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ARTICLE

The Integrating Between Cleaner Production and Benchmarking Practices and Its Impact on Achieving Sustainable Competitive Advantage

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Abstract
This research aims to clarify the theoretical foundations of both cleaner production and benchmarking, as well as the role of cleaner production within the framework of benchmarking in achieving sustainable competitive advantage for agricultural companies, particularly fish farming companies. The cleaner production methodology focuses on implementing production methods that promote sustainable development and finding solutions to the challenges faced by these companies. On the other hand, the benchmarking methodology guides companies in adopting the ideas and practices of leading and successful companies in the same sector, thus enabling them to chart a path for development and achieve competitiveness. This research focused on the fish farming sector in Iraq, using the Tigris Company as a case study for application and comparison of results. This was due to the challenges faced by companies in this sector, as well as the need to develop this industry and introduce modern management and production technologies that aim to achieve sustainable competitive advantages for companies and open new horizons for economic growth and development. One of the main conclusions of this research is that there is a synergistic relationship between cleaner production and benchmarking, which contributes to economic development by leveraging the experiences of others and applying them using modern methods that reduce costs and achieve sustainable competitive advantages.

Keywords: Cleaner Production; Benchmarking; Competitive Advantage, Reducing costs, Sustainability

Introduction

In recent decades, the growing concern over environmental degradation, resource scarcity, and global competitiveness has prompted companies to adopt modern management and production approaches that ensure both economic success and sustainability.[1] Among these approaches, cleaner production and benchmarking have emerged as vital tools for achieving continuous improvement and sustainable competitive advantage.[2] Cleaner production emphasizes preventive environmental strategies that minimize waste, emissions, and resource consumption, thereby improving both environmental performance and operational efficiency.[3] Benchmarking, on the other hand, enables organizations to learn from best practices, compare performance with industry leaders, and identify pathways for improvement and innovation.Integrating these two approaches offers a comprehensive framework that not only enhances productivity and reduces costs but also aligns corporate practices with the principles of sustainable development.[4] This integration allows companies—particularly in resource-intensive sectors such as agriculture and aquaculture—to overcome economic, technical, and environmental challenges by applying proven, efficient, and eco-friendly production models.[5]

Methodology

The research problem lies in the weakness of the agricultural sector in Iraq, particularly the fisheries sector, due to the scarcity of water resources and the state's failure to allocate sufficient water quotas to companies operating in this sector. Furthermore, these companies lack the use of modern production and management technologies that could enhance and promote development in this field. This results in a shortfall in meeting consumer demand, high production costs, and consequently, high prices for fish products. This situation necessitates the exploration of modern management methods and new approaches. Based on this, the following questions can be raised: What benefits can be derived from integrating cleaner production technologies with benchmarking practices for companies in the agricultural sector? Does the application of cleaner production technologies within a benchmarking framework lead to the competitive advantage that companies strive to achieve?This research aims to clarify the fundamental concepts of cleaner production and benchmarking, and their role in achieving sustainable competitive advantage. Furthermore, it aims to outline the methodology for each of the research variables and their potential to help companies that want to compete and find paths to success.The importance of this research lies in the ability of modern management and production technologies to help businesses in all sectors to develop and remain competitive in the market. These technologies also contribute to addressing environmental, social, and economic challenges. In the field of animal production, these technologies empower decision-makers to plan and implement strategies, especially given that this industry directly impacts human health and well-being. Therefore, the application of these technologies contributes to achieving sustainable development.

