

## STORAGE OPERATIONS IN WAREHOUSES: AN REVIEW

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### ABSTRACT

The research aims to identify the major strategies used to optimize warehouse storage operations, especially with increased competition among supply chain and logistics firms worldwide. Storage operations, being the primary activity in warehouses, calls for extensive strategies to make the entire process more effective and efficient. The researchers used the qualitative approach to collect data and information to achieve the study aims and answer the research questions. The research findings hold that optimizing warehouse storage operations requires actors to have intense training and development programs for their workforce, embrace sustainability, and responsibly embed Warehouse Management Systems (WMS) and the Internet of Things (IoT) in their operations.

**Keywords:** Storage Operations, Warehouse Supply Chain, Logistics, Warehouse Management Systems, Sustainability, IoT

### 1.0 INTRODUCTION

There is a growing need for logistics, transportation, and warehousing solutions arising from the progressive global economy evolution, the increasing interconnection among nations, and the steady rise of consumer-driven industrialism. Odeyinka and Omoegun (2023) highlight that warehouses play pivotal roles within the supply chain since they facilitate goods' storage from their production sites until they reach the final consumers. Warehouses are not simple rooms or spaces; they are built purposively and created by manufacturers or suppliers to hold and store goods before they are finally dispatched to the consumers (Odeyinka & Omoegun, 2023; Mohamud et al., 2023). Further, the modernization of the business environment instigated by fierce competition makes warehouses hubs for efficient value-added services execution and avenues for storing goods quickly before reaching the final customers. Odeyinka and Omoegun (2023) add that warehouses serve different functions, including meeting customer demands, enhancing the effective goods flow from sellers to buyers, allowing suppliers to make large purchases, and harmonizing the dichotomy between organizational goods inflow and outflow.

Also, the storage racks, specialists, warehouse employees, and material handlers are some of the major components coordinating and working together to realize a smooth and efficient warehouse functioning (Shah & Khanzode, 2017; Odeyinka & Omoegun, 2023). Shah and Khanzode (2017) add that the major warehouse operations are receiving, picking, storing, and

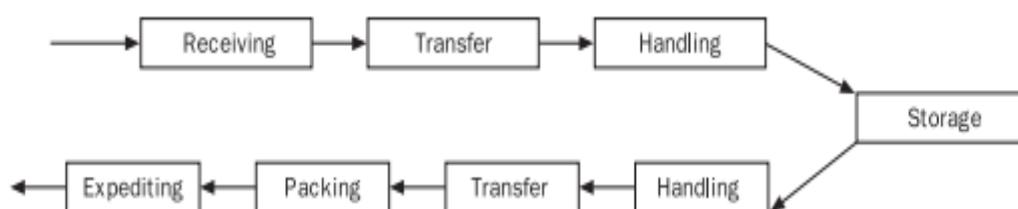
shipping. Thus, warehouse storage operations majorly deal with storing products at warehouses and logistics centers to provide a steady supply of goods to markets to fill the temporal gap between producers and consumers. It uses pallet racks, mobile shelves, static shelving, multi-tier racks, and mezzanine flooring to temporarily store different goods (Shah & Khanzode, 2017; Mohamud et al., 2023). According to Odeyinka and Omoegun (2023), the modernization of the supply chain and logistics industry focuses more on warehouse efficiency and optimization strategic efforts. Effective warehousing storage operations improve operational efficiency, reduce inventory costs, and also improve customer service (Mohamud et al., 2023).

The warehouse industry in Oman is a crucial supply chain player in the Sultanate. Rahman et al. (2021) reveal that the logistics sector earned around \$8.81 billion in market revenue in 2015. This accounted for close to 4.9% of the GDP, with the Omani logistics market share accounting for 12% compared to the other Gulf Cooperation Council (GCC) colleagues. Further, the Sultanate of Oman Logistics Strategy (SOLS) 2040 aims to see Omani's logistics sector among the top ten regarding warehousing and storage operations efficiency (Rahman et al., 2021). According to Mohamud et al. (2023), optimizing warehouse and storage operations improves the supply chain's efficiencies cost reduction, and ensuring accurate and timely order fulfillment. This study identifies warehouse storage operations by comprehensively unearthing their roles, types, and best practices to optimize them.

## 2.0 Literature Review

### 2.1 Warehouse Storage Operations

Most warehouses have six throughput activities: receiving, transfer, handling, storage, packing, and expediting. Warehouse storage systems form part of the operations, and they involve putting specific physical structures specially designed to aid in how organizations optimize their warehousing spaces. According to Gunasekaran, Marri, and Menci (1999), storage operations lie at the center of warehouse operations.



