

Impact of Warehouse Layout on Warehouse Efficiency and Cost Optimisation

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Abstract— In the current research the influence on the warehouse efficiency and optimisation of costs, of the modern logistics and supply chain - warehouse layout is analysed. No longer just a storage activity, warehousing today is a key operational asset which directly impacts on the management of inventory, material handling, labour productivity, order fulfilment and operational cost control. The respective analysed includes the warehouse layout structures and their effect on the workflow, space utilisation, accessibility of the inventory and movement of materials in warehouse environments. The primary data was gathered with the help of a well-designed questionnaire analyzed among the employees working in the warehouse, logistics executives, inventory controllers, and supply chain professionals. The secondary data sources were those research carried out in journals, books and warehouse management research. It is found that the appropriate planning of the layout of the warehouse optimizes warehouse management, eliminates redundant staff walking, reduces the time-consuming of material handling, optimizes space utilization and plays a big role in reducing warehouse costs. The research finally concludes that the optimisation of the layout of a warehouse is important and necessary as one of the efficient operational strategies for enhancing the performance of the warehouse and consequently, optimising warehouse costs in the long term in supply chain systems.

Keywords— Warehouse Layout, Warehouse Efficiency, Cost Optimisation, Supply Chain Management, Material Handling, Inventory Management, Logistics Operations, Space Utilisation.

I. INTRODUCTION

A. Background of the Study

The high demand for rapid delivery of products along with a high customer demand, global trade, and a tremendous growth of industrialisation and e-commerce activities have made warehousing as one of the vital elements in modern supply chain management. In today's competitive business landscape, enterprises continually strive to enhance warehouse performance and decrease operational costs and boost productivity. In today's fast-paced business environment, a warehouse has evolved from being just a holding area for goods to operating like a strategic business center that manages inventory, fulfills orders, processes materials, and distributes goods. The warehouse layout planning is one of the most important aspects of a warehouse that helps an organization optimize the efficiency of its operations and improve its cost performance among other set of various warehouse management practices. A warehouse layout is the organization of the storage racks, aisles, picking areas, loading docks, and material handling equipment in the warehouse environment. The right warehouse design can increase warehouse productivity, reduce the amount of movement, optimize storage space, minimize labour time and optimize workflow. Conversely, suboptimal warehouse designs can lead to cluttered spaces, delays, and inventory unavailability, and higher warehousing expenses. Hence, it is essential that organisations

move towards optimising their warehouse layout to enhance their supply chain and stay competitive.

B. Statement of the Problem

A common problem that many warehouse organisations face, is that their warehouse layout has not been well planned and space is not being used effectively. These problems are due to inadequate warehouse layouts and include the following: inefficient material handling, an overly congested inventory, too much labour movement, delays in order processing and increased operating costs. While warehouse management has improved with the help of technology and advancements, there are a number of organisations that still find themselves struggling with a lack of productivity and cost optimisation, due to the fact that their warehouse is designed with unsuitable structures. The current study is trying to investigate the influence of various warehouse facilities layout planning with their effect on the warehouse's efficiency and operation cost minimisation in the framework of the Warehouse Management Systems (WMS).

C. Objectives of the Study

To study the effect the layout of the warehouse has on the efficiency of the warehouse.

To understand how warehouse layout planning and cost optimisation is related.

To identify the main warehouse layout factors that influence its operational productivity and efficiency of material handling.

D. Research Questions

How will the layout of warehouses affect warehouse effectiveness?

How does they integrate with each other in terms of warehouse layout planning and optimising cost?

What are the key warehouse floor plan considerations that impact productivity and workflow?

E. Significance of the Study

This study is valuable for the warehouse managers, logistics related organizations, academics and researchers as it provides practical insights into the contribution of warehouse layout planning to the improvement of warehouse operations and reducing warehousing costs. The survey results can support organisations in implementing effective warehouse management practices that help drive higher warehouse workflow efficiency and productively, and better accessibility of inventory through the use of space.

F. Scope and Limitations

The study will center on the warehouse design and how this design could influence the efficiency and cost optimisation of the warehouse in a supply chain. Research is confined for warehouse activities like storage placement, movement and accessibility of materials and labours. There are also limitations

in the study pertaining to time, sample size, and basing findings on the opinions of the respondents, based on data gathered from survey questionnaires.