Results and Discussion

The research hypothesis is that integrating cleaner production practices with benchmarking contributes to achieving sustainable competitive advantage for companies.[6]

The United Nations Environment Programme (UNEP) introduced the concept of cleaner production in 1989 in response to unsustainable patterns of production and consumption. This concept has evolved into a major action program aimed at improving the economic efficiency of production, which is the first step in protecting the environment. This is achieved by reducing waste, emissions, and losses, while maximizing productivity through resource and energy analysis. (Mugwindiri et al) The concept of cleaner production began to emerge in 1991, when the United Nations Environment Programe Industry and Environment Office (UNEP-IEO) provided a formal definition: "The continuous application of an integrated, preventative environmental strategy to processes, products, and services to increase efficiency and reduce risks to humans and the environment."[7] Since then, cleaner production has been considered one of the most important preventative environmental approaches, improving the efficient use

of natural resources and energy, reducing risks to the environment and human health, and minimizing the environmental impact throughout the product lifecycle. (Scarazzato et al).From this concept, we can deduce that cleaner production analyzes and identifies opportunities for improvement, both economically and environmentally. It allows companies to understand the concept of environmental sustainability in their production processes and reinforces their belief that it is possible to increase production with minimal environmental impact. Researchers have offered several definitions of cleaner production. Researchers have offered several definitions of cleaner production. Petel, for example, defines it as a proactive approach to managing the environmental impacts of industrial processes and products, using technology, processes, resources, or practices to reduce waste and environmental risks, while also improving energy and resource efficiency. This, in turn, increases the efficiency of production processes and leads to a competitive advantage. Furthermore, it is applicable across all sectors, regardless of size or type. (Petel et al)Da Silva emphasized that cleaner production is a strategy applied to processes and products to increase their efficiency and reduce environmental damage and risks through the continuous application of integrated environmental prevention principles . Similarly, cleaner production is defined as the continuous integration of environmental prevention strategies into processes and products, aiming to enhance efficiency and reduce risks to the environment and human health (Neto et al)

Researchers in the field of cleaner production have discussed several principles. Joher identified the following principles:[8]

- Elimination and reduction of waste, which includes eliminating all types of waste, most importantly energy, processes, liquids, gases, and materials.
- Pollution-free production, where the production process aims to achieve an ideal transition from one stage to another without any emissions or pollution.
- Production energy efficiency, which focuses on conserving resources and energy, reducing material consumption, and achieving production efficiency.
- A safe working environment for both the production process and the products, where the workplace must be healthy for workers and employees, and the products must be environmentally friendly and more sustainab[9]

Cleaner production aims to improve the efficiency of raw material, energy, and water use, and to reduce waste and emissions at the source, rather than dealing with them after production. It also contributes to increased productivity for companies, as well as improving product design to make it more environmentally friendly and less costly. These are general objectives; however, the main objectives of cleaner production, as stated by are as follows:[10]

- Reducing costs and managing waste
- Improving material use efficiency, reducing waste, and minimizing emissions
- Reducing risks to workers and improving occupational health and safety
- To raise environmental awareness among all employees of the company.
- To enhance the company's image by adhering to environmental laws and regulations issued by relevant authorities.

The excessive depletion of natural resources and energy, which has detrimental effects on the environment in general and on human health in particular, and the unsustainability of these resources, which impacts the future generations' share of resources, has highlighted the need to develop innovative industrial production technologies that meet the demands of a society that has become more environmentally conscious and more aware of potential risks. Based on the above, the importance of cleaner production can be summarized as follows :[11]

- Cleaner production helps to conserve energy and resources, reducing their consumption and overall usage.
- It helps companies achieve economic benefits, as they must treat resources as valuable assets, thus employing efficient methods. Cleaner production serves as a methodology for resource conservation through rational resource management.
- Cleaner production contributes to reducing negative environmental impacts on human health and the environment.
- It reduces costs by decreasing the volume of waste and improving waste management.

There are three strategies for implementing cleaner production:

2-4-1- Source Reduction: Reducing pollution depends on the methods used in the manufacturing process, and improving these methods contributes to reducing waste and emissions. Examples of source reduction measures include :[12]

• Good operational practices – The concept of cleaner production requires that certain procedures be followed at all stages of production to minimize waste. These procedures can be implemented at each stage of production and include training workers on how to handle hazardous materials, how to store them, how to detect leaks, how to classify waste, and how to schedule production .