**Fig I: Warehouse Operations and Activities, Source (Gunasekaran, Marri & Menci, 1999)**

Figure I shows the major warehousing operations, with storage being the center of the operations. According to Abbasi (2011), storage, product allocations, and slotting form the ability and capacity of a firm to put items correctly in different places. Storage and allocating goods to their correct storage positions are crucial during warehousing operational planning (Abbasi, 2011; Albert Rönqvist & Lehoux, 2023). However, it is worth noting that different researchers have discovered that the warehouse types determine the storage operations undertaken. Studies have also indicated that it becomes challenging to fragment warehouse

operations because the receiving, storage, and distribution take place inside the warehousing premises (Gunasekaran, Marri & Menci, 1999; Abbasi, 2011; Albert, Rönnqvist & Lehoux, 2023).

The works of Wruck (2013) and Abbasi (2011) explain that the primary role of warehouses is to store goods temporarily before they are dispatched to the receivers. Thus, the storage operations include partitioning the warehouse into different storage zones according to the other classes. Wruck (2013) claims that the order-picking process is classified into batching, grouping customer orders into one batch, routing, and sorting, which are crucial warehouse storage operations. Rahman et al. (2021) add that decisions on the types of pallet rack storage, bulk storage, shelving, and automating operations depend on the warehouse capacity, resources, and the strategic direction adopted by the firm.

## 2.2 Warehouse Management Systems (WMS) and IT in Storage Operations

According to a study by Cross (2019), warehouse management systems (WMS) are crucial in supporting all resources, from moving goods within a warehouse facility to their storage and dispatch. Similarly, in their article, Odeyinka and Omoegun (2023) reveal that WMS is a series of interconnected processes designed to enhance and streamline the overall efficiency of warehouse operations. A WMS can complement and work with different internal and external software systems such as ERP (Enterprise Resource Planning), OMS (Order Management Systems), barcode scanning, and TMS (Transport Management Systems). WMS and OMS perfectly complement the other since the latter majorly focuses on monitoring the movement of inventory and orders across the supply chain, while the former has proved essential for both the 3PL (third-party logistics) and private warehouses (Abbasi, 2011; Odeyinka & Omoegun, 2023). These warehouses handle different order fulfillment types, such as pallet in/pallet out, B2B, B2C, omnichannel, and e-commerce.

After conducting a study at PT Shippindo Teknologi Logistik, Anugrah, and Patil (2023) discovered that integrating WMS in storage operations significantly improved the company's performance and productivity levels by 40.1%. Cross (2019) also supports this discovery by holding that WMS and integration of Information Communication and Technology (ICT) are great discoveries as warehouses shift from traditional storage operations to smart warehouses. WMS also helps streamline storage operations across bulk goods, hazardous materials, pharmaceuticals, wines and spirits, and cold storage by improving operational efficiencies (Odeyinka & Omoegun, 2023). WMS helps warehouses improve inventory visibility, facilitate ongoing improvement, optimize labor, and enhance warehouse traceability.

Modern warehouses, also known as smart warehouses, have incorporated ICT in their storage operations. For instance, Anugrah and Patil (2023) discovered in their article that warehouses with effective WMS have higher customer satisfaction because they have better storage operations practices, leading to efficiencies. Also, WMS and other technologies like robotic mobile fulfillment systems (RMFS), Automated Container Terminals (ACTs), Internet of Things (IoT), Cyber-Physical Systems (CPS), and Radio Frequency Identification (RFID) have significantly reduced errors, improved speed, efficiencies, safety, and enhanced customer satisfaction levels (Zhen & Li, 2022). Even though these WMSs and the invention of internet

technologies have yielded numerous benefits, researchers warn that maintenance costs, overdependence on technology, limited flexibility, and investment costs are some barriers they come with (Abassi, 2011; Cross, 2019; Zhen & Li, 2022).

## 2.3 Optimizing Storage Operations in Warehouses

According to Mohamud et al. (2023), organizations can optimize warehouse storage operations by implementing efficient layouts and designs. For instance, embracing sustainable warehousing by strictly following the lean manufacturing principles geared towards reducing waste and streamlining the storage processes (Popović et al., 2021). Sustainable supply chain management involves managing raw materials and services from the producers to the final consumers and back while having positive societal and environmental impacts (Popović et al., 2021; Varma, 2022). Additionally, Mohamud et al. (2023) suggest that training and developing the warehouse workforce on their safety and enhancing their knowledge and skills help optimize warehouse storage operations. Some scholars have also identified that having effective WMS and embedding technology in storage operations helps increase efficiencies, reduce errors, and maximize inventory controls and order fulfillment rates (Abassi, 2011; Varma, 2022; Odeyinka & Omoegun, 2023). WMS and warehousing technologies also pave the way for implementing more advanced storage systems.

