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The Role of Green Total Quality Management in Achieving Environmental Sustainability

Azzam Abdul Wahab Abdul Karim Al-Sabbagh
Middle Technical University – Administrative Technical College – Baghdad

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Abstract

Maintaining environmental safety and sustainability is one of the most important issues that concerns countries and organizations due to its impact on the present and future. In their efforts to study reducing potential environmental impacts, researchers have begun linking approaches and methods that focus on reducing damage and waste with approaches and methods that focus on environmental conservation. This includes linking quality management with the environment. The research problem lies in the increasing negative impacts on the environment resulting from the rush of organizations of all types to exploit natural resources for profit without considering the scarcity of some resources and the needs of future generations. This research aims to determine the relationship and impact of green Total Quality Management (TQM) on achieving environmental sustainability at an Iraqi university. The Middle Technical University was selected as the study sample. A questionnaire was used as the data collection tool, with 180 forms distributed. The data were then processed using SPSS software. The research concluded that there is a relationship and impact between green TQM and environmental sustainability at the university in the study sample.

Keywords*: Green Total Quality Management; Sustainable Environment*

1. Introduction

A changing environment is one of the most significant obstacles and constraints hindering organizations' progress. Therefore, organizations resort to adopting new strategies and policies to overcome rapid environmental changes. The shift in consumer preferences from traditional products to green and environmentally friendly products has led organizations to adopt new operating methods such as green supply chains and green manufacturing, as well as encouraging green innovation and creativity, all with the aim of producing green products that meet customer demands. At the same time, customers seek high-quality products, so green total quality management has become linked to the policies and procedures that organizations implement to attract customers and meet their requirements for green products. Many researchers have focused on studying the impact of environmental sustainability and green policies on organizational success, but this topic requires further research as it is a vital and evolving subject, given its connection to meeting customer needs. Organizations need to develop sound process planning to create a valuable product or service for their customers. Management systems have evolved over the years, and Total Quality Management (TQM) is one such system that has been used in various organizations worldwide. Total Quality Management (TQM) focuses on customer needs, and its implementation improves performance, increasingly impacting customer satisfaction. In recent years, TQM has gained significant importance as a methodology that, when properly implemented, can give organizations a competitive advantage (organizations that implement TQM offer high-quality products at lower costs). The principle of customer focus is a key principle adopted by many organizations, including higher education institutions, leading them to continuously embrace quality assurance

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principles. Therefore, in order to assess the quality of the educational process, numerous university rankings have emerged, establishing specific criteria. Adherence to these criteria grants a university entry into a particular ranking, such as the Times Higher Education World University Rankings and the Shanghai Ranking, among others. These rankings not only consider the educational aspect but also give considerable weight to the environmental dimension. Many of these rankings have adopted the principles of Total Quality Management in setting their standards, linking them to environmental considerations and how to preserve and utilize resources in a way that does not harm future generations. It is one of the best ways to enable sustainable and continuous development, achieve environmental sustainability, and improve environmental performance (Albloushi et al., 2023).

2. Literature Review

2.1 Total Quality Management (TQM)

Organizations of all types are under constant pressure from both governments and consumers to acknowledge their negative environmental impacts. To address these threats, organizations focus on two key aspects: social responsibility and Total Quality Management (Saeidi et al., 2024, p. 1). One study investigated the impact of (TQM) practices and green supply chain management on competitive advantage within the context of sustainability performance in small and medium-sized enterprises (SMEs). The study used a sample of SME owners in Indonesia to assess the relationship between the variables. The study concluded that TQM practices and green supply chain management each contribute individually to sustainability performance in SMEs (Masudin et al., 2025, p. 1). Gul et al. (2024, p. 1) aimed to identify the fundamental relationship between Total Quality Management (TQM) and Corporate Green Performance (CGP). Their study explored how TQM impacts CGP, using a sample of small and medium-sized Chinese organizations. The results demonstrated that TQM has a significant positive effect on CGP.

Khalil et al. (2021, p. 1) analyzed the impact of TQM practices on CGP and investigated the causal relationship between these practices and CGP. The researchers collected data from 123 large and medium-sized private companies in the healthcare sector in Pakistan. The study concluded that Total Quality Management (TQM) practices have a significant positive impact on green performance. This demonstrates that TQM practices greatly enhance an organization's efficiencies in achieving its green performance goals.

Another study examining the relationship between TQM practices and sustainability found that TQM and sustainability are the two most important approaches with a positive impact on organizational performance (Wassan et al., 2022, p. 1). One study also showed a positive relationship between TQM and companies' environmental performance. This study concluded that TQM plays a significant role in improving environmental performance (Soesilo et al., 2023, p. 1100). A study on the relationship between Total Quality Management (TQM) and the level of green manufacturing practices in Palestinian food manufacturing companies examined the sample of senior managers, quality managers, and human resources managers from 250 Palestinian food manufacturing companies. The study found a strong positive correlation between TQM practices and overall organizational performance (Hassan et al., 2021, p. 2). One of the few studies addressing green TQM is Heidari et al. (2020, p. 558), which aimed to investigate the impact of green supply chain management on organizational performance, focusing on the role of TQM as a mediator. The study included a sample of 152 managers, deputy managers, and supply chain experts from small and medium-sized enterprises (SMEs) in Iran. The results indicated that green supply chain management has a positive and significant impact on total quality management, environmental performance, and financial performance. Therefore, environmental issues and conservation have become among the most important criteria consumers consider when making purchasing decisions. Eid et al. (2024, p1) concluded that combining environmental sustainability practices with total quality management leads to better project outcomes, such as reduced environmental damage, increased efficiency, and greater stakeholder satisfaction. Total Quality Management (TQM) is an integrated management philosophy that combines strategy, culture, processes, and data to guide decision-making with the goal of continuously improving organizational output and customer satisfaction Total Quality Management (TQM) is based on the following principles, as explained by the American Society for Quality (ASQ): customer focus, employee engagement, process orientation, strategic alignment, continuous improvement, and fact-based decision-making (Okeke et al., 2025, p. 294). Chaher et al., 2025, p. 1, studied the relationship between TQM, green innovation, and

green performance in Tunisia. They concluded that TQM positively impacts both green innovation and green performance.

