Addis Ababa University

Addis Ababa Institute of Technology

School of Mechanical & Industrial Engineering

Warehouse Management Improvement Model via Lean Warehousing for the Case of National Oil Ethiopia PLC (NOC)

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By

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Declaration

I hereby declare that the work which is being presented in this thesis entitled **Warehouse Management Improvement Model via Lean Warehousing for the Case of National Oil Ethiopia PLC (NOC)** is original work of my own, has not been presented for a degree of any other university and all the resource of materials used for this thesis have been duly acknowledged.

_________________________ _________________________

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This is to certify that the above declaration made by the candidate is correct to the best of my Knowledge.

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Acknowledgement

First I would like to thank God for giving me the perseverance and capability to accomplish this project. Next, I would like to give my gratitude from my Advisor Dr. Gulelat Gatew for his unwavering support and for giving me with the constructive advices for making this thesis go the right direction. In addition, I would like to thank Ato Solomon Mengistu for helping me out on ways how to deal with certain problems and showing me better perspectives throughout the project. Finally, I would like to thank my family and my wife for believing in me throughout the process.

Abstract

This research has provided a specific model framework of ways to solve and address the warehousing problems using lean management techniques. The problems identified at the case company were synthesized to reflect on which performance indicator they affect by utilizing the studies of various researchers. Furthermore, 24 lean tools associated with lean warehousing presented and validated by different researchers were identified and they were characterized into seven based on their management techniques.

The wastes in warehousing of the case company were assessed seven principle of wastes which directly apply to a distribution warehouse. Interview with employees, first hand observation and collection of responses from questionnaire a sample size of 16 people was instrumental to analyze the wastes at each stages of the warehousing activities. The root cause of these wastes was analyzed by using combination of the 5W 1H history analysis method and 5 Whys root cause analysis technique and then Pareto analysis was utilized to recognize significant causes of warehousing problems. Consequently, twenty two cases were identified and these problems were further clustered to seven based on the notion they represent.

Afterward, it was necessary to identify which warehousing issues correspond to the problems stated in the problem statement. To analyze that, a questionnaire was distributed amongst 73 sample population in which the analysis was undertaken by using Relative Importance Method. With that regard, Storage System, Standardization, Existing Human Resources, Warehouse Design and Training were found to be attesting to the problem statement.

The next step taken after the identification of causes of major warehousing wastes was to identify which lean management tools can have an impact in solving these root causes. The sample size for questionnaire distribution and analysis for this step is similar to that of the previous step. With that regard, Continuous Improvement Management, Human Resource Management Lean Tools and Product and Process Management Lean Tools were found to have an impact in solving the warehousing issues at the case company.

The findings of this research indicate that the warehousing problems at the case company can be solved by utilizing the above mentioned lean management techniques and the tools that they are comprised of.

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Acronyms

NOC – National Oil Ethiopia PLC

ATM – Automatic Teller Machine

PLC – Private Limited Company

RII – Relative Importance Index

TPM – Total Productive Maintenance

SPC – Standardized Process Control

KPI – Key Performance Indicators

df – Degree of Freedom

r – Pearson's Correlation Coefficient

VSM – Value Stream Mapping

PDCA – Plan-Do-Check-Act

RFID – Radio Frequency Identification

HR – Human Resource

WD – Warehouse Design

SS – Storage System

EHR – Existing Human Rights

ST – Standardization

TE – Technology and Equipment

EM – Specialized Employment

TR – Training

SA – Strongly Agree

A – Agree

N – Neutral

DA – Disagree

SDA – Strongly Disagree

DoP – Damage of Products

EF – Equipment Failure

ICM – Inventory Count Mistake

ISS – Insufficient Storage Space

LD – Late Delivery

SoE – Safety of Employees

Chapter 1: Introduction

1.1. Introduction

With the current globalization is broadening the market place and increasing competitions to place demands on business owners to increase quality, serviceability and flexibility, while maintaining competitive cost (Laosirihongthong and Dangayach, 2005). As a result managing and improving the aspects of a supply chain has become to business which supply good (Waller, 2003).

The warehouse continues to play a major role within supply chains and will continue to do so for the foreseeable future, although these warehouses will appear in different guises (Richards, 2011). Gu et. Al. (2006) also states that warehouse is an essential component of a supply chain. This is further attested by Van Den Berg (2012) as he views a warehouse as a temporary place to store inventory and as a buffer in a supply chain. He continues to outline the importance of a warehouse by saying that it serves, as a static unit – in the main – matching product availability to consumer demand and as such has a primary aim which is to facilitate the movement of goods from suppliers to customers, meeting demand in a timely and cost-effective manner. The above statements can be used to show that improving the warehouse operations will improve the supply chain of a given organization or company.

In order to ensure efficient operation and improvement there have been numerous organizational improvement strategies that have arisen in the last several decades and become popular in the business press, namely Total Quality Management, Six Sigma, Lean Manufacturing, and Reengineering, among many others. These strategies focus on various aspects of quality improvement, elimination of variation, waste reduction, organizational restructuring, problem solving, cost cutting and the like, all in various combinations and permutations of different principles, tools, and techniques (Sobanski, 2009). This improvement can be attained via proper warehouse management as it is the art of operating a warehouse and distribution system or, better still, of operating it efficiently (Hompel and Schmidt, 2007). Of the different warehouse management models lean warehousing will be discussed thoroughly on this research.

The concept of lean has its origin from the book by Taichi Ohono named Toyota Production System: Beyond Large Scale Production (1986). The objective of Lean is to eliminate waste, to increase productivity and efficiency, to add value, to reduce costs, as well as to increase the competitive performance. All that aim at bringing customer satisfaction (customers, being the center of Lean). Lean thinking has become popular in the last 20 years and its techniques have been applied to different service industries. Examples are the replacement of the telephone operators by dialing systems, the implementation of ATM machines by the banks, and the implementation of the automatic payment devices implemented on the gasoline tanks on some gas stations (Ackerman 2007). Even though the concept of lean is subscribed to a production process, where the elimination of waste and the non-value added processes are most visible, the application of lean in the warehouse activities can lead to significant improvement, such as elimination of waste, improvement of the lead-times and better value creation (Gergova, 2010). Lean warehousing has been aimed at discussing the opportunities of applying lean tools and applications in the warehouse operations that would help to save the time and cost of these operations (Sobanski, 2009). Lean warehouses can serve production or business systems and supply chains in general by contributing to the achievement of lower costs of operations and increased flexibility and efficiency (Mustafa et. Al 2013).

This study focused on developing a model for improving the warehouse management of a company via lean warehousing by taking National Oil Ethiopia (NOC) as a case company. NOC uses a vast warehouse for the storage of various lubricant products that are supplied to the country. However, the warehouse management system has not evolved with together with the growth and influence of the company. The existing warehouse management has failed in the areas of ensuring the safety of the employees, delivering products to customers on time, avoiding mistakes with regards to inventory of products, providing a sufficient warehouse space to store products, avoiding the breakdown of material handling equipment and reducing product damage during loading, unloading and while storing. This has become a stumbling block in the day to day operation of the company.

1.2. Background of Case Company

National Oil Ethiopia (NOC) is the leading company in the importation and distribution of petroleum products to a wide range of customers in the different economic sectors of Ethiopia. Since its inception about 15 years ago, NOC has captured a confirmed overall market share of 37% with 180 service stations and broad base of corporate consumers across Ethiopia as at May, 2016 and maintaining same leadership position until now. In addition to the supplying of fuel, bitumen and LPG to the people of Ethiopia, NOC has partnered with Chevron to deliver high quality lubricants to the market.

National Oil Ethiopia (NOC) Plc is the first indigenous major oil marketer of petroleum products with a wide network of modern service stations strategically located across the country. We focus and continuously strive to improve our product and service offerings and expand our business operations in Ethiopia and other Countries in Africa.

Established in April 2004, National Oil Ethiopia Plc (NOC) is registering a sterling growth in the marketing of petroleum products in the Country. It markets one of the world's leading lubricant brand Chevron-Caltex Lubricants, and maintains a major market share in Ethiopia's Oil Industry with the supply of over 100 different lubricant grades of Industrial and Automotive applications. In addition, NOC markets other Petroleum products such as Bitumen, LPG, Petcock and Chemicals.

Vision: To be the Customer's First Choice for supply of Quality lubes, bitumen and Main fuels at competitive price and second to none quality services.

Mission: To be engaged in the importation, distribution and retailing of petroleum products including Jet Fuels, Gasoline, Gas oil, Kerosene, Fuel Oils, Lubricants, Bitumen, LPG, Petroleum Coke, Chemicals and products of petroleum.

NOC is currently operating with multi warehouse multi location warehousing system. NOC uses three ware houses at three different places. The warehouses are:

- Kality Warehouse: The main inventory location for pump spare parts, service station and distributors promotional items, and lubricant products.
- Dukem Warehouse: The main warehouse for bitumen products and LPG gas and cylinders. This warehouse is also where NOC's fuel depot is located. In addition, lubricant products are stored here.
- Aviation Warehouse: The main warehouse for aviation refueling vehicle spare parts and location for NOC's JET A1 fuel depot.

This study will be focusing on improving the warehousing at Kality Warehouse as it is the warehouse that serves high ins and outs of products and it is also a major storage location for NOC lubricant products that are distributed to the market. It can be considered as the major distribution point of lubricants. NOC uses a software named ACCPAC to monitor the warehousing, logistics, finance, clients, dealers, distributors and inventory of products within the company. This software is considered as the basic controlling media within the company. In addition, all orders and communications by the personnel working in the company are done via Microsoft Outlook.

Fig 1.1: NOC Kality Warehouse Compound

1.3. Problem Statement

Rohan Agarwal (2020), on his statement regarding an ideal warehouse, states that an ideal warehouse implements proper location of products, has sufficient space, uses mechanical appliances for loading and unloading, and needs proper management among others. Richards (2011) further states that warehousing faces challenges as such in the areas of efficiency and productivity, quality and accuracy, reduced lead times, safety, technological advancements, effects on environment as well as the workforce.

National Oil Ethiopia (NOC), even though a prominent figure in the lubricant industry in Ethiopia, it has to go a long way in the area of warehousing. The company has not yet assessed the impacts of the current warehousing method it is using on its supply chain, in fact there are no KPI's when it comes to warehousing. The company's record show that that the below problems are persistent within warehouse of the company:

- Damage of products and goods during loading, unloading and storage resulting an unnecessary cost on the company. Due to this, an estimate of products worth ETB 2,000,000.00 are damaged every year.
- Long queues during loading and unloading of products resulting late delivery. Due to this the time taken to finish up loading a vehicle (considering a vehicle with 40 quintal loading capacity) could go up to 2 hours and unloading up to an hour.
- Mistakes in inventory count causing subsequent mishandling of orders resulting customer dissatisfaction.
- Injury on employees ranging from minor to major. At least, one employee is injured per week. In addition, at least 3 employees report sick for 3 days within a month.
- Breakdown of material handling equipment during operation.
- There is no sufficient storage space for products, thus, the products could be stored at areas where there is no protection or that can lead to defect.

The following points were raised to further investigate the issue:

- What are the current practices of warehousing at the company?
- How do the aforementioned problems affect the overall performance?
- Which principles of lean warehousing can be utilized to improve a distribution warehouse?
- What kind of lean warehousing model can be developed for an oil company?
- How implementation of lean warehousing can affect the overall performance of the warehouse?

1.4. Objectives

1.4.1. General Objective

This study has the objective of generating a lean warehousing model to improve warehousing at National Oil Ethiopia.

1.4.2. Specific Objective

The specific objectives are the following

- To assess and explain the current warehousing performance of the company
- To assess how the problems affect the warehousing process of the company
- To assess the principles of lean warehousing that can improve a distribution warehouse.
- To conduct an empirical study on warehousing in an oil company and develop a model of lean warehousing
- To assess which lean tools can be utilized to improve the warehousing of the company

1.5. Significance of the Study

The study is significant as it outlines the concept of lean warehousing within the National Oil Ethiopia. It also shows the drawbacks of the current warehousing system used by the company that have constantly hindered the supply chain system. Furthermore, it helps other industrial and distribution sectors that employ large warehouse such as NOC to realize the following benefits of lean warehousing:

- Faster distribution network
- Saving inventory space
- Economical solution with less effort
- Reduction of waste
- Reduction of unnecessary work processes
- Safety of warehouse employees

1.6. Scope of the Study

The study focuses on the improvement of the supply chain by improving the warehouse at NOC. However, this study does not asses the marketing and distribution method and other aspect of the supply chain.

1.7. Limitation

One of the limitations of this research was the use of convenience sampling as a method to identify the root causes of waste in the warehousing process. This method may not capture the full range of issues that affect the efficiency and effectiveness of the warehouse operations. Another limitation was the secrecy of the case company, which prevented the access of some relevant data and information that could help identify more problems for improvement. A third limitation was the limited knowledge of the employees about lean warehousing and the concept of lean in general, which may have influenced their responses and perceptions during the interviews and surveys.

Chapter 2: Collected Literatures

2.1. Literature Review

2.1.1. Introduction and Definition of Key Terms

The purpose of this literature review is to provide background in the areas of warehousing, lean and lean warehousing. As the study focuses on providing a solution to a warehousing problem in the case company, it is important to understand the types of warehouses and activities within them. Moreover, having a grasp of knowledge in the area of warehouse performance metrics was found to be important to attest the existing warehouse problems. Furthermore, the principal sources of this literature review were from published literature, text books, hand books, journals, publications, articles and blog posts.

The following definitions are provided to clarify the terminology and stratification of the framework used in this research. The literature does not provide clear definition of whar warehouse and lean are.

- Warehouse: is a planned space for the storage and handling of goods and material. (Interlake Mecalux, 2023).
- Lean: is a set of management practices to improve efficiency and effectiveness by eliminating waste. The core principle of lean is to reduce and eliminate non-value adding activities and waste. (American Society for Quality, 2023)

2.1.2. Warehousing

As per Thi Thu Ha Tran (2015), warehousing is defined as holding goods until they are required. In the past, warehouse is known as a cost center but now organizations use warehouse as a place to add value by doing many related jobs such as labeling and packaging. The issues put forward for warehouse management are to increase productivity and accuracy, reduce and control cost of inventory and shipping while providing good customer service (Richards, 2011). Tostar and Karlson (2008) believe that the two major objectives for keeping a warehouse are to earn profit and provide customer service. While Gu (et al, 2007) stated that the role of a warehouse includes buffering the material flow along the supply chain to accommodate variability caused by factors such as product seasonality and/or batching in production and transportation; consolidation of products from various suppliers for combined delivery to customers. Ackerman (2007) the author also states that the aim of a warehouse is to support logistics activities by combining quality of customer service and low costs and these are achieved via:

- Providing necessary storage in supply chain
- Giving secure storage
- Keeping stock in good condition and minimizing damage
- Offering good customer services
- Controlling the flow of materials effectively
- Sorting materials quickly and accurately
- Picking materials departing quickly
- Being flexible to cope with variations in stocks

- Giving safe working conditions

From the above discussions it is possible to say that the aim of good warehousing process is to move products in any arrangement to the next step in supply chain with high concern about product damages and service quality. Hence, the thesis targets to guarantee better warehousing process in the case company to improve the supply chain.

2.2.1. Types of Warehouses

Over the years different authors have given different classification of warehouses. Rushton, et. Al. (2006, p. 256) classify the types of warehouses by the following demography:

- **By the stage in the supply chain**: materials, work-in-process or finished goods.
- **By geographic area:** national, local or regional, or such that may serve more than one country
- **By product type:** for example small parts, large assemblies, frozen food, perishables, security items or hazardous goods
- **By ownership:** owned by the user or owned by a third-party logistics company.
- **By company usage:** for example a dedicated warehouse for one company, or a shared-user warehouse
- **By area:** classification according to the storage dimension in square meters

On the other hand Berg and Zijm (1999) classify warehouses based on their purpose as follows:

- **Distribution warehouse**: warehouse in which products from different suppliers are collected (and sometimes assembled) for delivery to a number of customers
- **Production warehouse**: used for the storage of raw materials, semi-finished products and finished products in a production facility.
- **Contract warehouse**: facility that performs the warehousing operation on behalf of one or more customers.

In the case of National Oil Ethiopia (NOC), the Kality Warehouse can be categorized under the classification mentioned by the above authors as follows:

It is a warehouse dedicated for National Oil Ethiopia owned by the company itself with the intention of distributing readymade lubricant products and service station equipment all over Ethiopia.

2.2.3. Warehouse Activities

Berg and Zijm (1999) consider the flow of material when it comes to warehousing activity. Frazelle (2002) states that regardless of the type or classification of activities warehouses have a fundamental sets of activities in common while also stating that those activities are also indicated in the flow operation. As a result, Frazelle (2002, p. 229 – 231) states major tasks in a warehouse as follows:

i. **Receiving:** is the collection of activities involved in the orderly receipt of all materials coming into the warehouse, providing the assurance that the quantity and quality of such materials are as ordered, and disbursing materials to storage or to other organizational functions requiring them. Putaway is also included in this section of the activity by Frazelle (2002) as it is the act of placing merchandise in storage. Putaway includes the material handling, location verification, and product placement.

ii. **Storage:** is the physical containment of merchandise while it is awaiting a demand. The storage method depends on the size and quantity of the items in inventory and the handling characteristics of the product or its container. Rouwenhorst et. Al. (1999) further state the storage area may consist of two parts: the reserve area, where products are stored in the most economical way (bulk storage area) and the forward area where product are stored for easy retrieval by an order picker.

iii. **Order picking**: is the process of removing items from storage to meet a specific demand. It is the basic service a warehouse provides for customers and is the function around which most warehouse designs are based. Rouwenhorst et. Al. (1999) supplements Frazelle’s statements adding the sorting and consolidation (grouping) process within order picking.

iv. **Shipping**: includes checking orders for completeness, packaging merchandise in an appropriate shipping container, preparing shipping documents, including the packing list, address label, and bill of lading, weighing shipments to determine shipping charges, accumulating orders by outbound carrier, and loading trucks.

The above mentioned warehouse activities also apply to National Oil Ethiopia. The study will focus on identifying problems within the aforementioned activities and any improvement on these activities will improve the overall performance of the warehouse.

2.2.4. Warehouse Performance Measure

A literature research is carried out in order to identify the indicators or key factors utilized by authors to measure warehouse performance. Richards (2011) believes that the reason for performance measurement is important to ensure customer satisfaction and continuous improvement, discover potential pitfalls and train staffs in the right areas. Frazelle (2002) on the other hand discusses the need to measure warehouse performance from business perspective. Ramaa et. al (2012) highlights that researchers and managers attempt to find set of measures that incorporate most performance metrics thought to be essential over both short term and long term horizon.

Different authors over the years have put forward performance metrics for warehouse application. Ramaa et. al (2012) measures warehouse performance from the perspective of:

- **Order Fulfilment**: order time delivery, order fill rate, order accuracy, line accuracy, order cycle time and perfect completion
- **Inventory Management Measures:** inventory accuracy, damaged inventory. Storage utilization, dock to stock time, and inventory visibility
- **Warehouse Productivity:** orders per hour, lines per hour, items per hour, cost per order and cost as a percentage of sales

Richards (2011, p. 230-231) follows up on Ackerman's (2007) statement by saying should be measuring four areas within the warehouse:

- **Reliability:** includes on-time delivery, fill rates and accuracy

- **Flexibility:** Order cycle time is probably the best measure of flexibility as it covers all aspects of the customer order process: how we handle the order initially, whether we have the stock available, how quickly we can process the order through the warehouse and, finally, how quickly we can deliver to the customer
- **Cost:** include cost as a percentage of sales and productivity against labour hours.
- **Asset Utilization:** Asset utilization will include efficient use of warehouse space and storage equipment.

Staudt et. al. (2015) and Frazelle (2002) generalize the concept raised by the four authosrs by categorizing the metrics into four performance indicators for warehouses based on warehouse activities:

- **Time Indicators:** receiving time, putaway time, dock to stock time, replishment time, order picking time, shipping time, and delivery lead time
- **Productivity Indicators:** labor productivity, labor efficiency, receiving productivity, storage productivity, replenishment productivity, picking productivity, shipping productivity, delivery productivity, inventory utilization, turnover, transport utilization, warehouse utilization, equipment downtime and throughput,
- **Cost Indicators:** inventory costs, transportation costs, order processing cost, cost as a percent of sales, labor cost and maintenance cost
- **Quality Indicators:** receiving accuracy, storage accuracy, replenishment accuracy, physical inventory accuracy, picking accuracy, orders shipped accuracy, delivery accuracy, on time delivery, orders shipped on time, order fill rate, perfect order, customer satisfaction and stock out rate

Bogale (2016), in his study with regards to warehouse performance, sets four major indicators at different stages of warehousing activities:

- **Quality Indicators:** Inventory accuracy rates, Put-away accuracy, picking accuracy rate, Warehouse accident rates, defined security measures
- **Time Indicators:** Warehouse order processing time, Customs Clearance cycle, Put-Away time
- **Cost Indicators:** Total Warehousing Cost, Value of product damage in warehouse

- **Productivity:** Storage space utilization, Units moved per person-hour, percentage of storage dedicated to product handling

Warehouses are staffed by full-time, part-time and temporary workers and often operate under challenging conditions. Reducing health and safety hazards is everyone's responsibility and concern. All organizations and their staff should be made aware of safety standards and practices to reduce risk of injury and illness (CFA Institute, 2014). The above studies define various performance indicators or metrics for a warehouse. However, the aspect of safety in a warehousing environment is considered as a prime performance metrics in various literatures. This study intends to incorporate the essence of safety as warehousing metrics. The next section also shows the importance of safety in warehousing.

2.2.5. Health and Safety in Warehousing

Health and Safety Executive (2007) states that warehousing and storage encompass a broad range of activities with a variety of potential risks and hazards. Examining the hazards that develop at work and then putting practical health and safety measures in place to control them are essential components of effective health and safety management. The following are other causes included in the guide for serious injuries suffered by warehouse workers:

- Slip or trip
- Manual handling
- Falls from height
- Hit by moving, falling object
- Hit by moving vehicle
- Hit something fixed or stationary
- Other kinds of accidents such as fire and machine malfunction

Champion Brands, LLC overview on storage and handling of lubricants also suggests that hazardous substance markings on packages which identify toxic, harmful or flammable products must be understood and obeyed when storing, transporting or using the product. Moreover, employees should wear working overalls, impermeable aprons and gloves, etc. to eliminate unnecessary contact with oil. In addition, safety labels and first aid kits should also be made available.

This shows that the concept of safety is of paramount importance in warehousing. Therefore, health and safety should be proactively managed just like any other part of the business. This means appropriate health and safety arrangements should be put in place in order to protect employees as well as members of the public from harm.