II. LITERATURE REVIEW

storage is becoming one of the most critical operations in today's supply chain management systems as it directly impacts on inventory management, material handling, order fulfilment, customer satisfaction and logistics performance. With the boom in industries, ecommerce related data, retail distribution and global trade activities, there has been a great deal of emphasis put on efficient warehouse management practices. Every day, new organisations are trying to find a way to make the warehouse more productive at the same time as cutting costs and increasing the warehousing's delivery speed. This operating context makes the warehouse layout planning a big focus for researchers, logistics practitioners and supply chain managers as the layout arrangements of warehouses directly influence the operational flow, space utilisation, labour movement, product accessibility, and material handling efficiency. An efficient warehouse layout promotes easy movement of goods, less travel time for employees, less clutter in the warehouse, greater employee output and efficiency in inventory management. However, poorly planned warehouse structures can result in operational roadblock, delays in order processing, numb-toes, inaccessibility of stock, inefficient warehouse space utilization, and unnecessarily increasing warehousing costs. Many previous studies have explained that warehouse efficiency is attributed to layout optimisation as warehouse operations heavily rely on systematic storage arrangement, aisle configuration, picking zones, along with the coordination of the workflow. Researchers have also found that the warehouse layout planning becomes one of the major factors to minimize the waste in the operations and to make the warehouse operations more productive. Having a warehouse management system, automation technologies, barcode scanning systems and intelligent inventory tracking tools have to an increasing extent been adopted by many organisations to enhance the efficiency of warehouse operations and optimise warehouse layouts. The research on warehouses operations also suggest that warehouse configurations affect the order picking, the material handling time, the material density and the labour productivity. When observing warehouse layout structures, researchers have identified that there are three different layouts - U-shaped, I-shaped, and L-shaped - that offer different operational advantages based on the size of the warehouse, the volume of inventory and workflow needs. Usually, the storage areas are divided into two sections – receiving and shipping – with the U-shaped layout, which is used in many warehouses, offering greater coordination and cooperation between the two areas, whereas an I-shaped layout allows for linear management of warehouse operations in larger warehouses. L-shaped layouts are used in warehouses where space is a concern and/or the warehouse contains a special function or process. Also, the results of other researches suggest that efficiency of warehouse is one of the significant factors which can improve supply chain competitiveness because efficient warehouse helps moving the inventory faster, enhancing customer service and reducing the operational delays. Also cost optimisation of warehousing has become a key area of research, as warehousing costs usually make up a significant part of the overall costs of the logistic flows. Proper planning and organization of warehouse layouts has been noticed to help reduce labour costs, reduce material store handling time, increase storage space, and decrease wastage during the operation. Automation, robotics, smart

warehousing systems, lean operational frameworks and sustainable warehouse management practices are increasingly becoming the main focus of modern warehouse optimisation practices. While a lot of research has been done on warehouse management systems and operational efficiency, there are few studies that analyse the role of warehouse layout, warehousing efficiency, and the cost optimisation in integrated warehouse operations. Hence, the aim of this research is to analyse the impact of Warehouse Layout Planning on operational productivity and its role to enhance Warehouse efficiency and minimize warehousing cost in the modern supply chain system.