3. Sustainable Environment

Environmental sustainability and awareness are becoming increasingly important, as they have become a social responsibility incumbent upon all nations. Countries are focusing on developing policies and regulations to guide organizations across various sectors to ensure environmental sustainability in all their projects and products. Various service and industrial sectors impact the environment through the consumption of large quantities of water, increased waste, and high greenhouse gas emissions. The final product of projects can be either harmful or environmentally friendly, and environmental sustainability is a crucial aspect. It can be used to encourage organizations to use environmentally friendly materials in their products, ensuring that their products do not negatively impact current and future generations. Total Quality Management (TQM) focuses on using the materials customers need to achieve the required quality level. Customers, on the other hand, focus on using high-quality materials that are also environmentally friendly (Eid et al., 2024, p. 3). Zhou et al. (2025) studied the importance of collaboration between government and organizations to achieve net-zero emissions and a better, more sustainable environment. Researchers have concluded that when government agencies build constructive and productive relationships with organizations and involve them in decision-making, it will inevitably lead to proactive and interactive behavior between the two sides. This, in turn, significantly contributes to the adoption of effective policies and procedures for environmental protection. Radwan et al. (2026) studied how artificial intelligence interacts with factors that harm the environment and how government agencies address these damages to mitigate their negative impacts. Their study found that urbanization, increased industrialization, and economic expansion all contribute to environmental damage and compromise sustainability by impacting future generations' share of limited resources and simultaneously increasing pollution. However, the study also emphasized that the use of artificial intelligence tools and digital transformation can help reduce negative environmental impacts by minimizing waste release into the environment. In the area of the role of digital transformation tools and artificial intelligence in environmental conservation, Alam et al. (2025) presented a study demonstrating that automated systems significantly contribute to reducing the environmental damage caused by the waste, gases, and pollutants generated by traditional systems. Reducing reliance on manual labor leads to lower costs, reduced production losses, shorter production times, and the elimination of production waste. Furthermore, automation improves product quality and accelerates production. Ozbay (2025) studied the factors that facilitate the adoption of green technologies and policies, finding that investment in environmental research and development and building a skilled human capital are crucial for the successful implementation of green policies.. The data from the panels, which included 16 OECD countries, showed that human capital, market size, and the stringency of environmental policies play significant roles in the production of environmental technologies and innovations.

Harrou et al. (2025, p. 1) explored the application of swarm robotics, swarm computing, and evolutionary technologies in environmental management and sustainability through a bibliometric analysis of two sets of peer-reviewed research papers. The first set focused on specific applications of swarm robotics systems in environmental use cases, including drone swarms, for tasks such as environmental monitoring, agricultural management, and disaster response. The second dealt with the various swarm and evolutionary computing algorithms used in this specialized field, and the results it reached confirm the crucial role of swarm robots in environmentally focused tasks, such as ecosystem restoration, and the importance of safe cooperation mechanisms, paving the way for progress in the fields of agriculture, resource management, smart infrastructure, and urban systems.

4. Definition and Concept of Total Quality Management (TQM)

Total Quality Management (TQM) is an organizational system that encompasses the entire organization, working to meet customer expectations while reducing costs. In other words, TQM is a quality-focused management approach, including products, customer satisfaction, and employee satisfaction. TQM seeks to understand and meet customer expectations through continuous improvement in all organizational functions. It is defined as a systematic approach to managing the quality of an organization's products, processes, and resources to satisfy its internal and external customers. In short, TQM is an integrated management system that focuses on: a. Meeting the needs of

owners/customers by providing high-quality services at a reasonable cost. b. Continuous improvement. c. Appreciating the role of each individual in the organization. d. Viewing the organization as a system with a common goal. e. Focusing on how tasks are accomplished and emphasizing teamwork (Yadav., 2024, pp. 6-7). Total Quality Management (TQM) is a contemporary management philosophy based on a set of modern management indicators and concepts related to innovative efforts, basic management definitions, and specialized technical skills (Hassan, et al., 2021, p. 6). Some researchers describe TQM as the standardization of quality management standards such as ISO 9001, while others present TQM using models of organizational excellence (European Foundation for Quality Management, Baldrige Award, Malcolm X-Quality Award, Deming Prize) (Nguyen, et al., 2023, p. 312). Total Quality Management (TQM) is also defined as a philosophy and set of guiding principles that integrate management techniques, technical tools, and improvement efforts into a stable technical system with continuous improvement goals for managing the company (Abdullah, 2010, p. 3). Organizations must reassure consumers that the standards of their services and goods will be high and that their actions will not negatively impact the environment. Companies can use environmentally friendly approaches to address concerns related to the natural environment. These activities are characterized by environmentally friendly practices that an organization can adopt to become more sustainable. These organizations focus on reducing their environmental impact through initiatives that limit unethical environmental practices by ensuring that the company's practices meet minimum sustainability standards (Khalil et al., 2021, p. 2).

5. Definition and concept of a sustainable environment

The environment is defined as the surroundings or conditions in which humans, animals, or plants live or seek to grow. In other words, the environment encompasses all external and internal factors, both living and non-living, that affect living organisms (plants and animals). Conserving natural resources from depletion, protecting wildlife, and ensuring the continued flow of water are at the heart of environmental sustainability. At the same time, many challenges arise that are indirectly caused by humans, such as climate change, which generates both direct and indirect damage to the environment. This necessitates concerted efforts to reduce the human-caused factors. Overhunting, excessive use of fossil fuels, and dumping waste into rivers pose a threat to wildlife and biodiversity, with the impact being greater in developing societies (Aidonojie et al., 2025, p. 1). Humans are the most likely to cause a lot of damage to the environment through their expansion in the construction of factories and the fuel they consume, which, when burned, turns into gases that contribute to global warming and into waste and production byproducts that go into the environment. Also, the uprooting of trees and the damage it causes to the Earth’s crust contribute to increasing the effects of climate change (Ukhurebor et al., 2024, p. 2).Climate change negatively impacts the environment, causing rising temperatures, drought, food insecurity, biodiversity loss, and numerous other adverse environmental challenges (Rose, 2016, p. 1). Environmental degradation is a global problem affecting the entire world. All living organisms are affected by pollution in one way or another. Even animals living in the polar regions or on the ocean floor are affected. Increasing environmental degradation is linked to increased human activity (Kumae et al., 2022, p. 532). The environment consists of biotic and abiotic components, in addition to the human environment, which is linked to social, cultural, and economic systems (Tsai et al., 2018, p. 101). The environment is divided into three main types: the physical environment, the social environment, and the cultural environment.