2.2.6. Lubricant Warehousing

Cox (1972) claims that the main requirement when handling lubricants is to avoid contamination by dust, grit and water. Many applications require specialized lubricants but all the care with which a lubricant has been formulated, manufactured and packaged can be nullified by the presence of small quantities of contaminant. Publication by RC Grease and Lubricants supports the claim by stating that manufacturing of lubricants involves taking high precaution to avoid pollution and to deliver high-quality pollution-free products. All these precautions would be totally pointless if the end user failed to comply with certain storage and handling precautions.

The contamination factors in Chevron's (1997) study on the handling and storage of lubricants are comparable to those in Evans et al. The following is a fuller explanation of these factors:

- **Temperature** - Lubricant stability can be impacted by both severe heat (more than 110°F) and extreme cold (less than 0°F). Oil will oxidize more quickly when heated. Wax and probable sediment development are also effects of cold. Additionally, drums may breathe when exposed to extremes of heat and cold, which could lead to moisture contamination. Most lubricating oils and greases can be kept in storage at temperatures between 0°F and 110°F. The ideal storage temperature range is between 32°F and 77°F.
- **Light -** Light may affect the lubricants' color and appearance. Lubricants ought to be kept in the original metal or opaque plastic containers that came with them.
- **Water -** Water and some lubricant additives will react. At the oil/water interface, it may also encourage the growth of microorganisms. Lubricants should be kept dry and preferably inside of a building.
- **Particulate Contamination** - Particulate Contamination: Lubricant drums and pails shouldn't be kept in locations with a lot of dust or other airborne particles.

- **Atmospheric Contamination** - lubricants may react with oxygen and carbon dioxide, changing their viscosity and consistency. The best defense is to keep lubricant containers closed until the product is required.

Papers by both RC Grease and Lubricants and Champion Brand, LLC agree that lubricants should be stored indoors if space is available. However, if space is not available indoor storage priority should be given to:

- Small packaged lubricants which can be affected by frost,
- Greases,
- Transformer oils,
- Thermal fluids
- Refrigerating compressor oils,
- Brake fluids
- Soluble cutting oils, and
- Hydraulic oils

If outdoor storage is a must, it is absolutely essential to store the products on a sealed surface to prevent the pollution of the soil and accordingly of any groundwater, in the event of accidental spillage. For oil drums, systematic preference should be given to the lying-down position. This can be accomplished using storage racks. It is also preferable to use storage racks with protection from bad weather, or outdoor storage cabinets. Storing the drums lying down prevents the ingress of water or pollutants. Chevron's study also suggests that if drums must be stored outside it is important to use plastic covers or tip oil drums to direct water and contamination away from the bungs. However, greases should always be stored vertically to avoid oil separation.

All the above studies assert that the best way of unloading lubricants is to use a platform or a forklift truck. If manual handling should be undertaken, then drums should be rolled on flat surfaces by two people and carrying of small packages or pails should be done over small distances.

From the above studies, it is possible to comprehend the issues involved with regards to lubricants warehousing. Space and knowledge of lubricants characteristics is important to determine the storage and handling of lubricant.

2.2.7. Warehouse Management

Management is the art of knowing what you want to achieve and then ensuring that it is done in the best and least expensive way, according to F. W. Taylor's definition in his 1911 book. This definition of warehousing as delivering excellent customer service levels while both lowering costs through enhanced productivity and performance is further supported by Richards (2011). He continues by stating that there are limitations due to fewer inventory, shorter customer lead times, and the need to protect the safety and security of the workforce, equipment, and stock. The control and optimization of intricate warehouse and distribution systems is the broad definition of warehouse management provided by Hompel and Schmit (2007). Similar to this, Veeqo, a business that offers warehouse management systems, asserts that warehouse management is the act of organizing and controlling everything within your warehouse and ensuring that it all functions as efficiently as possible.

Confirming to the above definitions, optimizing the day to day warehousing activities with an effective organization skill, enhanced productivity, better performance and customer service level will lead to reduction of warehousing cost. In the above discussion in relation to the concept of lean, it is said the intension of lean system is to achieve more with less. Inherently, the concepts of lean and warehouse management are more or less similar.

As a result, this study will focus on the development of an improved of the warehouse management model at National Oil Ethiopia (NOC) by using lean as a warehouse management tool, hence lean warehousing. However, this practice has been implemented by various researchers and companies which will be explained further in the next section.

2.2.8. Lean

The Lean production was originated in Japan when the mass production was popular in many industries in America. Dehdari (2013) recounts the origin if lean production by saying that Taiichi Ohno came up with concept of lean production by wanting to stray from the common method of mass production and create value for the customer with higher level of efficiency and less waste. As described by Ohno (1986), the development of the manufacturing system was merged out of the necessity to develop the production flows with minimized or zero inventory. Eventually, he developed the Toyota Production System (TPS) to enable his organization to meet customer demand in a more efficient way. The main elements of TPS are Just in Time (JIT) and automation or the automation with human intervention (Jidoka). The other related concepts of lean manufacturing are derived from these two.

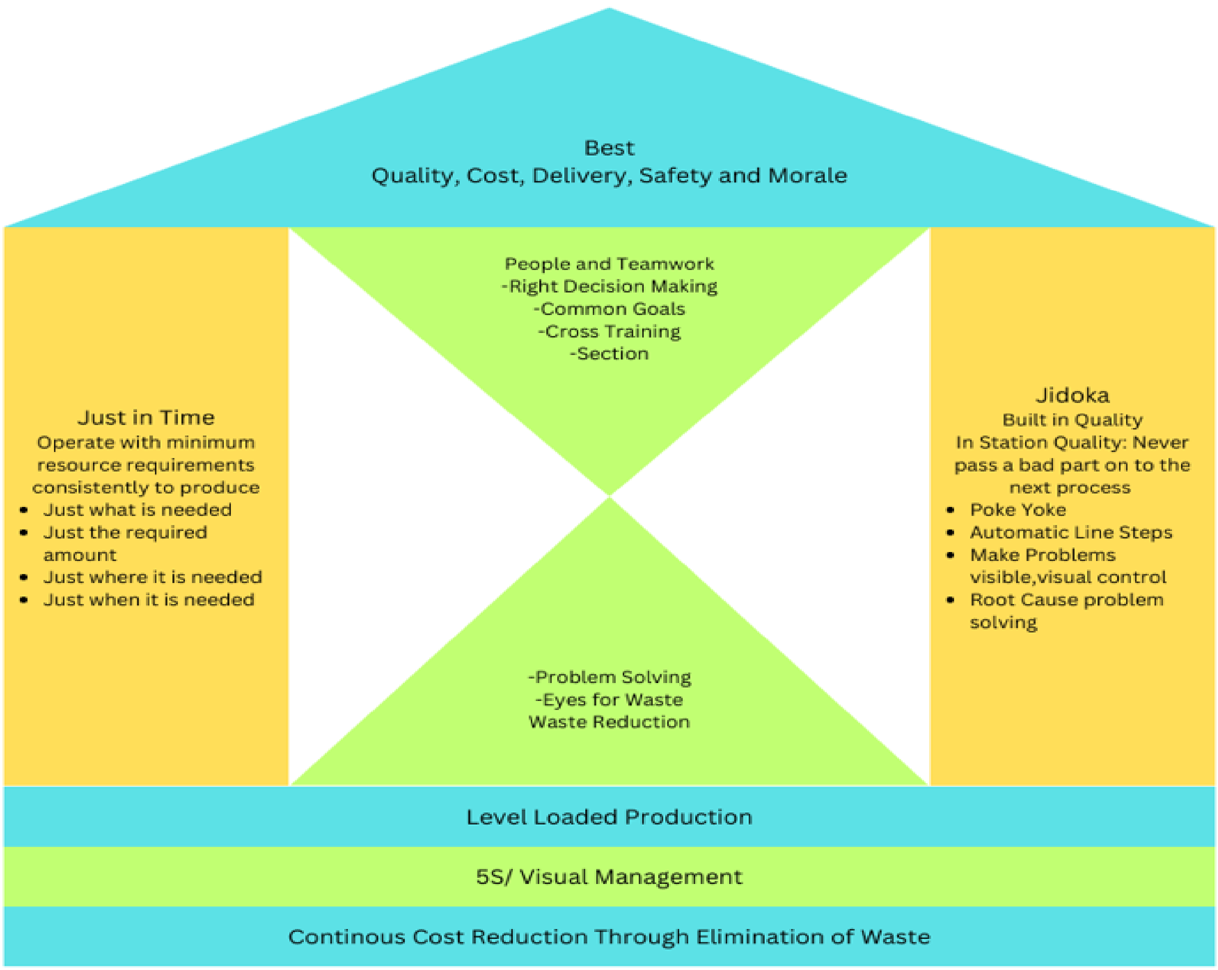

Fig 2.1.: Toyota Production System House

(Source:http://www.gembutsu.com/system_files/library/15.pdf)

The concept of seven types of waste are defined by Ohno (1986):

- **The waste of Over Production:** inept production that results in excess inventory
- **The waste of Waiting:** prevention of the processes to move forward, or queuing.
- **The waste of Transportation:** movement of materials, which adds no value, extend the process-time and may lead to handling damages

- **The waste of Over Processing:** the additional activities linked with overproduction, excess inventory or management of defective parts, e.g. rework, reprocessing, storage
- **The waste of Inventory:** this includes the materials in store, which are not needed for the customers' orders
- **The waste of Movement:** this refers to the motion of the personnel which is ineffective, which occurs with processing of defects or from inefficient layout.
- **The waste of Defects:** finished goods that confront with the requirements of the customers, or parts or products which have defects and require correction.

Womack (1996) adds an eighth waste which is **underutilization of people** that is also attested by Liker (2004). There are also some other important applications introduced by TPS i.e the ideas of profit making industrial engineering, maximizing worker utilization rather than machine utilization, small lot sizing, quick set up and preventive maintenance are presented. Ohno (1986) provides the fundamental framework from which the concepts associated with TPS are derived and subsequently the framework associated with lean manufacturing.

Womack (1996) further claims that lean thinking is the antidote or the cure to waste by stating the following 5 lean principles:

- **Specify Value**. Value can be defined only by the ultimate customer. Value is distorted by pre-existing organizations, especially engineers and experts. They add complexity of no interest to the customer.
- **Identify the Value Stream.** The Value Stream is *all* the actions needed to bring a product to the customer. In recent years, value stream mapping (VSM) has emerged as the preferred way to implement lean production. **VSM** is a mapping tool that is used to map a productive process and identify waste for improvement.
- **Flow.** Make the value-creating steps flow. Eliminate departments that execute a singletask process on large batches.
- **Pull.** Let the customer pull the product from you. Sell, one. Make one.
- **Pursue Perfection.** There is no end to the process of reducing time, space, cost and mistakes.

Fig 2.2. Lean Principles (Source: www.lean.org)

In addition to indicating an eighth waste similar to Womack (1996), Liker (2004) provides a inclusive and thorough description of the lean principles of management methods and structures and business control processes used by various lean manufacturing firms. He outlines the differences between traditional automotive firms and Toyota, the performance differences between the firms, and the underlying principles of problem solving, people and partners, processes, and corporate philosophy. Furthermore, he identifies 14 lean principles organized in 4 broad categories:

- Long-Term Philosophy
  - **Principle 1:** Even at the expense of short-term objectives, base your management decisions on a long-term perspective.
- The Right Process Will Produce the Right Results
  - **Principle 2:** Establish a continuous process flow to highlight issues.
  - **Principle 3:** Utilize the "Pull" System to reduce production.
  - **Principle 4:** Equalize the workload (work more slowly than quickly).
  - **Principle 5:** Create a culture where problems are stopped and quality is done correctly the first time.
  - **Principle 6:** The basis for ongoing development and employee empowerment is standardized work.

- **Principle 7:** To ensure that no issues are disguised, use visual control.
- **Principle 8:** Utilize only trustworthy, well-tested technology that supports your processes and employees.

- Add Value to the Organization by Developing Your People
  - **Principle 9:** Develop business leaders who fully get the mission, embody the philosophy, and impart it to others..
  - **Principle 10:** Create great teams and individuals who adhere to your business's ideology.
  - **Principle 11:** Challenge and assist your expanded network of partners and suppliers in improving as a sign of respect.
- Continuously Solving Root Problems Drives Organizational Learning
  - **Principle 12:** For a complete understanding of the issue, go and see for yourself.
  - **Principle 13:** Consensus choices should be made deliberately, carefully weighing all options, and judgments should be put into action quickly.
  - **Principle 14:** Become a learning company by reflecting often and making improvements.

The other antidote considered as a basement for lean improvement by Hirano (1990) is the 5s principle. The 5s principle is a set of five processes for achievement of standardization effective work place organization, and continuous improvement. The principles are as follows:

- Seiri (Sort): Removing unnecessary items from work place
- Seiton (Set in Order): Locate everything at the point of use
- Seiso (Shine): Clean and eliminate the source of filth
- Seiketsu (Standardize): Make routine and set standards for best practices
- Shitsuke (Sustain): Sustain the practice

DiBarra (2002) adds a sixth S that stands for safety. It refers to the safety of the work place and respectively of the employees.

Martinez-Sanchez and Perez-Perez (2001) develop a framework of six lean indicators and associated practices for each. The first indicator, elimination of zero-value activities, is characterized by the percentage of common parts in company products, value of work in progress in relation to sales, inventory rotation, number of times and distance parts are transported, and percentage of preventative maintenance over total maintenance.

The second Martinez-Sanchez and Perez-Perez (2001) indicator is continuous improvement constituted by the number of suggestions per employee per year, percentage of implemented suggestions, savings and/or benefits from suggestions, percentage of defective parts adjusted by production line workers, percentage of time machines are standing due to malfunction, value of scrap and rework in relation to sales, and the number of people dedicated primarily to quality control.

The third Martinez-Sanchez and Perez-Perez (2001) indicator is multifunctional teams comprised of percentage of employees working in teams, number and percentage of tasks performed by the teams, average frequency of task rotation, and the percentage of team leaders that have been elected by their own team co-workers.

The fourth Martinez-Sanchez and Perez-Perez (2001) indicator is JIT production and delivery consisting of lead time of customers' orders, percentage of parts delivered just-in-time by suppliers, level of integration between supplier's delivery and the company's production information system, percentage of parts delivered just-in-time between sections in the production line, and production and delivery lot sizes.

The fifth Martinez-Sanchez and Perez-Perez (2001) indicator is the integration of suppliers including percentage of parts co-designed with suppliers, number of suggestions made to suppliers, the frequency with which suppliers' technicians visit the company, the frequency with which company's suppliers are visited by technicians, percentage of documents interchanged with suppliers through EDI or intranets, the average length contract with the most important suppliers, and the average number of suppliers in the most important parts.

The final Martinez-Sanchez and Perez-Perez (2001) indicator is flexible information systems defined by the frequency with which information is given to employees, number of informative top management meetings with employees, percentage of written procedures in the company, percentage of production equipment that is computer integrated, and the number of decisions employees may accomplish without supervisory control.

The aforementioned points thus demonstrate that being lean involves getting more done with less resources. Utilize the least amount of time, space, materials, money, energy, equipment, and labor while providing customers with exactly what they want and making sure that all workers participating in the process are safe. As a result, the idea of lean can be applied to the process of warehousing since it's important to detect wastes during these processes and get rid of them. The part that follows expands on this.

2.2.9. Lean Warehousing

Richards (2014), claims that the challenges in warehousing are:

- Data and Information transfer
- Environmental Issues
- Labor Cost and Availability
- Increases in Stock-keeping Units
- Greater Fluctuation in Demand
- Smaller, more Frequent Orders
- Delivery Through Multiple Channels
- Shorter Order Lead Times and Stock Availability
- Achieving the Perfect Order
- Pressure to Reduce Operating Costs

Richards, further states that one way of overcoming some of the above challenges is the introduction of 'lean' concepts into the warehouse operation. The idea behind lean is to remove any activity that uses resources but doesn't create any additional value. He claims that lean thinking revolves around having a clean and streamlined operation and removing non-value-adding processes. As a result, Richards states removal of wastes in warehousing activity is essential. Therefore, he brings the concept of waste stated by Ohono (1986) into warehousing parameters by giving an example to each waste as follows:

- Transportation: operating a forklift with no cargo;
- Defects: time spent fixing mistakes like misspicks;
- Inventories: traffic jams at the entrance and exit points;

- Motion: halting motion, as when arranging goods prior to storage;
- Waiting time: bottlenecks at docks;
- Overproduction: keeping too much inventory; and; and
- Over Processing: adding extra stages, like verifying and labeling.

Myerson (2012) claims that lean warehousing is focused on adequate and efficient order request. It involves minimizing non-value adding activities at all warehouse operations: receiving, storing, picking order, packing and shipping. He further states an eighth waste in warehousing aside from what Richards (2014) has stated, i.e. waste behavioral waste or employee underutilization.

As Garcia claims and Gergova (2010) quotes warehouse improvement refers to improvement of the material flow, order picking, replenishment, and dock operations. Gergova then concludes the study by the utilization of the lean tool 5S in a warehousing operation.

Successful application of Lean techniques would lead to reduced lead-time (the unnecessary time part of the order-to-delivery processes), order picking time, and the time for material handling. This can be achieved through reduction of the non-value adding activities, and improvement of velocity and flow in the warehouse. In other words, it is the elimination of waste that is important.

Salman (2015) identified five constructs and proposed them for lean warehousing. The identified constructs were:

- Waste Control
- Flow Management
- Quality Assurance
- Human Resource Management
- Continuous Improvement

Salman in his study focused on the construct Waste Control and tried to identify the underlying factors of wastes in each warehousing activity. The wastes considered by Salman are the same as Ohono's (1986) seven wastes.

Based on the research concluded by Sobanski (2009), the following were identified as key Lean principles that particularly relate to warehousing:

- Standardized processes
- People
- Quality assurance
- Visual management
- Workplace organization
- Lot sizing
- Material flow
- Continuous improvement

As described by Bozer (2012) the principles of lean warehousing do not change by the type of warehouse. Therefore, the results of this study should be applicable to all types of warehouse as much as possible. Accordingly, the outcome of this study will be generic and could be applied to warehouses of all types.

It can be seen that the intent of these authors is to improve the efficiency of the activities in a warehouse by removing waste. With that regard, the authors have used various approaches in implementing lean warehousing. Meanwhile, these authors, except Richards (2014), did not manage to indulge into the concept of cost while implementing lean warehousing. Richards' explanation of cost can be a stepping stone for understanding the costs within a warehousing activity. The intent in his book is also to showcase that reduction of costs within warehousing parameters via various warehouse management systems, including lean warehousing, can be achieved for the good of a company or an organization. However, the book is only determined in displaying how cost is important parameter in warehousing. It does not show how much cost is reduced practice of lean warehousing.

The limitation of the above implementation of lean warehousing by these researchers, except Richards, is that they do not showcase the cost suffered by not using lean warehousing techniques. While, Richards discussion of cost is not specific to lean warehousing. Therefore, these are considered the limitation of these studies.

2.2.10. Applying Lean Warehousing

Shingo (1989) acknowledges the principles of waste by Ohono (1986) and believes that these wastes can be eliminated mainly through continuous improvement and additionally by means of fool-proofing, inspection processes, visual controls (value stream mapping) and Five-Whys among others.

Sobanski (2009) defined fifty-eight lean practices that attest to the aforementioned lean principles with in these constructs and three facilities within an organization were selected for developing the shop-floor operational definitions and evaluation points of the lean constructs and lean practices identified. Following that he found out that out of the fifty-eight lean practices the below key underlying factors were highly correlated to the following:

- A3 reports
- Management Style
- Kaizen Events
- Systems View and
- PDCA

Salman (2015) identified the causes of each wastes in his lean warehousing research using the 5Ws technique. The 5W is a lean tool that tries to address the root cause of a problem by asking the questions What, When, Where, Why and Who. After finding the root cause, Salman (2015) proposes the use of lean practices that corroborate with the afore mentioned lean constructs

Lean Constructs	Lean Practices
Waste Control	VSM
	5s
	Standardized Process
	Preventive Maintenance
Flow Management	Levelled Flow
	Pull System
	Optimized Picking Plan
	Cross Docking
Quality Assurance	Quality at the Source
	Visual Management
	Root Cause Analysis
	Inspection and Autonomation (Jidoka)

Human Resource Management	Leadership and Commitment
	Training and Communication
	Teamwork and Empowerment
	Employee Recognition and Motivation
Continuous Improvement	PDCA
	Kaizen Events
	Employee Suggestions

Table 2.1.: Salman (2015) Lean Constructs and Lean Practices

Cagliano et. Al. (2018), similarly to Salman, first laid out the warehousing process and activities of the case company. Then analyzed the waste with regards to Ohono's (1986) waste classification by the use of 5Ws. Finally, proceeded to the waste reduction using 5S and Value Stream Mapping.

Tostar and Karlson(2008) claim that to be lean in warehousing is to improve the processes that are necessary for maintaining the warehouse's purposes and to avoid processes that can be avoided without reducing the warehouse's ability to perform its function. Possible tools for further leverage Lean in warehousing should then be tools that primarily improve the flow and increase the visibility; this together with efforts for avoiding processes and wastes. They further recommend the usage ABC tool to select most demanded items, Heijunka to level the work flow and Total Preventive maintenance to avoid having to do the optimization to many times.

Visser (2014) states that applying lean in warehousing is a powerful tool to improve quality by reducing errors. Due to the amount of resources required for implementation the effect on productivity and efficiency is rather positive than negative. Following the study he conducts, lean tools such as supplier involvement, customer involvement, total preventive maintenance and 5S tend to have high effect on the performances of a warehouse. To a lesser note, lean tools like standardized process control, pull (kanaban), cross docking and employee involvement seem to influence warehousing performances.

Swart (2015) bases his study on Sobanski's (2009) doctoral thesis while analyzing the current understanding of principles in lean warehousing for a third party logistics company. He further establishes seven lean constructs and 13 lean principles shown below for his study.

Lean Constructs	Lean Practices
Value	Customer Value
Standardized Work	Kaizen Events
	Employee Involvement
Visual Management	Metrics and KPI Boards
	VSM
Flow	Heijunka
	Layout and Zones
Work Place Organization	5S

Table 2.2.: Swat's (2015) Lean Constructs and Lean Principles

In the year 2017, a consulting company by the name of Four Principles Management Consulting FZ-LLC released a report on lean warehouse operations. According to Richards (2014), the paper draws its findings on the wastes outlined by Ohono (1986). It goes on to say that lean tools like kanban, one piece flow, Takt, and zero defects can be applied at various phases of warehouse activities in order to eliminate those wastes. Takt, which concentrates on the amount of manufacturing time you have available to create each part in order to satisfy customer demand, cannot be used in this situation because the warehouse chosen for this study is not a production warehouse (The Lean Enterprise Institute, 2008). Additionally, this study cannot use a one-piece flow. One-piece flow describes the movement of pieces through processes one at a time or in small batches, without any work-in-progress (WIP) in between. The optimal configuration for this system is a cellular structure where all necessary equipment is placed inside of cells in the order that it is needed (Ani, 2012). Since the warehouse used for this study is designed to store previously packaged and manufactured goods, all movements take place in one piece.

