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THE ROLE OF SUSTAINABILITY TECHNOLOGIES IN ENHANCING SUPPLY CHAIN MANAGEMENT: A SURVEY OF MANAGERS AND EMPLOYEES AT NORTH OIL COMPANY – KIRKUK

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Abstract
The research aims to identify the role of implementing sustainability technologies in enhancing supply chain management across its dimensions. To achieve the research objective and answer its main questions—particularly, "What is the nature of the relationships and effects between the application of sustainability technologies and supply chain management?"—a random sample of 82 employees was selected from North Oil Company. The questionnaire form was used as the primary tool for data collection from the surveyed company. For data analysis, the researcher relied on the SPSS V25 program. The study concluded with several findings, the most prominent of which is the existence of a significant correlation and effect of the application of sustainability technologies on supply chain management. Based on these results, a set of recommendations was presented to the company's management, the most important of which is the necessity of increasing attention to all means that would enhance supply chain management within the surveyed company.

Keywords: Application of sustainability technologies, supply chain management, master production scheduling.

Introduction

Sound planning leads to successful implementation and the achievement of desired objectives. The process of planning and controlling production operations consumes a significant amount of managers' time and effort. Therefore, companies that produce final products require an efficient system for applying sustainability technologies and the components involved in producing these products to maximize the benefits of available capacities. To achieve this, it is essential to utilize modern management approaches, notably the implementation of sustainability technologies, which assist companies in planning production quantities and schedules accurately within available resources. Today, companies are increasingly considering optimal resource use while ensuring the sustainability of resources for future generations.

Given the limited studies linking the application of sustainability technologies—which ensure proper planning of production processes—and supply chain management, especially in North Oil Company, there is a growing interest among industrial companies to develop techniques that enable them to meet customer demands without harming the environment

and while preserving resources for future generations. To this end, adopting advanced planning and resource acquisition systems is necessary, and the implementation of sustainability technologies is considered the most suitable approach for this purpose.

First Chapter: Research Methodology

This chapter presents a methodological framework for the research, structured around the following axes:

First — Research Problem:

The core problem of the research revolves around understanding the role of implementing sustainability technologies in enhancing supply chain management. This can be formulated through the following questions:

1. Does the management of the surveyed company have a clear vision regarding the application of sustainability technologies and supply chain management?
2. What is the nature of the relationship between applying sustainability technologies and supply chain management?
3. Does the application of sustainability technologies contribute to strengthening supply chain management?

Second — Importance of the Research:

The importance of this study is highlighted in the following aspects:

1. Cognitive significance: This lies in addressing a modern topic within the Iraqi industrial sector—specifically, the use of sustainability technologies and their role in enhancing supply chain management in the oil products sector, along with the potential outcomes. Studying this topic also encourages further research by opening new perspectives and exploring variables not covered in this study, thus contributing to accumulated knowledge.
2. Field significance: This manifests in guiding the surveyed field to adopt and implement these topics to improve the company's performance, raise awareness and interest among officials regarding modern management methods, and understand how to apply these approaches effectively. It also aims to produce results that can specifically help improve the company's performance.

Third — Research Objectives:

Based on the problem and its importance, the main goal is to clarify the nature of the correlation and impact between sustainability technologies and supply chain management in the company under study. The specific objectives include:

1. Reviewing previous related studies and best practices in applying sustainability technologies and supply chain management in oil production operations.
2. Exploring current practices in the oil products sector regarding sustainability technologies and supply chain management, and assessing possibilities for improvements.
3. Clarifying the nature of the relationship and influence of applying sustainability technologies on supply chain management.

Fourth — Research Methodology:

Considering the nature of the research and its objectives, the descriptive-analytical approach was adopted. This approach focuses on studying phenomena as they exist in reality, providing detailed qualitative descriptions and quantitative measurements, describing the phenomenon and its characteristics qualitatively, and quantifying its extent, volume, and degrees of correlation with other variables.

Fifth — Research Hypotheses:

Based on the problem and objectives, the following hypotheses are proposed:

First hypothesis: There is no significant correlation between the application of sustainability technologies and supply chain management. The sub-hypotheses include:

a. There is no significant correlation between the environmental dimension and supply chain management.

b. There is no significant correlation between the economic dimension and supply chain management.

c. There is no significant correlation between the social dimension and supply chain management.

d. There is no significant correlation between the technological dimension and supply chain management.

