agents) and data science as well as machine learning. [2] also defined strategic engineering for neuromarketing (NSE) as the process of building a complex marketing system, based on an intensive study of the cultural mental models of all marketing managers and users, as well as analyzing the data obtained through marketing research in neuroscience, while [3] referred to strategic engineering as an integrated strategic approach from non-standard engineering management approaches through which the organization and its leaders seek to encourage their employees to think strategically in order to enhance and support creative and advanced ideas and provide innovations and engineering designs for products and services. These trends do not appear except with the presence of management that engineers for the future, and relies on systems and a mental roadmap, evoking the future, and adopting efficient and flexible systems that enable it to make a significant contribution to developing strategies that guarantee its success, superiority, and continuity, leading to achieving organizational prosperity. From another point of view, it is a science, art, and creative method characterized by novelty to produce everything that calls for competition and strategic renewal through the organization’s ability to prepare appropriate scenarios for each event and anticipate future events in the external environment, and move from merely anticipating the future with insight A window and transforming it into realistic works with agility and high efficiency [4]. Accordingly, researchers see that strategic engineering is the process of creating cadres with distinguished knowledge and diverse scientific levels with the ability to anticipate the future in a multi-faceted manner, since strategic engineering is a creative intellectual process that seeks to find appropriate solutions to the difficult problems that the organization may face in its future.

3.2 Advantages and importance of strategic engineering:

What makes strategic engineering important is that it has a comprehensive strategic base from which the strategic engineer chooses what is appropriate for the company and its strategic ideas, starting with the financial aspect that is concerned with the economic aspects related to rationalizing costs and how to use assets and grow revenues and profits, as well as the marketing framework that is concerned with market share and targeted marketing programs and satisfying customers to reach their happiness, while the operational aspects are related to optimal production and reducing defects and errors to a minimum, while the human framework is concerned with human and informational wealth. All of the aforementioned concerns are basic and necessary aspects that must be available in every strategy for every company, and here the role of the strategic engineer emerges in determining priorities for each stage of strategic implementation, and this is the essence of the importance of strategic engineering [5].

On the other hand, many complex systems suffer from stability or fixation and the inability to keep up with change or use better technologies despite knowing their many benefits [6]. Therefore, strategic engineering is important for its use in several fields. There are also several points that represent the importance of strategic engineering from the point of view of s researchers including [7]) and [8] as follows:

1- The importance of strategic engineering lies in diagnosing the difficulties and obstacles of technical development by identifying the basic factors that affect innovation.
2- Determine the basic trends and rules of systems with the aim of addressing simulation modeling in line with systems engineering environments.
3- Create a new generation of engineers capable of dealing with strategic thinking based on quantitative models so that they can support the decision-making process and use assistive technologies such as advanced simulation and modeling.
4- Focus most strategic engineering activities on tactics or problem solving and clearly define the goal and how to solve the problem and the possibility of following it up.

3.3 The basic functions of strategy engineering:

Strategic engineering performs three main functions, which are as follows [8]:

First: - It works to create a model for the new operations of strategic management and its activities, which ensures that all functions of planning, implementation and monitoring interact with each other in an interactive manner without interruptions. Many of the main operations of the management system are also subject to strategic engineering, and through it, development in strategy, planning, implementation, testing and linkage are activated in all aspects of work [6].

Second: The strategic unit must include a large group of operations such as financial management, communication strategy, human resources planning, performance management, information technology planning, initiative management, and mutual provision of the best information. In most organizations, these operations already exist and have their owners, but they are not integrated with each other, and therefore they are often not compatible with the strategy, as it is necessary to combine all operations and enter them into a state of strategic exchange [6]. The use of strategic engineering management to enhance ethical behaviors ultimately leads to improving the company's performance by motivating and enabling positive behaviors [9].

3.4 Dimensions of strategic engineering:

Many studies indicate that the dimensions of strategic engineering are numerous. This is due to the novelty of the subject, as researchers have not agreed on specific dimensions for it, as shown in the table below:

Table 1. Dimensions of strategic engineering

DIMENSIONS	RESEARCH TITLE	YEAR	THE AUTHOR
- SKILLS -ORGANIZATIONAL STRUCTURE ENGINEERING - IT INFRASTRUCTURE - DIGITAL LEADERSHIP	Strategic Engineering as a Method for Developing Business And Achieving High Performance	2020	Joe L. Post & Kate S Sank
- EDUCATION AND TRAINING - DECISION SUPPORT - MODELING AND SIMULATION	NATO needs of Future Strategic Engineers. In Workshop on	2019	Mazal, J., & Bruzzone, A. G.