• Process changes – Changes can be made to the processes to achieve cleaner production by altering or replacing materials, improving control of production processes, replacing equipment and machinery, and adopting new technologies.[13] This can be achieved through the methods described in Materials: Using materials that are less harmful to the environment and allow for an improved product lifecycle, while maintaining high quality, whether for primary, secondary, or operational materials.Processes: Ensuring that production processes are optimized for resource efficiency. Production processes and processing speeds should be monitored to achieve the most efficient method possible.Replacing or Modifying Equipment and Machinery: Replacing or upgrading machinery and equipment used in the production process with more efficient alternatives to achieve desired outcomes, and training employees to reduce waste rates.Technological Change: Adopting new technologies for processes and machinery, whether through incremental, continuous, or radical improvements.[14] This change should not result in excessive costs.2-4- 2- Recycling: Recycling primarily aims to recover materials from products that have reached the end of their useful life . Furthermore, recycling is one of the fundamental pillars of the circular economy, where products have a limited lifespan, defined as the period during which the product can perform its intended functions without significant loss of performance. After this lifespan, the product enters the recycling stream.

2-4-3- Product Modification: This refers to changes made to the product's characteristics, with the aim of reducing waste during production, use, or post-consumption. These modifications can lead to redesign of the product and its technical components, as well as reducing environmental impacts throughout the product's life cycle. This can involve changes to quality specifications, modifications to the product's composition, or replacement of components[15].

The concept of benchmarking refers to the continuous and systematic comparison of a company's quality, efficiency, and activities. It involves identifying and comparing the company's standards, processes, and performance with those of best-in-class organizations, using them as benchmarks . It can also be described as the process of researching, comparing, and evaluating a company's products, processes, or services against those of leading and successful companies in the same industry. Benchmarking allows the participating company to identify best practices, processes, and products, and to determine its strengths and weaknesses . Horngren further emphasized that it is a continuous process of comparing performance levels in delivering products or services and conducting activities against best-in-class performance levels, helping companies understand their competitive position . It is a systematic approach to learning from others and gaining knowledge by observing the outstanding performance practices of other companies that have gained expertise in a specific economic sector .Based on the above, we can summarize the importance of benchmarking as follows:

1. It makes a significant contribution to performance improvement by identifying the gap between the company's performance and best-in-class performance, and by setting realistic improvement targets .
2. Benchmarking is an ideal tool for providing relevant information to decision-makers and helps to obtain guidance regarding the current situation, as well as specific information about success factors, areas of application, and potential challenges .[16]

Therefore, the objectives of benchmarking are to validate performance targets, enhance organizational confidence, and assess performance based on a comparative analysis of internal and external data. This helps identify required competencies, reduce costs, and target areas

for improvement, as well as enabling organizations to track competitors' strategies and operate in a proactive manner .

There are three types of benchmarking; the choice of which depends on the company's needs and requirements, as well as the available expertise and resources. These types are as follows :

1. Internal benchmarking: This type focuses on comparing different departments, employees, or products within the same company.
2. Competitive benchmarking: This type compares the products, processes, or activities of a company with those of a similar company in the same industry. It involves selecting the best competitor and identifying the performance gap. This type requires establishing collaborative relationships between companies.[17]
3. Process benchmarking: This type compares a specific process that is common across different companies and industries, such as human resource management or communication systems.

This research will focus on and apply a benchmarking approach using a similar industry as a reference, as this method is most suitable for the practical aspects of the research and the nature of the business of the case study company.

It is easy to identify a competitive advantage when a company does something better than its competitors, resulting in higher profits and potentially a larger market share. However, it is more difficult to identify a sustainable competitive advantage, as it must be relatively enduring and incorporate certain environmental and social aspects, since competitors constantly strive to replicate these advantages . [18] Therefore, the concept of sustainability is relative; some advantages persist longer than others due to changes in the business environment, such as technological advancements, competitive moves, and shifts in customer preferences. Consequently, companies must be prepared for these changes (Thompson et al). A sustainable competitive advantage is defined as a long-term strategy that allows a company to maintain its lead over its competitors . It is also defined as a unique strategy that aims to create long-term value and benefits by leveraging a company's internal resources and capabilities in a way that competitors cannot easily imitat.