Second hypothesis: There is no significant impact of applying sustainability technologies on supply chain management. The sub-hypotheses include:

a. No significant impact relationship exists between the main environmental dimension and supply chain management.

b. No significant impact relationship exists between the economic dimension and supply chain management.

c. No significant impact relationship exists between the social dimension and supply chain management.

d. No significant impact relationship exists between the technological dimension and supply chain management.

Sixth — Research Boundaries:

These include:

1. Geographical boundaries: The research is limited to North Oil Company as the study sample.
2. Temporal boundaries: The research covers the period from 10/1/2025 to 10/4/2025.
3. Human boundaries: The researcher selected a purposive sample composed of senior and middle management leaders within the surveyed company.

Chapter Two: The Theoretical Aspect of the Research

This chapter includes two main axes: the first regarding sustainability technologies, and the second focusing on supply chain management, as follows:

First Axis: Sustainability Technologies

It includes the following:

First — Concept of Sustainability Technologies: Sustainability technologies refer to systems and practices aimed at reducing the consumption of natural resources, lowering emissions, and improving efficiency across various sectors such as energy, water, and waste (Elkington, 1999:123).

Examples: Solar panels, water harvesting systems, green buildings.

Second — Applications of Sustainability Technologies:

1. In the Energy Sector: Renewable energy sources like solar and wind power are used to reduce reliance on fossil fuels (IRENA, 2020:98).

Example: Using solar panels for electricity generation in rural areas.

2. In the Construction Sector: Designing green buildings that utilize sustainable materials and thermal insulation systems, which reduce energy and water consumption (World Green Building Council, 2021:87).

Example: "LEED" buildings certified according to sustainability standards.

3. In Water Management: Technologies such as greywater recycling, water-saving devices, and improved water distribution networks to reduce wastage (United Nations, 2015:78).

4. In Agriculture: Smart farming that relies on techniques like drip irrigation and using renewable energy to operate agricultural systems (IRENA, 2020:101).

Third — Benefits of Applying Sustainability Technologies: These technologies aim to achieve several benefits, summarized as follows:

- Reducing carbon emissions (Elkington, 1999:124).
- Lowering operational costs in the long term (IRENA, 2020:99).
- Improving public health and quality of life (World Green Building Council, 2021:102).
- Preserving natural resources (United Nations, 2015:80).

Fourth — Challenges: Several literature sources addressing sustainability technologies highlight key challenges in their application within companies, including:

- High initial costs of certain technologies (Elkington, 1999:127).
- The need for societal awareness and behavioral change (United Nations, 2015:82).
- The necessity of strong government regulations (World Green Building Council, 2021:90).

Fifth — Dimensions of Sustainability Technologies: Their dimensions are as follows: (United Nations, 2015:85; World Green Building Council, 2021:92)

1. Environmental Dimension: This dimension emphasizes the importance of conserving the environment and its natural resources from pollution, through rational and optimal use of resources, including:

- Water conservation.
- Protecting the climate from greenhouse gases caused by industrial waste.
- Creating an environmentally friendly, pollution-free green environment.
- Ecosystems.
- Biological diversity.
- Biological productivity.

2. Economic Dimension: This dimension revolves around the impacts and outcomes of the economy on the environment, and how to improve industrial technologies through economic benefits to the environment, including:

- Sustainable economic growth.

- Raising living standards.
- Capital efficiency.
- Investing available resources sustainably.
- Equitable distribution of services among society.
- Equality among individuals in meeting basic needs and resource and income distribution.

3. Social Dimension: This calls for attention to individuals within society and fairness between generations through:

- Justice in distribution.
- Stabilizing demographic growth.
- Importance of maintaining population distribution.
- Health and education.
- Promoting democracy and defending human rights.
- Continuous development of institutions.
- Social mobility.
- Respecting individuals' private rights.

4. Technological Dimension: This pertains to all aspects related to technology in manufacturing, with a focus on reducing waste and conserving resources.

Second Axis: Supply Chain Management

Supply chain management is considered one of the fundamental pillars for the success of organizations in modern work environments. It ensures the smooth flow of goods, information, and services from suppliers to customers. With rapid technological advancements, supply chain management has become a critical competitive element for global companies (Chopra & Meindl, 2019:152).

This axis includes the following:

1. Concept of Supply Chain Management: Supply chain management is defined as "the coordination and integration of activities involving sourcing of raw materials, manufacturing, transportation, distribution, and delivering products to the end-user" (Heizer et al., 2020:219).

2. Importance of Supply Chain Management: Supply chain management plays a pivotal role in: (Christopher, 2016:99)

- Cost reduction.
- Achieving customer satisfaction.
- Enhancing flexibility.
- Gaining a competitive advantage.