- STABILITY - SAFETY - FINANCING	Applied Modelling & Simulation A Strategic Engineering Management Approach to Innovation and Organizational Sustainability: An Addition to the Engineering Management Curriculum?	2014	Dr. Michael Browder, Dr. Andrew J. Czuchry. Ms. Leslie Boughers, Ms. Caroline Deutsch, Nina Muehl
- CREATIVITY - REDUCE MARKETING TIME - RESOURCES - RISK MANAGEMENT	The Quantitative Design Process in Embedded System and Strategic Engineering	2012	Graham R. Hellestrand

Source: Prepared by the Researchers

Accordingly, the researchers will rely on the field survey method by distributing a questionnaire to experts to obtain the dimensions that are appropriate for the application of this study. The questionnaire was distributed and the dimensions of greatest importance and suitability for the researched circle were determined, and also because they are the most appropriate for the research environment, as follows:

1. Organizational structure engineering:

Organizational structure engineering expresses how organizations are designed to perform their work at the basic level and how they can perform very large tasks by dividing them into smaller and faster tasks in an attempt to accomplish them. Through organizational structure engineering, it is determined whether work is divided into operations such as development, design, sales and service, or whether it is better to divide work according to the type of customers and targeted businesses [10]. The problem of optimal organizational design lies in finding the appropriate organizational structure for the decision hierarchy, allocating resources and functions to businesses, and the structure of communications between different levels. The optimal organizational design ultimately depends on the actual task criteria and organizational constraints [11]. The characteristics of organizational structure engineering specifically mean the unique characteristics of the structure, which is very important for understanding the subtle or subtle structural effects of organizational design. There are six main structural characteristics: centralization, formalization, specialization, interdependence, integration, modularity, and centralization, which express the extent to which the authority to make decisions and take actions lies at the upper limits of the hierarchy[5]. [12 also pointed out that organizational structure engineering indicates The way in which influential decision-making and powers are transformed, and is a basic means of achieving the organizational function in addition to being a tool for coordinating the various works and activities performed by all departments in the organization. On the other hand, organizational structure engineering is the transformation of business into a complex organizational system that can be viewed from a number of perspectives that are usually overlapping. These include organizational structure, organizational culture, business processes, strategy, and individual human or artificial agents [11]. The design of an organization's structure must support its purpose and objectives and lead to the creation of value for it and the effective allocation of resources and activities as well as the relationships that are included in it. The organizational design affects the overall effectiveness, efficiency, and agility of the work of organizations. Efficiency refers to doing things right, while effectiveness is doing the right things. After implementing the design, the question arises as to whether the work should be arranged sequentially in combined lines such as category design or sequential implementation steps [12].

2. Digital Leadership Architecture:

Digital leadership is an important factor in managing the challenges facing organizations, and it has become a key concept in the discussion about the types of skills that managers need for digital transformation [13], as leaders are not all equal in their style and do not practice leadership using the same tools, as the concept of digital leadership shows that it is a style of leadership using online conversation and the use that digital microblogs can provide.

[14] indicated that leadership is the process of mutual influence between leaders and followers in achieving pre-determined organizational goals [15], as the accelerating project requires effective leaders who have a high degree of adaptability to changing events, and this is

necessary in order to respond to emerging requirements at the appropriate place and time, as leaders must be prepared to learn from failure in specific contexts in order to enhance the organization's flexibility and the ability to allocate the necessary time to understand the impact of the digital revolution on their business, and they also need to look closely at the administrative implications, including speed, scope, and risks, and they need to develop a comprehensive roadmap for their organizations, which includes both daily adaptive behaviors and long-term exploration of new projects [16].

” In the same vein, leadership is defined as the use of power and influence to direct the activities of employees towards achieving goals [17]. Researchers [18] have indicated that digital leadership is a set of positive qualities and characteristics that managers possess and have the ability to influence the behavior of employees and direct them towards achieving organizational goals based on advanced digitization processes, as well as according to the competency model for digital leaders, where two dimensions can be distinguished that form a successful digital leader, which are: -

(1) The attitudes, behaviors, and competencies that managers need in the current digital age (e.g. digital literacy / digital competencies)

(2) Competencies that help in digital transformation, for example, strong leadership skills to successfully master the challenges of digital transformation as well as enhance critical job resources Managers have any digital leadership skills/capabilities, as they face special challenges such as excessive work demands as well as when they are not accompanied by sufficient job resources and increased risks of burnout [13]. There is an approach called digital citizenship that promotes leadership development around digital technologies, and this approach has been developed into elements of digital citizenship that include digital etiquette, communication and access, literacy, commerce, law, rights and responsibilities, mental health, and digital security, and using the concepts of digital literacy and citizenship with them, a framework for digital leader competencies has been proposed, which are [19]:

1. Awareness of emerging technology tools and platforms.
2. Analyzing digital content and sorting information accurately and with quality and distinguishing it from false or misinterpreted information.
3. Self-understanding of dealing with online applications and expressing the digital file in a conscious manner.
4. Developing and committing to professional, strategic and functional brands online.

3. Strategic alignment engineering

Strategic alignment shows the ability of organizations to develop the strategic planning process and enhance compatibility based on several main dimensions, including permanent efficiency, which can be a source of competitive advantage. The most important elements of strategic alignment are three as follows [20]:

First - Fixed alignment

Second - Maturity of alignment processes, as they become building blocks in a unified measure of the organization's dynamic strategic alignment efficiency.