According to the publication issued by an IT and business Consultancy Company named Net at Work in the area of improving warehouse performance (2016), the 5S lean tool is an important aspect. Nevertheless, employee involvement, KPIs and ABC tools are considered factors in warehouse improvement.

While assessing lean warehousing Tran (2015), Myerson (2012) and Prasetyawan and Ibrahim (2020) found that the utilization of 5S technique and VSM is important in improving warehousing performance. Garcia (2003) also shared the idea of using VSM for improving warehousing operations, although it was the only lean tool used in his study. However, unlike Tran (2015) and Garcia (2003) the Myerson (2012) and Prasetyawan and Ibrahim (2020) consider other lean tools as important.

- Prasetyawan and Ibrahim (2020): Relay Outing, Kanban, Material Handling Technology, Kanban and Poka-Yoke (error proofing)
- Myerson (2012): 5W, Total Preventive Maintenance, Line Balancing, Standardized Work, Kanban and Poka-Yoke

Bashir et Al (2020) application of lean warehousing in a retail hyper market implements VSM with RFID application. Similarly, Chen et Al (2010) also implemented similar lean tools to improve the logistics efficiency of distribution center stores.

A publication by a third party logistics provider named Orderhive (2020) focuses on utilization of 5S, Kanban and Kaizen to achieve lean warehousing.

2.2.11. Summary of Literature Review

Several researches have been conducted in the areas of warehousing, lean and lean warehousing and are described in the statements above. The lean practices indicated in the literatures were primarily intended for a production scenario. Nevertheless, through time it has been discovered that the concept of lean can be utilized in various applications. As the main purpose of this study is to improve the warehousing of NOC by applying lean concepts, major focus was given in the researches containing lean warehousing and warehousing performance metrics.

Based on the literatures assessed with regards to warehousing performance indicators, the problems identified within the warehousing practices of NOC were synthesized to reflect which performance indicator they affect. The below table categorizes the identified problems at NOC to their corresponding performance indicators raised by various authors.

Table 2.3: Indicators Addressed in Various Literatures Vs. Stated Problems

Identified Problems at NOC	Indicators from Literature	Ramaa (2012)	Richards (2011)	Ackerman (2003)	Staudt et. Al. (2015)	Frazelle (2002)	Bogale (2016)
Damage of Products Late Delivery Mistake in Inventory Counts Equipment Failure	**Reliability**	**X**	**X**	**X**			
Mistake in Inventory Counts Damage of Products Safety of Employees	**Quality**	**X**			**X**	**X**	**X**
Late Delivery Mistake in Inventory Counts Safety of Employees	**Productivity**	**X**			**X**	**X**	**X**
Late Delivery Equipment Failure	**Time**		**X**	**X**	**X**	**X**	**X**
Damage of Products Insufficient Storage Space Mistake in Inventory Counts	**Cost**		**X**	**X**	**X**	**X**	**X**
Insufficient Storage Space	**Asset Utilization**		**X**	**X**			
Safety of Employees Equipment Failure	**Safety**						**X**

Following this, the lean practices associated with lean warehousing presented and validated by various authors are summarized on Table 4. Even though, various authors and companies used different lean tools in warehousing their main intention was to eliminate the wastes associated with warehousing using the principles of Ohono (1986) and Womack (1996) as a base. However as the warehouse of NOC is not a production warehouse the waste of overproduction will not be considered in this study.

Lean Tools	Sobanski (2009)	Swart (2015)	Visser (2014)	Salman (2015)	Four Principles (2017)	Gergova (2010)	Tran (2015)	Chen et Al (2010)	Prasetyawan et Al (2020)	Net at Work (2017)	Cagliano et Al (2018)	Order Hive (2020)	Garcia (2003)	Myerson (2012)	Bashir et Al (2020)	Tostar and Karlson (2008)
A3 Reports	X															
VSM		X		X			X	X	X		X		X	X	X	
Systems View	X															
KPI Boards		X								X						
Standardized Work														X		
Management Style (Leadership and Commitment)	X			X												
Employee Involvement		X		X						X						
Teamwork and Empowerment	X			X												
TPM			X	X												X
Kaizen Events	X	X		X								X				
PDCA	X			X												
Technology								X	X						X	
5S		X	X	X		X	X		X	X	X	X		X		
Customer Involvement		X	X													
Kanban			X	X	X				X			X		X		
Layout and Zones (Relayouting)		X							X							
ABC Tools										X						X
Supplier Involvement			X													
SPC			X	X												
Quality at the Source				X												
Jidoka (Zero Defect and Poka Yoke)				X	X				X					X		
Optimized Picking Plan				X												
Cross Docking				X												
Heijunka (Line Balancing)		X		X										X		X

Table 2.4.: Lean Tools Addressed in Various Lean Warehousing Studies

2.2. Lean Tool Characterization and Detailed Analysis

The literature review, here above, provides the historical context, evolution, fundamental constructs, and corresponding practices associated with lean manufacturing and lean warehousing. The lean principles that relate to warehousing are of particular interest. For that matter, 24 lean tools that have brought impact on warehousing, as discussed by various authors and researchers, were selected in order to bring about changes within the warehousing of the case company.

These lean tools were operationally characterized with respect to the management techniques essential at various evaluations points comprising the various warehousing processes in a facility.

2.2.1. Visual Management Lean Tools

Cherry's Industrial Equipment Publication on The Benefits of Implementing Visual Management in Warehouses (2022) states that visual management is a crucial lean management technique. Moreover, in visual management, the focus is on communicating information through visuals instead of text. While text can share ideas thoroughly, visual shorthand can convey concepts at a glance. This is further attested by Shimbun (1995) and Tezel et. Al. (2009) as they state that it is a management system that attempts to improve performance of an organization by means of visual stimuli. These visual stimuli communicate important information of the organization at a glance, helping to convey relevant, easy to understand information in context. This management approach relies on the acting on information presented to achieve organizational process transparency.

The below stated lean tools attest to the above management system in which visual methods are utilized to achieve lean warehousing.

2.2.1.1. A3 Reports

An A3 report is often a single page document that provides details on how a procedure is currently progressing. The idea behind A3 is that all the information you require regarding a topic or issue can be found on a single sheet of paper. Typically, this material is organized into the following sections:

- **Background**: A brief description of the issue including relevant contextual information and why the problem is important to the organization.

- **Current Situation**: A succinct summary of the current state and usually includes visual depiction.
- **Analysis**: A root analysis tool, like the fishbone diagram, is visually represented as a way to analyze why the problem occurred.
- **Goal**: The desired outcome is identified in describing what the situation would need to avoid the problem in the future.
- **Recommendations/Countermeasures**: A brief list of possible countermeasures the team brainstormed, with the best option highlighted.
- **Implementation plan**: A prescription of how to implement the proposed solution including tasks, responsibilities, and the duration of implementation.
- **Follow up**: A map representing how the follow-up process to ensure changes are maintained.

As per the aforementioned, an A3 report shows the process of the entire warehouse on a single page. This single page document can be distributed to each member of team involved in the warehousing activity so as to show the description of the tasks and process that they are responsible of. Despite the fact that A3 report provides the responsibility of each people or team involved in warehousing, it focuses on showing the process and if there are improvements to be made it is going to be on the process.

2.2.1.2. VSM (Value Stream Mapping)

According to Sobanski (2009), Value Stream Mapping is a lean technique used to spot waste, non-value-added activities, and opportunities for continuous improvement. The value stream describes what occurs to a product at each stage of its production, from product design to ordering raw materials to eventually delivering the finished product. The flow of information and materials is indicated in many areas of the map while creating a VSM. Additionally shown are the locations where products wait for the subsequent process and its duration. As a result, it is simple to distinguish which lead time and processing time are value-added and which are not for a certain product (Tran, 2015). The Lean Enterprise Institute (2008) describes it as a straightforward representation of each stage in the information and material flows required to bring a product from order to delivery.

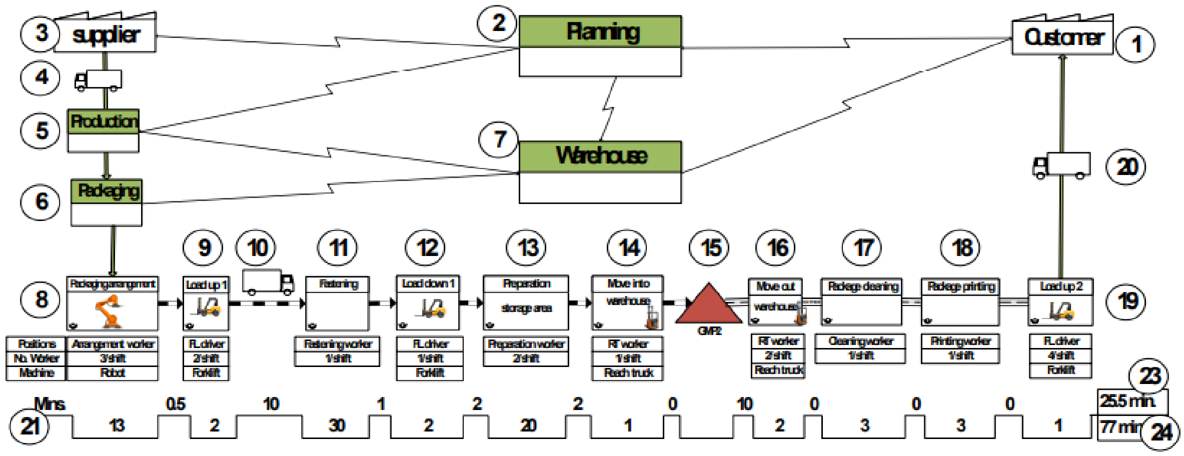

Fig 2.3.: Warehouse VSM (Ketchanchai et Al., 2021)

VSM can be also analyzed as a visual management system that can show the time and human resource needed at each warehousing activity or towards the overall process. It can be instrumental in identifying the process in which improvement can be made.

2.2.1.3. Systems View

Refers to the idea put out by Deming (1993), wherein staff members, managers, and supervisors comprehend their specific roles, the impact that their facilities and departments have on other operations, the supply chain, and the organization as a whole. A system, according to him, is "a network of interdependent components that attempt to achieve the aim of the system." In addition to the aforementioned idea, Evans (1996) adds that a system needs to have a goal, and that goal must:

a) Be clear for everyone in the system
b) Include plans for the future
c) Be a value judgment
d) Be defined in terms of activities or methods

Even though the above concept of system view was intended for production setting, it can be applied to improve warehousing even if there is nothing produced. It can further lay the ground works of a positive work environment in which all employees involved within the warehousing process know their respective responsibilities along with its effect on the task of others and avoid blame shifting.

2.2.1.4. KPI Boards

Swart (2015) states that Key Performance Indicator (KPI) Boards serve as a form of visual communication, to measure and track the targeted performance versus the actual. Misbakhetdinov (2020) defines KPIs as a list of evaluation criteria based on parts of the company, which are vital and critical for existing situation and future development. David Parmenter (2010), defined and introduced 7 characteristics of KPIs:

- Measurements are not expressed in financial terms
- Constant measurements
- Full involvement and control by top management
- Definition of clear actions
- Presence of a leader, that can take actions
- Considerable influence on development
- Empowering and motivational effect

According to Marziali et. Al (2021), KPIs can be used effectively solve warehousing problems. According to the publication issued by companies named Net at Work and High Jump Supply Chain Solutions in the area of improving warehouse performance (2016), KPIs can be used to as a benchmark to compare warehousing performance with other companies engaged in warehousing.

This shows that tracking and measuring performances can be used in reducing the wastes in warehousing. KPI boards have can be used as a springboard to compare the desired performance with the existing and realize the problem within the process and the responsible party.

2.2.1.5. Standardized Work

As per Myerson (2012), Standardized work refers to the standardization of best work practices—as the work is actually done in real life. The idea is to make work safe and repeatable with as little variation as possible along with high productivity. It is the best combination of employees, equipment, materials, and procedures. Sobanski (2009) further describes it as the amount of work dispatched to workers combining the steps, amount of WIP, and time required to complete the task. Standardized work dispatch information allows for accurate planning and tracking of work. This document should have the time it take to complete one task, its work sequence and its impact on inventory.

This shows that standardizing work in a warehouse setting can help reduce waste that arises from over processing.

2.2.2. Human Resource Management Lean Tool

Human resource management (HRM) is the process of hiring individuals, providing them with the necessary instruction and compensation, defining regulations pertaining to them, and creating retention plans, according to The Open University of Hong Kong. Sangeetha (2021) goes on to define the process, saying that it is the process of hiring individuals, fostering their potential, utilizing, maintaining, and compensating their service in accordance with the demands of the position and the organization with the aim of advancing the objectives of the latter two. Because employees are an organization's main source of values, Andrea Botman ties this idea together in a web publication on the AIHR website by stating that the ultimate goal of lean human resource management is to continuously work toward eliminating redundancy and waste in employee processes and their service delivery. According to Andrea's concept, everyone who is involved—from the top down to the food chain—must work together in order to succeed.

With that regard the below lean tools are important in managing the workforce within an organization and most notably within a warehousing setting.

2.2.2.1. Management Style

Sobanski (2009) cited management style, notably the practice of obtaining consensus before making changes, as being crucial to lean warehousing. It is also described as a means by which a manager strives to achieve their objectives in Valamis' (December 2022) online publication. The manner a manager prepares, organizes, decides, delegated, and managed their team is referred to as their management style. It goes on to state that there are three different management philosophies, which Efere (2003) supports.

- **Autocratic:** a style of management characterized by a top-down, one-way flow of information from managers to staff. This is the most controlling management style since it gives the management total authority over all workplace choices. Employees are handled like drones, closely watched as they work within boundaries that have been set. Employees are not encouraged to offer queries or recommendations for process improvement, and in certain situations, they are deliberately discouraged from doing so.

- **Democratic:** refers to a method of decision-making where managers invite staff participation but ultimately maintain authority over the choice. Communication at all levels, from the top down to the bottom up, strengthens team cohesion. This process allows a range of perspectives, skills, and ideas to have an impact on decisions.
- **Laissez-faire:** a management style in which management defers to leadership. Staff members are trusted to complete their task without monitoring, and they are given control over how they make decisions and solve problems. While present throughout the stages of task delegation and delivery, management otherwise takes a back seat and lets employees be in charge of their own workflow and results. The only time management gets involved in the procedure is when the staff wants it.

According to Sabonski (2009), Leadership direction and roles relate to the sense of urgency, change initiative origin, ownership and input of employees as it relates to implementing lean warehousing in the facility. Similarly as described by Ackerman (2007), the change agent is an absolute requirement for implementation of lean thinking in a warehouse operation, leadership is a necessary part of the program. An effective leader is one who has the ability to inspire others to make productive changes. As warehouse involves people, an effective leader is important to ensure a well-managed warehouse, one in which people play by the rules because they know that to do otherwise will downgrade the warehouse operation and ultimately their own jobs. Enforcing warehouse discipline requires leadership. As per The Lean Enterprise Institute (2008), team leaders do not take disciplinary action and do not have a fixed job. Rather, they provide support by knowing all the jobs performed by their team members so they can relieve workers, fill in for absentees, or help workers who need assistance or are falling behind. They respond to problems such as line stops and take a lead role in kaizen activities. They also use standardized work audit sheets to do daily checks of team members to make sure people are following standardized work and to surface problems.

As seen from the above studies management style is responsible in getting out the best from the personnel responsible for the implementation of activities in warehousing. Choosing the right type of management style will be crucial in regards to implementing changes within a system. They also show that, a leadership that understands lean process can be instrumental in achieving a lean warehouse.

2.2.2.2. Employee Involvement

As per Guerrero and Barraud-Didier (2004), if employees receive suitable information and training, the workforce may develop shared abilities and a better understanding of the processes in which they participate. Moreover, Swart (2015) further denotes that employees should not only be given information but also give ideas and thoughts on possible improvements, developments and recognition of activities. Marin-Garcia and Bonavia (2015) say that Employee involvement is operationalized through four related variables: empowerment, training, contingent renumeration and communication. Publication on the website of Falcon Fastening (2014) further denotes that keeping employees involved as you move toward lean improvement is a win-win. They will feel respected and valued, and in return you will get more help working to reach your goals through both support and potentially beneficial insights.

These studies show that employee involvement has high impact on lean improvement of warehousing process.

2.2.2.3. Teamwork and Empowerment

Teamwork and Empowerment relates to the organizational work structure utilizing team leads, the authority given to individuals to make changes, and to initiate the continuous improvement process in and of their selves. Miller (2005), states that, Lean organization, based on a clear focus on the horizontal flow of the work, managed by highly empowered teams that can make decisions on-the-spot, has become the most successful form of organization. It is not only a work system, but a management system and a social system. These “lean teams” achieve both high intimacy and high economic efficiency. He further states that the teams should be designed around the process, clear purpose should be outlined for the team along with the decision maker and how decision should be made, the team building and empowerment should be done from top of the management to the bottom, the team should be business focused and the role of the management should nourish the aforementioned characteristics.

As it can be seen from the above publications, warehousing involves people and an effective result will be achieved if these people involved at every level of the warehousing are working in tandem. Empowering them will also lead the reduction of waste of underutilizing people.

2.2.2.4. Total Productive Maintenance (TPM)

A group of methods to guarantee that each machine in a production process can always fulfill the necessary functions were first developed by Denso in the Toyota Group in Japan. Total refers to the technique in three different ways. First, it needs the full involvement of every employee, including line managers, production engineers, quality specialists, and operators in addition to maintenance staff. Second, by concentrating on downtime, changeover time, minor pauses, speed losses, scrap, and rework, it aims to maximize the productivity of the equipment. Thirdly, it tackles the entirety of the equipment life cycle to update maintenance procedures, activities, and advancements according to the stage of the equipment's life cycle. Contrary to conventional preventive maintenance, which depends on maintenance staff, TPM involves operators in routine maintenance, improvement projects, and simple repairs. (The Lean Enterprise Institute, 2008). This concept is also supported by Visser (2014), Tostar and Karlson (2008) and Salman (2015).

The above studies show that utilizing preventive and predictive maintenance techniques within warehousing can have a positive impact with regards to waste of waiting and over processing.

2.2.3. Continuous Improvement Lean Tools

Continuous improvement, according to Singh and Singh (2015) and Arun Hariharan (2014), is the constant enhancement of goods, services, or procedures through incremental and ground-breaking developments. These initiatives may aim for "breakthrough" progress all at once or "incremental" development over time.

With that regard the below lean tools work towards achieving and maintaining a constant enhancement of employees, services and processes.

2.2.3.1. Kaizen Events

Employees who are directly touched by changes are involved in creating solutions for improvement during these actual continuous improvement activities, which are also documented. Continuous system or process improvement to generate more value while using less resources. The Lean Enterprise Institute (2008), which asserts that it is continual improvement of a single process or an entire value stream to create more value with less waste, further supports this. Additionally, it claims that kaizen has two levels.

a. **System or flow kaizen** focusing on the overall value stream. This is kaizen for management.
b. **Process kaizen** focusing on individual processes. This is kaizen for work teams and team leaders.

It has been utilized, according to the pamphlet released by Graphic Products, Inc. (2006), as a technique to increase production effectiveness as well as employee morale and safety. Additionally, in a Kaizen environment, upholding and raising standards is one of management's primary objectives with the main purpose of upholding that improvement and then improving upon it once more.

Therefore, implementing Kaizen will be important with regards to the improvement of quality, safety, process and human resource standard within a warehouse. However, this improvement will not be once but continuous because maintaining the improvement is also as important. This lean tool will be instrumental towards providing an overall improvement as it can be involved in every process and personnel taking part in warehousing.

2.2.3.2. PDCA (Plan-Do-Check-Act Cycle)

According to Moen and Norman (2009) and an article on the Kanbanize website, William Deming later developed Walter Shewhart's PDCA cycle, which later became a widely used framework for ongoing improvements in management, manufacturing, and other fields. According to the publications cited above, the Plan-Do-Check-Act cycle is a methodology for implementing change. It is a crucial component of the lean manufacturing concept and a necessary condition for ongoing advancements in both people and procedures. Furthermore, according to Sobanski (2009), it is the planning, sustaining, and specific continual improvements initiatives. According to Deming (1993), PDCA is an iterative process for enhancing goods, people, and services continuously. The Plan-Do-Check-Act cycle includes testing solutions, assessing the outcomes, and streamlining the procedure. As it can be seen from the name, the cycle consists four process (The Lean Enterprise Institute, 2008):

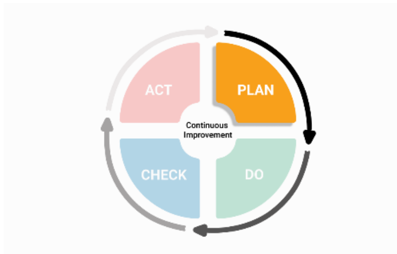

Fig 2.4.: PDCA Cycle

i. **Plan:** determine goals for a process and needed changes to achieve them
ii. **Do:** implement the changes
iii. **Check:** evaluate the results in terms of performance
iv. **Act:** standardize and stabilize the change or begin the cycle again, depending on the results

Similar to Kaizen Events, PDCA focuses on continuous improvement, however, it is a bit different form it as it provides a framework and structure for identifying improvement opportunities and evaluating them objectively as opposed to Kaizen events application of small, daily changes that result in major improvements over time.

2.2.3.3. Technology

Technology can be defined as "Systematic knowledge and action, usually of industrial processes, but applicable to any recurrent activity closely related to science and engineering and viewed as providing the means of doing something desirable. Technology may be embodied in a physical reality (hardware) or in a method, technique, collection of techniques, or know-how, that is, the capacity to use technology (software)." (Heller, 2012). Introducing warehouse technology into an organization´s processes has dramatically changed how the jobs are conducted at warehouses around the globe and its main purpose in warehousing is to control the movement and storage of the products, together with the benefit of enhanced security and quicker handling" (Škerlič et al. 2017).

The website of Interlake Mecalux (2022) states that Warehouse technology is used to equip facilities with tools that enhance productivity and maximize efficiency. These technology solutions increase accuracy in processes such as inventory control, order fulfillment, and internal movements of goods in the warehouse. Olofsson and Rylander (2021), state that the technology in warehousing is divided into ICT systems (Bar Code, RFID, Warehouse Management system and voice and light picking system) and handling equipment (forklift, pallet truck, conveyors, automated guided vehicles, stacker crane and Automated Storage and Retrieval Systems). In an effort to improve logistic efficiency, Chen et. Al (2010) utilized RFID in a warehouse setting to get remarkable results. This is similar to the work done by Bashir et. Al (2020), while trying to implement lean warehousing for retail hypermarket. While Olofsson and Rylander (2021) utilized RFID, Barcode and Warehouse Management System to improve warehouse efficiency.