To achieve a competitive advantage, certain measures or factors must be in place, and companies must adopt specific approaches or strategies, including cleaner production.[19] To implement cleaner production effectively, we need to identify the constraints and limitations, which can be summarized as follows

1. Financial constraints, such as high capital costs and investment requirements in the industry.
2. Economic constraints: In some cases, investments in cleaner production may be ineffective given the company's economic environment or the country's economic and political situation.
3. Regulatory constraints: In some cases, there may be no support for cleaner production strategies, and environmental management practices may not be well-established within the company's operations.
4. Technical constraints: Some companies cannot implement cleaner production strategies due to the lack of suitable technologies, complex production processes, or limited access to supporting equipment, such as high-tech devices.[20]

This is where benchmarking comes in; it is a supporting strategy for cleaner production. It helps overcome limitations and provides insights and best practices by adopting the manufacturing processes of leading companies. Benchmarking enables companies to increase their competitive awareness, understand their competitors' production methods, identify opportunities and threats, set improvement goals, and establish a framework for programs and for evaluating and assessing processes. (Kinny, et al) Therefore, companies can implement cleaner production by leveraging benchmarking strategies and results, thus achieving a sustainable competitive advantage. As (Baines et al) pointed out, investments by companies in environmental initiatives throughout the product lifecycle increase resource productivity, helping to offset environmental costs and ultimately reduce overall expenses. emphasize that companies adopting proactive environmental improvement strategies achieve higher performance levels. explains that the objectives of cleaner production include waste reduction,

efficient resource utilization, raising environmental awareness, and improving performance programs. This, in turn, enhances companies' competitiveness, fosters a better understanding of long-term planning, and promotes a holistic approach to production, quality, and the environment.[21]

To validate the research hypothesis, data and information from the Tigris Fish Farming Company in Al-Suwairah district, Wasit province, were used as a case study, given its expertise in the field. This company was selected to demonstrate the application of cleaner production techniques within a benchmarking framework. The following section will present an overview of the company's operations, its processes, and the level of advancement in its production methods.

1. The fish farming process at this company involves several stages, each requiring specific types of ponds depending on the fish species and their size, from the egg stage to the stage when the fish are ready for market.[22]
2. The company relies on earthen and concrete ponds for its fish farming operations, which must be located near the Tigris River. This traditional method requires access to all necessary resources for production. However, given the scarcity of resources and the prevailing economic and political conditions, particularly regarding water availability, the company will face numerous challenges and high costs.
3. Open-air, unprotected ponds rely on nearby water sources for their primary water supply. Being exposed to the sun, birds, and other environmental factors can cause disruptions in operations, resulting in additional costs and losses for the company.[23]

Based on the above, this company will be used as a case study to illustrate its investment and operational costs for an aquarium with dimensions of (20 meters wide, 50 meters long, and 1.5 meters high).

Table (1)
investment costs for a fish tank(Value in Iraqi dinars)

Sequence	Quantity	Cost per unit	Total cost
Preparing and digging the land	**1000 meters**	**10,000**	**10,000,000**
Perimeter concrete structure	**1000 meters**	**50,000**	**50,000,000**
Water intake and discharge pipes	**500 meters**	**15,000**	**7,500,000**
Water recycling machines	**3**	**500,000**	**1,500,000**
Pool supplies and equipment	**----**	**-----**	**2,000,000**
Total investment cost			**71,000,0000**

As shown in Table (1), the company's investment costs amount to seventy-one million dinars. The company uses a traditional method for fish farming, which does not employ modern production techniques or advanced technologies, either in terms of management or technology.[24] The operational costs associated with this method are shown in Table (2).