Third - Historical alignment

A number of researchers have comprehensively addressed the dimensions of strategic alignment, the most important of which are the social and intellectual dimensions. The social dimension of strategic alignment has been defined as the state in which business managers understand information technology within an important organizational unit and work to set and adhere to business and information technology goals and plans. The intellectual dimension of strategic alignment is defined as the state in which there is a set of high-quality information technology and interconnected business plans and linked intellectually [21]. There are types of alignment and their fields in strategic information technology management, as explained by [22] as business alignment, strategic compatibility, structural design, and information technology assignment. [23] also believes that one of the most appropriate methodologies for the requirements of programs related to business strategy is strategic alignment due to the weak integration with business and analysis of business strategy towards organizational information technology requirements through various levels (e.g., vision, mission, goal, etc.). However, it can be shown accurately that strategic alignment depends on the extent to which the strategy is appropriate to contribute to achieving the organization's goals and the requirements of its organizational work environment programs to meet part of the previously defined strategic goals.

4. Strategic modeling and simulation:

In the current era, modern methods such as integrated modeling and simulation are used to show the characteristics of the system life cycle in the possible future, and the increase in the value of the life cycle can be dealt with as an emerging system characteristic using integrated methods such as multidisciplinary design optimization, as purely technical simulation or optimization methods face difficulty in capturing the challenges of the social and technical design of infrastructure systems [24], and that the results of basic simulation are important for evaluating the effective benefits related to introducing new technologies and new solutions to traditional processes and determining the details and requirements for their implementation, and strategic engineering requires comparing the actual results achieved in reality with the estimates provided by virtual models and algorithms in order to verify whether they are reliable and correct and to identify the differences recorded in implementation and is an opportunity to modify factors and take corrective actions and adjust models in order to obtain better estimates and improve the predictive capabilities of simulation devices, and the use of optimization algorithms and solutions that allow moving forward in this direction automatically to ensure the ability to adjust immediately [25].

4 Sustainable Lean Manufacturing System

4.1 The concept of the sustainable lean manufacturing system:

The term sustainable lean manufacturing, abbreviated as (S.L.M), also takes the same meaning as sustainable lean production or sustainable loss-free production (Sustainable Lean Production), abbreviated as (S.L.P), and thus they give the same meaning and are used interchangeably and vice versa. [26] The contributions and opinions of writers and researchers in defining the concept of the sustainable lean manufacturing system have varied, as is the case with other modern administrative concepts, as this diversity is due to the difference in points of view, the goal of using this concept, and addressing and discussing it from more than one direction. A group of writers looked at Mechanism as a philosophy for ideal, waste-free manufacturing, while another team approached it from the content (tools and techniques), and there are those who approached it from multiple angles and combined more than one direction, while emphasizing that sustainable lean manufacturing aims in its final vision to eliminate all types of waste in the manufacturing process, and improve the manufacturing performance of the industrial organization without harmful effects on the environment while preserving it. Despite the multiplicity of concepts related to the sustainable lean manufacturing system, researchers agreed to highlight many of the basic aspects of sustainable lean manufacturing, and this diversity is not a contradiction as much as it is an integration. From the standpoint that sustainable lean manufacturing is expressed as a philosophy for ideal green manufacturing, some see it as an integrated production philosophy based on eliminating waste, environmental sustainability, and continuous improvement of processes through which the greatest amount of outputs are obtained with the least possible inputs and low or no levels of storage of materials and production, and less impact on the environment, and the production of green products and fewer workers, which is what other researchers see [27]. [28] believes that the sustainable lean manufacturing system is a system that uses a set of techniques and tools that focus on eliminating all forms of waste and loss and getting rid of activities that do not add value to the final product and providing green products through the effective use of available resources and not wasting them and achieving the greatest possible outputs using the least possible inputs and emphasizing low cost, high quality, appropriate flexibility, rapid delivery of the final product and preserving the environment. While there are those who have addressed the concept of the lean manufacturing system from multiple angles and combined more than one perspective, as [29] explained that it is a manufacturing strategy that aims to increase profit while reducing resource consumption and preserving the environment from harmful waste, as on-time production, providing green products, reducing waste, continuous improvement strategies, defect-free production and standardization of work are the main characteristics of the sustainable lean manufacturing system.[30] indicated that the sustainable lean manufacturing system is the process of discovering and identifying all manufacturing processes that do not add value and working to remove them in order to increase value and improve product quality and green production processes. In the same context, [31] referred to sustainable manufacturing as a manufacturing approach that seeks to build value using sustainable production elements to provide green products that can recover their value (reuse - recycling - renewal - repair - redesign - remanufacturing). Based on the above, it can be said that the sustainable lean manufacturing system is an integrated production methodology directed by the customer's desires and based on reducing waste and waste by relying on continuous improvement of all activities and processes using a set of sustainable methods and systems that enable the efficient and effective use of the organization's resources and the removal of activities that do not add value to the final product and emphasizing cost reduction, increasing value, high quality, appropriate flexibility and rapid delivery of the final product in order to respond to the customer and achieve his satisfaction by obtaining environmentally friendly products.

4.2 The importance and benefits of the sustainable lean manufacturing system:

The importance of the sustainable lean manufacturing system is highlighted by its focus on reducing human effort and environmental impact, its need for less manufacturing space, reducing the waiting period for production lead times, as well as reducing defects. The importance of this system stems from the fact that it provides the necessary methods to improve quality, meet customer expectations, reduce waste in all processes, enhance employee satisfaction, shorten delivery times, and provide environmentally friendly products.

The benefits of the sustainable lean manufacturing system can be explained as follows [32]:

1- Eliminating waste during manufacturing processes, i.e. eliminating all types of activities and processes that do not add value to the process of manufacturing products.