This shows that, technology is important in achieving waste reduction in a warehouse setting if effectively and appropriately utilized.

2.2.3.4. 5S

The Lean Enterprise Institute (2008) considers them as five related terms, beginning with an S sound, describing workplace practices conducive to visual control and lean. Tran (2015) claims that the main purpose of 5S practice is to provide a safe, organized and efficient workstation, resulting in a reduction of waste and improvement of performances of workers and in processes. The five terms in Japanese and English are (The Lean Enterprise Institute, 2008):

1) **Seiri (Sort):** Separate needed from unneeded items—tools, parts, materials, paperwork—and discard the unneeded.
2) **Seiton (Straighten):** Neatly arrange what is left—a place for everything and everything in its place.
3) **Seiso (Shine):** Clean and wash.
4) **Seiketsu (Standardize):** Cleanliness resulting from regular performance of the first three Ss.
5) **Shitsuke (Sustain):** Discipline, to perform the first four Ss. According to Visser (2014), this includes training and auditing people on a regular basis.

Gregova (2010) claims that the successful implementation of 5S can be used as a bridge to other improvement-related tools such as visual management this is further supported by Salman (2015) as he developed a lean warehousing model that primarily utilizes 5S then proceeds with VSM, a visual management technique depicted above.

The above studies show that, a safe, clean and organized work place with a management that intends to train and audit employees could lead to reduction of wastes such as, transportation, people and inventory.

2.2.4. Demand Management Lean Tools

Demand management, according to Croxton et al. (2016), is the process that strikes a balance between client demands and supply chain capabilities. With the proper procedure in place, management can execute the plan with little disruption by anticipating demand and supply. Demand management, according to Raeburn (2022), focuses on how to recognize and meet customers' needs.

Therefore integrating what the customer demands within a warehouse process can help saving warehouse space and reduce warehouse inventory waste. In that regard, the below lean tools can be utilized to manage demand.

2.2.4.1. Customer Involvement

According to Bicheno and Holweg (2016), value can only be defined by the ultimate customer. It is imperative to thoroughly understand what the customer perceives as value. By recognizing what is important to the customer and their perspective on value, is the starting point of Lean. This can be accomplished through identifying the value adding activities in an operation. This point is also seconded by Swart (2015). Davis (2022) defines customer value as the perception of what products and services are worth to customers. It looks at systems and processes, as well as mindsets and trends linked to customer value. A publication on Vector Solutions Website states that the critical element of lean improvement consists listening to, understanding, acting on, and aligning your actions with the voice of the customer.

This shows that the perception and involvement of the company's customers can have a considerable effect towards improving the warehouse operation of the company.

2.2.4.2. Kanban

According to the Pinaroc (2022) web magazine, the 'Kanban' or 'pull' system is centered on inventory management in the warehouse. This system "pulls" supplies or items based on what is required or what has been ordered from the warehouse. The "Kanban" system creates an organized flow of commodities in an effort to increase supply chain efficiency. Halton's (2022) article on the Investpedia website, which notes that while this system is normally employed in a production environment, it may also be used to control stocks when purchasing from suppliers, supports this. Four Principles 2017 saw the publication of a paper by Management Consulting FZ-LLC on lean warehouse operations.

This system shows that kanban is holistic approach for warehousing. It does not only apply to the activities to warehousing but also to activities such as purchasing, marketing and sales.

2.2.5. Layout Management Lean Tools

BigRentz (2006) website blog publication claims that a good warehouse layout can simplify workflow within the warehouse and create faster shipping times. As per Baker & Canessa (2009), managing the layout of a warehouse involves:

- Analyzing the situation and the process flow of the warehouse
- Determining the operating policies for each warehousing activities
- Utilizing the right type of activities for any warehousing situation
- Determining and classifying storage, picking, processing and equipment areas,
- Determining the spaces for aisles and total space within the warehouse
- Setting up facility locations

Successful implementation of a proper warehouse layout is empirical for the reduction of wastes from transportation, movement and waiting among others. As discussed by different authors, the below lean tools can be utilized to achieve a good warehouse layout.

2.2.5.1. Layout Zones

Sobanski (2009) states that Layout Zones denote the physical layout of products within the warehouse, in order to optimize the manpower and material movement throughout the process. According to Swart (2015), it allows for optimal planning of work required per process, equipment needed, racking configuration and worker and equipment movement. It makes picking and binning activities easier and optimizes storage. It also minimizes the travelling distance, movement and motion associated with picking an order or performing a put-away task. Ultimately ensuring a faster picking and put-away process.

The above studies having proper layout zone ensure reduction of wastes from transportation, movement and waiting.

2.2.5.2. ABC Tools

Tome (2014) states that, The ABC analysis of inventory states that inventories have not an equal value to a firm. Consequently, all the inventories should not be managed in the same way. The ABC classification allows organizations to separate inventory items into three classes:

- A – products with the highest criticality
- B – products with moderate criticality
- C – product with low critically

ABC classes are based on Pareto's principle "the vital few and the trivial many" as per Tostar and Karlsson (2015). A stands for 80% of the value that's interesting (volume, frequency, cost and etc), B stands for 15 % and C for 5%. These percentages are not final but are just an initiative for a classification. The boundaries for determine ABC classes are based on how the output of percentages look and policy making. Both studies agree that certain steps should be taken to perform ABC Classification:

1) Sort the articles from largest to smallest of the interesting parameter. E.g. volume, frequency or profit.
2) Calculate each article percentage of the total volume for the interesting parameter.
3) Calculate each article accumulated parameter starting with the articles with the highest value.
4) Classify articles into classes based on the Paretos principle.
5) Draw a chart to help visualize the group of articles.

The above studies show that ABC analysis in a warehouse can be used to identify the products that are in demand. A company can then use its precious warehouse space to adequately stock those goods and maintain lower stock levels for Class B or C items. It can help in reducing wastes from inventory among others.

2.2.6. Product and Process Management Lean Tools

As per Gillis (2022) product management is the process of defining, developing, and launching new products or services. While, as per Apian (2023), process management is the discipline of designing, improving, and managing processes within an organization.

Both product management and process management are complementary processes and essential for ensuring that organizations are able to deliver products and services that meet the needs of their customers in a timely and efficient manner.

2.2.6.1. Supplier Involvement

Visser's (2014) effort to measure lean maturity in warehousing shows that involving product suppliers in regards to sharing and providing their expertise for the products they supply has a high impact in attaining lean maturity. Moreover, letting the suppliers know inventory positions of a given warehouse can help reduce inventory wastes and standardized supplier certification for products can lead to reduced waste of defects as well as over processing.

2.2.6.2. Standardized Process Control (SPC)

According to Lightfoot and Kaufman (2003), it is the use of statistical techniques to track and manage the quality of a process. This makes it easier to make sure the procedure goes smoothly and successfully. Every process, whether it's creating a physical good or a service, uses the same basic components: people, tools, inputs, processes, and environments. These all work together to create an outcome. Every process is intended to behave in the same way each time it is run in order to offer consistency in the output. However, there is some output variability due to the natural changes in materials, people, equipment, and environments, as well as how these factors interact. When these circumstances exist, SPC is a method that can be used for monitoring the variability to ensure it does not exceed a tolerance required to produce an acceptable quality of output. The SPC measures the degree of statistical control within warehouse processes. By implementing SPC all warehouse processes are monitored and errors and mistakes are spotted quickly. By doing so SPC ensures a flow of error free orders through all warehouses processes (Shah and Ward, 2007). Visser (2014), actually confirms that a warehouse that does not implement SPC has the lowest maturity level.

This shows that the variation of errors caused by whatever or whomever involved within the warehouse will lead to various types of wastes. Monitoring the warehousing process using SPC will assist in identifying those errors that need improvement.

2.2.6.3. Quality at the Source

In a production scenario, Quality at the source belongs to lean manufacturing and means that there should not be production of bad work at any workstation. Self-checks and successive checks can be good way of ensuring the quality at the source. Errors and quality related issues should be checked at the source and defective materials and products should not pass through to downstream operations. (Salman, 2015). Similarly, for a warehouse setting, it can be implemented by quality inspection by self-checks and by successive checks at every step of warehousing operations rather checking the quality at the last steps (before delivery).

It shows that quality output is the responsibility of every individual that contributes to each warehousing activity not just at the end. If faults are found at certain process levels they can be assessed for further improvement.

2.2.6.4. Jidoka

According to a blog article by TUP published on Logistik Knowhow's website in 2018, the Jidoka principle refers to a system's capacity to shut itself down in the event of faults, poor quality, or production issues. The Lean Enterprise Institute (2008) adds that there should be an autonomous system that recognizes an unhealthy situation and stops operations, which further attests to this. Jidoka, which according to Bashir et al. (2020) means "humanized automation," is the second pillar of the Toyota Production System House (Ohono, 1986). Jidoka is a series of cultural and technical issues pertaining to the use of equipment and manpower together; it entails using people for specific tasks they can perform and allowing devices to self-regulate the quality. In addition, a blog post by International Society of Six Sigma (2013) states that Jidoka has three stages:

1) Prevent the error before it occurred

2) 100% detection of an error that has occurred
3) Prevention of an error from going to the next stage of activity

According to Ohono (1986) and The Lean Enterprise Institute (2008), Jidoka utilizes lean tools such as

- Poka Yoke: a Japanese term for mistake-proofing. A poka yoke is a way to make so that it is virtually impossible to pass on a defective part or piece of information from one process to another. (Myerson
- Zero Defect: promotes a constant, conscious desire to do a job right the first time, where the performance of the individual have a crucial role. A way to efficient performance is by constant awareness; where the workers task is important, the product the worker is working on is important and the effort by the worker is not neglected by the management (Todorovski and Krstevski, 2011).

As per the studies above, Jidoka focuses in the complete seizure of operation when error is found then it proceeds with correcting that error. This will assist in a warehousing process as it aids continuous improvement and reduce wastage from defect.

2.2.7. Flow Management Lean Tools

According to Rachel Hand (2023), flow management is the practice of controlling and managing the flow of goods through a warehouse. To ensure that inventory is physically moved to the following warehousing activity, a system or set of procedures must be established and followed. She continues by saying that when there is fluid product flow, inventory passes from stage to stage quickly and accurately, without any hiccups.

In that regard, the below lean tools can be essential in realizing a smooth flow of product within a warehouse.

2.2.7.1. Optimized Picking Plan

Picking is defined by Salman (2015) as moving the product from storage area to loading according to the customer order. Picking the right items within assigned time for the process is a very important activity among warehousing operations. This process is further described by Mulcahy (1993), there are three basic methods in which the picking process is completed: the employee either walks or ride to the product or the product moves from storage to the workstation. Therefore, Optimized Picking Plan refers to the process of finding the fastest way to navigate the warehouse in order to pick products quickly, accurately, and efficiently (Logiwa). According to Hovart (2012), it focuses on reducing the total time it takes to pick an order and the picking process is comprised of:

- Travel Time between pick locations and between pick locations and the loading depot
- Search time for the ordered product
- The time it takes to pick a specific order from storage location and placing it on picking device (eg. Forklifts, wheel barrows, or just plane hands)
- Set-up time for administrative tasks and emptying of picking device at the loading depot

It can be seen that optimizing a picking is important in reducing wastes that arise from transportation, people, waiting and movement.

2.2.7.2. Cross Docking

According to Sobanski (2009), Cross-Docking in this warehousing analysis refers to physically moving product directly from inbound to outbound functions where customer demand requires eliminating the steps of placing product into storage and consolidating freight to reduce transportation expenditure. Cross-docking is a valuable supply chain strategy given that it offers several benefits, for example, reduction in inventory holding costs, reduction in transportation costs, and on-time deliveries. It also utilizes less workforce due to the products no longer requiring picking and putting away in the warehouse facility. (Mavi et. Al, 2020).

As this system removes the warehousing activities of order picking and storage as it goes directly from receiving to shipping it can be instrumental for waste reduction.

2.2.7.3. Heijunka

Heijunka, according to Swart (2015) is the process of creating a levelled flow and work relate to balancing the flow of material with that of the manpower, in order to successfully manage the completion of work within the warehouse. This is further supported by Sobanski (2009). Furthuremore, Salman (2015) claims that levelling of the flow of materials in warehouse operations i.e dividing the equal load of work among different segments of warehouse operation can help to improve the flow of materials in warehouse and avoids the bottle necks in flow of materials. Considering the advantage associated with this lean practice of "levelled flow", it has been considered as an attribute to flow management. In the picking process the shipping order can level the picking routes and the Heijunka can visualize how the workload is divided. The leveling would be on how for example how long a route it, how much the items in a route weight or on volume. This could help companies become leaner because it would clearly visualize the workload and reduce transport waste (Tostar and Karlson, 2008).

Therefore, having a levelled flow that considers the HR, distance and the task available at each warehousing activity will have an impact in reducing wastes.

2.3. Gaps in Literature

While collecting literature data for this research, the aspect of employee safety in the warehousing industry is not discussed as a major factor to measure warehouse performance. The safety of employees engaged in the warehousing activity is important to boost the morale among workers and also to ensure the continuity of operational activities. This study consider safety as one of the warehouse performance measurement indicators.

Furthermore, most of the researchers concluded in the area of lean warehousing attest to the application of lean tools to a production warehouse. However, studies that focus the application of lean tools in a distribution warehouse, as such at NOC, are not discussed enough. Of the analyzed literature documents, only Bashir et. Al (2020) deals about distribution warehouse.

Lean warehousing in Ethiopian industries is not explored and there are no studies in the areas of lubricant warehousing.

Chapter 3: Research Methodology

3.1. Research Design

In previous chapter a related literature review on lean warehousing has been presented. In this chapter (3) the research design and methodology used in the study has been described. The research design, Target Population and Sample Size, the participants of the study, the type of data source, and the research instrument used to collect the data, the methods of data collection and analysis were presented.

3.1.1. Target Population

The target population is said to be a specified group of people or object to which questions can be posed or observation is made to develop the required data structures and information.

This research has followed a purposeful sampling targeting the major parties involved in the day to day warehousing activities at NOC are the employees, the customers and the logistics providers.

3.1.1.1. Sampling

Sampling is one of the most important factors which determines the accuracy of a study. Sampling is defined as a procedure to select a sample from individual or from a large group of population for certain kind of research purpose (Bhardwaj, 2019). McMillan (1996) further elaborates the definition of sampling by stating that it is the method of attain information about an entire population by examining only a part of them. For this research two types of sampling methods were used.

Convenience sampling: is a type sampling where members of the target population that meet certain practical criteria, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate are included for the purpose of the study (Dörnyei, Z., 2007). Upon the observation made, there are various parties involved within the warehousing process at NOC. These may include lubricant resellers, lubricant provider, customs officers etc…. However, the major parties involved in the day to day warehousing activities at NOC are the employees, the customers and the logistics providers. Therefore convenience sampling was considered for this research.

For identifying the root cause of wastes of warehousing at NOC on each warehousing activities, 16 people with prolonged direct and frequent involvement were chosen. This selection picks the employees, customers and third party logistics providers that have been working with the company for more than 10 years. This is done because, it was important to analyze the history of warehouse activities of the company since its establishment and changes made along the way. This selection narrows down the sample size as follows:

- 3 third Party Logistics Providers
- 3 Major Customers
- 10 Employees

In order to further determine and select the major problems, established on the above step, that attest to the dependent variables (the stated problems) of this study and for the selection of suitable lean tools proposed by various researchers, simple random sampling was considered from the total population that is involved in warehousing at NOC (both internal and external parties).

Simple Random Sampling: is a form of probability sampling in which means that every case of the population has an equal probability of inclusion in sample. (Ghauri and Gronhaug, 2005). Since the population size is small or the size of the individual samples and their number are relatively small, random sampling provides the best results since all candidates have an equal chance of being chosen for this study.

The sample size is then identified by using the equation developed by Freedman et Al., (2007)

$$n_0 = \frac{z^2 * p(1-p)}{c^2} \ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$n_f = \frac{n_0}{1+\frac{n_0-1}{N}} \ldots\ldots\ldots 2$$

Where:

- n_0= initial sample size
- n_f= target sample size
- z = Z-values for confidence levels (1.96 for 95% confidence level used for this study)

- p = percentage picking a choice, expressed as decimal 0.5 used for sample size needed
- c = confidence interval, expressed as decimal; $0.08 = \pm 8$
- N = Population = 141 workers

$\boldsymbol{n_0} = 150.06$ and therefore $\boldsymbol{n_f} = 73$

Thus $\boldsymbol{Sampling\ Size = nuber\ of\ workers\ or\ representatives\ x\ \frac{n_f}{Total\ Population}}$

NOC Employees		
Department	**Total Workers**	**Sampling Size**
Finance	26	13
Retail	10	5
Commercial	12	6
Warehouse	12	6
HR	2	1
Ecard	4	2
IT	4	2
Maintenance	5	3
Logistics	12	6
Leadership	4	2
External Parties		
Designation	**Total Representatives**	**Sampling Size**
Distributors	20	10
High Volume Customers	20	10
Third Party Logistics	10	5
Total Population	**141**	

Table 3.1. : Identified Sample Size

3.2. Data Collection Method

Primary Data: Kabir (2018) states that data that has been collected from first-hand-experience is known as primary data. For this research, relevant data was gathered using formal and interview and questionnaires from people at different levels within the company, third party logistics managers, and customers. Observation of the current warehousing at the case company was taken into account.

Identification of root causes of the wastes of warehousing was done via interview, questionnaire and observation. The designed interview questions were based on assessing the current warehouse performance of the company as stated on the specific objective of this research. Furthermore, the questionnaire distributed among the 16 people selected, as explained here above, was designed similar to base of the interview. Moreover, the structure of the questionnaire was a combination of unstructured and structured multiple choice questionnaire. As per Ahmad (2012), structured multiple choice questionnaires are closed ended questions with more than two alternatives. In parallel, unstructured questionnaires are in which the respondents answers in their own words.

Additionally, first hand observation of the warehousing process and activities were conducted at the premise of NOC warehouse. This was important to identify the day to day operation within the warehouse.

For the determination and selection of the warehouse major problems that attest to the dependent variables (the stated problems) of this study and for the selection of suitable lean tools proposed by various researchers, likert scale questionnaire was distributed among the 73 target sample size. As per Singh (2006), Likert scale is a set of statements offered for a real or hypothetical situation under study. Participants are asked to show their level of agreement (from strongly disagree to strongly agree) with the given statement on a metric scale. Here all the statements in combination reveal the specific dimension of the attitude towards the issue, hence, necessarily inter-linked with each other. For this research, a 5 point likert scale questionnaire was utilized with responses weighted below.

- Strongly Disagree = 1
- Disagree = 2
- Neutral = 3
- Agree = 4
- Strongly Agree = 5

Secondary Data: Kabir (2018) again describes data collected from a source that has already been published in any form is called as secondary data. Several researches, publications, books and articles by different authors with regards to warehousing, lean, warehouse management, supply chain management and several others that are considered supplemental to the research will be used and taken into account for this study. These secondary data were valuable with regards to understanding the warehousing process and activities, understanding of lean tools, identification of wastes, clustering of major warehouse waste issues and understanding each lean tools.

3.3. Validity and Reliability

As per Heale and Twycross (2015), Reliability and validity are both about how well a method measures something. Validity is defined as the extent to which a concept is accurately measured in a study while Reliability relates to the consistency of a measure.

In order to assess and understand the collected data of the interview, observation as well as the structured and unstructured questionnaires, data triangulation method off validity was utilized. As per Mekonta (2019), data triangulation is the use of a variety of data sources. It is a strategy for increasing the validity of data and research findings. It enhances the validity and reliability of existing observations about a given data. It provides an important way of ensuring the validity of the research. This study has triangulated data from the case company through interviewing and gathering questionnaire responses from various stake holders with regards to warehousing operations. Furthermore, direct observation by the researcher that included the warehouse facilities of the case company along with vivid interpretation of the activities handled by the warehouse employees, lubricant customers and logistics providers was conducted.

Reliability analysis for the likert scale questionnaire responses was done using Cronbach's Alpha Reliability Coefficient via SPSS. As per Gliem and Gliem (2003), Cronbach's alpha coefficient measures the internal consistency, or reliability, of a set of survey items. It is used to help determine whether a collection of items consistently measures the same characteristic. They further state that, Cronbach's alpha quantifies the level of agreement on a standardized 0 to 1 scale. This is vividly explained on the website of Statics by Jim as:

- Zero: indicates that there is no correlation between the items at all. They are entirely independent. Knowing the value of a response to one question provides no information about the responses to the other questions.

- One: indicates that they are perfectly correlated. Knowing the value of one response provides complete information about the other items.

Perry (2004), expands the above explanation as follows:

- 0.90 and above shows excellent reliability
- 0.70 to 0.90 shows high reliability
- 0.50 to 0.70 shows moderate reliability
- 0.50 and below show low reliability

Validity of the likert scale questionnaires was tested using construct validity. As per Bhandari (2022), construct validity is about how well a test measures the concept it was designed to evaluate. Construct Validity is shown on the implementation of the work by Adil Zla (2020), for which Validity of a questionnaire is tested Using Pearson's Correlation Coefficient. Adil Zla (2020) correlates each item questionnaire scores with the total scores. The correlation is done using Pearson's Biviriate formula where the standard significance is 0.05 and the correlation coefficient (r) can be used by utilizing the degree of freedom (df) formula which is found by using the target sample size.

$df = n - 2$

Where: n = target sample size

For this study, the target sample size is considered to be 73 therefore using the above formula df = 71. Consequently, the correlation coefficient can be realized from Critical Values for Pearson's Correlation Coefficient (r) table for which it is 0.1940.

If the correlation of each item questionnaire scores with the total scores results significant correlation and the correlation value is greater than 0.1940 (the correlation coefficient), then it is possible to say that the questionnaire is valid.

Chapter 4: Data Collection, Analysis and Results

4.1. Data Collection

For this study data has been gathered through the collection of documents, face to face interviews, questionnaires and visiting case company warehouse. This research presents the data collected from the structured interviews conducted with employees of the case company, its customers, third party logistics providers, visual observation as well as data from the company.

The selection of employees, customers and logistics providers that shed a light with regards to the current warehouse operation of the case company was carefully crafted in order to have full picture to proceed with the research. Furthermore, the first hand observation made at the premise of the warehouse of the case company was essential to visually identify and understand the day to day challenges within the warehouse. The observation was also attested by various publications that correspond on the effectiveness of a distribution warehouse.

Data collection was done three times at different steps while conducting this research. The data collected at each step had different purposes, however, the analysis of these data at each step was used as an input for the next one finally fulfilling objective of this research.