3. Components of the Supply Chain: The supply chain consists of several main components, including: (Chopra & Meindl, 2019:85)

- Suppliers.
- Manufacturers.
- Logistics service providers.
- Distributors.
- Final customers.

4. Challenges Facing Supply Chain Management: Some of the most prominent challenges include: (Ivanov et al., 2019:224)
- Instability of supply chains.
- Demand fluctuations.
- Lack of accurate data.
- Sustainability issues.

5. Modern Trends in Supply Chain Management: Modern trends include: (Heizer et al., 2020:311)
- Digitization and artificial intelligence.
- Predictive analytics.
- Blockchain technology.
- Sustainability and reducing carbon footprint.

Based on the above, the researcher believes that applying these three main dimensions (environmental, economic, and social) within industrial companies is essential to achieving sustainability. This can be accomplished by equipping organizations with raw materials that help preserve the environment and reduce waste from production processes, while also generating good economic returns for the organizations. Additionally, it is important to avoid excessive use of these materials to prevent harming future generations, and to ensure fairness among society members.

Chapter Three: The Practical Framework of the Research

First — Brief Overview of the Surveyed Company: North Oil Company is one of the 16 companies affiliated with the Iraqi Ministry of Oil. Its headquarters is located in Kirkuk. The company's geographical area extends from the Turkish border in the north to the latitude line at 32.5° south, and from the Iranian border in the east to the Jordanian and Syrian borders in the west. It includes the northern and central Iraqi provinces such as Kirkuk, Mosul, Salahuddin, Erbil, Sulaimaniyah, Duhok, Baghdad, Diyala, and parts of Babel and Dhi Qar provinces.

The company’s tasks involve the production of crude oil and natural gas from oil and gas fields within its operational center. It manages more than fifty facilities, including pumping stations, refining complexes, storage fields, gas separation and compression stations, and numerous oil wells. All these are interconnected via multiple pipeline networks and main pipelines distributed across the company's scope. The company supplies crude oil of various types to Iraqi refineries in the north and center, in addition to associated gas to the North Gas Complex and power stations. It also exports large quantities of crude oil abroad through northern export lines via the Iraqi/Turkish pipeline, southern through the strategic line, and western through the Western System to Syria and Lebanon.

Operations Department: Includes the pipeline division and production division.

Some key tasks and activities of North Oil Company:

1. Producing oil and gas from the company's oil and gas fields within its geographical scope.
2. Processing the produced oil in refining complexes and transporting it to refineries and export outlets.

3. Separating and compressing associated gas and gases from domes, and delivering them to the North Gas Complex for the production of liquefied gas and dry gas for industrial use.
4. Drilling and rehabilitating wells through contracts with the Iraqi Drilling Company and other contractors, and implementing all supporting operations for drilling and rehabilitation.
5. Geological control of wells, conducting geological studies of the fields, and performing field measurements.

Second — Description of the Sample of the Research: Individuals working in the surveyed company were selected, specifically those possessing knowledge of the company's tasks and decisions, and practicing strategic roles. This includes senior, middle, and operational management, represented by factory managers, department heads, section chiefs, and their assistants, as they are most relevant and closely related to the variables of the study and better able to understand and grasp the content of the questionnaire. A total of 85 questionnaires were distributed to the respondents, with 83 recovered. One questionnaire was disregarded due to invalidity, leaving 82 valid questionnaires, representing a response rate of 96.4%.

Third — Description and Diagnosis of the Variables of the Study:
First Variable: Sustainability Technologies: The researcher measured the variable of sustainability technologies entirely through its strategies and to assess the level of awareness among the respondents regarding this variable. The total number of items was 60, using a three-point Likert scale. The following is a description of this variable as perceived by the respondents:
Table (1): Summary of the frequency distributions, means, standard deviations, response rate, and coefficient of variation for the sustainability technologies variable in the surveyed company.

Symbol	Response Rate			Means	Standard deviations	Response rate%
	Agree %	Neutral %	Disagree %			
Environmental Dimension	%6	%30	%55	3.4777	0.80181	%69.55
Economic Dimension	%9	%40	%76	3.5098	0.74477	%70.20
Social Dimension	%12	%38	%65	3.4598	0.80227	%69.20
Technological Dimension	%10	% 33	%44	3.4658	0.89577	%68.40
General Average	%9	%36	%65	3.48243	0.78333	69.65

Reference: The table is prepared by the researcher based on outputs from the statistical software (SPSS).
As shown in Table (1), there is a low level of agreement among the respondents' opinions regarding the sustainability technologies items, with an overall consensus rate of 9%. This indicates a weak level of responses from the individuals surveyed concerning the sustainability technologies items. Conversely, the overall disagreement rate among respondents on these items is 65%, while the neutral responses constitute 36%. The mean score (3.48243) supports this interpretation. The response rate was 69.65%.