2- Leads to a significant increase in manufacturing flexibility.

3- Creating an organizational culture based on continuous improvement and environmental sustainability.

4- Implementing the sustainable lean manufacturing system significantly reduces pollution and harmful effects on the environment.

5- Improving working capital and productivity.

4.3 Wastes addressed by the sustainable lean manufacturing system:

Muda is a Japanese word meaning waste (waste), and refers to any activity that requires specialized resources but does not add value. Taiichi Ohnu, CEO of Toyota, introduced the concept of muda to refer to all activities that require resources but do not add value to the product or process, and customers are not willing to buy them and thus constitute waste [33].

[34] indicated that there are eight types of waste that negatively affect the productivity of manufacturing companies and which sustainable lean manufacturing works to address, namely:

1- Overproduction (waste): This means producing more goods than necessary at a certain time, i.e. producing items without actual orders, which leads to an increase in inventory, which in turn requires an increase in the number of workers and storage space as well as transportation, and this constitutes waste and thus large costs incurred by the organization.

2- Waiting time: It is a waste of productive time and is represented by the time that the process waits for the completion of another process, and it can happen in different ways due to the performance of workers or idle workers or machine breakdown or lack of knowledge of the work or lack of inventory ... and others.

3- Unnecessary transportation operations: This is represented by transporting products under manufacture over long distances, as unnecessary transportation is a great waste of time and effort and results in harmful emissions to the environment.

4- Excess inventory: This means that the levels of inventory under work are high, and is represented by raw materials in excess of the actual need for production, or the production of excess parts to meet customer requirements.

4.4 Dimensions of the sustainable lean manufacturing system:

Several an names are given to the dimensions or foundations of the sustainable lean manufacturing system application. Some call them tools, others call them techniques or methods, and others call them foundations, while others call them elements. In this study, the researchers will adopt the term dimensions because it is closer to the concept, in addition to the fact that they represent basic dimensions that are relied upon when applying the sustainable lean manufacturing system. The researchers agree in defining the dimensions of the lean manufacturing system with what [24] and [35] went to in defining four dimensions of the sustainable lean manufacturing system, which are (cellular manufacturing, automatic error detection, sustainable supply chain, and workplace organization).

The following is a brief explanation of each of them:

1 - Cellular Manufacturing:

Cellular manufacturing is one of the important technologies for the sustainable lean manufacturing system, and it uses the concepts of cluster technology to form a system that benefits from similarities in products, components or processes. It is a group of workstations that are located in a compact manner, where a group of sequential and multiple operations are carried out on one or more families of raw materials or parts [36]. He pointed out that cellular manufacturing organizes the entire process for a specific product or similar products in a group, including all machines, equipment and operators. He explained that it is a manufacturing approach based on cluster technology that exploits the advantages of similarity in the processing characteristics and design of parts. Regarding the goal of applying cellular manufacturing in a sustainable manner, he also explained [37] that it aims to reduce complexity in the production process, increase flexibility, reduce preparation times, work cycle time and delivery time, reduce variation in processing times, reduce transportation time, reduce work-in-progress inventory, and thus reduce waste, enhance product quality and control the production process. [9] also defined it as a group of operations in the work center or in work cells that produce similar products with similar requirements, because it is an input used to produce diverse products with the least possible waste, such that the work stations and equipment are arranged in a sequential manner that facilitates the flow of materials and components during the production process.

2- Automated error detection:

There are many modern methods for detecting errors in manufacturing processes, including manual inspection, automated tools, and testing. Manual inspection involves manually reviewing the code or data to identify errors and thus reduce them. Testing involves running the code or data through a set of pre-defined tests to identify errors. This method is more efficient than manual inspection, but it may not be able to detect all errors, meaning it lacks accuracy. Recently, advanced tools, equipment, and algorithms use smart programs to detect errors in code, data, or information about the manufacturing process. This approach is the most efficient and accurate, but it also requires specialized tools and expertise [4]. On the other hand, comprehensive productive maintenance is very important, as an organization cannot be agile without strong and reliable equipment. Therefore, comprehensive maintenance is a prerequisite for a longer life cycle for machines in industry. It is an innovative approach to maintenance that improves equipment effectiveness, eliminates breakdowns, and enhances independent operator maintenance through daily activities that include the total workforce. Comprehensive productive maintenance is characterized by three aspects [38]:

Productivity: It means that there is no activity that contains waste or does not add value to the activities and work to produce products that meet and exceed customer expectations.

Comprehensiveness: This means every individual in the organization, from the highest level, which is senior management, to the executive level, which is workshop workers who have a comprehensive responsibility in contributing to maintenance operations.

Maintenance: It means keeping equipment, machines and the factory in good working condition on an ongoing basis.

Regarding the goal of comprehensive productive maintenance, [39] indicated that it seeks to achieve the maximum efficiency in production machines and work to eliminate the waste of waiting time for the machine and workers, to improve the performance of the machine and the quality of products and detect errors while increasing the morale and job satisfaction of workers.