- **First Step Data Collection:** for this step data collection was conducted via interview, combination of structured and unstructured questionnaire and first hand observation with an intent to identify and marginalize the root causes of problems within the warehousing. As stated on Chapter 3 of this document, the questionnaire was distributed among 16 employees, customers and third party logistics providers that have been working with the company for more than 10 years. Furthermore, interview was conducted with warehouse manager and operations manager of the company as they are the ones that are the direct decision makers within the company. First hand observation at the warehouse of the case company was also was important as it was essential to see the major obstacles that created the problems in the first place.
- **Second Step Data Collection:** for this step likert scale data collection method was utilized with an intent to identify the major warehousing problems, identified from the analysis of the first step data collection, that closely attest to the problems stated problems on Chapter 2 of this document. From the total 141 people directly or indirectly involved in the warehousing operations of the company, a sample size of 73 people were selected and the questionnaire developed were distributed among them.
- **Third Step Data Collection:** for this step, again, likert scale data collection method was utilized with an intent to identify which lean management techniques will have an impact on the causes of major warehousing wastes gathered by the analysis of the second step data collection. Similarly, a sample size of 73 people were selected and the questionnaire developed were distributed among them.

4.2. First Step Data Collection Analysis and Results

The data collected on this step were analyzed based on the 7 wastes stated by Ohono (1986) and Womack (1996) while discussing lean

The concept of seven types of waste are defined by Ohno (1986) include, The waste of Over Production, The waste of Waiting, The waste of Transportation, The waste of Over Processing, The waste of Inventory, The waste of Movement and The waste of Defect.

However, as NOC is not a production company and provides a readymade goods to the market based on the market demand Ohono's waste of over production was not considered. Instead, Womack's (1996) waste of people (underutilization of people) was considered.

Based on the data collected the root causes lean wastes on each warehousing activities were identified by using the combination of the 5W 1H history analysis method and 5 Whys root cause analysis technique.

The 5W 1H method is commonly known as The Kipling Method. This method deals with six keywords that are easily attached with any possible words to create question expression. The keywords or also known as the six "service-men" in the above saying are 'who', 'what','where', 'when', 'why' and 'how' (Rozan and Makimi). These are useful in collecting information to grasp the current situation and correctly define the problem, as in "What is the problem, when and where did it occur, who did it affect, why is it a problem, and how did it occur?" (Miller, 2017). Four of the W's (who, what, where, when) and the one H is used to comprehend for details, analyze inferences and judgment to get to the fundamental facts and guide statements to get to the abstraction. The last W (why) is asked so that one can drill down to get to the core of a problem This technique pinpoints the essential information that will lead to the comprehension of knowledge within any problem (Rozan and Mikami). For this step of the data collection, the intent is identifying the root cause for the wastes in warehousing and not how these wastes came to be there for the question "How?" was not utilized. As the question "Why?" is available within this method, the 5 Whys root cause analysis was combined with it.

Serrat (2017) describes 5Whys as an iterative interrogative strategy used to investigate the cause-and-effect connections underlying a specific issue. The technique's main objective is to identify the underlying cause of a flaw or issue by asking "Why?" repeatedly. The next question is based on each response. The number "5" in the name comes from anecdotal evidence about how many iterations were required to address the issue. Not every issue has a single underlying cause. The procedure must be performed with each new set of questions being asked in order to identify various fundamental causes.

Following this, based on the data collected the root causes lean wastes on each warehousing activities were identified as the Table 3.2 is used as an example for the process (all root cause analysis is shown on Section 7.3 of this document).

Waste Type	When?	What?	Where?	Who?	Why?
Waste of Transport	Receiving	• Long movement of Delivery Truck to Storage Location • Long movement of material handling equipment with product to • Storage Location Multiple trip (back and forth) for large batch receivables	Warehouse Entry/Exit Point Warehouse Grounds and Warehouse Buildings	Product receiver Product Carrying Labor Delivery Truck Driver	• Poor Warehouse layout design • Poor product storage designation • Lack of adequate personnel • Lack of adequate material handling equipment • Lack of Quality Standard • Poor warehouse ground control • Lack of optimized strategy for receiving • Overcrowded warehouse ground
	Storage	• Movement of material handling equipment to storage location • Movement of laborers and material handling equipment in search of storage location • Multiple trip of laborers and material handling equipment for large batch storage	Warehouse Grounds and Warehouse Buildings	Product Storage Personnel Product Carrying Labor	• Poor Warehouse layout design • Poor product storage designation • Lack of adequate personnel • Lack of optimized strategy for storage • Lack of Quality Standard • Lack of adequate material handling equipment • Overcrowded warehouse ground
	Order Picking	• Laborers and Material handling equipment moving around inventory to access stock	Warehouse Grounds and Warehouse Buildings	Order Picking Personnel Product Carrying Labor	• Poor product storage designation • Lack of optimized strategy for order picking • Lack of Quality Standard
	Shipping	• Long movement of Delivery Truck from Storage Location • Long turnaround time for vehicles/ trucks Long movement of material handling equipment with product from Storage Location • Multiple trip (back and forth) for large batch orders	Warehouse Entry/Exit Point Warehouse Grounds and Warehouse Buildings	Product Shipping Personnel Product Carrying Labor Delivery Truck Driver	• Poor Warehouse layout design • Poor product storage designation • Lack of adequate personnel • Poor warehouse ground control • Lack of Quality Standard • Lack of optimized strategy for Shipping • Lack of adequate material handling equipment • Overcrowded warehouse ground

Table 3.2.: Root Cause of Waste Identification

After the identification of the root causes for wastes at each stages of the warehousing activities was carried out, the major causes for the wastes were selected using Pareto analysis.

According to Wood (2012), Pareto analysis is a statistical method used in decision-making for the choice of the few tasks that have the most important overall impact. It applies the theory that in order to fix 80% of the issues, the top 20% of reasons must be addressed. Vilfredo Pareto, an economist and sociologist, is credited with developing the idea after he noticed that a sizable percentage of a country's wealth frequently fell under the control of a relatively small group of people. Having made this observation it enabled him to formulate the following rule – ‘in any series of elements to be controlled, a selected small factor in terms of the number of elements almost always accounts for a large factor in terms of effort.’

With that regard, the Pareto analysis for each warehousing wastes and their root causes was conducted (as seen on Section 7.4). Using this analysis it was possible to identify the significant problem issues that ensure warehousing waste occurs. The below graph shows the Pareto analysis for the noteworthy issues the cause waste of transport within the warehouse of the case company.

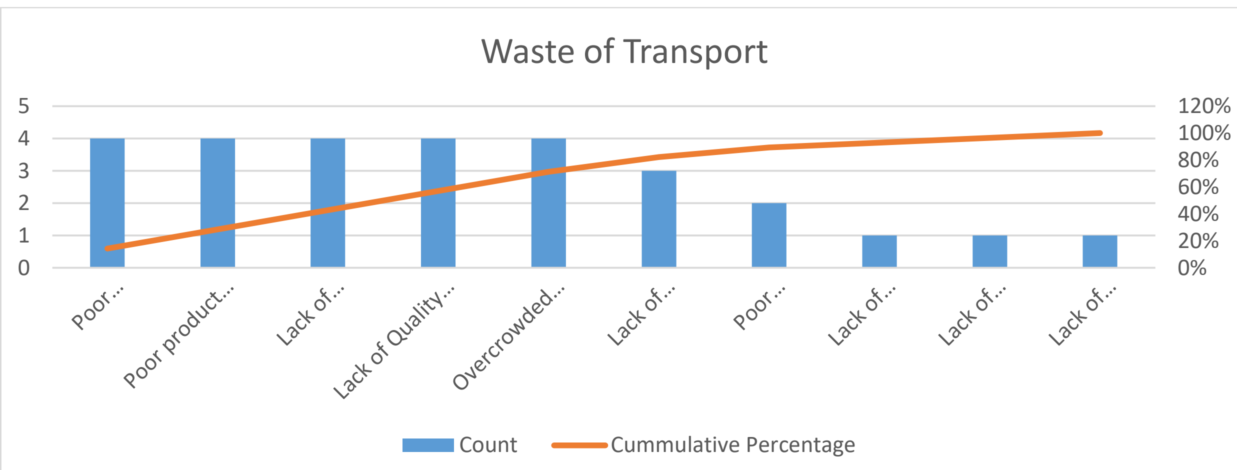

Fig 3.1. : Pareto Analysis on Waste of Transport

Subsequent to the Pareto analysis carried out across each warehousing wastes, the following 22 issues were identified to cause the warehousing wastes at different stages of the warehousing activities. These issues were further clustered depending on the areas of effect they correspond to.

No.	Causes of Major Warehousing Wastes	Clustered Representation
1	Poor Warehouse layout design	Warehouse Design (WD)
2	Overcrowded warehouse ground	
3	Poor warehouse ground control	
4	Poor product Tool & storage designation	Storage System (SS)
5	Lack of optimized strategy for storage	
6	Already occupied dock	
7	Lack of adequate personnel	Existing Human Resource (EHR)
8	Lack of trained Personnel	
9	Human error	
10	Already occupied personnel & Over burden of tasks on an employee	
11	Lack of motivators from the company for workers	
12	Lack of Quality Standard	Standardization (ST)
13	Lack of safety Standards	
14	Lack of adequate material handling equipment	Technology and Equipment (TE)
15	Lack of adequate PPEs for employees	
16	Information error	
17	Lack of technological equipment to catalyze the task	
18	Lack of maintenance personnel	Specialized Employment (EM)
19	Lack of Paramedics	
20	Lack of product training	Training (TR)
21	Lack of Material Handling Training	
22	Lack of safety training	

Table 3.3. : Clustered Representation of 22 Causes of Major Warehousing Wastes

4.2.1. Literature on 22 Causes of Major Warehousing Wastes

4.2.1.1. Warehouse Design

According to Sederova et. Al (2021) and Ries et. Al (2017), warehouse design is the process of planning and constructing a warehouse that meets the specific needs of a company. Ries et. Al (2017) further continues by saying that warehouse design should consider aspects of warehouse layout, operation strategy, information and control technology and resource dimensioning (product, employee and material handling equipment dimensioning). Both authors aim in redefining a given warehouse inured for it to reduce cost, improve safety, increase safety and upturn customer satisfaction.

In light of the above dimensions three warehouse design issues were found in the warehousing at NOC.

a. Poor Layout Design

According to Fishgang (2023), Warehouse layout design principles are essential for efficient and safe operations in logistics management. A well-designed warehouse can optimize the flow of goods, reduce costs, improve customer service, and prevent accidents. Sunol (2023), also claims that an inefficient warehouse layout can affect speed, efficiency, and productivity which will directly impact your profits. Both authors agree on the fact that it leads to messy operations, wasted spaces, poor inventory management, substandard processing and excessive cost.

Therefore, it can be said poor layout design will affect the general productivity of a given warehouse.

b. Overcrowded Warehouse Ground

According to the article on the website of DAK Solutions (2023), overcrowded warehouse is a common problem in the warehouse and one that causes all too many accidents every year. Overcrowding in the warehouse can lead to a variety of safety issues like overloaded pallet racking that could collapse and lost time due to slow movement caused by congested aisles. WSL (2023) describes overcrowding by stating that areas of the facility become motionless and congested as travelling units enter a bottleneck situation which initially forces a significant slowdown followed by a complete halt in movement. This results in the accumulation of stationary units, unable to move freely and it's a situation that can drag on for quite some time. It also mentions the signs of an overcrowded warehouse as the signs include, frequent jams, too much activity in a specific area, high labor cost but low productivity and subpar customer satisfaction level.

For the above mentioned articles, it is possible to say that overcrowded warehouse is a safety hazard, a jeopardy for efficiency, high cost risk and reason for reduced customer satisfaction.

c. Poor Warehouse Ground Control

Warehouse ground control, according to the website of Lucasware.com (2023), is the process of controlling the movement of people and goods on a warehouse's floor. It entails tasks including making sure that aisles are clear, that equipment is stored correctly, and that workers are adhering to safe procedures. For the warehouse to be a safe and effective working environment, ground control is crucial. The concrete slab and flooring in warehouses and logistics facilities are essential to the smooth operation of the operations, claims Sika Group (2023). Mecalux (2023) adds to this evidence by stating that level and flat warehouse flooring is essential for the efficient movement of handling equipment. To avoid machine faults and, more crucially, issues with the installation of racks, some material handling equipment needs a concrete floor that is extremely level. The tipping over of merchandise could be caused by uneven warehouse ground. According to Fairchild Equipment (2022), any warehouse ground that is not a concrete slab would have a lot of debris, which could harm the products and workers' health. The operation of the warehouse could be hampered in an unsupervised warehouse if ground aisles are blocked by merchandise or misplaced pallets.

Hence, as seen from the above publications and blogs, a warehouse that lacks a proper ground control suffers high costs, reduced efficiency and uncontrolled safety issues.

4.2.1.2. Storage System

According to Extensiv.com (2022), a warehouse storage system is a collection of physical constructions that are especially made to aid in the efficient utilization of warehouse space. When properly deployed, these solutions will significantly increase a warehouse's efficiency and offer the assistance required for good scaling. Having a solid warehouse storage system, it is further stated, will benefit the warehouse in terms of safety, effectiveness, and getting the most storage space possible. In addition to supporting the definition of the storage system provided above, Interlake Mecalux (2021) notes that each product should preferably be stored in the appropriate system in a facility where numerous products are maintained.

It can be said that having a proper storage can have a significant impact on the efficiency, accuracy, and safety of warehouse operations.

a. Poor Product and Tool Storage Designation (Warehouse Slotting)

According to a 2011 article by Patterson, warehouse slotting is the process of assigning the right item to the right place based on slotting criteria. Labor and space savings are the main justification for undertaking a warehouse slotting operation. Slotting is a metaphor for the warehouse being tuned. This is further supported by the publication from AGI World Wide on 2023, which asserts that properly slotting a facility lowers high labor costs, significantly increases throughput, and does so by reducing ergonomic risks linked to inefficient picking and replenishment operations.

As it can be seen from the above publications, proper warehouse slotting is essential for businesses that want to improve their efficiency, reduce their costs, and improve their customer service. By taking the time to properly slot their products, businesses can save time and money, improve customer satisfaction, and reduce their risk of safety hazards.

b. Lack of Optimized Strategy for Storage

According to Sunol (2022), one of the most significant issues warehouse managers deal with is optimizing storage. He goes on to describe the storage process as the movement of goods into the best storage space. If done improperly, it may result in costly consequences such as clogged aisles, misplaced supplies, and low productivity. According to Tomkins and Harmelink (2004), factors like quick development, seasonal peaks, and slow sales usually lead to warehouses running out of storage space. Having a successful storage plan in place is essential to making the most of your warehouse's available space. Effective warehouse storage puts the stock management system in place without sacrificing efficiency.

An optimized storage strategy can help a warehouse to avoid the above mentioned negative effects and improve. By taking the time to carefully consider their storage needs and develop a plan that meets those needs, businesses can save money, improve efficiency, and increase customer satisfaction.

c. Already Occupied Dock

A docking station, according to the website of Saloodo.com (2023), is a particular location near or inside a building where transport vehicles park for loading or unloading. Don Catalano (2023) adds to this by adding that it is a crucial component of entry and shipment since it serves as the entrance or exit point for items that are being loaded into or unloaded from trucks and vans. According to a Mecalux document titled Warehousing Docking Areas (2023), anytime a warehouse design is put into practice, warehouse docks should be thoroughly analyzed because they serve as the entrances to any storage facility. Don Catalano (2023) stresses the fact that highly efficient loading docks maximize the flow of goods in and out of the warehouse, ensuring that customers are served quickly and efficiently. The wrong loading dock system or the occupation of loading and unloading docks can result in delays, higher labor costs, lost business opportunities and customer dissatisfaction.

As it can be seen from the above studies, when docking stations are always being occupied the receiving of shipping process of the warehousing will be jeopardized. As a result, delays, high labor cost and customer dissatisfaction could follow.

4.2.1.3. Existing Human Resource (Human Capital)

According to Di Bartolo (1999) Human capital consists of those individuals' abilities that are characteristic of them and remain the same in any social environment and can be exploited on the labor market in exchange for economic resources of any kind. Practically, human capital consists educational capital and biological capital. Furthermore, Bottone (2008) claims that Human capita has been defined as the capacity of human beings to produce an income. In other words, it is the stock of ability and productive knowledge embodied in individuals. Consequently, human capital is defined in a wider sense on Wikipedia as human resource and it is stated as the set of people who make up the workforce of an organization, business sector, industry, or economy. These people consist of employees, workers, or laborers.

As denoted by the above authors, human capital refers to the people that are involved in any operation and when we are considering warehousing it refers to the individuals who are part of the warehousing operations. Therefore, issues that arise from human capital in warehousing will have a negative impact in the operation and activity of the warehouse.

a. Lack of Adequate Personnel

A report on Edays (2020) states that understaffing refers to a lack of suitable staff and denotes the employment of too few employees in situations when the business does not have enough individuals to cover all the tasks necessary to maintain a smooth operation. A warehouse contains a lot of moving parts. To maintain the facility running at its best, each one needs employees that are knowledgeable in specific fields. The effects of a staffing shortfall are felt by everyone in the business, including its clients (2023, Prologis). The website of Edays (2020) and publication of Di Vincenzo (2022) both address the consequences of having insufficient personnel. They both claim that understaffing leads to High-Stress workplace, a decrease in work quality, brand damage, high employee turnover and increase risk of accidents.

Therefore, it is important to note that if a warehouse is not equipped with the sufficient amount of personnel the entire operation will suffer and also lead to various wastes.

b. Lack of Trained Personnel

In the blog by Southern States Storage and Handling (2022), lack of staff or unskilled or untrained staff can lead to increased labor costs, slow business growth, and damage the company's reputation with customers. This is further discussed by Wollard (2014), and he claims that productivity may actually decrease if the workforce is totally unaware of the inner workings of the warehouse and if they make mistakes too often. He then states that unskilled workers are liable to injuries, customer dissatisfaction and breach of organization policies, safety legislations or legal policies.

Thus, the above publications state that having adequate personnel is not only enough to sustain proper warehousing process but also having trained or skilled professionals working in the warehouse.

c. Human Error

According to Dewa et al. (2017), human beings play crucial roles in warehouse operations because they are so dependent on manual labor. It is crucial to satisfy human requirements in order to reduce errors and achieve outstanding warehouse efficiency. According to a Sunol (2023) post on the website of Cyzerg Warehouse Technology, too many errors made by warehouse staff can have a detrimental impact on the operation of the warehouse and result in damage, injuries, lengthy delays, and subpar customer service. This is further confirmed by a blog on the website of Human Error Solutions by Collazog (2023), which claims that up to 90% of workplace mishaps are caused by human error, which can be expensive, cause a loss of time, and disrupt productivity at work.

Consequently, the above stated authors stress that it is important to avoid errors in order to have a smooth running warehouse.

d. Already Occupied or Overburdened Staff

Overworked workers just do not have the same physical capacity as newer hires, claims Hapi Gig (2023). Warehouse workers may skip shifts and report for work sick more frequently if they don't get adequate breaks during the workday and in between shifts. Regardless of whether they are otherwise dependable to stay on task and achieve warehouse quotas, a weary employee may not be able to keep up with a better-rested one when they do arrive at work. Employees that are overworked may become distant with others, mentally disconnect from their task, or contribute to a toxic workplace culture that lowers warehousing productivity. No employee should be required to work in a physically hazardous workplace, according to Heller-Ono (2021). Additionally, a warehouse worker who is multitasking will be less productive in the short and long term (Bannister and Remenyi, 2009). According to Wick (2017), if a worker tries to handle two or more tasks at once, he or she is only dividing our attention and dumbing down all of the results in the process. A staff member who is already working cannot take up a task or activity that is consequential or entirely unrelated without abandoning the one they are already working on.

As mentioned by the above authors, overburdened employees and employees doing multiple tasks are subject to low workplace efficiency and health.

e. Lack of Employee Motivators

An article from 2019 that was published on the Interlake Mecalaux website claims that motivated and engaged employees complete all necessary tasks more swiftly and effectively. The aforementioned idea is supported by an article posted on the website of 6 River Systems, which also adds that warehouses should place a strong priority on motivating employees and retaining the greatest talent. According to a piece on Packagex (2021), the quality and performance of your company's talent pool will typically be directly impacted by how well your employee benefits strategy is implemented. Additionally, Tannady (2023) makes the same claim. All of the aforementioned academics are focused on the financial aspect of storage as their main motivation. Promotions and consideration for the personnel are often viewed as important motivators.

Therefore, it is important to note that employee motivation will have an impact on the productivity of employees.

4.2.1.4. Standardization

As per the article published on the website of The Statesman (2023), The standardization of warehousing is primarily intended to make the whole process more efficient for warehouse staff by ensuring that they know where they ought to be and what they should be doing. This will result in both money and energy savings. It also makes it easier to have a rotational schedule for employees since they now have a clear pattern to follow, which makes it simpler for them to take on new responsibilities without feeling burdened by them. Karlsson (2017) states that if standardization is not applied using best practice and make an optimal standard for every process, it can be possible to say that every employee in the warehouse will have as many ways to perform a process as many as their number. A publication by Redwood Logistics (2023) states that standardization is critical for the management of a supply chain, including warehouse, and claims it has advantages over cost, waste reduction, improved productivity, safety of employees, reduced downtime of equipment, fewer errors and delays and high turnaround of goods.

As stated by the above authors, standardizing the warehousing process and the activities will play an important role with regards to eliminating wastes and increasing productivity of the warehouse.

a. Lack of Quality Standards

According to Shewart (1931) and Levy (1972), quality is compliance to requirements. A product or service's quality of compliance refers to how closely it adheres to specific design criteria. According to Knight and Dy (2020), the set of requirements that must be completed in order to guarantee that products are kept and handled in a safe and effective manner are known as quality standards in warehousing. These requirements are made to safeguard both the workers' health and safety in the warehouse as well as the quality of the goods. On the Compliance Help (2023) website, the International Organization for Standardization lists four certification categories that can be applied for warehousing. Of the four, IS0 9001 outlines the requirements and best practices for businesses to set up a structured Quality Management System (QMS). The QMS will help the warehouse by streamlining and managing its processes, raising operational effectiveness, reducing risks, and offering first-rate services.

As seen from above, having a quality standard within a warehouse can be a valuable tool for improving the efficiency, accuracy, and safety of warehouse operations. By implementing quality standards, companies can improve customer satisfaction, reduce costs, and improve employee morale.

b. Lack of Safety Standards

Vuorinen et. al (2015) state that a safe and healthy workplace benefits everyone. It means the staff feels well and work flows smoothly. Szymonik (2015) states that the safety of a warehouse depends on the following three groups of factors: technical, legal and human. Technical factors that have an effect on warehouse safety are related to appropriate equipment and infrastructure which provide for proper warehousing, internal transport, order picking, sorting, shipping, and security of the facility. Legal (organizational) factors include the development and implementation of documentation, and establishment of procedures. Full compliance with the established procedures minimizes the risk of accidents or material losses. Human factors considers safety of personnel that work in a warehouse. The standardization of the personnel could start from recruitment that considers competences, qualifications, and experience; whereas, for the ones already employed, providing employees with opportunities for continual professional training should not be neglected. An ISO certification that can be utilized to standardize safety in a warehouse is ISO 45001, as per the website of Compliance Help (2023). It states that the handling of heavy equipment and forklift, working in extreme conditions like cold, heat, or pressure, and exposure to indoor pollutants such as carbon monoxide, nitrogen oxides, etc. pose serious threats to the health of workers in a warehouse. This makes this standard for occupational health and safety management system a prerequisite for you're a warehouse to ensure employees' safety. Achieving the standard implies that a warehouse has implemented a definite Occupational Health and Safety Management System (OHSMS) to identify and prevent/lessen work-related injuries or sicknesses in the workers. This concept is also further attested by Szymonik (2015).