a. The physical environment: This includes plants, animals, and climatic factors such as temperature, wind, sunlight, soil, and rocks.
b. The social environment: This is the environment created and inhabited by humans, such as schools, homes, roads, airports, ports, bridges, stadiums, markets, banks, shops, and farms.
c. The cultural environment: This encompasses the cultural and social aspects of a particular society, such as customs and traditions, clothing styles, food types, and religious activities in places of worship like churches and mosques.

The authors agree that the following are the main dimensions of a sustainable environment: protecting natural resources, combating pollution, preserving biodiversity, ensuring the sustainable use of resources, and the institutional and legislative dimensions.

Second: Study Methodology

1.Study Problem

a. Does the organization under study adopt the principles of Green Total Quality Management (TQM)?
b. What is the level of concern of the organization under study for maintaining the safety and sustainability of the external environment?
c. Does Green TQM contribute to maintaining environmental sustainability in the organization under study?
d. What is the nature of the relationship and impact between Green TQM and a sustainable environment?

2.Study Objectives: The study objectives stem from the research problem and its questions, as follows:

a. To determine whether the organization under study applies the principles of Green TQM.
b. To determine the extent to which the organization under study prioritizes environmental sustainability.
c. To identify the nature of the relationship between green Total Quality Management (TQM) and environmental sustainability within the organization under study.
d. To test the impact of green TQM on environmental sustainability within the organization under study.

3.Study Hypotheses

The first main hypothesis: There is a statistically significant correlation between green Total Quality Management and a sustainable environment in the study sample. The following sub-hypotheses stem from this main hypothesis:

a. There is a statistically significant correlation between senior management commitment and a sustainable environment.
b. There is a statistically significant correlation between focusing on the environmental customer and a sustainable environment.
c. There is a statistically significant correlation between continuous environmental improvement and a sustainable environment.
d. There is a statistically significant correlation between green process management and a sustainable environment.
e. There is a statistically significant correlation between employee participation, environmental training, and a sustainable environment.
f. There is a statistically significant correlation between supplier relationship management and a sustainable environment.

Second Main Hypothesis: There is a statistically significant effect between green Total Quality Management and a sustainable environment in the study sample. The following sub-hypotheses stem from this main hypothesis:

a. There is a statistically significant effect between senior management commitment and a sustainable environment.
b. There is a statistically significant effect between focusing on the environmental customer and a sustainable environment.
c. There is a statistically significant effect between continuous environmental improvement and a sustainable environment.
d. There is a statistically significant effect between green operations management and a sustainable environment.
e. There is a statistically significant effect between employee participation, environmental training, and a sustainable environment.
f. There is a statistically significant effect between supplier relationship management and a sustainable environment.

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Third: The Practical Aspect

1. Research Population and Sample:

The employees of the Presidency of the Middle Technical University, numbering (385) employees, were chosen as the study population. A random sample was selected from them to represent the study sample. The Middle Technical University is considered one of the leading universities in the field of environmental awareness and is included in a number of environmental classifications. The size of the selected sample was determined with a margin of error of 7% and a confidence level of 95% for the total number of employees according to the following equation:

$$n= N/(1+N(e)^2)= \quad 385/(1+385(0.07)^2) =133$$

Required sample size = n
Total study participants = N
Accuracy level = e

From this, it is clear that the acceptable sample size is (133). To increase accuracy, (200) questionnaires were distributed, of which (188) were returned, and the number of valid questionnaires was (180).

A. Face Validity Test of the Research Measures

The questionnaire was presented to a number of specialists from several Iraqi universities to test its face validity and to obtain their opinion on the suitability of its items to the dimensions of the research variables. They provided a number of observations that were taken into account in order to make the questionnaire more accurate. After that, the questionnaire was distributed to the research sample.

B. Reliability Test Using Cronbach's Alpha

To test the validity, reliability, and consistency of the questionnaire items, Cronbach's alpha was used. Table (1) shows the reliability of the study variables. For green total quality management, the test score ranged from 0.964 for top management commitment (highest reliability threshold) to 0.929 for continuous environmental improvement (lowest reliability threshold). For sustainable environment, the test score ranged from 0.983 for protecting natural resources (high reliability threshold) to 0.968 for sustainable resource use (lowest reliability threshold). Table (1) shows the results of Cronbach's alpha test for the study variables.

Table (1) Cronbach's Alpha Test for Study Variables

Independent variable	Dimensions	Cronbach's Alpha	Number of paragraphs
Green Total Quality Management	Top Management Commitment	0.964	4
	Focus on the Environmental Customer	0.946	4
	Continuous Environmental Improvement	0.929	4
	Green Operations Management	0.953	4
	Employee Engagement and Environmental Training	0.956	4
	Relationships with Green Suppliers	0.959	4
	All Axes of the Independent Variable	0.954	6
	optimal utilization of natural resources	0.983	4

Dependent variable: Environmental sustainability	Reducing Environmental Pollutants:	0.982	4
	Preserving Living Organisms and Their Diversity	0.972	4
	Preserving resources for future generations	0.968	4
	Compliance with Environmental Laws and Regulations	0.976	4
	All aspects of the adopted variable	0.975	5

The results were prepared by the researcher using SPSS V.28 software.