3- Sustainable supply chain:

It is a modern concept and these concepts vary and differ according to the researchers' points of view. The same applies to sustainable supply chain management. [31] defined it as those practices that start with the processes of supplying raw materials, through their manufacture, storage, and transportation, reaching distribution centers, and finally to the final customer. [40] indicated that it is integrated environmental thinking through supply chain management, as it includes product design, sources of raw materials, the manufacturing process, and delivering the final product to customers, and managing product deterioration at the end of its productive life. [41] defined it as the integration of environmental thinking in sustainable supply chain management, including product design, selection of suppliers and sources of materials, product packaging, product delivery to customers, manufacturing processes, and product management after use. [42] defined it as the process of using environmentally friendly inputs and converting these inputs into outputs in a way that enables them to be reused and repaired at the end of their life cycle, thus creating a sustainable supply chain. [43] defined it as a large group of activities and dimensions of sustainable manufacturing, practices to reduce energy consumption and pollution, practices of social responsibility of the organization, practices to manage relationships with suppliers and customers, and training activities directed at employees to enhance their ability to practice sustainability activities. [44] also defined it as the internal and external practices of organizations that are practiced in order to make the supply chain more sustainable in terms of taking into account the three dimensions of sustainability, which are environmental - societal - economic sustainability. Finally, defined as an interconnected group of practices and dimensions represented in internal management, sustainable information systems, green design, green purchasing, manufacturing and remanufacturing, sustainable storage, green logistics, cooperation with customers, waste disposal or recycling, working to follow up on practical developments of products and make them environmentally friendly, and contributing to achieving environmental sustainability for advanced business organizations. The dimensions of the sustainable supply chain are also multiple and are represented in (sustainable information technologies, sustainable manufacturing, sustainable purchasing, sustainable marketing) [18].

4 - Organizing workplaces:

Organizing workplaces is the cornerstone of the successful implementation of sustainable manufacturing agility in the organization and can be implemented throughout the organization. This technique focuses on organizing and arranging the workplace, which is often a problem that causes waste, pollution, and increased losses, such as the inability to find the required equipment or the loss of papers and main files. This technique is based on the assumption that organizing the workplace is a basic condition for producing products of distinctive quality, with little or no waste and high productivity [4]. Organizing workplaces referred to by the researchers' agreement [45] consists of the following Japanese phrases:

A- Sort: It means sorting materials according to their use or need, i.e. keeping only what is required and removing the unwanted things, as well as identifying the unnecessary parts. The filtering process usually takes place according to four steps as defined by [46], which are the stage of answering questions, the stage of examining before starting implementation, the stage of reviewing, and the stage of using the red card.

B-Straighten(Seiton) Arrangement: Arrange the required items in the work area in an effective manner, as each item should have its place and be easily accessible when required, and after getting rid of all unnecessary items, it is time to start organizing the area to raise the effectiveness of the work environment and increase the level of safety in the work area in general.

C-Shine(Seiso) Cleaning: This means cleaning the workplace by wiping off dust and deposits, polishing and even painting the machines, and this includes not only the work area but all tools, machines and other equipment to return them to a condition as close to new as possible, and it is the process of removing all unwanted effects in the workplace such as waste, oils, grease, etc.

D-Standardize(Seiketsu) Standardization: Ensuring that what was done in the first three stages has become standardized, and one of the most common tools in this step is the checklists, which are usually kept after various periods of time, and these lists set the standards that should be evaluated when conducting the examination and inspection.

C-Sustain(Shitsuki) Sustainability: Ensure discipline in practicing and repeating the first four steps until they become part of the organization's culture. This is the first step in creating a sustainable culture in the organization. This technique seeks to improve safety at work, improve work efficiency, improve productivity, as well as create a sense of ownership among employees, develop their belonging and increase their loyalty to the organization, as well as reduce inventory to the lowest possible level.

Practical aspect, conclusions and suggestions

5 Testing the Study Model and Hypotheses:

5.1 Description of the research sample:

A deliberate sample was chosen, which consisted of the researched individuals who had experience and knowledge and were aware of the laboratory's activity and tasks, to ensure that the accurate and useful information provided by them was benefited from, in addition to the possibility of obtaining ideas and suggestions that enhance the importance of the research. In line with this, the researchers began distributing (210) questionnaires that included the general manager, department heads, branch managers, units and divisions, as well as production line supervisors. (206) valid questionnaires were obtained for analysis, meaning that the response rate reached (96%).

5.2. This topic is devoted to verifying the validity of the hypothetical research scheme, which reflects the testing of the first and second main research hypotheses regarding the nature of the relationship and influence between the dimensions of Sustainable lean manufacturing system and the dimensions of the Strategic Engineering in the company under research, as follows:

First: Analyzing the correlation relationship between Strategic engineering (collectively and individually) and the dimensions of the Sustainable lean manufacturing System dimensions: This analysis undertakes the task of verifying the validity of the first main hypothesis and the sub-hypothesis emanating from it, as follows:

1. **Analysis of the relationship between the dimensions of Strategic Engineering (combined) and the dimensions of the Sustainable lean manufacturing system :** This analysis expresses the test of the first main hypothesis, which states that there is a significant correlation between the strategic engineering dimensions and the dimensions of the Sustainable lean manufacturing system (combined), as the data in Table (1) indicate the presence of A strong correlation between them in terms of the value of the correlation coefficient of (0.863 *) at a significant degree (0.05), which explains the strength of Sustainable lean manufacturing system dimensions in the possibility of the company in question adopting the dimensions of the Strategic engineering and thus accepting the first main hypothesis.