The second variable: Description of the supply chain management variable: The researcher measured supply chain management comprehensively to assess the level of awareness among the respondents about this variable. The total number of items was 70, using a three-point Likert scale. The following is a description of this variable as perceived by the respondents:

Table (2): Summary of the frequency distributions, means, standard deviations, response rates, and coefficients of variation for supply chain management techniques in the surveyed company.

Symbol	Response Rate			Means	Standard deviations	Response rate%
	Agree %	Neutral %	Disagree %			
Supply Chain Management	%8	%18	%56	3.6439	0.76463	%72.88
	%12	%49	%47	3.3465	0.76635	%66.93
	%16	%39	%60	3.2634	0.85387	%65.27
General Average	%12	%35	%54	3.45785	0.799865	68.17875

Reference: The table is prepared by the researcher based on outputs from the statistical software (SPSS).

From the data in Table (2), there is a noticeable agreement among the respondents' opinions regarding the supply chain management items, with an overall agreement rate of 12%. The overall disagreement rate for respondents regarding these items is 54%, and the neutral responses account for 35%. This is supported by the mean score of 3.45785. The response rate was 68.178%.

Third — Testing the Correlation Relationships Between Sustainability Technologies and Supply Chain Management: The results of Table (3) indicate the testing of the primary hypothesis and its sub-hypotheses. The main hypothesis states that there is a significant correlation between the standards of sustainability technologies and supply chain management collectively. The sub-hypotheses, which emerged from this, suggest that there is a significant correlation between each dimension of sustainability technologies and supply chain management collectively.

Table (3): Results of the correlation relationship between the standards of sustainability technologies and supply chain management as a whole in the surveyed company.

Sustainability Technologies	Supply Chain Management	Probability Level
Environmental Dimension	0.05	0.000
Economic Dimension	0.06	0.000
Social Dimension	0.04	0.000
Technological Dimension	0.07	0.000
Total Index	0.05	0.000

$P \leq 0.05$, $N = 82$

Reference: The table is prepared by the researcher based on outputs from the statistical software (SPSS).

As shown in Table (3), there is a statistically significant correlation between the standards of sustainability technologies and supply chain management as a whole within the studied company. The overall correlation coefficient value is 0.05 at a significance level of 0.05, indicating a weak relationship between the two variables. This result suggests that the management of the studied company needs to increase its focus on the standards of sustainability technologies and supply chain management collectively.

Based on the above, the primary hypothesis can be accepted at the level of the studied company.

Regarding the relationship between each dimension of sustainability technologies and supply chain management (sub-hypotheses), the following points are noted:

1. The company's management's efforts to enhance the training and awareness standards will contribute to achieving effective supply chain management.
2. The company's efforts to strengthen awareness programs will contribute to achieving effective supply chain management.
3. The company's efforts to improve the design of adult learning programs will contribute to achieving effective supply chain management.
4. The company's efforts to enhance industrial field visits will contribute to achieving effective supply chain management.
5. The company's efforts to reduce waste will contribute to effective supply chain management.
6. The company's efforts to conserve resources will contribute to effective supply chain management.

In line with the above, the primary hypothesis and the sub-hypotheses are accepted at the level of the studied company.

Fourth — Testing the Impact Relationships Between Sustainability Technologies and Supply Chain Management: This hypothesis states that there is a significant impact relationship of sustainability technologies on overall supply chain management, as well as on its sub-dimensions, each representing a significant influence of each dimension of sustainability technologies on supply chain management. This relationship was analyzed at the level of the surveyed company.

Table (4): Impact of sustainability technologies standards on overall supply chain management in the surveyed company.

Sustainability technologies	Effect		R^2	F		Probability Level
	0β	1β		Calculated	Tabulated	
Supply chain management	15.744	0.618 *(14.282)	0.719	203.974	3.973	0.000

Reference: The table is prepared by the researcher based on outputs from the statistical software (SPSS).