Analysis of Sample Responses

A. Personal Data

Table (2) shows the personal data of the research sample. It is evident that the sample consisted of 108 males and 72 females. Regarding the educational level of the research sample, 104 participants held a bachelor's degree, representing the largest percentage. As for academic specialization, humanities disciplines constituted the largest group, with 96 participants. The length of service data showed that the largest group comprised newly appointed employees, totaling 80 individuals. Regarding professional development, most employees reported completing several training courses during their careers

Table (2) Personal Data of the Research Sample

Gender	Male	female			
	108	72			
Educational Attainment	Preparatory	Bachelor's	Higher Diploma	Master's	PhD
	0	104	20	36	20
Major	Engineering	Pure Sciences	Humanities	Social Sciences	Under Specialization
	32	40	96	4	8
Length of Service	Less than 5	5-less than 10	10-15 less than	15 less than 20	20 and above
	80	44	12	32	12
Number of Courses	1-2	3-5	6-8	9-12	13 and above
	10	20	35	45	70

The table was prepared by the researcher.

B. Analysis of Responses Related to the Independent Variable: Green Total Quality Management

a. Following the commitment of senior management: Table (3) shows that this dimension achieved a mean of (3.494), which is higher than the hypothetical mean, with a standard deviation of (1.158) and a coefficient of variation of (33.14%). As for the questions within this dimension, question (1) (senior management support for environmental policies) achieved the highest mean of (4.089), which is also higher than the hypothetical mean, with a standard deviation of (0.814) and a coefficient of variation of (19.91%). This indicates that the

university administration is interested in and supports environmental policies, which is reflected in the university's inclusion in environmental rankings. Item (3) (Senior Management Integrates the Environmental Dimension into the General Strategy) achieved the lowest mean score (3.00), which is considered good, with a standard deviation of (1.252) and a coefficient of variation of (41.69%). This indicates that the administration does not include the environmental dimension in its strategies.

b. After focusing on the environmental customer: This dimension achieved a mean score of (3.500), which is considered good, with a standard deviation of (0.946) and a coefficient of variation of (27.04%). Regarding the items within this dimension, item (7) (The organization offers environmentally friendly products) achieved the highest mean score (3.711), which is considered good, with a standard deviation of (0.656) and a coefficient of variation of (17.67%). This indicates that the university is committed to ensuring its products and student projects are less harmful to the environment. Question (8), "The organization works to improve customer satisfaction through environmental practices," achieved the lowest mean score (3.133), which is higher than the hypothetical mean, with a standard deviation of (1.027) and a coefficient of variation of (32.78%). This suggests a lack of focus on stakeholder engagement in the university's environmental practices

c. Improving environmental sustainability: This dimension achieved an average of (3.644), which is higher than the hypothetical average, with a standard deviation of (0.848) and a coefficient of variation of (23.27%). Regarding the items within this dimension, items (9 and 11) (The organization adopts continuous improvement of environmental performance) and (The organization applies modern methods to improve environmental processes) achieved the highest mean scores (3.578), also considered good, with standard deviations of (0.616 and 1.088), and coefficients of variation of (17.22% and 30.41%, respectively). This indicates the university administration's strong commitment to the environment and its efforts to improve performance in a way that reduces emissions and potential environmental damage. Paragraph (10) (The organization seeks to continuously reduce waste and emissions) achieved the lowest arithmetic mean (3.800) at a good level and with a standard deviation of (0.620). As for the coefficient of variation, it achieved (16.31%), which indicates that there is still gas emissions, especially in student training workshops.

d. Green Operations Management: This dimension achieved a mean score of (3.432), which is considered good, with a standard deviation of (0.957) and a coefficient of variation of (27.89%). Regarding the questions within this dimension, question (15) (The organization is concerned with monitoring the impact of student work in workshops and laboratories on the environment) achieved the highest mean score (3.622), which is higher than the hypothetical mean, with a standard deviation of (0.678) and a coefficient of variation of (18.72%). This indicates that the university's culture of routine environmental oversight aligns with a genuine administrative commitment to environmental responsibility. Question (13) (The university is keen to ensure that student projects are environmentally friendly) achieved the lowest mean score (3.044), which is also higher than the hypothetical mean, with a standard deviation of (1.077) and a coefficient of variation of (35.38%). This low mean score is concerning, as it suggests that the university administration may not be adequately addressing the environmental damage caused by student experiments in laboratories and workshops.

e. After employee participation and environmental training: This dimension achieved a mean of 3.419, which is higher than the hypothetical mean, with a standard deviation of 1.088 and a coefficient of variation of 31.82%. Regarding the questions within this dimension, question (18) (The university encourages its employees to participate in environmental initiatives) achieved the highest arithmetic mean of 3.978, which is higher than the hypothetical mean, with a standard deviation of 0.776 and a coefficient of variation of 19.52%. This indicates that the university supports environmental conservation activities, as evidenced by the annual environmental events that include tree planting both on and off campus. Question (20) (The university supports environmentally-related ideas presented by employees) achieved the lowest arithmetic mean of 3.044, which is higher than the hypothetical mean, with a standard deviation of 1.336. The coefficient

of variation was 43.89%. This indicates that the number of environmentally conscious ideas presented by employees remains limited.

f. Furthermore, regarding relationships with environmentally conscious suppliers: this dimension achieved a mean score of 3.569, exceeding the hypothetical mean of 3, with a standard deviation of 1.076 and a coefficient of variation of 30.15%. Specifically, question (23) (The university prefers to deal with environmentally committed suppliers) achieved the highest mean score of 4.111, also exceeding the hypothetical mean, with a standard deviation of 0.739 and a coefficient of variation of 17.98%. Prioritizing supplier selection based on adherence to environmental standards signifies operating within a framework of environmentally responsible decision-making. In contrast, question (21) (Does the university consider environmental standards when selecting material suppliers?) achieved the lowest mean score of 3.267, which is higher than the hypothetical mean, with a standard deviation of 1.107 and a coefficient of variation of 33.88%. This result indicates that supplier selection is still not based on their adherence to environmental standards.