Table 2. The relationship between the dimensions of the Strategic engineering (combined) and the dimensions of the Sustainable lean manufacturing system

Independent Variable / Dependent Variable	Dimensions of the Strategic Engineering
Dimensions of Sustainable Lean Manufacturing System	0. 863*

1. **Analysis of the relationship between strategic engineering (collectively) and each dimension of the sustainable lean manufacturing system dimensions (individually)** : This relationship reflects the testing of the sub-hypothesis emanating from the first main hypothesis, which states that there is a significant correlation between strategic engineering dimensions (collectively) and each dimension of The of the sustainable lean manufacturing system (individually) in the company under study, as it is clear from the data of Table (3) that:

a. There is a significant correlation between the strategic engineering and the **sustainable supply chain** dimension, as the value of the correlation coefficient was (0.751*) at a significant degree (0.05), and this confirms the fact that the strategic engineering represents the active element in the company, and that the greater the strategic engineering, the greater its impact on sustainable supply chain dimension..

B. There is a significant correlation between the strategic engineering and the **organizing workplaces** dimension , as the value of the correlation coefficient was (0.811 *) at a significant degree (0.05), and this indicates the role of strategic engineering in guiding workers and working in an ideal manner, committed to instructions and guidelines, and the availability of strict performance standards that regulate Work and lead the company to success and progress.

c. There is a significant correlation between the strategic engineering and the **cellular manufacturing** dimension, as the value of the correlation coefficient was (0.783*) at a significant degree (0.05). This result confirmed that most managers must adopt a certain management or digital modeling and simulation approach in the company that differs from another company according to the situation or situations it faces, which calls for the use of an appropriate pattern of cellular manufacturing according to the imposed situation in a way that contributes to achieving success for the organization.

d. There is a significant correlation between the strategic engineering and the **automatic** error detection dimension, as the value of the correlation coefficient reached (0.793*) at a significant degree (0.05), and this indicates that the strategic engineering has a role in implementing the work in the programmed form according to regular electronic programs that have an effective impact in achieving organizational goals .

Table 3. Correlation relations between dimensions of sustainable lean manufacturing system (individually) and the dimensions of the strategic engineering

independent variable / dependent variable	Dimensions of strategic engineering			
	Strategic alignment	Digital modeling and simulation	Digital leadership	Organizational structure engineering
Sustainable lean manufacturing system	0.739*	0.783*	0.811*	0.751*

Second: Presenting the results of the confirmatory factor analysis: Structural Equation Modeling (SEM) is one of the latest data analysis methodologies. The constructivist of the measurement tool through a set of indicators (indicators of good conformity), which are shown in Table (1), which show the quality of the hypothetical model on the basis of which it is accepted or rejected), which is one of the analysis methods within the statistical program (AMOS), Accordingly, the research model and its indicators will be presented to identify the extent to which these indicators match the standard indicators, as well as to identify the saturation values of the model, as shown in Figure (2) and Table (4):

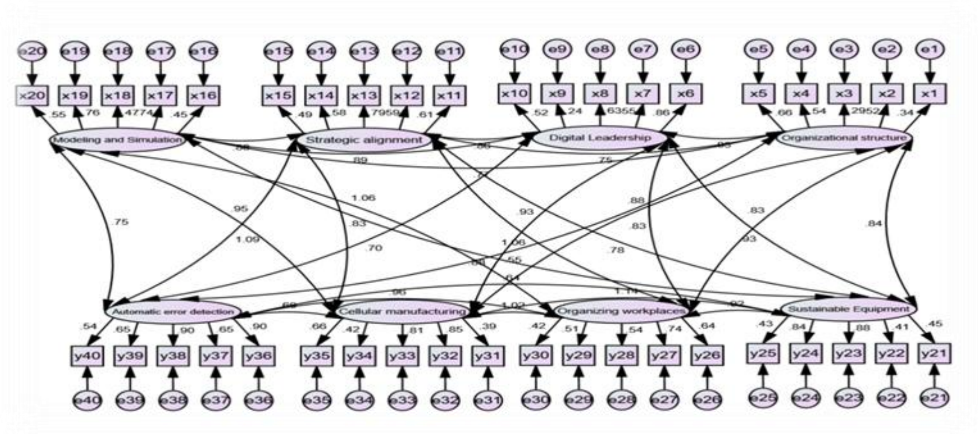


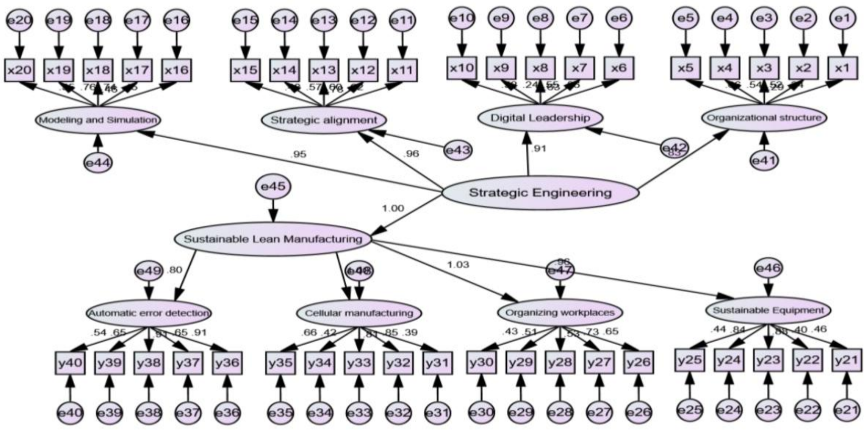
Fig. 2. The results of the first stage of the research model test