Therefore, assuring safety helps to enhance the competitive advantage of a warehouse of a company. It helps attract skilled workers from the workforce, improve the morale and see improved performance of the already existing workers.

4.2.1.5. Specialized Employment Issues

As per the article on the website of Indeed.com (2022), job specialization is a process that occurs when employees gain knowledge, education and experience in a specific area of expertise. According to the blog on 21 Types of Warehouse Positions & Their Duties on the website of extensive.com (2021), specialized employment refers to the employment of people who have certain skills and perform specific tasks.

Therefore, it can be said that specialized employment refers to the employment of people to handle a specific task in a warehousing environment.

a. Lack of Maintenance Personnel

According to Christiansen (2023), if a warehouse is not properly maintained, it is just a matter of time before it turns into a hazardous place to work. Most equipment-related mishaps are avoidable with adequate warehouse maintenance. According to research conducted by Marketing Dubai in 2023, a warehouse is one of the most important facilities and assets a business can own. Like any other asset, it must be protected at all costs to ensure that it fulfills its function for as long as possible. Companies are highly careful about keeping their warehouses and ports in good condition. Every year, they spend millions to make sure that nothing bad happens to it. According to Van Der Walt (2023), warehouse upkeep is crucial since it boosts productivity, saves money, and ensures workplace safety.

Therefore, it can be said that the employment personnel that is responsible for the specific task of maintenance in warehousing will increase productivity. Furthermore, a warehouse without a maintenance personnel is unsafe and has low productivity.

b. Lack of Paramedics

Brennan, MD (2021) defines a paramedic as a medical specialist who specializes in delivering emergency care. Outside of a hospital setting, paramedics provide patients with emergency medical help. They have training in basic and advanced life support, patient assessment, and transporting patients to a hospital or other medical facility (Eaton et al., 2022).

According to the OSHA (2006), paramedics are important in warehousing because they can provide medical care to employees who are injured or become ill while working. Warehouses can be dangerous places, and employees are often exposed to heavy lifting, machinery, and hazardous materials. As a result, there is always the potential for an accident or illness to occur. Paramedics can quickly and effectively assess and treat injuries or illnesses, which can help to prevent serious complications or even death.

4.2.1.6. Technology and Equipment

According to Flora (2023), warehouse technology is any technology utilized in warehousing operations to increase production and efficiency. These technological solutions help companies perform a variety of warehouse tasks, such as order processing, inventory control, packing and shipping, internal product movement, receiving and storage, and many more. Some programs even let you totally automate specific tasks, while others let you speed up your workflow and increase precision. Getting the correct technology and equipment for your warehouse, according to Sunol (2022), will not only make it easier for items to move through each process area, but it will also lessen the risk of accidents and product damage.

It can be said that technology and equipment are essential for modern warehousing. They can help to improve efficiency, accuracy, and safety in the warehouse.

a. Lack of Adequate Material Handling Equipment

Material handling, according to Das and Mishra (2019), includes the fundamental procedures related to the movement of bulk, packed, and individual products in a semi-solid or solid condition using manually or electrically powered equipment. The aforementioned assertion is supported by Kay (2012), who adds that it can be utilized to generate time and place utility through the handling, storing, and management of content. Therefore, any apparatus utilized to manage material in the aforementioned aspect is referred to as a material handling apparatus. According to Kay, there are five different types of material handling equipment that can be utilized for conveying, positioning, load formation, storage, and control in warehousing. Foley (2021) states that it helps store, move, load, and ship out material. The choice of equipment speeds up this process and adds to the staff's convenience and also helps to facilitate all these operations efficiently, prevent accident and reduce cost within the warehouse.

Therefore not having the proper and adequate material handling technology will lead to reduced efficiency, safety risks, product damage and inaccuracy in the warehouse.

b. Lack of Adequate Personal Protective Equipment

A blog article on the Verge Safety Barriers website (2020) claims that warehouses are hazardous work environments that call for the employment of efficient risk management strategies. Risk management must be done before starting any warehousing work. Any potential risks in the workplace must be considered, along with strategies for minimizing or eliminating them. A key element of warehouse safety management is the use of personal protective equipment (PPE), which has the potential to lower risk levels and guarantee the health and safety of workers on the working site. Personal protection equipment (PPE), as defined by the U.S. Department of Labor's Occupational Safety and Health Administration (2023), is gear worn to reduce exposure to a variety of risks. Gloves, foot and eye protection, protected hearing equipment (earplugs, muffs), hard helmets, respirators, and complete body suits are a few examples of PPE. According to the safety training offered by Peabody Insurance Agency in 2023, warehouses are regarded as risky workplaces where significant accidents might happen and even end in fatalities. Personal protective equipment (PPE) will shield workers from workplace safety concerns even if it is the least effective technique of doing so and does not eliminate the hazard at its source. When engineering and administrative measures are neither practical nor successful in bringing risks down to acceptable levels, PPE is used to lessen worker exposure to hazards.

As seen from the above concepts, providing adequate PPE to warehouse workers, employers can help to protect their workers, reduce their costs, and improve their safety record.

c. Information Error

Information errors in warehousing, according to Skerlic and Muha (2017), are any errors that happen during the data entry, storage, or retrieval of information regarding items, inventories, orders, or clients. These mistakes can significantly hurt a business's bottom line by increasing expenses, decreasing productivity, raising safety risks, causing damaged goods, and displeasing customers. They may result from process faults, system errors, or environmental variables.

The mistakes with regards to the management and transmission of information could lead to increased costs, damage of products, low efficiency and safety risk.

d. Lack of Technological Equipment to Catalyze Tasks

According to Stazzone (2033) and Supply Chain Junction (2023), technology is advancing quickly across all economic sectors. Warehouses must be outfitted with the technologies necessary to stay up with production, manufacturing, and consumer demand if they are to keep up. Automation increases productivity, efficiency, and accuracy in a smart warehouse, and the solutions put in place provide personnel and processes more flexibility. Sunol (2023), who asserts that warehouse technology is an efficient, cost-effective, and sustainable approach to tackling the difficulties of the warehouse, further supports this. It is becoming more and more important to transition warehouses away from overly depending on expensive human labor and toward a more automated and technologically focused operation, especially now that the market is shifting to e-commerce platforms that are accessible and open 24/7/365. All writers concur that automation lowers overhead costs, gives flexibility to operating hours, and enables more precise workforce demand estimation in addition to reducing human error, lowering risk of injury, and optimizing throughput.

The use of technology and equipment in warehousing is becoming increasingly important as businesses look for ways to improve efficiency, accuracy, and safety in their operations.

4.2.1.7. Training

According to Sunol (2023), training for warehouse workers should cover more than just the abilities needed to use a certain piece of machinery or warehouse equipment or carry out a procedure. Additionally, the curriculum should be created to motivate staff members and assist them in realizing how important their contributions are to the success of the business. Employee unhappiness and significant employee turnover are caused by a lack of training.

a. Lack of Product Training

As per Maltesson and Sandberg (2020), part of training in warehousing is learning about the products that will be stored in the warehouse. This includes understanding the products' physical characteristics, such as size, weight, and fragility. It also includes understanding the products' storage requirements, such as temperature, humidity, and light exposure. Trainings include: product identification, storage requirements, damage prevention and handling procedure.

By training employees on the products that will be stored in the warehouse, companies can help to ensure that those products are handled safely and efficiently. This can help to prevent product damage, improve customer satisfaction, and reduce costs.

b. Lack of Material Handling Training

Williams (2023) asserts that material handlers, or specific warehouse employees, move products and materials to and from production or storage areas, loading docks, and delivery trucks manually or with motorized equipment, such as forklifts, generally in the manner described in the aforementioned sections. Training in material handling frequently includes lessons on how to operate certain equipment and organize a warehouse in connection to other tasks. Georgia Tech Professional Education (2023) claims that before discussing the fundamentals and economics of material handling, it is vital to define the term. The preferred equipment and handling techniques for the various materials can then be used. It also asserts that offering training in material handling can help the trainee by educating them on how to lower material handling-related costs, enhance the planning and effectiveness of material handling systems in a specific warehouse, and know how and when to use automation in material handling.

By providing this type of training, companies can help to improve safety, efficiency, and productivity within their warehouses.

c. Lack of Safety Training

Glomacs.com (2023) asserts that a secure, well-organized warehouse is essential to a smooth operation. The Online Safety Trainer (2022) website acknowledges this and goes on to state that organizations should regularly conduct safety inspections and training in order to ensure warehouse safety. While training can give staff members the knowledge and abilities they need to carry out their responsibilities safely, safety inspections can assist in identifying possible dangers and helping to take action to correct them. A blog post by Essential Skillz (2023) and Safety Culture (2023) claims that a warehouse worker who has received safety training will understand how to recognize and eliminate risks in the warehouse, enforce ergonomically appropriate task approaches constantly, be effective, and foster a safe environment and positive work culture.

Warehouse safety training is an important investment for any company that operates a warehouse. By providing this type of training, companies can help to protect their employees from accidents and injuries, improve efficiency, and create a positive safety culture.

4.3. Second Step Data Collection Analysis and Result

The next step taken was to determine and further select the major wastes, established on the above step, that attest to the problem statement or dependent variables of this study. The dependent variables of this study are:

- Damage of Products
- Late Delivery
- Mistake in Inventory Count
- Safety of Employees
- Insufficient Storage Space
- Material Handling Equipment Failure (Equipment Failure)

The questionnaire distributed among the target sample of 73 people assessed which of warehousing waste issues had a direct impact on the aforementioned dependent variables. The analysis, reliability and validity of this questionnaire was carried out using IBM SPSS Statistics 26 and Microsoft Excel 2013 software.

4.3.1. Reliability of Questionnaire

Reliability of the responses of 73 respondents was analyzed by the use of Cronbach's Alpha Reliability Coefficient on IBM SPSS Statistics 26 software for which the internal consistency of the clustered warehouse wastes issues analyzed.

	Reliability Statistics						
	Chronbach's Alpha for						
Dependent Variable	Warehouse Design	Storage System	Existing Human Resource	Standardization	Technology and Equipment	Specialized Employment	Training
Damage of Product	0.97	0.911	0.843	0.788	0.745	0.866	0.952
Equipment Failure	0.929	0.875	0.965	0.872	0.967	0.895	0.889
Inventory Count Mistake	0.902	0.873	0.957	0.886	0.798	0.908	0.866
Insufficient Storage Space	0.913	0.917	0.815	0.88	0.798	0.908	0.952
Late Delivery	0.834	0.953	0.952	0.877	0.881	0.894	0.938
Safety of Employees	0.916	0.918	0.959	0.86	0.859	0.868	0.885

Table 3.4.: Reliability Analysis of Questionnaire of Second Step Data Collection

As it can be seen from the above table, all values of Chronbach's Alpha are greater than 0.7, therefore it is possible to say that the questionnaire is reliable.

4.3.2. Analysis of Questionnaire

After determining the reliability of the questionnaire, the next step taken was to analyze the response of the respondents for the questionnaire. The analysis of the questionnaire was carried out by using Relative Importance Index Analysis (RII) in order to identify which clustered representation of warehouse issue has a high impact on the dependent variables using both Microsoft Excel and IBM SPSS Statistics 26 software. According to Rooshdi et. Al (2018), Relative importance index analysis allows identifying most of the important criteria based on participants' replies and it is also an appropriate tool to prioritize indicators rated on Likert type scales. Tholibon et. Al, use RII to rank factors of satisfaction in their research by claiming that it shows the degree of importance and stress that it is especially important for questionnaires to use likert scales. The RII formula as stated by both authors is as shown below:

$$RII = \frac{\sum G}{SN} = \frac{5SA + 4A + 3N + 2DA + 1SDA}{5x73}$$

Where:

G = respondent's weighting of each factor

S = the highest weight

N = Total Population of Respondents

For this research, the questionnaire utilized is a five point likert scale questionnaire. Therefore, the above formula can be further explained as follows:

SA = Strongly Agree with weight of 5

A = Agree with weight of 4

N = Neutral with weight of 3

DA = Disagree with weight of 2

SDA = Strongly Disagree with weight of 1

S = 5, as it is the highest weight

N = 73, as it total number of respondents

Consequently, the RII was carried out on the clustered representation of the warehouse issues (shown on Table 7) by taking the mean of the responses of the respondents. Based on the ranks obtained from the analysis, the impacts were categorized as advanced, medium level and low level.

- Low Level (RII<50%)
- Medium Level (50%<RII<95%)
- Advanced Level (RII>95%)

As shown on Annex 7.5.1. of this document the following results were determined and its summary is shown on the below table.

Dependent Variables	RII Ranking	
Damage of Product	Training (97%)	Storage System (97%)
Equipment Failure	Standardization (98%)	
Inventory Count Mistake	Human Capital (96%)	
Insufficient Storage Space	Storage System (97%)	
Late Delivery	Warehouse Design (98%)	
Safety of Employees	Training (96%)	

Table 3.5. : RII Ranking Summary of Second Step Data Collection

As discussed before, the above table shows which warehouse representation has an impact on the dependent variables through ranking.

4.3.3. Validity of Questionnaire

As discussed on Chapter 3 of this document, the validity of the questionnaire was tested using construct validity on IBM SPSS Statistics 26. The responses of each respondents was correlated using Pearson's Bivariate formula where the standard significance is 0.05. During this process, each responses were correlated with their total scores. Furthermore, to identify the correlation coefficient from the Critical Values for Pearson's Correlation Coefficient (r) the degree of freedom (df) was necessary. As the df was determined to be 71, then from the table r = 0.1940.

For testing the validity of the questionnaire, If the correlation of each item questionnaire scores with the total scores results significant correlation and the correlation value is greater than 0.1940 (r), then it is possible to say that the questionnaire is valid. The correlation data is shown on Annex 7.6.1. of this document and the following were deduced by considering both the correlation matrix data and RII result shown above.

- The questionnaire utilized to assess the impact of warehousing issues on Damage of Product valid for Warehouse issues corresponding to Storage Systems (Correlation Value > r and significant) but not with Training (Correlation Value >r but not significant)
- The questionnaire utilized to assess the impact of warehousing issues on Equipment Failure is valid for Standardization (Correlation Value > r and significant)
- The questionnaire utilized to assess the impact of warehousing issues on Inventory Count Mistake is valid for Existing Human Resource (Human Capital Issues) (Correlation Value > r and significant)

- The questionnaire utilized to assess the impact of warehousing issues on Insufficient Storage Space is valid for Storage System (Correlation Value > r and significant)
- The questionnaire utilized to assess the impact of warehousing issues on Late Delivery is valid for Warehouse Design (Correlation Value > r and significant)
- The questionnaire utilized to assess the impact of warehousing issues on Safety of Employees is valid for Training (Correlation Value > r and significant)
- The questionnaire utilized to assess the impact of warehousing issues on Equipment Failure is valid for Standardization Issues (Correlation Value > r and significant)

4.3.4. Summary of Second Step Data Collection Analysis

The intent of the Second Step Data Collection was to select the major warehousing issues that attest or that have impact to the problem statement of this research. The data collection was done using 5 point Likert Scale Questionnaire and the questionnaires were distributed among 73 respondents. The reliability of the responses made by the respondents was checked using Chronbach Alpha and all the response show High Reliability. Moreover, the selection of warehousing issues that have high impact on the problem statements or dependent variables was selected via RII. Consequently, this result was further validated using construct validity and the following clustered representation of major warehousing issues were shown to have an impact on the dependent variables:

- Storage System Issues
- Standardization Issues
- Existing Human Resource Issues
- Warehouse Design Issues and
- Training Issues

The above results will be used as an input for the third step as the third step will identify which lean management techniques will have an impact in solving the above issues.

4.4. Third Step Data Collection Analysis and Result

This third step uses similar reliability, analysis and validity method to the second step, however, its main intent is to select which lean management technique will have an impact to solve the warehousing issues identified through the second step data collection and analysis.

4.4.1. Reliability of Questionnaire

Similar to the second step, Reliability of the responses of 73 respondents was analyzed by the use of Cronbach's Alpha Reliability Coefficient on IBM SPSS Statistics 26 software.. For this step, as shown on Chapter 3 of this document, the lean tools were operationally characterized with respect to the management techniques essential at various evaluations points comprising the various warehousing processes in a facility as shown on the below table.

Lean Tools	**Characterization Based Management Technique**
A3 Reports	Visual Management Lean Tools
VSM	
Systems View	
KPI Boards	
Standardized Work	
Management Style (Leadership and Commitment)	Human Resource Management Lean Tools
Employee Involvement	
Teamwork and Empowerment	
TPM	
Kaizen Events	Continuous Improvement Lean Tools
PDCA	
Technology	
5S	
Customer Involvement	Demand Management Lean Tools
Kanban	
Layout and Zones (Relayouting)	Layout Management Lean Tools
ABC Tools	
Supplier Involvement	Product and Process Management Lean Tools
SPC	
Quality at the Source	
Jidoka (Zero Defect and Poka Yoke)	
Optimized Picking Plan	Flow Management Lean Tools
Cross Docking	
Heijunka (Line Balancing)	

Table 3.6.: Characterized Representation of Lean Tools based on Management Techniques

Internal consistency of responses for the lean tools characterized based on the management techniques was conducted.

Warehousing Issues	Reliability Statistics						
	Chronbach's Alpha for Lean Management Tools of						
	Visual	**HR**	**Continuous Improvement**	**Demand**	**Layout**	**Product and Process**	**Flow**
Storage System	0.929	0.896	0.884	0.87	0.908	0.896	0.958
Standardization	0.955	0.867	0.93	0.857	0.896	0.916	0.877
Existing Human Resource	0.96	0.879	0.913	0.904	0.904	0.916	0.864
Warehouse Design	0.924	0.785	0.885	0.838	0.908	0.934	0.936
Training	0.971	0.92	0.906	0.922	0.895	0.928	0.918

Table 3.7.: Reliability Analysis of Questionnaire of Third Step Data Collection

As it can be seen from the table, all the values of Chronbach's Alpha for Lean Management Tools show high reliability. Therefore, it is possible to say the data from the questionnaire is reliable.

4.4.2. Analysis of Questionnaire

Analogous to the second step, the questionnaire was analyzed via RII. The RII was carried out on the characterized lean management tools (shown on Table 3.7) by taking the mean of the responses of the respondents. Based on the ranks obtained from the analysis, the impacts were categorized as advanced, medium level and low level. As shown on Annex 7.5.2. of this document the following results were determined and its summary is shown on the below table.

Warehousing Issues	RII Ranking for Lean Tools of
Storage System	Continuous Improvement Management (97%)
Standardization	Product and Process Management (97%)
Existing Human Resource	Human Resource Management (97%)
Warehouse Design	Continuous Improvement Management (97%)
Training	Continuous Improvement Management (95%)

Table 3.8. : RII Ranking Summary of Third Step Data Collection

As discussed before, the above table shows which lean management tool has an impact on the on solving the major warehousing issues by the means of ranking.

4.4.3. Validity of Questionnaire

Again, the validity of the questionnaire was tested using construct validity on IBM SPSS Statistics 26. The responses of each respondents was correlated using Pearson's Bivariate formula where the standard significance is 0.05. During this process, each responses were correlated with their total scores. Furthermore, to identify the correlation coefficient from the Critical Values for Pearson's Correlation Coefficient (r) the degree of freedom (df) was necessary. As the df was determined to be 71, then from the table r = 0.1940. The correlation data is shown on Annex 7.6.2. of this document and the following were deduced by considering both the correlation matrix data and RII result shown above.

- The questionnaire utilized to understand which lean management tool to solve the issues of Storage System, Warehouse Design and Training is valid for Continuous Improvement Management Lean Tools
- The questionnaire utilized to understand which lean management tool to solve the issue of Existing Human Resource is valid for Human Resource Management Lean Tools
- The questionnaire utilized to understand which lean management tool to solve the issue of Standardization is valid for Product and Process Management Lean Tools

4.4.4. Summary of Third Step Data Collection Analysis

The intent of the Second Step Data Collection was to select lean management tools that can solve the major warehousing issues realized from the second step data collection analysis. The data collection was done using 5 point Likert Scale Questionnaire and the questionnaires were distributed among 73 respondents. The reliability of the responses made by the respondents was checked using Chronbach Alpha and all the response show High Reliability. Moreover, the selection of lean management tools that can solve the warehousing issues were selected via RII. Consequently, this result was further validated using construct validity and the following lean management tools were shown to have an impact on solving the warehousing issues at the case company:

- Continuous Improvement Management Lean Tools

- Product and Process Management Lean Tools
- Human Resource Management Lean Tools

4.5. Lean Improvement Model Structure

Based on the results from the above shown analysis, a new model of lean warehousing was developed and illustrated on Fig. 4.1. Of the 24 lean tools, 12 lean tools (marginalized into three management methods) are found to have an impact to solve the wastes proposed by Ohono (1986) and Womack (1996) which in turn will show a significant impact to solve the problems stated on the problem statement. Prior to that, the stated problems were analyzed based on the key warehouse performance metrics indicators proposed by various researchers. Furthermore, for the progression of this model, root cause analysis of wastes at each warehousing activity was completed and 22 major root causes for warehousing waste within the warehouse were identified. They were further clustered into 7 depending on the areas of effect they correspond to. Afterwards, of the 7 issues of wastes 5 showed attestation towards influencing the stated problems. Finally, the three lean management methods showed strong impact towards solving the problems stated.