III. RESEARCH METHODOLOGY

Research methodology is the process of systematically and scientifically collecting, analyzing, interpreting and presenting data pertaining to a problem under research. Offers a systematic approach to research that can be followed in a logical and precise manner. One of the most vital parts of academic research is the methodology section as it is here that the methodology, procedures, techniques, and approaches that were used throughout the investigation process are explained. Based on this the present study will be focussed on analysing the impacts of the warehouse layout on warehouse efficiency and cost optimisation in warehouse management and in the supply chain operations. Because the layout of a warehouse directly affects the way items are stored, how they are handled, labor productivity, access to items and handling of workflow management, it becomes critical to have a systematic study pertaining to the relationship between warehouse design and warehouse efficiency. The present research is descriptive research and analytical research since the study not only described the existing conditions on the complexity of the operations of the warehouse but also aimed to analyse the impact on the productivity of the warehouse operating system in relation to the layout planning of the warehouse and cost reduction. The study is quantitative in nature since the numerical response that will be obtained from the respondents is for operational analysis and interpretation. It is also an empirical type of research as the results are gathered from the practical operational responses from warehouse practitioners and logistics participants. For doing the study, both primary as well as secondary sources of data were used. The primary data is from a structured questionnaire filed by the respondents of the study consisting of Warehousemen, Warehouse Supervisors, Logistics Executives, Inventory Controllers and Well connected Supply Chain Professionals with the warehouse operations. Secondary Data consist of Publications on Warehouse layout planning and optimisation of warehouse operations from books, scientific research papers, journals, logistics reports and warehouse management studies. Primary and secondary data sources were used which aids in developing a balance theoretical and practical knowledge of the practices about warehouse efficiency and cost optimisation. The study targeted individuals directly involved in warehouse operations, inventory management and material handling activities, as well as persons performing logistics coordinating functionalities. The chosen sample of 60 respondents was deemed to be adequate for getting the responses of the respondents and for the statistical interpretation. Convenience sampling technique was used in the study because respondents involved in the warehouse operation are often hard to reach to due to workload and time constraints. The researcher employed convenience sampling to obtain the responses of the respondents who were available for the study for the duration he selected. The respondents were solicited using physical survey in addition to

online survey in order to elicit more respondents and to ensure efficient collection of the responses. Data was collected by the use of a well formulated questionnaire based on the objectives of the study which contained both demographical and operational questions pertaining to warehouse layout planning, space utilisation, labour movement, accessibility of inventory, material handling efficiency and cost optimisation. Most of the questions were formulated in multiple choices and likert scale questions as they facilitate quantitative analysis and systematic interpretation. To ensure that the participants would be able to understand the questionnaire and that response accuracy was increased, the questionnaire was written using simple and understandable language.

To guarantee in the data gathering process reliability, consistency, and operational relevance about the responses obtained, the data collecting process was done systematically. Before administering the questionnaires, the subjects were apprised and oriented of the academic nature of the research and asked to provide sincere operational feedback from their hands on experience in warehouses. The participation in the survey was voluntary and maintenance of confidentiality of the respondent information was made throughout the research process. Completed questionnaires returned were carefully collected, checked and orderly arranged to avoid the incomplete and unclear responses that might affect the analysis. Collected data were coded and presented in tabular form, statistically, and operationally to facilitate the interpretation and evaluation of the data. The responses collected from the participants were analysed using the different analytical tools and techniques. These were Percentage Analysis, Frequency Distribution Tabs, Comparative Analysis, Bar Graphs, Pie Charts and explanation of survey results. To get insight in the distribution of the respondents on the one hand and insights in the trends of warehouse operation with respect to warehouse layout planning and warehouse efficiency, percentage analysis was used. Data for all numerical responses were collated in a frequency table to help the structuring of numerical data and make it easier to interpret. Instructional material in the form of graphical presentation using bar graph and pie chart was also used to facilitate the visual understanding of the operational results and patterns of warehouse performances. Warehouse layout planning was used as the independent variable in the research and the phenomenon encompasses the warehouse storage organisation, aisle configuration, inventory location, warehouse operation zones and material flow planning. The variables of the dependent variable were the warehouse efficiency and cost optimisation, which encompassed aspects like space efficiency, labour productivity, material handling efficiency, inventory access, and cost savings. The study also formulated hypotheses to investigate the warehouse layout planning and the performance of the warehouse operation. Based on previously mentioned research, the research hypothesis can be formulated as follows: The warehouse layout planning has a significant influence on the efficiency of warehouse and cost optimisation. To ensure the reliability and validity of the research, the questionnaire was systematically designed, the objectives of the research and the questions in the questionnaire were closely aligned, and the procedures for collecting the questionnaire respondents' samples were carefully designed. To ensure content validity and content-related operational relevance of the questionnaire, secondary literature and preexisting warehouse management literature were also examined. Ethical issues were adhered to during the study to ensure fairness, honesty, confidentiality and responsible handling of the information

from the respondents. All data collected has been kept from the unauthorised viewing of persons and organisations for academic purposes only. It can be concluded that the general research procedure was selected in this research, this research can be systematically operational and can be analyzed the role of warehouse layout planning on warehouse efficiency and role in modern warehouse management systems towards reducing cost.