Table (2)
Operating costs (Value in Iraqi dinars)

Sequence	Quantity	Cost per unit	Total cost
Employee salaries	**7*6 month**	**750,000**	**31,500,000**
Fuel and energy	**---------**	**--------**	**3,000,000**
Pool guard	**1*6 month**	**500,000**	**3,000,000**
harvest fishing costs	**-------**	**------**	**500,000**
Fish feed and food	**-------**	**------**	**4,000,000**
Maintenance	**-------**	**------**	**1,500,000**
Veterinary costs	**-------**	**------**	**3,000,000**
Total Operating cost			**46,500,000**

Table (2) shows that these operating costs are incurred during the production cycle, as the fish farming period lasts for six months, and these costs pertain to that period. To achieve development, competitiveness, and sustainability, the company must adopt modern and advanced production and management techniques. One such method is benchmarking, which

is a systematic approach to learning from others and acquiring knowledge by implementing best practices and leveraging their expertise. Implementing cleaner production is another modern technique that empowers companies to remain competitive, while also addressing the challenges and problems inherent in traditional methods. Some of the problems and limitations faced by the Tigris Company, the subject of this research, are as follows:[25]

1. Given Iraq's current situation of freshwater scarcity and financial crisis, the water allocation for the company to fill its fish ponds fluctuates and is unstable, depending on the availability of water in the rivers. However, the method used by the Tigris Company requires that the fish ponds be located near the river, and this requires government approval.
2. Open-air fish ponds, especially those belonging to companies with multiple ponds covering a large area, are vulnerable to theft and predation by birds, resulting in losses in fish production.
3. Because open-air fish ponds are directly exposed to the sun, the amount of water that evaporates is significant, approximately 20% of the total water volume.
4. During the fishing season, these open-air ponds require additional labor and expenses, as the fishing process takes place with the fish still submerged in the water, making it difficult to accurately assess the catch.[26]

To address these challenges facing the company, it must work on improving its production methods and technologies. Through benchmarking, it can adopt advanced production methods used by leading companies in the field, utilize cleaner production techniques, and implement sustainable technologies that ensure the company's economic, social, and environmental sustainability. One modern method offered by benchmarking is fish farming in mesh-bottomed, water-filled tanks. This method has a lower initial investment cost compared to the method currently used by Tigris Company. Below are details and advantages of these types of fish tanks.

a. Durable, portable fish ponds made of hot-dip galvanized steel mesh, available in various sizes (5m, 8m, 10m, and 16m), with a PVC/HDPE liner. Ideal for both urban and rural areas, these ponds are easy to use for fish farming. These portable ponds are perfect for commercial fish farming operations. The portable tarpaulin pond is the latest technology in fish farming, used in many countries worldwide. These ponds offer an ideal solution for fish farmers who do not own land, and are preferred over concrete ponds due to their portability.[27]
b. Easy to manage: These ponds feature a simple design and require minimal maintenance. They only need periodic checks of the water inflow, and they are equipped with an automatic waste removal system that maintains water quality.[28]
c. These ponds offer low production costs and a fast return on investment compared to traditional concrete fish ponds. They are easy and quick to install, saving the business time, effort, and money. They also boast a long lifespan, corrosion resistance, low maintenance costs, and are durable and reliable.

Table (3) shows the investment costs for prefabricated water tanks with a capacity of 1000 m3. The primary advantage of this method is that it addresses the challenge of water supply by using a well instead of relying on a river source. This eliminates the need for the company to obtain water rights, permits, and other official approvals from the government for using river water.[29]

Table (3)

investment costs for Ready-made fish tank (Value in Iraqi dinars)