Table 3 of Mean, Standard Deviation, and Coefficient of Variance for Green Total Quality Management Variable

Independent Variable	Dimensions	Item Number	Symbol	Mean	Standard Deviation	Coefficient of Variance	Item Sequence
Green Total Quality Management	Top Management Commitment	1	TQ1	4.089	0.814	19.91	1
		2	TQ2	3.267	1.185	36.26	3
		3	TQ3	3	1.251	41.69	4
		4	TQ4	3.622	1.042	28.76	2
		Total		3.494	1.158	33.14	
	Focus on the Environmental Customer	5	TQ5	3.667	0.945	25.78	2
		6	TQ6	3.489	1.006	28.82	3
		7	TQ7	3.711	0.656	17.67	1
		8	TQ8	3.133	1.027	32.78	4
		Total		3.5	0.946	27.04	
	Continuous Environmental Improvement	9	TQ9	3.578	1.088	30.41	3
		10	TQ10	3.8	0.62	16.31	1
		11	TQ11	3.578	0.616	17.22	3
		12	TQ12	3.622	0.952	26.29	2
		Total		3.644	0.848	23.27	
		13	TQ13	3.044	1.077	35.38	4

	Green Operations Management	14	TQ14	3.572	1.052	29.45	2
		15	TQ15	3.622	0.678	18.72	1
		16	TQ16	3.489	0.862	24.7	3
		Total		3.432	0.957	27.89	
	Employee Engagement and Environmental Training	17	TQ17	3.3	1.041	31.53	3
		18	TQ18	3.978	0.776	19.52	1
		19	TQ19	3.356	0.901	26.84	2
		20	TQ20	3.044	1.336	43.89	4
		Total		3.419	1.088	31.82	
	Relationships with Green Suppliers	21	TQ21	3.267	1.107	33.88	4
		22	TQ22	3.411	1.002	29.36	3
		23	TQ23	4.111	0.739	17.98	1
		24	TQ24	3.489	1.207	34.61	2
		Total		3.569	1.076	30.15	

The results were prepared by the researcher using SPSS V.28 software.

C. Data Analysis of the Dependent Variable: Sustainable Environment

a. The dimension of optimal utilization of natural resources: Table (4) shows that this dimension achieved a mean of (3.793), which is higher than the hypothetical mean, with a standard deviation of (1.075) and a coefficient of variation of (28.329%). As for the questions within this dimension, question (2) (The university uses clean, environmentally friendly energy (such as solar energy)) achieved the highest mean of (3.950), which is also higher than the hypothetical mean, with a standard deviation of (1.058) and a coefficient of variation of (26.797%). This result confirms that the university has adopted a path towards transitioning to renewable energy, with solar energy installations representing the most prominent manifestation of this transition. In contrast, question (4) (The university implements programs to preserve natural resources) achieved the lowest mean of (3.689), which is higher than the hypothetical mean of 3, with a standard deviation of (1.026) and a coefficient of variation of (27.824%). However, the relatively low score on this question indicates that the university's programs with specific requirements for resource conservation are still underdeveloped.

b. Reducing Environmental Pollutants: This dimension achieved a mean score of 3.857, higher than the hypothetical mean, with a standard deviation of 1.078 and a coefficient of variation of 27.962%. Regarding the questions within this dimension, question (8) (The university strives to reduce pollution resulting from its operations) achieved the highest mean score (4.022), also higher than the hypothetical mean, with a standard deviation of 1.008 and a coefficient of variation of 25.063%, indicating the university administration's strong commitment to environmental protection. Question (6) (The university adopts technologies for treating waste before disposal) achieved the lowest mean score (3.628), also higher than the hypothetical mean, with a standard deviation of 1.224 and a coefficient of variation of 33.733%. Participants' evaluations of this question

indicate that the university's waste treatment infrastructure lags behind its stated commitments, necessitating improvement.

c. Preserving Living Organisms and Their Diversity: This dimension achieved a mean score of 3.922, higher than the hypothetical mean of 3, with a standard deviation of 1.068 and a coefficient of variation of 27.222%. Regarding the questions within this dimension, question (12) (The organization considers environmental balance in its decisions) achieved the highest mean score of 4.222, also higher than the hypothetical mean, with a standard deviation of 1.028 and a coefficient of variation of 24.344%. This indicates the university's commitment to environmental balance and its role as a criterion in decision-making, particularly when decisions have environmental implications. Item (11) (The organization's contribution to supporting environmental initiatives) achieved the lowest mean score of 3.711, also higher than the hypothetical mean, with a standard deviation of 1.235 and a coefficient of variation of 33.276%. This indicates that initiatives aimed at raising environmental awareness at the university and how to preserve the environment have not yet reached the required level.

d. Preserving resources for future generations: This dimension achieved a mean score of 4.179, considered good, with a standard deviation of 1.063 and a coefficient of variation of 25.427%. Regarding the questions within this dimension, question (14) (The organization strives to minimize waste and loss in production processes) achieved the highest mean score of 4.372, exceeding the hypothetical mean, with a standard deviation of 1.109 and a coefficient of variation of 25.360%. This indicates a quality-oriented operational culture, where accuracy and adherence to standards naturally contribute to additional environmental benefits by reducing waste and material spoilage. Question (15) (The university adopts clean production practices) achieved the lowest arithmetic mean (3.994), which is also higher than the hypothetical mean, with a standard deviation of (1.044) and a coefficient of variation of (26.129%), indicating that clean production, although partially adopted by the university, has not been fully integrated into the operations

e. Compliance with Environmental Laws and Regulations: This dimension achieved a mean score of (3.942), which is higher than the hypothetical mean, with a standard deviation of (1.090) and a coefficient of variation of (27.642%). Regarding the questions within this dimension, question (17) (the organization's commitment to environmental laws and regulations) achieved the highest mean score of (4.178), which is also higher than the hypothetical mean, with a standard deviation of (1.139) and a coefficient of variation of (27.269%). This indicates the university administration's commitment to implementing legal regulations related to environmental protection. However, question (20) (the organization's provision of training for employees on environmental practices) achieved the lowest mean score of (3.739), which is also considered good, with a standard deviation of (1.048) and a coefficient of variation of (28.039%). This indicates that the formal training infrastructure focused on environmental protection practices is insufficient compared to what is required

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Table 4 of mean, standard deviation, and coefficient of variation for the sustainable environment variable