IV. RESULTS AND DISCUSSION

This is the chapter where the data gathered from the structured questionnaire supported in the study focused on the "Impact of Warehouse Layout on Warehouse effectiveness and cost Optimisation" is analysed and interpreted. There were 60 respondents who had warehouse related, inventory management, logistics coordination, supply chain related activities. The data collected were analysed using percentage analysis and method of frequency distribution. The results aid to grasp the impact of warehouse layout planning on warehouse efficiency, operational productivity, space utilisation, material handling, and cost optimisation practices. Analysis has been presented systematically in the form of numerical tables, graphical representation references and analysis.

Table 4.1. Awareness of Warehouse Layout Planning

Awareness Level	Number of Respondents	Percentage (%)
Highly Familiar	18	30.0
Familiar	22	36.7
Neutral	10	16.7
Slightly Familiar	6	10.0
Not Familiar	4	6.6
Total	60	100

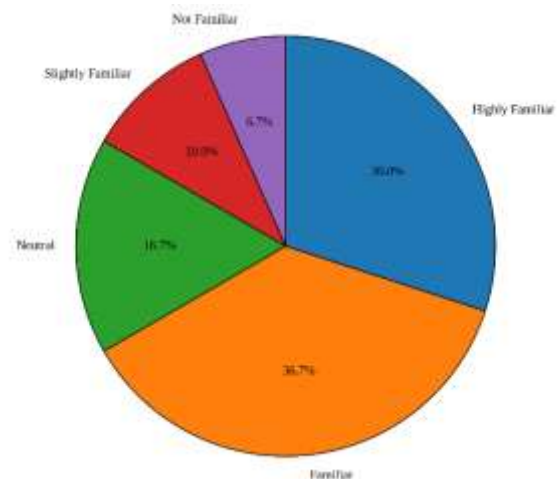


Fig. 4.1. Awareness of Warehouse Layout Planning (Pie Chart)

Interpretation:

Awareness level of the respondents about the warehouse design layout and warehouse operational design practices is shown in the above table. The results showed that 36.7% knew something about warehouses layout planning and 30% knew high about warehouse layout structures, and operational processes managing warehouses. These findings indicate that majorities of the respondents have a practical operational knowledge on warehouse planning and storage arrangement

systems. Some participants had moderate operational exposure to Warehouse Planning activities, with some 16.7 per cent undecided in the question. Approximately 10% knew 'a little' of the system and only 6.6% 'not at all' of the warehouse layout system. Above results undoubtedly indicate that warehouse layout planning is identified as one of significant operation factors to be considered in warehouse management system. Most of the respondents have practical knowledge about operations in a warehouse, so the answers they gave to the questions related to warehouse efficiency and cost optimisation give certain operational information that can be trusted with regard to the information sought. The findings also show that there is a growing interest in layout optimisation and workflow planning as key strategies in the modern warehouse organisation for enhanced operational performance and for reducing warehousing inefficiencies.

Table 4.2. Preferred Warehouse Layout Type

Warehouse Type	Layout Number Respondents	of Percentage (%)
U-Shaped Layout	26	43.3
I-Shaped Layout	15	25.0
L-Shaped Layout	11	18.3
Mixed Layout	5	8.4
Not Sure	3	5.0
Total	60	100

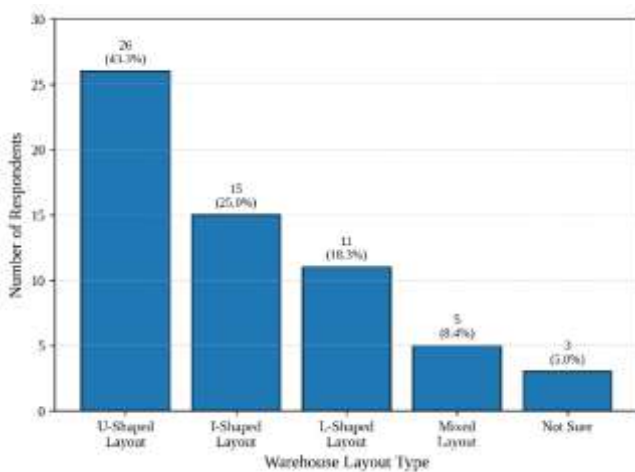


Fig. 4.2. Preferred Warehouse Layout Type (Bar Graph)