Table 4. quality indicators of the prototype

	Standard indicators	Acceptance limits	Model Indicators	Matching result
1	(CMIN/ DF)	**2 > CMIN/ df Exact match, 5 < CMIN/ df Accept the model**	**1.55**	**identical**
2	(RMR)	**The value of RMR is 0.08 and less, and the closer to zero, the better the model matches**	**0.98**	**identical**
3	(GFI)	**GFI > 0.90 Model quality, GFI < 0.90 Poor matching**	**0.93**	**identical**
4	(AGFI)	**AGFI > 0.85 Acceptable Match, AGFI=1 Exact Match**	**0.92**	**identical**
5	(PGFI)	**The closer to 1, this indicates a good fit of the model**	**0.81**	**identical**
6	(NFI)	**NFI=1 perfect match, NFI >0.90 best match**	**0.92**	**identical**
7	(RFI)	**0.90)> RFI) data matches the model**	**0.91**	**identical**
8	(PRATIO)	**0.95) > RFI) better match, 1=(RFI) perfect match(**	**0.91**	**identical**
9	(PNFI)	**Its value ranges from (zero - 1) so that the value that exceeds (0.90) indicates a good conformity with the model.**	**0.84**	**identical**

Third : Test the hypotheses of the current study: After conducting the confirmatory factor analysis (CFA) and accessing the model to the required quality standards of conformity, it became possible to test the hypotheses that were identified as follows:

1. There is a significant effect of the Sustainable lean manufacturing system in the Strategic Engineering: For the purpose of testing and verifying the validity of this hypothesis, a structural equation model was built, as shown in Figure (3). The values of the tests in this model, which lead us to accept our hypothesis or not, were also clarified, as shown in Table



(5) **Fig. 3. The first main hypothesis test model**

Table 5. The analysis values for the first main hypothesis

P-value	95% Confidence Interval		Estimate	SRW	Dependent Variable	Direction of Influence	Independent Variable
0.01	0.968	Lower Bound	1.001	1.014	Strategic Engineering	→	Sustainable lean Manufacturing System
	1.027	Uppr Bound					

The data of Table (5) indicates that there is a direct and significant effect of the Strategic engineering in the possibility of establishing a sustainable lean manufacturing system through the value of the standard regression coefficient (SRW) of (1.014) as well as the non-standard regression coefficient (Estimate) of (1.001), and this effect is significant in terms of the probability value (P-value) of (0.01) which is less than (0.05), and the same result confirms the confidence limits (95% Confidence Interval) for the value of the non-standard regression coefficient, which is in its lower and upper limits (... - 1.055). The period does not include the value (zero) between its terms, and this is evidence of the significance of the effect of the interpreted variable on the dependent variable, **Therefore, the second main hypothesis is accepted .**

2. There is a significant effect of the strategic engineering in each dimensions of the sustainable lean manufacturing system: To test the sub-hypothesis of the second main hypothesis, we include Figure (4) and Table (6) as follows:

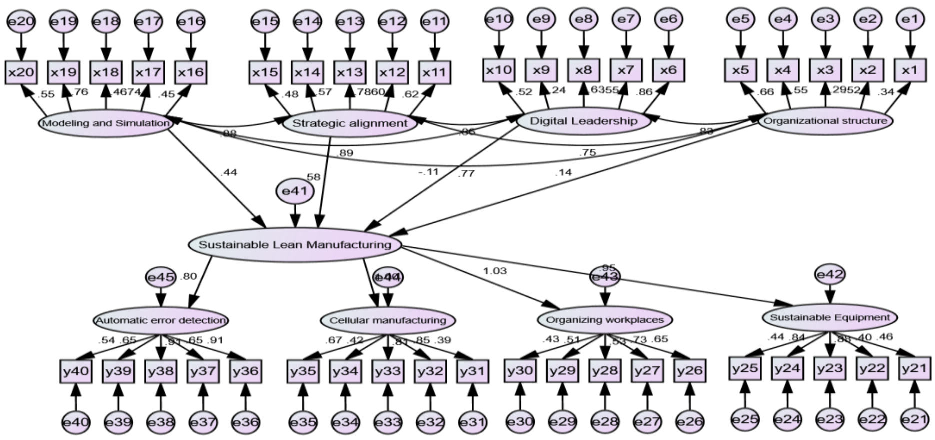


Fig (4). The Second main hypothesis Test

Table 6. Analysis values for the second main hypothesis

Independent Variable	Impact Direction	Dependent Variable	SRW	Estimate	95% Confidence Interval		P-value
Organizational Structure Engineering	→	Sustainable lean manufacturing	0.539	0.089	Lower Bound	0.430	**0.022**
					Upper Bound	0.657	
Digital Leadership	→	Sustainable lean manufacturing	-0.107	-0.069	Lower Bound	-1.089	**0.904**
					Upper Bound	-----	
Digital modeling and simulation	→	Sustainable lean manufacturing	0.577	0.656	Lower Bound	0.454	**0.043**
					Upper Bound	1.322	
Strategic Alignment	→	Sustainable lean manufacturing	0.441	0.322	Lower Bound	0.209	**0.021**
					Upper Bound	0.986	