## 3.0 METHODS

### 3.1 Problem Statement

Logistics industries face enormous challenges in optimizing their warehouse to achieve maximum efficiencies. Mohamud et al. (2023) assert that most warehouses struggle to determine the appropriate structures and designs capable of enhancing efficiencies while simultaneously reducing operating costs. Researchers have also noted that most warehouses lack the required warehouse management systems (WMS), information and technology tools, sustainability strategies, inventory controls, and inefficient storage practices, which usually result in higher operational costs, susceptibility to errors, and increased inefficiencies. Hence, addressing these challenges and other storage operations struggles like space utilization, lack of visibility, and increasing storage demands can lead to more optimized and sustainable warehouse storage operations.

### 3.2 Aims and Objectives of the Study

#### 3.2.1 Study Aim

The research aims to identify the major strategies used to optimize warehouse storage operations, especially with increased competition among supply chain and logistics firms worldwide.

#### 3.2.2 Research Objectives

- a. To identify warehouse storage operations and review their merits and demerits.
- b. To identify the roles of Warehousing Management Systems (WMS) and other IT practices in streamlining storage operations.

- c. To outline the relevant strategies supply chain and logistics actors can use to optimize warehouse storage operations to improve efficiencies.

### 3.2.3 Research Questions

- a. What are the major storage operations in warehouses to store goods, and what are their merits and demerits?
- b. How can WMS and other IT practices streamline warehouse storage operations?
- c. What strategies and efforts can the logistics and supply chain industry use to achieve optimized storage operations?

### 3.2.4 Significance of the Study

This study is a significant addition to the logistics and supply chain management (SCM) field since it explores the area of storage operations in warehouses, which has not been fully exploited in SCM and logistics studies. It reveals the types of storage operations, their merits, and their demerits. Also, it recommends the best practices SCM and logistics professionals can use to enhance and optimize these operations' performances, eventually improving the firm's productivity, effectiveness, and competitive levels. The findings derived from this article are also helpful for academia and industry-wide applications that promote sustainable warehousing and storage operations processes.

### 3.3 Methodology

This study used the qualitative approach to collect data and information to achieve the study aims and answer the research questions. The research questions were as follows;

**RQ1.** What are the major storage operations in warehouses to store goods, and what are their merits and demerits?

**RQ2.** How can WMS and other IT practices streamline warehouse storage operations?

**RQ3.** What strategies and efforts can the logistics and supply chain industry use to achieve optimized storage operations?

According to Tenny, Brannan, and Brannan (2022), qualitative studies are crucial in gathering participants' experiences, perceptions, and behaviors by answering the hows and whys rather than how many and how much. The researcher also used the literary search qualitative study approach to complement the research participants' responses. The study followed these steps to achieve the inclusion/exclusion criteria. (1) Narrowing to warehousing journal articles that have been peer-reviewed, (2) including papers with minimal limitations, and (3) articles available as full text and not as abstracts. Hence, articles available as abstracts and not peer-reviewed were excluded from the study. The study retrieved the articles from databases like Google Scholar, JSTOR, Research Gate, PubMed, and SCOPUS. Keywords like warehouse management systems (WMS), warehouse storage operations, optimizing warehouse storage operations, warehouse operations, and IT in storage operations were used to gather the articles.

On the other hand, the researchers also complemented the literary information by interviewing four supply chain and logistics leaders across Oman. The participants were assigned codes P1, P2, P3, and P4 and held senior positions for at least five years. They also held different positions across the organization, allowing for better diversity and a more comprehensive response. The researchers were the primary data collectors; they interviewed these participants using eight open-ended questions, which allowed for a more thorough review of recurring themes. Tenny, Brannan, and Brannan (2022) add that purposive sampling in qualitative studies helps researchers select participants according to their abilities to be the most informative and the research rationale.

## 4.0 DISCUSSION AND FINDINGS

The study's primary aim was to identify the major strategies used to optimize warehouse storage operations, especially with increased competition among supply chain and logistics firms worldwide. However, the three research questions paved the way for a more in-depth study.

### **RQ1. What are the major storage operations in warehouses to store goods, and what are their merits and demerits?**

According to P1, an employee at Transom SATS, the major warehouse storage operation is the documentation process. P1 highlighted that documentation helps sort stored goods awaiting export, import, and dispatch. Verma, Tripathy, and Singhal (2022) support the notion that documentation helps determine order-picking processes, the type of storage for goods, space utilization efforts, and the projected seasonal growth. Leng et al. (2019) also assert that documentation in warehouse storage systems is crucial in making data-informed decisions regarding warehouse growth. However, P4 lamented that the documentation processes are only effective when the warehouse can handle enormous amounts of data and expose the warehouses to data breaches and attacks. Similarly, Verma, Tripathy, and Singhal (2022) highlight that storage policies and legislation across different nations keep changing, making it challenging to streamline these operations effectively.