Interpretation:

The following table shows the type of warehouse layout structures normally implemented in the respondent organisations. Results show that the most desired operational configuration was the U shape as it accounted for 43.3 per cent of all the responses. This means that many warehouses opt for the U-shaped layout, which enhances the productivity of inbound and outbound activities, and limits any unnecessary movements in the warehouse. The I-shaped design received a 25 per cent response rate as it plays a vital part in large warehouses and distribution centres, where linear operational flow is needed to move inventory and other material handling activities. 18.3 percent of the responses were for the L shaped and this was seen more frequently if a warehouse was operating under any space constraints or special inventory configurations.

Few respondents, 8.4%, reported that they had mixed layout systems and 5% were unsure of the type of layout used in their organisation. The results indicate that as more organisations look to store more inventory in their warehouses, structured layouts that enable operational efficiencies, process coordination, and easy inventory access increase. The popularity of the U shaped designs also shows warehouse owners have a strong interest in minimizing delays and facilitating flow in the warehouse environment.

Table 4.3. Effectiveness of Warehouse Layout in Space Utilisation

Response	Number Respondents	of Percentage (%)
Very Effective	20	33.3
Effective	24	40.0
Moderately Effective	10	16.7
Ineffective	4	6.7
Very Ineffective	2	3.3
Total	60	100

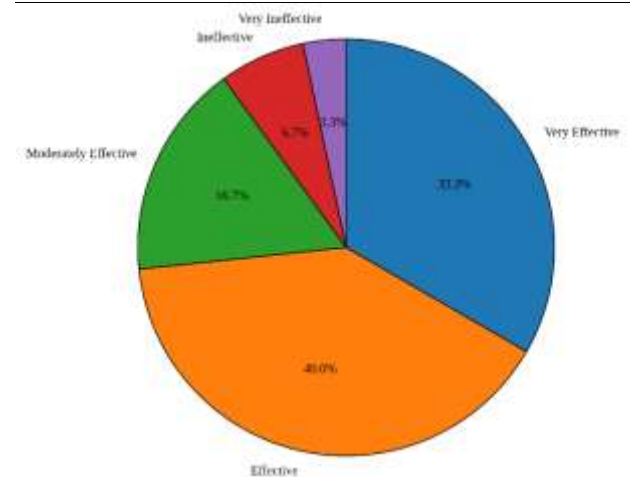


Fig. 4.3. Impact of Warehouse Layout on Space Utilisation (Pie Chart)

Interpretation:

Analyses the respondents opinions on the above table about the role playing of warehouse layout planning on improving space utilisation. The results showed 40% of the respondents found warehouse layouts very effective to improve storage utilisation while 33.3% found it effective. All of these responses illustrate that a major majority of the respondents are convinced that ULP can definitely increase the efficiency of storage operation and coordination. Some warehouse organisations still face some constraints with storage arrangement and space allocation practice with 16.7 percent of the respondents reporting moderate performance of warehouse layouts. The top two answers for the "Warehouse Layout" question were "Ineffective" and "Very Ineffective," both of which accounted for less than 5% of respondents. The results show that a good system in a warehouse facilitates the storage, which makes better use of space, inventory accessibility and management of flows. Warehouse organisations use the available warehouse space more efficiently by proper handling of the aisles, racks, storage zones, and picking areas and are flexible to operate.

They also show that efficient space utilization can be a direct cost optimization as well since efficient layouts eliminate the need to unknowingly rent additional warehouse space and increase the efficiency in managing the stock.