Sequence	Quantity	Cost per unit	Total cost
Fish tank roofs	**1200 meters**	**20,000**	**24,000,000**
Ready-made fish tank (10 m3)	**100**	**154,000**	**15,400,000**
Drilling a water well with equipment	**1**	**1,500,000**	**1,500,000**
Solar panel system with a capacity of (30 amps)	**1**	**6,000,000**	**6,000,000**
Electrical board with electrical installations	**1**	**1,000,000**	**1,000,000**
plastic water pipe size (4 inches)	**250 meters**	**5000**	**1,250,000**

water pumps	**4**	**1,000,000**	**4,000,000**
Water tank capacity (2000 liters)	**2**	**250,000**	**500,000**
Water treatment unit	**1**	**5,000,000**	**5,000,000**
Water temperature processing unit	**1**	**2,000,000**	**2,000,000**
Total investment cost			**57,650,000**

The operational costs for the pre-fabricated tanks can be summarized in Table (4).

Table (4)

Operating costs (Value in Iraqi dinars)

Sequence	**Quantity**	**Cost per unit**	**Total cost**
Employee salaries	**2*6 month**	**750,000**	**9,000,000**
Fish feed and food	-------	------	**3,000,000**
Maintenance	-------	------	**500,000**
Veterinary costs	-------	------	**1,000,000**
Total Operating cost			**13,500,000**

By using a benchmarking approach, comparing traditional production methods with modern ones, and incorporating cleaner production principles, we found significant differences in both the investment and operational costs for the company. Furthermore, this approach yielded other sustainable competitive advantages, including social and environmental benefits. Economic competitive advantages: The tables above show the investment and operational costs for both the traditional and modern methods. The results and the percentage reduction in costs can be analyzed using Table 5.

Table (5)

Analysis of results (Value in Iraqi dinars)

Production method / Cost	**Fish farming using concrete tanks**	**Fish farming in ready-made tanks**	**The difference between costs**	**percentage of difference**
investment costs	**71,000,0000**	**57,650,000**	**13,350,000**	**%19**
Operating costs	**46,500,000**	**13,500,000**	**33,000,000**	**%71**
Total cost reduction			**46,350,000**	

The reasons for this cost reduction can be summarized as follows:

1. Prefabricated fish ponds do not require land leveling or excavation.
2. Prefabricated fish ponds do not require a concrete structure, which is a costly element.
3. While traditional methods require fish ponds to be located near rivers, prefabricated ponds can be installed anywhere and can use well water instead of river water.
4. With prefabricated fish ponds, fewer workers are needed, there is no need for manual harvesting, no harmful plants grow, and there is no waste of feed. Furthermore, they require minimal maintenance and operate using clean energy, eliminating fuel costs. The water is treated in a water treatment unit, and a water temperature control unit further reduces veterinary costs for the fish, as confirmed by experts in this field.[30]

Social and economic advantages: Fish farming using prefabricated tanks offers job opportunities for many investors because it addresses political and logistical constraints. It does not require proximity to rivers and does not waste the country's water resources, as it uses water from wells, allowing it to be implemented anywhere. This, in turn, creates employment opportunities for many people and promotes the sector, contributing to overall human and economic development.[31]Environmental competitive advantages: Ready-made fish farming systems, based on the principles of cleaner production, offer several competitive advantages related to environmental sustainability. These include energy efficiency, elimination of emissions from fuel-powered pumps (as they use clean energy), and the fact that the water extracted from the tanks after fish production is not contaminated with fish waste, since it undergoes a dedicated treatment process.

Conclusions

Clean production is recognized as an effective approach for improving resource efficiency and optimizing the use of natural resources, thereby reducing or limiting harmful emissions and environmental impacts throughout the production process, both at the source and at the end of the process. It is considered a strategic approach for achieving competitive advantage, and its implementation can be tested in a laboratory setting before being applied in the actual production process.Implementing clean production technology helps reduce the environmental impact and associated costs by minimizing the quantity of different types of waste generated during the production process.The integration of cleaner production and benchmarking enables companies to plan and develop new strategies, as well as improve their production and manufacturing processes.By applying the research hypothesis, it was found that integrating cleaner production with benchmarking practices yielded economic, social, and environmental competitive advantages.

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