From Table (4), which presents the regression analysis results, there is a statistically significant effect of sustainability technologies on the overall supply chain management. The calculated F-value is 203.974, which is greater than the tabulated value of 3.973 at degrees of freedom (1, 80) and a significance level of 0.05. The coefficient of determination (R^2) is 0.719, meaning that 71.9% of the variability in supply chain management can be explained by the combined influence of sustainability technologies, while the remaining variation is due to random variables outside the regression model or factors that cannot be controlled.
Furthermore, the regression coefficient β_1 is 0.618, and the associated t-value is 14.282, which is significant and exceeds the tabulated value of 1.993 at the significance level of 0.05 with (1, 80) degrees of freedom. This indicates that the application of sustainability technology standards significantly contributes to enhancing supply chain management in the surveyed company. Consequently, the second main hypothesis is accepted.
To clarify the impact relationship between each dimension of sustainability technologies and supply chain management at the company level, and based on the sub-hypotheses derived from the second main hypothesis, the impact relationships between each dimension of sustainability technologies and supply chain management were analyzed, as shown in Table (5).

Table (5): The impact of each dimension of sustainability technologies on supply chain management collectively at the surveyed company.

Supply chain management / sustainability technologies	Effect		R^2	F		Probability Level
	0β	1β		Calculated	Tabulated	
Environmental Dimension	34.513	3.649 *(8.989)	0.503	80.805	3.973	0.000
Economic Dimension	27.486	1.830 *(10.394)	0.575	108.041	3.973	0.000
Social Dimension	49.338	3.165 *(8.875)	0.496	78.760	3.973	0.000
Technological Dimension	41.764	5.930 *(9.751)	0.543	95.077	3.973	0.000
Cultural Dimension	56.774	3.302 *(6.829)	0.500	46.629	3.973	0.000
Institutional Dimension	53.345	(3.530) (*9.592)	0.534	92.009	3.973	0.000

$P \leq 0.05$, N =82, df = (1, 80), t = (1.993)

Reference: The table is prepared by the researcher based on outputs from the statistical software (SPSS).

From Table (5), it is evident that each dimension of sustainability technologies, when considered independently as an explanatory variable, has a significant impact on overall supply chain management. The most influential dimension was the economic dimension.

In line with the above, both the main hypothesis and the sub-hypotheses are accepted at the level of the studied company.

Fourth Chapter: Conclusions and Recommendations

First — Conclusions:

1. The descriptive and diagnostic results of data analysis in North Refineries Company revealed that the overall variable of sustainability technologies in the surveyed field has a moderate level of awareness and focus—not high nor low—indicating a suitable foundation for adopting and implementing sustainability principles and technologies in the company, which can lead to many benefits from this approach.
2. There is a positive correlation between the requirements of sustainability technologies (collectively) and supply chain management in the surveyed company, suggesting that the more the company pays attention to applying the dimensions of sustainability technologies, the more it will contribute to enhancing lean manufacturing strategies positively.
3. There is a positive relationship between each dimension of sustainability technologies (collectively) and supply chain management (collectively), indicating that increasing the management's attention to the dimensions of sustainability technologies in detail will help strengthen overall supply chain management.
4. There is a significant impact of the dimensions of sustainability technologies (collectively) in enhancing supply chain management (collectively) within the company, clearly pointing to the possibility of a positive influence of these dimensions on supply chain management.
5. Each dimension of sustainability technologies (collectively) has a significant impact on supply chain management (collectively). The technological dimension was the most influential in promoting supply chain management, as demonstrated by the statistical results.

Second — Recommendations:

Building on the methodological requirements and based on the conclusions presented, the researcher finds it appropriate to propose a set of recommendations that can help the surveyed companies in employing sustainability technologies to improve supply chain management and thereby strengthen their market position. These recommendations include:

1. The need to increase management's focus on training related to supply chain management and energy management, and to deepen this focus in connection with improving productivity and protecting the environment through continuous improvement of inputs, processes, outputs, and feedback mechanisms.
2. Motivating the management of the company under study to adopt and promote supply chain management techniques and sustainability technologies among managers and employees.
3. Broadening the awareness and knowledge of employees and management regarding supply chain management techniques and sustainability technologies by providing the latest developments in these fields to keep pace with ongoing advancements and increase managers' and employees' understanding by observing leading companies in applying these technologies.

4. Preparing special programs for field visits and working to familiarize managers and employees with the experiences of leading companies in sustainability and supply chain management through visits or hosting specialists in these fields.
5. Increasing attention to the concept of the environmental dimension and applying it practically to reduce waste and minimize production losses by implementing the 5S steps, ensuring resource conservation and preventing depletion.

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