Table 4.4. Impact of Warehouse Layout on Material Handling Efficiency and Cost Optimisation

Response	Number of Respondents	Percentage (%)
Strongly Agree	28	46.7
Agree	20	33.3
Neutral	6	10.0
Disagree	4	6.7
Strongly Disagree	2	3.3
Total	60	100

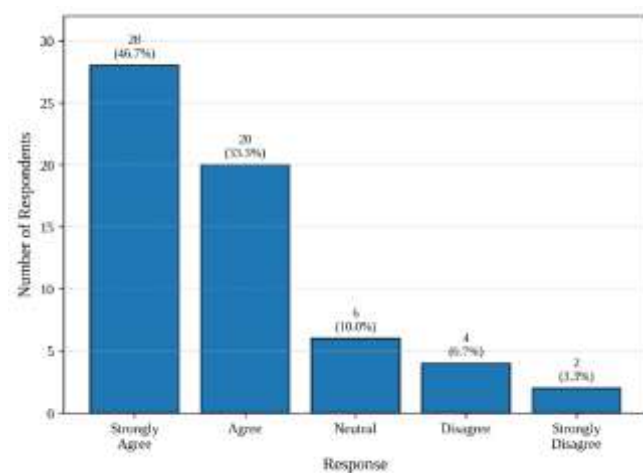


Fig. 4.4. Impact of Warehouse Layout on Material Handling Efficiency (Bar Graph)

Interpretation:

The table above shows the answerer's opinion about the effect that warehouse layout planning has on material handling and whether setting up a warehouse allows for optimisation of operational costs. The results indicate that 46.7 percent were strongly in agreement that an effective warehouse design would save material handling time and enhance the productivity of the operation while an extra 33.3 percent were in agreement. The result shows that the warehouse layout is an important factor that influences the flow of people, the accessibility of inventory and the coordination of operational flow in a warehouse. Effective warehouse design lessens the amount of unproductive workers movement, decreases the distance between working areas, and increases efficiency of picking and retrieving inventory. About 10% were neutral and very few disagreed. Based on the results, it can be concluded that the warehouse layout optimisation directly affect the reduction of inefficiency and to increase the efficiency of the warehouse productivity. Optimal warehouse configurations also help to minimise operational delays, labour fatigue and enhance employee productivity in warehouse operations. The outcomes also indicate that warehouse layout planning can help in cost optimisation by decreasing material handling costs, enhancing labour productivity, and minimising operational waste. With effective warehouse layouts, companies can thus better meet the criteria of operating competitiveness, warehouse performance and cost efficiency within the entire system of warehouse management.

V. CONCLUSION AND FUTURE WORK

For this reason, the present study is done in order to analyse the effect of the warehouse layout in the warehouse and supply chain operation to maximize the cost optimisation and warehouse efficiency. The functions of warehousing have become important as it has a direct impact on various aspects like inventory management, material handling, order fulfillment, labour productivity, and logistics performance. The research aimed to gain insights into the role of warehouse layout planning and the effect it has upon operational workflow, utilisation of warehouse space and accessibility of stock and cost reduction practices within a warehouse. Based on the response obtained from 60 respondents related to activities in the warehouse and logistics, it can be concluded that warehouse layout planning significantly affects the efficiency of the warehouse and productivity in warehouse operations. The study results showed that, with a proper design, the layout of a warehouse can utilize the available space and optimize the flow of materials, minimize unnecessary movements of labour, and facilitate easy access to inventory. The study also revealed that the preferred layout for the warehouse in the organisations was U-shaped structure as it facilitates the coordination between receiving and dispatching operation and minimizes congestion during operation. It was also found that warehouse efficient designs help to cut down the material handling time and thus improve the labour productivity, thereby better operational cost optimisation. By organising the storage racks, aisles, operational zones, and picking areas, warehouse organisations can enhance the management of their workflows and reduce delays in their operations. The results further indicate that the layout planning of a warehouse is not just a physical activity of arranging it, but an important strategic operation tool to enhance warehouse performance and supply chain competitiveness. The study also revealed that in the current scenario of modern supply chain systems, where customer expectations, inventory levels and overall warehouse operating costs are rising, there is an increased attention on warehouse organisations towards warehouse optimisation practices. There are some of study limitations, such as limited sample size, limited geographical coverage, time constraints and reliance on respondent opinions as gathered via the surveys and questionnaires. Future study can be done if the size of the sample or industrial coverage is extended to enhance the generalization. It is also possible to carry out a comparison of the effectiveness of the various layouts of a warehouse between different sectors: retail, e-commerce, industrial manufacturing, cold chains and third party logistics services. In the future, simulation software, automation systems, real-time analytics of warehouses, and advanced operational modelling techniques can be added to the studies of warehouse layout optimisations to analyse it more accurately and scientifically within the modern warehouse management systems.

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