It is evident from Table (6) That:

a. There is a direct and significant effect of the **organizational structure Engineering** in enhancing the sustainable lean manufacturing system through the value of the standard regression coefficient (SRW) of (0.539) as well as the non-standard regression coefficient (Estimate) of (0.089), and this effect is significant in terms of the probability value (P-value) of (0.02)., which is less than (0.05), and the same result confirms the confidence limits for the value of the non-standard regression coefficient, which is in its lower and upper limits (0.430 - 0.657), and it is noted that this period does not include the value (Zero) between its limits, and this indicates the significant effect of the independent variable on the dimensions of the dependent variable (**organizational structure engineering**).

b. That there is a direct and significant effect of the **digital leadership** in enhancing strategic engineering through the value of the standard regression coefficient (SRW) of (-0.107) as well as the non-standard regression coefficient (Estimate) of (1.069), and this effect is significant in terms of the probability value (P-value) of (0.90), which is less than (0.05), and the same result confirms the confidence limits for the value of the non-standard regression coefficient, which is in its lower and upper limits (-1.089 - ***), and it is noted that this period does not include the value (Zero) between its limits, and this indicates the significance of the effect of the independent variable on the dimensions of the dependent variable (**digital leadership**).

C. There is a direct and significant effect of **digital modeling and simulation** in enhancing sustainable lean manufacturing system through the value of the standard regression coefficient (SRW) of

(0.557) as well as the non-standard regression coefficient (Estimate) of (0.656), and this effect is significant in terms of the probability value (P-value) of (0.04) which is less than (0.05), and the same result confirms the confidence limits for the value of the non-standard regression coefficient, which is in its lower and upper limits (0.454 – 1.322), and it is noted that this period does not include the value (Zero) between its limits, and this indicates the significance of the effect of the independent variable on the dimensions of the dependent variable (**digital modeling and simulation**).

D. There is a direct and significant effect of **Strategic Alignment** in enhancing Sustainable lean manufacturing system through the value of the standard regression coefficient (SRW) of (0.441) as well as the non-standard regression coefficient (Estimate) of (0.322), and this effect is significant in terms of the probability value (P-value) of (0.02), which is less than (0.05), and the same result confirms the confidence limits for the value of the non-standard regression coefficient, which is in its lower and upper limits (0.209 - 0.986), and it is noted that this period does not include the value (Zero) between its limits, and this indicates the significance of the effect of the independent variable on the dimensions of the dependent variable (**Strategic Alignment**).

6 Conclusions and Suggestions:

6.1 Conclusions

The study reached a set of conclusions related to the study variables as follows:

1. Strategic engineering is one of the most important principles of modern management applied today around the world, as it is a basic entry point for improving industrial and operational processes efficiently
2. The philosophy of the lean manufacturing system provides a set of tools and mechanisms that provide radical solutions for companies that enable them to get rid of waste, waste and pollution that may occur in all its forms.
3. The individuals surveyed in the company under study have an appropriate level of experience, and most of them have good academic qualifications, which gave them sufficient understanding of their work, which contributed to their understanding of the questionnaire paragraphs accurately and reaching good and realistic results
4. The management of the company under study works to provide its employees and engineers with the skills and experiences necessary to train them, qualify them and give them the required knowledge to ensure that work and tasks are carried out without errors or problems and with minimal harm to the environment, thus keeping pace with the rapid developments in the environment surrounding their work.

6.2 Suggestions:

The study concluded with a set of proposals related to the study variables as follows:

1. Increasing the interest of the management of the company under study in the components of administrative thought in modern fields, especially strategic engineering, and deepening its role among managers and employees of the laboratory under study, as this contributes to enhancing the ability to survive and grow in the business world.
2. Increasing the interest of the management of the company under study in the dimensions of strategic engineering such as organizational structure engineering, digital leadership, digital modeling and simulation, and strategic alignment in an attempt to produce products that meet the needs of its customers in terms of quality and appropriate cost, as well as the economic benefits that the company derives from applying strategic engineering in its four dimensions.
3. The officials and managers in the senior management of the company under study must work to raise the morale of individuals and workers and enhance their belonging to the company in which they work by giving them more powers to make decisions, as well as working to provide sufficient information about the application of modern and sustainable systems in the laboratory so that individuals can deal with them and make decisions about them.
4. Increase the awareness of the management of the company under study of the need to adopt the dimensions of the sustainable lean manufacturing system, in addition to striving to adopt the dimensions of strategic engineering by increasing interest in discovering untapped opportunities, as well as striving towards advanced technologies in sustainable manufacturing and actual interest in the digital control of the laboratory and clarifying the important role it plays in improving the

performance of the laboratory, taking into account the environmental and social aspects and preserving them.

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