Independent Variable	Dimensions	Item Number	Symbol	Mean	Standard Deviation	Coefficient of Variance	Item Sequence
sustainable environment	optimal utilization of natural resources	1	SE1	3.756	1.122	29.869	3
		2	SE2	3.95	1.058	26.797	1
		3	SE3	3.778	1.081	28.611	2
		4	SE4	3.689	1.026	27.824	4

		Total		3.793	1.075	28.329	
	Reducing Environmental Pollutants	5	SE5	3.95	0.987	25	2
		6	SE6	3.628	1.224	33.733	4
		7	SE7	3.828	1.046	27.314	3
		8	SE8	4.022	1.008	25.063	1
		Total		3.857	1.078	27.962	
	Preserving Living Organisms and Their Diversity	9	SE9	3.789	0.986	26.02	3
		10	SE10	3.967	0.933	23.52	2
		11	SE11	3.711	1.235	33.276	4
		12	SE12	4.222	1.028	24.344	1
		Total		3.922	1.068	27.222	
	Preserving resources for future generations	13	SE13	4.161	1.074	25.801	3
		14	SE14	4.372	1.109	25.36	1
		15	SE15	3.994	1.044	26.129	4
		16	SE16	4.189	0.996	23.778	2
		Total		4.179	1.063	25.427	
	Compliance with Environmental Laws and Regulations	17	SE17	4.178	1.139	27.269	1
		18	SE18	3.872	1.057	27.302	3
		19	SE19	3.978	1.073	26.963	2
		20	SE20	3.739	1.048	28.039	4
		Total		3.942	1.09	27.642	

The results were prepared by the researcher using SPSS V.28 software.

Testing the research hypotheses

A. Testing and analyzing the correlation relationships between the study variables

In order to determine the strength and direction of the correlation coefficient between the variables, Pearson's correlation coefficient was used to measure the strength of the correlation. The value of this coefficient ranges between (+1) and (-1). Table (5) shows the division of the strength of the correlation

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Table (5) Strength and direction of correlation coefficient values

0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
No correlation	Acceptable correlation			Moderate correlation			Strong correlation			Perfect correlation
0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9	-1

Source:Daney,C.P,&Reidy,J.(2017).Statistics without math for psychology (7th.ed), Harlow, Pearson, prentice Hall, p128

1.Testing the first main hypothesis and its sub-hypotheses:

Table (6) shows the correlation values between the independent variable, green total quality management, and the dependent variable, environmental sustainability

Table 6 of results for the test of the relationship between green Total Quality Management and the dependent variable, environmental sustainability.

Independent variable: Green Total Quality Management	Dependent variable: Environmental Sustainability	Level of significance
Top Management Commitment	0.779**	0
Focus on the Environmental Customer	0.776**	0
Continuous Environmental Improvement	0.788**	0
Green Operations Management	0.835**	0
Employee Engagement and Environmental Training	0.852**	0
Relationships with Green Suppliers	0.815**	0
Total Green Quality Management	0.777**	0

** is statistically significant at the significance level (0.01)

The table was prepared by the research team based on the results of SPSS V.28.

Table (6) shows the value of the correlation coefficient between green total quality management and its dimensions with the dependent variable, the sustainable environment. The correlation coefficient between green total quality management and the sustainable environment reached (0.777**) at a significance level of (0.000), which is less than the significance level of ((0.05 and at a strong level. Therefore, the first main hypothesis is accepted, which is based on ((there is a statistically significant correlation between green total quality management and its dimensions and the sustainable environment in the study sample)).

a. First Sub-Hypothesis: The correlation coefficient between senior management commitment and a sustainable environment was (0.779**) at a significance level of (0.000), which is less than the significance level of (0.05)

and is considered strong. Therefore, the hypothesis is accepted, which states that there is a statistically significant correlation between senior management commitment and a sustainable environment in its dimensions.

b. Second Sub-Hypothesis: The correlation coefficient between focus on the environmental customer and a sustainable environment was (0.776**) at a significance level of (0.000), which is less than the significance level of (0.05) and is considered strong. Therefore, the hypothesis is accepted, which states that there is a statistically significant correlation between focus on the environmental customer and a sustainable environment in its dimensions.
c. Third Sub-Hypothesis: The correlation coefficient between continuous environmental improvement and a sustainable environment was (0.788**) at a significance level of (0.000), which is less than the significance level of (0.05) and is considered strong. Therefore, the hypothesis is accepted, which states that there is a statistically significant correlation between continuous environmental improvement and a sustainable environment in its dimensions.
d. Fourth Sub-Hypothesis: The correlation coefficient between green process management and a sustainable environment was (0.835**) at a significance level of (0.000), which is less than the significance level of (0.05) and is considered strong. Therefore, the hypothesis is accepted, which states that there is a statistically significant correlation between green process management and a sustainable environment in its dimensions.
e. Fifth Sub-Hypothesis: The correlation coefficient between employee participation, environmental training, and a sustainable environment was 0.852** at a significance level of 0.000, which is less than the significance level of 0.05 and therefore considered strong. Therefore, the hypothesis is accepted, which states that there is a statistically significant correlation between employee participation, environmental training, and a sustainable environment in its various dimensions.
f. Sixth Sub-Hypothesis: The correlation coefficient between relationships with green suppliers and a sustainable environment was 0.815** at a significance level of 0.000, which is less than the significance level of 0.05 and considered strong. Therefore, the hypothesis is accepted, which states that there is a statistically significant correlation between relationships with green suppliers and a sustainable environment in its various dimensions.

2.Testing the second main hypothesis and its sub-hypotheses

The second main hypothesis and its sub-hypotheses will be tested using a simple linear regression model to determine the impact of green total quality management and its dimensions on the sustainable environment. Table (7) shows the statistical indicators for analyzing the impact of the dimensions of the green supply chain on the sustainable environment.