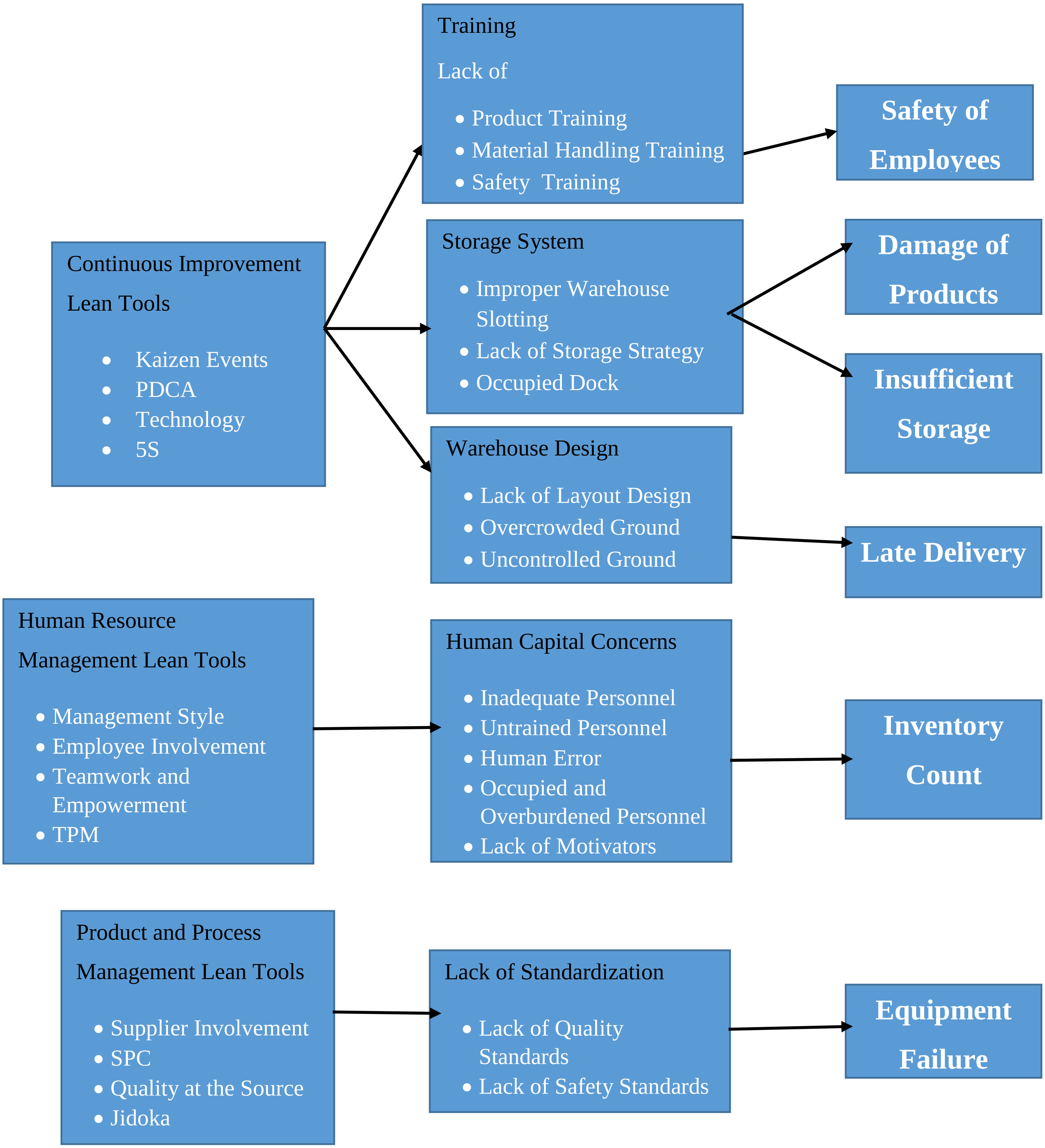

Fig 4.1. : Lean Warehousing Model for Improving the Warehouse Management of National Oil Ethiopia PLC

Chapter 5: Discussions, Conclusions and Recommendations

5.1. Discussion of Second Step Data Collection Results

5.1.1. Effect of Storage System on Damage of Product

Improper storage system has a significant effect on product damage in a warehouse.

- Improper warehouse slotting: When goods are not kept in the proper spot, picking and packing processes might take longer, which raises the possibility of product damage. Additionally, when products are not kept in the proper position, it may be difficult to locate them when needed, which may cause staff members to search more inappropriately and quickly, raising the possibility of product damage.
- Lack of a clear storage plan: When there is no plan for how to keep things, objects may be thrown together carelessly, increasing the chance of anything becoming broken. Additionally, it can be challenging to maintain track of inventory levels when there is no defined storage strategy, which can result in products being out of stock or overstocked, both of which raise the risk of product damage.
- Dock that is occupied: An occupied dock might delay the receipt or shipment of products, which raises the possibility of product damage, as the products are going to be stranded on an undesired space. The dock can also become a traffic hazard when it is occupied, raising the possibility of accidents and hence the possibility of product damage.

5.1.2. Effect of Standardization on Equipment Failure

Equipment failure in a warehouse can be significantly impacted by poor quality and safety standards. It might be challenging to guarantee that equipment is properly maintained and inspected when there are no standards in place. This may result in equipment breakdowns, which may harm products and injure workers.

Different authors have suggested that lack of quality standards negatively impact the warehousing process. Even in the case of equipment failure, when a warehouse does not have quality standards equipment tend to have:

- Increased downtime: When equipment malfunctions, repairs or replacements may take some time. Increased downtime as a result of this may have an adverse effect on profitability and service delivery.

- Reduced efficiency: When equipment malfunctions, the workflow at a warehouse may be affected. Costs may rise and efficiency may decline as a result.

Furthermore, in a warehouse lacking proper safety standards employees are more prone to cause equipment failure as they don't adhere to safe work procedures. This might be the result of things like overloading the machinery, not employing the right safety gear, or failing to follow the right procedures. Moreover, an equipment is more likely to malfunction when there is no appropriate equipment inspection or audit standard with regard to safety. This may be as a result of failing to check for wear and tear, look for loose bolts, or functionally test equipment.

5.1.3. Effects of Storage System on Insufficient Storage Space

For warehouses, not having enough storage capacity can be a serious issue. Customers may become dissatisfied, there may be lost revenue, and costs may rise.

- Improper warehouse slotting can result in not enough storage capacity. First, it can result in things being kept in the incorrect location. This may make it challenging to locate things when needed, which may result in missed sales. Second, it could cause items to be kept in a way that takes up more room than is essential. Costs may rise and space may be wasted as a result. Thirdly, because of incorrect storage, it may result in product damage. In addition, lost revenues and higher expenses may result from this.
- Lack of storage strategy can also lead to insufficient storage space. Without a storage strategy, it is difficult to determine how much space is needed for each type of product. This can lead to products being stored in a way that takes up more space than necessary. Additionally, without a storage strategy, it is difficult to identify areas where space can be reclaimed. This can lead to wasted space and increased costs.
- Insufficient storage capacity can also result from an occupied dock. The dock is unavailable for goods loading and unloading when it is occupied. As a result, inventory may begin to build up in the warehouse, taking up space and posing a safety risk. Additionally, when the dock is occupied, it may delay the receipt or shipment of goods, which may result in a loss of revenue and an increase in expenses.

5.1.4. Effects of Warehouse Design on Late Delivery

Poor warehouse layout design, overcrowded warehouse ground, and uncontrolled warehouse ground can all have a negative impact on late delivery in warehousing.

- Poor warehouse layout: A poorly designed warehouse can make it challenging to locate products, which can cause delays in selecting, loading, unloading and shipping orders. A bad warehouse layout design can also cause traffic jams and accidents, which can cause delays.
- Overcrowded warehouse floor: When a warehouse floor is populated, it can be challenging to move products, which can cause delays in picking and moving orders. A warehouse floor that is too congested can also pose a safety risk and result in mishaps.
- Uncontrolled Warehouse ground floor can lead to an inefficient workflow. Employees may have to walk long distances to get to the products they need as the warehouse ground is not suitable for material handling equipment. Furthermore, clutter and debris on the warehouse floor can create a safety hazard. Employees can trip and fall, or equipment and products can be damaged. This can lead to injuries, downtime, and lost productivity.

5.1.5. Effect of lack of Training on Safety of Employees

The safety of employees in warehouses is significantly impacted by a lack of training. With their heavy gear, moving parts, and potentially harmful chemicals, warehouses such as the case company's, are frequently unsafe places to work. Employees who lack enough training in the safe use of machinery and the handling of hazardous chemicals are more likely to sustain injuries.

- Employees that receive product training are better able to comprehend the characteristics and dangers of the products they are working with. Without this training, workers could not be aware of the items' inherent risks, which could result in accidents. For instance, a worker who has not received training on the risks associated with a specific chemical might not be aware that it can burn skin when it comes into touch with it. Due to this ignorance, touching the chemical could cause harm to the employee.
- Employees that receive material handling training learn how to lift, handle, and move objects securely. Employees could not be employing the right lifting techniques without this instruction, which could result in back injuries. For instance, a worker who hasn't

received training on the right lifting method for a large box would attempt to lift it using their back instead of their legs, which could lead to a back injury.

- Employees learn how to recognize and avoid hazards at work through safety training. Employees may not be aware of the dangers that could exist in the warehouse without this training, which could result in accidents. For instance, a worker who has not received training on the risks associated with working in a busy area might not be aware of the possibility of getting hit by a forklift, which could cause significant injuries.

5.2. Discussion of Third Step Data Collection Results

5.2.1. Effects of Continuous Improvement Management Lean Tools in Solving Training

5.2.1.1. Kaizen Events

- Training issues in warehouses can be greatly improved by kaizen events. Kaizen events allow for the identification and implementation of solutions that can significantly improve productivity, safety, and compliance by assembling a group of employees to concentrate on a single issue.
- Better product and material handling understanding: Kaizen activities can aid staff members in comprehending the products they are handling and in developing a better grasp of the procedures utilized in the warehouse for material handling. This can be accomplished by giving staff members access to information on the products and material handling procedures, such as safety data sheets, product manuals and process manuals as well as by offering them hands-on training with the products along with material handling equipment.
- Improved training techniques: Kaizen events can also contribute to the advancement of the training techniques employed in a warehouse. Inefficiencies in the training procedure can be found and fixed, and the training can be made more interesting and participatory.
- Increased emphasis on safety: Kaizen events can also assist to make training more safety-focused. This is due to the fact that kaizen events frequently include detecting and addressing any safety risks connected to the products being handled.

5.2.1.2. PDCA

The Plan-Do-Check-Act, is a cyclical process that can be used to improve training problems in warehouses.

- The Plan stage of the PDCA process can be used to determine an employee's training needs. You can do this by polling the workforce, holding interviews, or looking through accident reports.
- New training materials can be created during the Do stage of the PDCA process. This could entail producing new training guides, interactive training modules, or videos.
- The Check stage of the PDCA cycle can be used to assess training efficacy. This can be achieved by giving testing, gathering employee feedback, or counting the number of accidents.
- The PDCA process' Act step can be used to enhance training. This could entail adjusting the instructional methods, training delivery methods, or warehouse design.

It is possible consistently improve training issues in your warehouse by using the PDCA cycle. This can aid in ensuring that staff members are adequately trained to handle products in a safe and efficient manner.

5.2.1.3.Technology

Technology can improve training problems in warehouses in a number of ways.

- Improved accessibility: Regardless of an employee's location or time zone, technology can make training more available to them. This is due to the fact that training can be distributed via mobile or internet platforms.
- Personalization: By adapting the course material to each employee's unique needs, tasks and interests, technology can make training for staff memberss more tailored to their demands. This can help increase the effectiveness of training and guarantee that workers are learning the necessary material.
- Real-time feedback: Technology may offer staff members feedback on their performance in real-time, enabling them to spot and address any areas for improvement. This can help to improve the quality of training and ensure that employees are learning effectively.
- Information tracking: Using technology, it is possible to monitor an employee's progress during training and determine what areas require further assistance. By using this data, the training program can be improved and it can be made sure that all staff are getting the training they require.

Overall, technology has the potential to significantly improve training issues in warehouses. Training can be made more accessible, interesting, individualized, efficient, and tracked by successfully utilizing technology. This can aid in ensuring that staff members are adequately trained to handle products in a safe and effective manner.

5.2.1.4.5S

In a warehouse, the 5S approach can help with training issues in a variety of ways:

- It can create a more organized and efficient training environment. When materials and equipment are properly sorted, set in order, and shined, it is easier for trainees to find what they need and to understand the process.
- It can help to identify and correct training problems. By making problems visible, 5S can help to identify areas where training is not effective. This can lead to improvements in the training process, such as better documentation or more hands-on training.
- It can improve communication between trainers and trainees. When the workplace is clean and organized, it is easier for trainers to communicate with trainees and to provide feedback. This can help to ensure that trainees are learning the material correctly and that they are able to apply what they have learned to their work.
- It can help to create a more positive training experience. When trainees are working in a clean and organized environment, they are more likely to be motivated and engaged in the training process. This can lead to better learning outcomes.

In general, the 5S methodology can be a useful tool for addressing training issues in a warehouse. 5S can aid in ensuring that trainees are able to acquire the subject efficiently and apply what they have learned to their work by fostering a more orderly, effective, and secure learning environment.

5.2.2. Effects of Continuous Improvement Management Lean Tools in Solving Storage System

5.2.2.1.Kaizen Events

In the literatures above it has been established that a warehouse with poor storage system can lead to inefficient picking and packing operations, stock outs and increased inventory carrying costs, and delays in loading and unloading trucks. Kaizen events are a great way to improve problems that arise from storage systems by:

- During kaizen events, a group of people who are familiar with the warehouse operations come together to find and fix issues. This may involve slotting issues, improper storage, and occupied docks.
- Kaizen meetings can aid in enhancing communication within the warehouse's various sections. Better coordination and cooperation may result from this, which may boost effectiveness along with the changes on the arrangement of product storage and utilization of docks.
- Kaizen events are made to bring about improvements swiftly. This is crucial for warehouse operations since even minor adjustments can have a significant effect.

5.2.2.2.PDCA

It can be used to improve storage system issues in warehouses by following the below steps as the name indicates

- Plan: Determine the present circumstances and the desired outcomes. Analyze the underlying causes of the issues and provide potential solutions. For instance, it is feasible to understand the present slotting, storage, and dock performance through data analysis, observation, surveys, etc.
- Do: Implement the selected solutions in a trial or small-scale setting. Track the outcomes and gather comments. For instance, to enhance picking operations and cut down on travel times, one may test a new slotting optimization model that takes into account divisible sites in the first level. Another method is to test various storage solutions based on the characteristics of the product, customer demand, and stackability. It is also feasible to experiment with various docks when creating a plan to lessen traffic and wait times.
- Check: Compare the outcomes to the goals and metrics. Evaluate the solutions' efficacy and efficiency. Find any omissions or mistakes. Use graphs, tables, charts, etc. to show the performance indicators before and after implementation, for instance. Statistical methods are used to evaluate the importance of the improvement.
- Act: Determine whether to adopt, adapt, or abandon the solutions based on the evaluation. Standardize the solutions, if they are chosen, and inform all parties involved. If modified, make the appropriate corrections and repeat the process. If abandoned, look for new approaches and begin again.

Overall, PDCA can be a valuable tool for improving storage system problems in a warehouse. By following the four steps of the PDCA cycle, warehouses can identify problems, implement solutions, and measure the results of their improvements. This can lead to significant improvements in efficiency, productivity, and customer satisfaction.

5.2.2.3.Technology

Technology can improve warehouse slotting, storage strategy, and occupied dock problems in a various ways:

- Warehouse management systems (WMS) can help to optimize warehouse slotting. WMS has the ability to monitor inventory levels and movement, find the best places for storage, and produce picking and packaging instructions. As a result, picking and packing times might be shortened, order accuracy could be improved, and warehouse productivity could rise.
- RFID technology can help to improve storage strategy. Products and pallets can be given RFID tags so they can be traced throughout the warehouse. By doing so, stockouts can be avoided and inventory visibility can be improved.
- Automated guided vehicles (AGVs) can help to improve occupied dock problems. AGVs are driverless vehicles that can be programmed to move pallets and other materials around the warehouse. Employees may be able to concentrate on other activities, such picking and packing, as a result of this.

By using the right technology, warehouses can achieve significant improvements in the areas of storage systems.

5.2.2.4.5S

By applying the 5S technique, warehouses can improve their slotting, storage and dock operations in the following ways:

- Sort: By sorting out unnecessary items and clutter from the warehouse, space can be freed up and optimize the use of storage systems. Travel distance and time for picking and loading operations can also be reduced as a result.

- Set: By setting up a clear and logical layout for the warehouse, the visibility and accessibility of items can be improved. Process and work flow can be streamlined for picking and loading operations.
- Shine: By shining and cleaning the warehouse regularly, you can maintain a high standard of hygiene and safety for the employees and also for the safe being of the products. Cleaned and well maintained warehouse locations can also be used as storage spaces creating better and maximized storage space.
- Standardize: By standardizing the procedures and policies for the warehouse, it is possible to ensure consistency and quality in slotting, storage and dock operations. Errors, accidents and deviations caused by human factors can also be reduced. For example, naming system to identify all the locations and products in the warehouse.
- Sustain: By sustaining the 5S culture and habits, it is possible to continuously monitor and improve the slotting, storage and dock performance.

5.2.3. Effects of Continuous Improvement Management Lean Tools in Solving Warehouse Design

5.2.3.1. Kaizen Events

Kaizen events are a great way to improve warehousing issues that arise from Warehouse design issues.

- Improved layout: By identifying and removing waste, enhancing teamwork and communication, and implementing tiny, gradual improvements, kaizen events can assist to enhance the layout of a warehouse. A more effective and productive warehouse may result from this.
- Improved process design: By detecting and removing safety risks, enhancing the flow of goods, and making the warehouse more user-friendly, kaizen events can also assist to enhance the design of a warehouse. A safer and more effective warehouse may result from this.
- Traffic flow: By locating and removing bottlenecks, enhancing the design of the aisles, and facilitating staff movement, kaizen events can assist to enhance traffic flow in a warehouse. A more effective and productive warehouse may result from this.

- Improved ground control: By finding and removing spills, enhancing illumination, and making the floor more slip-resistant, kaizen events can also assist to enhance the floor of a warehouse. A safer and more effective warehouse may result from this.

5.2.3.2.PDCA

The PDCA cycle can be used to improve warehouse problems that arise from warehouse design issue by following these steps:

- Plan: Listing the exact issues to be resolved. For instance, the intent could be to increase the safety of the warehouse floor, decrease the number of incidents, or improve the movement of materials through the warehouse.
- Do: Putting small, gradual improvements into place to solve the issues. For instance, reorganizing the storage bins, installing guardrails, or upgrading the lighting of the warehouse.
- Check: Gather data to assess the effects of the adjustments. For instance, it is possible to keep track of how long it takes to choose and pack orders, how many accidents occur, or how many people trip and fall.
- Act: Put into practice the modifications that worked, and keep an eye on the outcomes. Return to the Plan stage and make adjustments to the plan if the changes weren't successful.

The PDCA cycle is a cyclical procedure, therefore it is necessary to keep going through the four steps until the desired outcome is achieved.

5.2.3.3.Technology

Technology has a significant impact on improving problems of warehouse design.

- Layout: By providing real-time data on the location of items, the flow of materials, and the utilization of space, technology can aid in improving warehouse layout. This information can be used to pinpoint areas where the layout needs to be changed in order to increase productivity and efficiency. This can be sued by utilizing RFID Tags for products.
- Design: Technology may also assist in improving warehouse design by offering insights into the most effective ways to store goods, transfer supplies, and ensure worker safety. Designing warehouses that are more productive, safe, and efficient can be done using this

data. Warehouse management system (WMS) can be used to optimize the flow of materials in a warehouse.

- Overcrowd: By giving real-time information on the whereabouts of staff members and equipment, technology can help to improve warehouse traffic. This information can be used to locate regions with heavy traffic and to put improvement measures in place. Technologies such as real-time location systems (RTLS) can be utilized to track the location of employees and equipment in the warehouse.
- Warehouse ground: Technology can also help warehouse grounds by giving information about their state, the likelihood of slips and falls, and the best methods for maintaining and cleaning them. By using this information, warehouse floors can be made safer and accident risk can be decreased. Floor sensor system can be used to track the condition of warehouse ground and identify areas where the floor needed to be repaired or replaced.

5.2.3.4.5S

The 5S can be used to improve warehouse problems that arise from warehouse design.

- Enhance the flow of goods through the warehouse: The 5S methodology can assist in enhancing the flow of materials through the warehouse by removing extraneous things and organizing the remaining products in a logical and effective manner. A more effective and productive warehouse may result from this.
- Reduce accidents: The 5S methodology can assist in reducing accidents by cleaning and maintaining the warehouse to keep it organized and clutter-free. This is so that tripping hazards and other safety dangers are less likely to exist in a neat and ordered warehouse. Thus, decreasing delay in warehouse operations.
- The 5S methodology can assist in enhancing the safety of warehouse floors by developing and putting into place guidelines for how the warehouse is set up and kept up. This is due to standards' ability to guarantee that the warehouse floor is tidy, clutter-free, and well-maintained. It thus decreases bottlenecks in the warehousing process caused by issues that come from, for instance, damaged floors that halt the use of material handling equipment or overcrowding of a specific warehouse ground due to other parts of the warehouse being dangerous or hazardous.

By following the five steps of the 5S methodology, warehouses can become more efficient, safer, and more productive.

5.2.4. Effects of Continuous Improvement Management Lean Tools in Solving Human Capital

5.2.4.1. Management Style

Numerous options exist for management style to address human capital issues in warehousing. Some of the more significant ways are listed below:

- By fostering a positive workplace culture: A supportive, valued, and respectful work environment is one where employees feel valued and supported. This may result in higher output, lower attrition, and higher morale.
- By giving precise and clear instructions: In order for an employee to succeed, they need to understand what is expected of them. Instructions that are clear and to the point can lessen confusion and mistakes.
- By offering employees opportunities for training and development, employers can aid workers in honing their abilities and expanding their knowledge. This may result in higher output, lower attrition, and higher morale.
- By giving employees the chance to offer feedback: In order to improve the working environment, employees need to be allowed to do so. This can assist in locating and solving issues before they worsen.
- By being fair and consistent: In order for employees to feel valued and respected, they must be treated properly and consistently. This can lead to increased productivity, decreased turnover, and improved morale.

5.2.4.2. Employee Involvement

As established in the former chapters, employee involvement is a management philosophy that encourages employees to participate in decision-making and problem-solving. It can be utilized to solve human capital issues in warehousing in various ways:

- Productivity gains: Employees are more likely to feel invested in the outcome when they participate in decision-making. Employees are more likely to work hard to reach the goals they helped define, which can result in higher productivity and less mistake.

- Reduced turnover: Workers are less likely to quit their positions when they feel like they are a valuable member of the team. Companies may save money on hiring and training expenses as a result of this as well as suffer the consequences of the waiting time needed to adapt a new employee into the existing process.
- Increased morale: Employees are more likely to be content with their jobs when they feel that their opinions are appreciated and that their efforts are heard. As a result, morale may rise, which may have a number of positive effects on the business, including higher output and decreased absenteeism.

Employee involvement is a strong instrument that may be utilized to tackle warehousing's human capital issues and enhance the warehouse's overall performance.

5.2.4.3.Teamwork and Empowerment

Two key ideas that can be used to address human capital issues in warehousing are empowerment and teamwork.