P3 claimed that determining the right storage system is another vital warehouse storage operation. Verma, Tripathy, and Singhal (2022) stated that mobile racks, pallet racks, static shelving, wire partitions, or multi-tier racks help the warehouse utilize its floor spaces according to the nature of the goods. These systems also inform the warehouse storage staff to implement LIFO or FIFO arrangements according to the nature of the goods, dispatch times, and forecasts. However, P2 raised concerns that even though most of these storage systems help ease the movement and storage of products, they are expensive to acquire and maintain. Additionally, managing stock-keeping units (SKUs) is another crucial warehouse storage operation, as revealed by P3. These SKUs are vital in identifying inventory stored in the warehouse (Leng et al., 2019; Verma, Tripathy & Singhal, 2022). However, P4 added that SKUs require enormous time and effort to set up and maintain.

### **RQ2. How can WMS and other IT practices streamline warehouse storage operations?**

According to P4, WMS and the Internet of Things (IoT) have revolutionized warehouse storage operations. P1 also identified that WMS and IT programs at Oman SATS LLC have helped improve communication with the customers, increased visibility, reduced operational costs, quickened service delivery, and minimized errors associated with human errors. Rizki, Zarory, and Luthfi (2023) assert that IoT in storage warehouses helps streamline operations by eliminating the weaknesses of the barcode technology, requiring the workforce to hold them closer to the reader. Similarly, barcode storage capacity is minimal (Rizki, Zarory & Luthfi, 2023; Verma, Tripathy & Singhal, 2022). However, WMS and IoT help speed storage and the overall warehousing processes by fastening inventory turnovers, controlling stocks better, optimizing warehouse spaces, and improving customer experiences by improving efficiencies and effectiveness.

Oman SATS LLC has deployed several WMS and IoT in its storage operations. P1 highlighted that the company uses the Webtrack Plus Website, which helps in faster clearance of goods from the goods stored (Transom SATS, 2023). Besides, once a customs broker, freight forwarder, shipper, or consignee registers via the website, they do not have to physically travel to the cargo terminal to make transactions since they can do that online using their mobile phones or computers. Conversely, P3 identified that Al Nowras Logistics Solution has a mobile application allowing consumers to transact and interact with the different warehousing storage operations using their phones at their convenience. Rizki, Zarory, and Luthfi (2023) add that WMS and IoT tools like RFIDs, Machine Learning, Artificial Intelligence (AI), robotics, automation, and Big Data have effectively helped streamline storage operations across numerous warehouses because they lead to efficiencies and reduce time wastages, make the company more productive, and helps in customer satisfaction.

### **RQ3. What strategies and efforts can the logistics and supply chain industry use to achieve optimized storage operations?**

The research participants P1, P2, P3, and P4 unanimously agreed that the principal strategy for optimizing warehouse storage operations is by responsibly integrating WMS and IoT into the storage operations. WMS and IoT also help optimize operations by improving collaboration across the supply chain (Dogbe, Afshan & Dehmani, 2022). These ICT tools are crucial in implementing efficient warehouse layouts, and designs that reduce the distances traveled when handling equipment. They also pave the way for utilizing advanced storage systems across the warehouse. Further, P3 highlighted that training staff and equipping them with the knowledge and skills to operate these WMS and other storage protocols could lead to a more optimized storage operation (Odeyinka & Omoegun, 2023). Varma (2022) also adds that embracing sustainability across warehousing storage operations can optimize the processes. Having eco-friendly solutions like sustainable storage equipment, energy-efficient lighting, optimizing distance traveled by machines, and going paperless can lead to a more optimized storage operation (Varma, 2022).

## **5.0 CONCLUSION**

This article has focused on studying the complexities of warehouse storage operations. The four research participants interviewed majorly gave accurate and consistent responses to the

existing literature. The researchers also dedicated their time to identifying significant strategies to optimize warehouse storage operations, especially with increased worldwide competition among supply chain and logistics firms. The study findings have highlighted that warehouses can optimize their operations by deploying efforts capable of generating more speed and efficiency gains in inventory operations. However, these organizations must also navigate barriers like investment costs, maintenance costs, minimal training, and safety concerns accompanying these storage operations.

## 6.0 RECOMMENDATIONS

Thus, based on this research's findings, the researchers present the following recommendations to warehouses to optimize their operations and increase customer satisfaction levels.

- a. Invest in training and development programs for the workforce to equip them with the skills and knowledge needed to reduce accidents injuries, and improve efficiencies.
- b. Deploying the different WMS and IoT tools like Big Data Analytics, AI, Machine Learning, sensors, and RFID to record real-time equipment health and storage conditions monitoring (Rizki, Zarory & Luthfi, 2023). However, the companies must also responsibly deploy these tools.
- c. Embrace sustainable practices by going green, promoting eco-friendly storage practices, and going paperless in documentation processes. Sustainability also helps improve the company's reputation, eventually improving customer satisfaction (Popović et al., 2021).

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