Table 7 of statistical indicators for analyzing the impact of green total quality management dimensions on a sustainable environment

The independent variable of green total quality management and its dimensions			t	Adjusted R Square	R Square	F Change	sig	The dependent variable
Top Management Commitment	(α)	1.268	15.851	0.606	0.606	1106.616	0	Sustainable environment
	(β)	0.723	33.266					
Focus on the Environmental Customer	(α)	0.709	7.317	0.602	0.602	1087.812	0	
	(β)	0.881	32.982					
Continuous Environmental Improvement	(α)	0.155	1.425	0.62	0.62	1173.668	0	
	(β)	0.998	34.259					

Green Operations Management	(α)	0.576	7.015	0.697	0.697	1651.819	0	
	(β)	0.937	40.643					
Employee Engagement and Environmental Training	(α)	0.915	13.231	0.726	0.726	1906.138	0	
	(β)	0.842	43.659					
Relationships with Green Suppliers	(α)	0.887	11.026	0.664	0.665	1424.096	0	
	(β)	0.814	37.737					
Total Green Quality Management	(α)	1.021	24.907	0.604	0.604	5487.517	0	
	(β)	0.834	74.078					

The table was prepared by the research team based on the results of SPSS V.28.

The second main hypothesis: From Table (7) above, it is clear that the calculated value of (F) reached an amount of (5487.517), which is higher than the tabulated value of (F) of (3.94) at a significance level of (0.05), which means accepting the hypothesis, which is based on (there is a statistically significant effect between green total quality management and the sustainable environment).

((Green Total Quality Management) 1.021 + 0.834 = Sustainable Environment)

This means that the university's adoption of Green Quality Management (GQM) in all its dimensions significantly contributes to improving the university's sustainability performance. Furthermore, the t-test results for the regression coefficient (β) of the Green Quality Management variable showed a stability value of 74.078, which is higher than the critical value (1.984) at a significance level of 0.05. This indicates that Green Quality Management is remarkably effective in explaining changes in the environmental level. The convergence of the downward slope (β) also has a positive effect, as each unit increase in Green Quality Management leads to an 83% increase in the sustainability environment. This is further demonstrated by the adjusted coefficient of determination (Adj R^2), which shows that a 60% increase in the expected progress in the constructive sustainability model is critical

a. **First sub-hypothesis:** The results related to the impact of the senior management commitment dimension on the sustainable environment indicate that the calculated value of (F) reached (1106.616), which is higher than the tabulated value of (F) of (3.94) at a significance level of (0.05). This means accepting the hypothesis, which is based on (there is a statistically significant effect between senior management commitment and the sustainable environment), i.e., that:

((Top management commitment) 1.268 + 0.723 = Sustainable environment)

This means that senior management commitment significantly impacts the achievement of environmental sustainability. Furthermore, the t-test results for the regression coefficient (β) of senior management commitment showed a value of (33.266), which is higher than the critical value of (1.984) at a significance level of (0.05). This indicates that senior management commitment has a significant effect in explaining changes in the level of achieving environmental sustainability. The marginal slope (β) also reflects a positive effect, as each one-unit increase in the level of green purchasing leads to a 72% increase in environmental sustainability. The adjusted coefficient of determination (Adj R^2) shows that the analysis model explains 60.6% of the changes in the level of achieving environmental sustainability.

b. **Second sub-hypothesis:** The results related to the effect of the focus on the environmental customer indicate that the calculated value of (F) reached (1087.812), which is higher than the tabulated value of (F) of (3.94) at a significance level of (0.05). This means accepting the hypothesis, which is based on (there is a statistically significant effect between the focus on the environmental customer and the sustainable environment), i.e., that:

((Focus on the environmental customer) 0.709+0.881 = Sustainable Environment)

This means that the focus of green Total Quality Management on the environmental customer significantly contributes to improving environmental sustainability. Furthermore, the results of the t-test for the regression coefficient (β) for the environmental customer focus dimension showed a value of (32.982), which is higher than the critical value of (1.984) at a significance level of (0.05). This indicates that focusing on the environmental customer has a significant effect in explaining changes in the level of environmental sustainability. The marginal slope (β) also reflects a positive effect, as each one-unit increase in the level of environmental customer focus leads to an 88% increase in the level of environmental sustainability. Moreover, the corrected coefficient of determination (Adj R^2) shows that the analytical model explains approximately (60%) of the changes in the level of environmental sustainability.

c. **Third Sub-Hypothesis:** The results regarding the impact of the continuous environmental improvement dimension on a sustainable environment show that the calculated value of (F) reached (1173.668), which is higher than the tabulated value of (F) of (3.94) at a significance level of (0.05). This means accepting the hypothesis that (there is a statistically significant effect between continuous environmental improvement and a sustainable environment). That is:

((Continuous Environmental Improvement 0.155 + 0.998 = Sustainable Environment)

This means that continuous environmental improvement significantly contributes to improving efforts towards achieving a sustainable environment by reducing pollutants and waste. Furthermore, the results of the t-test for the regression coefficient (β) for the green storage variable showed a value of (34.259), which is higher than the critical value of (1.984) at a significance level of (0.05). This indicates that continuous environmental improvement has a significant effect in explaining changes in the level of sustainable environment. The marginal slope coefficient (β) also reflects a positive effect of continuous environmental improvement on sustainable environments, as every one-unit increase in the level of continuous environmental improvement leads to a 99% increase in the level of sustainable environment. Additionally, the corrected coefficient of determination (AdjR^2) shows that the analysis model explains 62% of the changes in the level of sustainable environment.

d. **Fourth Sub-Hypothesis:** The results related to the impact of the green operations management and sustainable environment dimension indicate that the calculated value of (F) reached (1651.819), which is higher than the critical value of (3.94) at a significance level of (0.05). This means accepting the hypothesis that (there is a statistically significant effect between green operations management and a sustainable environment). That is:

((Green Operations Management) 0.576 + 0.937 = Sustainable Environment)

This means that green process management contributes to achieving a sustainable environment. Furthermore, the results of the t-test for the regression coefficient (β) for the green transport variable showed a value of (40.643), which is higher than the critical value of (1.984) at a significance level of (0.05). This indicates that green process management has a significant effect in explaining changes in the level of environmental sustainability. The marginal slope (β) also reflects a positive impact of green process management on environmental sustainability, as each one-unit increase in the level of green process management leads to a 93.7% increase in environmental sustainability. The corrected coefficient of determination (Adj R^2) shows that the analysis model explains 69.7% of the changes in the level of environmental sustainability.

e. **Fifth Sub-Hypothesis:** The results related to the impact of employee participation, environmental training, and a sustainable environment indicate that the calculated F-value reached (1906.138), which is higher than the critical value of (3.94) at a significance level of (0.05). This means accepting the hypothesis that (there is a statistically significant effect between employee participation, environmental training, and a sustainable environment). That is:

((Employee participation and environmental training) 0.915 + 0.842 = Sustainable Environment)

This means that employee participation and environmental training significantly contribute to improving work towards a sustainable environment. Furthermore, the results of the t-test for the regression coefficient (β) for the employee participation and environmental training variable showed a value of (43.659), which is higher than the critical value of (1.984) at a significance level of (0.05). This indicates that employee participation and environmental training have a significant effect in explaining changes in the level of a sustainable environment. The marginal slope (β) also reflects a positive effect of employee participation and environmental training on the level of a sustainable environment, as each one-unit increase in the level of employee participation and environmental training leads to an 84.2% increase

in the level of a sustainable environment. Moreover, the corrected coefficient of determination (Adj R^2) shows that the analysis model explains 72.6% of the changes in the level of a sustainable environment.

f. **Sixth Sub-Hypothesis:** The results related to the impact of the dimension of relationships with green suppliers and the sustainable environment indicate that the calculated value of (F) reached a value of (1424.096), which is higher than the tabulated value of (3.94) at a significance level of (0.05). This means accepting the hypothesis, which is based on (there is a statistically significant effect between relationships with green suppliers and the sustainable environment), i.e., that:

((Relationships with green suppliers) 0.887 + 0.814 = Sustainable Environment)

This means that relationships with green suppliers contribute significantly to achieving a sustainable environment. Furthermore, the results of the t-test for the regression coefficient (β) for the variable of relationships with green suppliers showed a value of (37.737), which is higher than the critical value of (1.984) at a significance level of (0.05). This indicates that relationships with green suppliers have a significant effect in explaining changes in the level of a sustainable environment. The marginal slope (β) also reflects a positive effect of relationships with green suppliers on the level of a sustainable environment, as every one-unit increase in the level of relationships with green suppliers leads to an 81.4% increase in the level of a sustainable environment. Moreover, the corrected coefficient of determination (Adj R^2) shows that the analysis model explains 66.4% of the changes in the level of a sustainable environment**.**

Conclusions

Based on the findings of the researcher in the practical aspect, the following conclusions were formulated**:**

a. The university applies a number of Total Quality Management principles, working to reduce waste and reuse materials, especially in laboratories and educational workshops.
b. There is a history of monitoring the implementation of projects not only within the academic sphere but also within its environmental institution, the campus boundaries, and the surrounding community. The primary goal is to protect the environment by minimizing waste generation..
c. The university has established business incubator pathways and facilitated the creation of business partnerships for students from the industry. It also engages faculty members in modern technological projects to support and market them
d. Instead of treating quality management and micromanagement as parallel and separate systems, the university has sought to integrate them thoughtfully. This is facilitated through incentive programs that reward new contributors and encourage faculty members to integrate environmental thinking into their research programs.
e. University events and institutional initiatives contribute to raising awareness of environmental issues—particularly tree-planting campaigns—by helping to reduce emissions and biodiversity.
f. The university administration closely monitors the results of projects in terms of their impact on the internal and external environment. This oversight aims to maintain environmental health by minimizing pollutants and production waste.
g. The university evaluates festivals and initiatives that support environmental conservation and contribute to reducing gas emissions, particularly those focused on green spaces and fruit tree planting.
h. The university administration considers environmental factors when making decisions related to construction, expansion, the establishment of new departments, or the creation of green spaces, all of which contribute to achieving environmental balance.
i. The university is committed to implementing laws, regulations, and instructions related to environmental protection and pollution prevention. It continuously reviews its policies regarding compliance with environmental laws and corrects any deviations that may occur.
j. University students contribute to environmental protection by participating in volunteer campaigns to remove pollutants, thus contributing to a clean learning environment.
k. The university administration encourages its departments to use clean and environmentally friendly energy sources by establishing solar power systems. Educational laboratories have been built that rely primarily on this type of energy. The university has also harnessed wind energy by installing wind turbines at several of its campuses.

l. The university conducts ongoing evaluations of its staff and offers courses and programs that focus on the importance of environmental protection and how to use resources wisely to prevent their depletion.

Recommendations

Based on the study's findings, the following recommendations can be made:

a. It is essential to integrate the environmental dimension into the university's overall strategies and develop the necessary policies to achieve environmental sustainability.
b. Greater attention should be paid to the opinions of stakeholders in the labor market regarding the university's role in environmental conservation and the practices it undertakes to this end, particularly within the region where the university is located.
c. The university should make better use of student project remnants that are often neglected after the academic year ends.
d. Greater emphasis should be placed on implementing green quality management principles within the university's operations, especially in workshops and laboratories, and the use of environmentally friendly materials in experiments should be prioritized.
e. The university should support and encourage its researchers and faculty members to submit ideas and initiatives that contribute to environmental conservation and sustainability.
f. Greater attention should be paid when selecting suppliers, ensuring that in addition to their environmental commitment, they also adhere to environmental standards in the materials they supply.
g. Work should be undertaken to develop programs for conserving natural resources, especially water. The rainwater harvesting program, currently implemented in several university departments, should be expanded to include the university's main campus.
h. It is essential to utilize waste treatment technologies before disposal to minimize pollution.
i. Clean production practices should be adopted as they protect the environment from harmful waste and byproducts. Furthermore, clean production aligns with green quality management practices.
j. Greater emphasis should be placed on providing training courses and programs that raise employee awareness about the importance of environmental conservation and the key practices required for achieving environmental sustainability.
k. Investment should be increased in modern technologies that minimize polluting gases and emissions during student training in workshops and laboratories.

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