- Teamwork can be utilized to enhance communication, collaboration, and problem-solving in a warehouse environment. This may result in higher output, fewer mistakes, and enhanced security. Examples include creating a cross-functional teams of employees who work together to solve problems or creating a system for tracking the progress of work orders in order to improve coordination.
- Empowerment may boost staff morale, motivation, and productivity in a warehouse environment. This may result in a staff that is more motivated and effective. Examples include, improving employee morale by creating a system for recognizing employee achievements or creating a system for providing feedback to employees.

A given warehouse may foster a more collaborative and empowered workplace that can enhance the operation of the warehouse overall and assist in resolving human capital issues in warehousing.

5.2.4.4.TPM

Total productive maintenance (TPM) is a maintenance philosophy that focuses on preventing equipment failures and breakdowns. It can solve human capital issues:

- By decreasing downtime: Employees don't have to spend time fixing or replacing equipment that isn't malfunctioning. Employees may be able to concentrate on other responsibilities, such choosing and packing orders, as a result of this. As a result, staff will be more able to concentrate on their tasks without having to worry about equipment breakdowns, which may result in fewer errors when counting inventory.

- By boosting productivity: Employees can work more effectively when the machinery is functioning properly. Because there will be less time for human error, this could result in higher productivity and output, which could lower inventory count errors.
- Through enhancing safety: When equipment is well-maintained, accidents are less likely to occur. This may contribute to making the workplace safer for workers, which may result in fewer errors in inventory counts since workers are less likely to suffer an injury and be unable to work.
- By cutting maintenance costs: Equipment maintenance is less expensive when it isn't breaking down. This can help businesses save money on maintenance expenses, which they can then invest in the warehouse's other areas, such employee training to lower inventory count errors.

5.2.5. Effects of Continuous Improvement Management Lean Tools in Solving Standardization

5.2.5.1. Supplier Involvement

Participating suppliers can assist in a number of ways to address quality and safety issues in warehousing.

- By offering feedback: Suppliers can offer feedback on the caliber of the machinery they offer. This feedback can assist in locating potential equipment issues before they result in breakdowns.
- By offering instruction: Vendors can offer instruction on how to utilize the device correctly. By lowering the possibility of human error, which can cause equipment failure, this training can help.
- By offering maintenance: Suppliers are able to offer maintenance services for the machinery. This upkeep can lower the likelihood of breakdowns and keep the equipment in good working order.

- By cooperating: To find and fix issues with the equipment, suppliers and warehouse managers can cooperate. This cooperation can aid in identifying solutions that benefit both parties and stop failures in the future.

5.2.5.2.Statistical Process Control (SPC)

As established prior to this chapter Statistical Process Control (SPC) is a methodology that uses statistical techniques to monitor and control processes. It can be applied in a variety of ways to address issues with quality and safety standards.

• Problem detection: SPC can be used to find process issues before they result in failures. This is accomplished by gathering information on the procedure and searching for patterns or trends that suggest that the procedure is out of control.

- Failure prevention: SPC can be used to stop failures by taking remedial action as soon as issues are found. The procedure may need to be modified, or the manner the process is run may need to be altered.
- Enhancing quality: SPC can be used to enhance quality by reducing process variance. This can be accomplished by locating and removing the sources of variation.
- SPC can be used to identify and get rid of dangers, hence ensuring safety. This can be accomplished by gathering information about the procedure and searching for patterns or trends that point to a process's lack of safety.

SPC can be used to monitor the performance of the equipment in order to identify variation it causes during a given process, to identify the problems it has and to prevent failure. Safety can be improved via SPC by monitoring the number of accidents in the warehouse and identifying the trends or patterns that imply that the warehouse is not safe.

5.2.5.3.Quality at the Source (QAS)

Quality at the source (QAS) places an emphasis on making sure that equipment is of excellent quality before it is used in a warehouse. Contrary to the conventional method, which involves checking for flaws in the equipment after it has been installed in the warehouse.

- By preventing defects: QAS can aid in the prevention of faults by making sure that equipment is of a high caliber prior to use. This can be accomplished in a number of ways, including checking the equipment for flaws before shipping it to the warehouse, testing the equipment to make sure it fulfills specifications, and training staff members on how to use the equipment safely.

- By enhancing quality: QAS can contribute to enhancing quality by lowering the incidence of faults. This may result in greater customer satisfaction and lower expenses for warranty and recall repairs.
- By guaranteeing safety: QAS can contribute to guaranteeing safety by making sure that the equipment is safe to use. Several methods can be used to do this, including: Recognizing and removing equipment-related dangers, employing safety protocols and training staff on how to utilize equipment properly.

5.2.5.4.Jidoka

Jidoka can be applied in a variety of ways to address issues with quality and safety standards.

- By preventing defects: Jidoka can help to prevent defects or breakdowns from occurring by stopping the warehousing process immediately when a defect is detected. This allows the defect to be corrected immediately, preventing it from causing further problems. This can help to improve quality standards in the warehouse by ensuring that equipment meet the required specifications. For instance, reduction of equipment failures can be achieved by using Jidoka to install sensors on equipment that can detect defects.
- By improving quality: Jidoka can help to improve quality by reducing the number of defects that occur. This can lead to improved customer satisfaction and reduced costs associated with recalls and warranty repairs. This can help to improve quality standards in the warehouse by ensuring that equipment meet the required specifications and are free from defects. Example include, using Jidoka to train employees to stop the warehouse process when they see a defect.
- By ensuring safety: Jidoka can help to ensure safety by stopping the warehousing activity immediately when a safety hazard is detected. This prevents accidents from happening, which can save lives and reduce injuries. This can help to improve safety standards in the warehouse by ensuring that employees are working in a safe environment. For illustration, it is possible to use Jidoka to install sensors on equipment that can detect safety hazards.

5.3. Conclusions

The objective of this research was identifying a lean warehousing model that can improve warehousing at the case company National Oil Ethiopia PLC. The results showed that the application of three lean management techniques that involve continuous improvement, Quality and Human Resource could be empirical to solve the warehousing problems by reducing wastes throughout each warehousing activities. The model developed is easy and can be utilized to improve for each warehouse KPIs, as the stated problems were analyzed based on the key warehouse performance metrics indicators proposed by various researchers, the effective utilization of this model will help improve these indicators. Based on the discussions and analysis made in the Chapters 2, 3 and 4 of this thesis the main research questions can all be answered. Throughout this research, the current warehousing process of the case company were explained and assed and lean tools were identified that can be applied to a distribution warehouse. Therefore, it can be said that this research has fulfilled objective.

5.4. Recommendations

Based on the findings and conclusion of this research, analysis on the application of the aforementioned model could be lead to a vivid presentation of effects of warehouse improvement. The study should be continued by amalgamating other improvement methods such as Six Sigma to get a better and improved warehousing model. Further research on the below points could be instrumental to achieve a lean distribution warehouse:

- Research that focuses on which and when lean tools are supposed to be used
- Research on the warehousing of other distribution warehouses
- Research on the relationship of different lean tools to address problems in a warehouse

Chapter 6: References

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Chapter 7: Annex

7.1. Questionnaire

Dear respondents,

My name is Abraham Negash; and I am working towards my Degree of Masters of Science in Industrial Engineering Stream. I am interested to conduct my research on your esteemed Company for the partial fulfillment of the requirements for my Thesis.

The information you are providing me will be used only for the academic purpose and will be treated with utmost confidentiality. Your participation and assistance with this regard is highly appreciated.

7.1.1. First Step Data Collection Questionnaire

1. What is your name and affiliation with NOC?
2. Do you think that the warehouse is safe from hazards for employees and customers?

Yes	
Yes, but needs improvement	
No	

3. Which areas of the warehouse are hazardous?

Vehicle Pathways	
Indoor Lube Storage Buildings	
Outdoor Drum Sheds	
Outdoor Drum Storage	
Entrance	
All	

4. Does injury occur to employees or customers?

Yes	
No	

If Yes, which ones?

Injury	Scale (1 – Not Much…5 – Very Often)				
	1	2	3	4	5
Injury from Slip or Trip					
Injury from Manual Handling					
Injury from fall from height					

Injury from hitting something fixed or stationary					
Injury from moving vehicle					
Injury from fire					
Injury from machine malfunction					
Others (Please specify)					

5. Are there Safety Signs in the Warehouse?

Yes	
Yes, but needs improvement	
No	

6. Is there an Assembly point in case of fire?

Yes	
No	

7. Is there fire extinguishing equipment readily available in the warehouse?

Yes	
No	

If yes, are they adequate?

Yes	
No	

8. Are there first aid kits readily available in the warehouse?

Yes	
No	

If yes, are they adequate?

Yes	
No	

9. Is there a paramedic team available for help?

Yes	
No	

10. Is there an employee that has training on first aid treatment?

Yes	
No	

11. Are employees subjected to wear personal protective equipment?

Yes	
No	

If yes, which ones?

Hard Hats	
Safety Boots	
High Visibility Clothing	
Overalls	
Safety Goggles	
Safety Gloves	
Respirators	
Others (please specify)	

12. Is safety training available for employees?

Yes	
No	

13. Are corridors or alleyways for transporting goods wide enough to allow material handling equipment or employees?

Yes	
No	

14. Are safety inspections carried out for the warehouse?

Yes	
No	

If yes, how often? (Please specify) ____________________________

15. What are the main causes of product damage?

Causes	Scale (1 – Not Much…5 – Very Often)				
	1	2	3	4	5
Poor product handling					
Improper storage					
Dirty Work Space					
Impact					
Delivery Problem					
Dust					
Moisture					
Humidity					
Light					
Others (Please specify)					

16. Is product handling training given to employees?

Yes	
No	

If yes, how often? (Please specify) ___________________________

17. Does the company employ material handling technology?

Yes	
Yes, but needs improvement	
No	

18. Are lubricants stored on storage racks?

Yes	
No	

19. Are sheds available for outdoor storage?

Yes	

Yes, but needs improvement	
No	

20. Is there a designated space for damaged products?

Yes	
No	

21. Is the warehouse space utilized appropriately?

Yes	
Yes, but needs improvement	
No	

22. Is there available space for warehouse expansion?

Yes	
No	

23. Is the product storing and product handling equipment well maintained?

Yes	
Yes, but needs improvement	
No	

24. Is there a maintenance team dedicated for the warehouse?

Yes	
No	

If Yes, are they qualified?

Yes	
No	

25. Does the company employ a modern warehousing software?

Yes	
Yes, but needs improvement	
No, it needs improvement	

26. Is the inventory count stated on the software and actual inventory count always similar?

Yes	
No	

27. Are products attested with regards to bill of loading during product receiving?

Yes	
No	

If Yes, please specify how?

Manually	
Using Software	

28. Is there a designated area for each product?

Yes	
No	

29. What is the basis for product storage within the warehouse?

Product Size	
Product Type	
Product Demand	
Space Availability	
Product Quantity	
No Specific Method	

30. Is the warehouse condition inspected?

Yes	
No	

If Yes, how often? Please specify __________

31. How often is inventory count carried out?

Daily	
Weekly	

Monthly	
Every 3 Months	
Every 6 Months	
Every 9 Months	
Every Year	

32. What is the attitude of the workers in the warehouse?

Positive	
Indifferent	
Negative	

33. Are the available workers in the warehouse adequate?

Yes	
No	

34. Is a quality standard set by the company for warehouse operations?

Yes	
Yes, but needs improvement	
No	

35. Is there a reliability standard set by the company for warehouse equipment?

Yes	
Yes, but needs improvement	
No	

36. Are products attested with regards to order invoices during product shipment?

Yes	
No	

If Yes, please specify how?

Manually	
Automated	

37. Are products strapped to truck during shipping?

Yes	
No	

If Yes, please specify how?

Manually	
Automated	

38. Are products strapped to truck during storage?

Yes	
No	

If Yes, please specify how?

Manually	
Automated	

39. Are products attested with regards to order invoices during order picking?

Yes	
No	

If Yes, please specify how?

Manually	
Automated	

40. How is order picking done?

Manually	
Automated	

41. Can product receiving and shipping be done at the same time?

Yes	
No	

42. Are there specifically designated workers to manage product receiving?

Yes	
No	

43. Are there specifically designated workers to manage product storage?

Yes	
No	

44. Are there specifically designated workers to manage order picking?

Yes	
No	

45. Are there specifically designated workers to manage product shipping?

Yes	
No	

46. Are there safety officers within the warehouse?

Yes	
No	

47. Is the location of products updated to the system the company employs?

Yes	
No	

48. Are the aisles in the warehouse wide enough to ensure free mobility?

Yes	
No	

49. Are there product storage guidelines set by the company?

Yes	
No	

50. Is there a specifically designated area for product loading?

Yes	

No	

51. Is there a specifically designated area for product receiving?

Yes	
No	

52. Are products loaded for shipping attested with regards to the picked orders?

Yes	
No	

If Yes, please specify how?

Manually	
Automated	

7.1.2. Second Step Data Collection Questionnaire

Key for Likert Scale	
SDA (1)	Strongly Disagree
DA (2)	Disagree
N (3)	Neutral
A (4)	Agree
SA (5)	Strongly Agree

7.1.2.1. Questionnaire for Damage of Property

a) What is your name and affiliation with NOC

	Questions	Response
DOP1	**Are products damaged due to Poor Warehouse layout design?**	
DOP2	**Are products damaged due to Overcrowded warehouse ground?**	
DOP3	**Are products damaged due to Poor warehouse ground control?**	
DOP4	**Are products damaged due to Poor product Tool & storage designation?**	
DOP5	**Are products damaged due to Lack of optimized strategy for storage?**	
DOP6	**Are products damaged due to Already occupied dock?**	

DOP7	**Are products damaged due to Lack of adequate personnel?**	
DOP8	**Are products damaged due to Lack of trained Personnel?**	
DOP9	**Are products damaged due to Human error?**	
DOP10	**Are products damaged due to Over burden of tasks on an employee or equipment?**	
DOP11	**Are products damaged due to Lack of motivators from the company for workers?**	
DOP12	**Are products damaged due to Lack of Quality Standard?**	
DOP13	**Are products damaged due to Lack of safety Standards?**	
DOP14	**Are products damaged due to Lack of adequate material handling equipment?**	
DOP15	**Are products damaged due to Lack of adequate PPEs for employees?**	
DOP16	**Are products damaged due to Information error?**	
DOP17	**Are products damaged due to Lack of technological equipment to catalyze the task?**	
DOP18	**Are products damaged due to Lack of maintenance personnel?**	
DOP19	**Are products damaged due to Lack of Paramedics?**	
DOP20	**Are products damaged due to Lack of safety training?**	
DOP21	**Are products damaged due to Lack of Material Handling Training?**	
DOP22	**Are products damaged due to Lack of product training?**	

7.1.2.2. Questionnaire for Warehouse Design

a) What is your name and affiliation with NOC

	Questions	**Response**
EF1	**Does Equipment Fail due to Poor Warehouse layout design?**	
EF2	**Does Equipment Fail due to Overcrowded warehouse ground?**	
EF3	**Does Equipment Fail due to Poor warehouse ground control?**	

EF4	**Does Equipment Fail due to Poor product Tool & storage designation?**	
EF5	**Does Equipment Fail due to Lack of optimized strategy for storage?**	
EF6	**Does Equipment Fail due to Already occupied dock?**	
EF7	**Does Equipment Fail due to Lack of adequate personnel?**	
EF8	**Does Equipment Fail due to Lack of trained Personnel?**	
EF9	**Does Equipment Fail due to Human error?**	
EF10	**Does Equipment Fail due to Over burden of tasks on an employee equipment?**	
EF11	**Does Equipment Fail due to Lack of motivators from the company for workers?**	
EF12	**Does Equipment Fail due to Lack of Quality Standard?**	
EF13	**Does Equipment Fail due to Lack of safety Standards?**	
EF14	**Does Equipment Fail due to Lack of adequate material handling equipment?**	
EF15	**Does Equipment Fail due to Lack of adequate PPEs for employees?**	
EF16	**Does Equipment Fail due to Information error?**	
EF17	**Does Equipment Fail due to Lack of technological equipment to catalyze the task?**	
EF18	**Does Equipment Fail due to Lack of maintenance personnel?**	
EF19	**Does Equipment Fail due to Lack of Paramedics?**	
EF20	**Does Equipment Fail due to Lack of safety training?**	
EF21	**Does Equipment Fail due to Lack of Material Handling Training?**	
EF22	**Does Equipment Fail due to Lack of product training?**	

7.1.2.3. Questionnaire for Insufficient Storage Space

a) What is your name and affiliation with NOC

	Questions	**Responses**
ISS1	**Is storage space shortage caused due to Poor Warehouse layout design?**	

ISS2	**Is storage space shortage caused due to Overcrowded warehouse ground?**	
ISS3	**Is storage space shortage caused due to Poor warehouse ground control?**	
ISS4	**Is storage space shortage caused due to Poor product Tool & storage designation?**	
ISS5	**Is storage space shortage caused due to Lack of optimized strategy for storage?**	
ISS6	**Is storage space shortage caused due to Already occupied dock?**	
ISS7	**Is storage space shortage caused due to Lack of adequate personnel?**	
ISS8	**Is storage space shortage caused due to Lack of trained Personnel?**	
ISS9	**Is storage space shortage caused due to Human error?**	
ISS10	**Is storage space shortage caused due to Over burden of tasks on an employee equipment?**	
ISS11	**Is storage space shortage caused due to Lack of motivators from the company for workers?**	
ISS12	**Is storage space shortage caused due to Lack of Quality Standard?**	
ISS13	**Is storage space shortage caused due to Lack of safety Standards?**	
ISS14	**Is storage space shortage caused due to Lack of adequate material handling equipment?**	
ISS15	**Is storage space shortage caused due to Lack of adequate PPEs for employees?**	
ISS16	**Is storage space shortage caused due to Information error?**	
ISS17	**Is storage space shortage caused due to Lack of technological equipment to catalyze the task?**	
ISS18	**Is storage space shortage caused due to Lack of maintenance personnel?**	
ISS19	**Is storage space shortage caused due to Lack of Paramedics?**	
ISS20	**Is storage space shortage caused due to Lack of safety training?**	
ISS21	**Is storage space shortage caused due to Lack of Material Handling Training?**	

ISS22	**Is storage space shortage caused due to Lack of product training?**	

7.1.2.4. Questionnaire for Inventory Count Mistake

a) What is your name and affiliation with NOC

	Questions	Responses
ICM1	**Is inventory Mistake caused due to Poor Warehouse layout design?**	
ICM2	**Is inventory Mistake caused due to Overcrowded warehouse ground?**	
ICM3	**Is inventory Mistake caused due to Poor warehouse ground control?**	
ICM4	**Is inventory Mistake caused due to Poor product Tool & storage designation?**	
ICM5	**Is inventory Mistake caused due to Lack of optimized strategy for storage?**	
ICM6	**Is inventory Mistake caused due to Already occupied dock?**	
ICM7	**Is inventory Mistake caused due to Lack of adequate personnel?**	
ICM8	**Is inventory Mistake caused due to Lack of trained Personnel?**	
ICM9	**Is inventory Mistake caused due to Human error?**	
ICM10	**Is inventory Mistake caused due to Over burden of tasks on an employee equipment?**	
ICM11	**Is inventory Mistake caused due to Lack of motivators from the company for workers?**	
ICM12	**Is inventory Mistake caused due to Lack of Quality Standard?**	
ICM13	**Is inventory Mistake caused due to Lack of safety Standards?**	
ICM14	**Is inventory Mistake caused due to Lack of adequate material handling equipment?**	
ICM15	**Is inventory Mistake caused due to Lack of adequate PPEs for employees?**	
ICM16	**Is inventory Mistake caused due to Information error?**	

ICM17	**Is inventory Mistake caused due to Lack of technological equipment to catalyze the task?**	
ICM18	**Is inventory Mistake caused due to Lack of maintenance personnel?**	
ICM19	**Is inventory Mistake caused due to Lack of Paramedics?**	
ICM20	**Is inventory Mistake caused due to Lack of safety training?**	
ICM21	**Is inventory Mistake caused due to Lack of Material Handling Training?**	
ICM22	**Is inventory Mistake caused due to Lack of product training?**	

7.1.2.5. Questionnaire for Late Delivery

a) What is your name and affiliation with NOC

	Questions	**Responses**
LD1	**Are products delivered late due to Poor Warehouse layout design?**	
LD2	**Are products delivered late due to Overcrowded warehouse ground?**	
LD3	**Are products delivered late due to Poor warehouse ground control?**	
LD4	**Are products delivered late due to Poor product Tool & storage designation?**	
LD5	**Are products delivered late due to Lack of optimized strategy for storage?**	
LD6	**Are products delivered late due to Already occupied dock?**	
LD7	**Are products delivered late due to Lack of adequate personnel?**	
LD8	**Are products delivered late due to Lack of trained Personnel?**	
LD9	**Are products delivered late due to Human error?**	
LD10	**Are products delivered late due to Over burden of tasks on an employee equipment?**	
LD11	**Are products delivered late due to Lack of motivators from the company for workers?**	

LD12	**Are products delivered late due to Lack of Quality Standard?**	
LD13	**Are products delivered late due to Lack of safety Standards?**	
LD14	**Are products delivered late due to Lack of adequate material handling equipment?**	
LD15	**Are products delivered late due to Lack of adequate PPEs for employees?**	
LD16	**Are products delivered late due to Information error?**	
LD17	**Are products delivered late due to Lack of technological equipment to catalyze the task?**	
LD18	**Are products delivered late due to Lack of maintenance personnel?**	
LD19	**Are products delivered late due to Lack of Paramedics?**	
LD20	**Are products delivered late due to Lack of safety training?**	
LD21	**Are products delivered late due to Lack of Material Handling Training?**	
LD22	**Are products delivered late due to Lack of product training?**	

7.1.2.6. Questionnaire for Safety of Employees

a) What is your name and affiliation with NOC

	Questions	**Response**
SoE1	**Is the safety of employees jeopardized due to Poor Warehouse layout design?**	
SoE2	**Is the safety of employees jeopardized due to Overcrowded warehouse ground?**	
SoE3	**Is the safety of employees jeopardized due to Poor warehouse ground control?**	
SoE4	**Is the safety of employees jeopardized due to Poor product Tool & storage designation?**	
SoE5	**Is the safety of employees jeopardized due to Lack of optimized strategy for storage?**	
SoE6	**Is the safety of employees jeopardized due to Already occupied dock?**	

SoE7	**Is the safety of employees jeopardized due to Lack of adequate personnel?**	
SoE8	**Is the safety of employees jeopardized due to Lack of trained Personnel?**	
SoE9	**Is the safety of employees jeopardized due to Human error?**	
SoE10	**Is the safety of employees jeopardized due to Over burden of tasks on an employee equipment?**	
SoE11	**Is the safety of employees jeopardized due to Lack of motivators from the company for workers?**	
SoE12	**Is the safety of employees jeopardized due to Lack of Quality Standard?**	
SoE13	**Is the safety of employees jeopardized due to Lack of safety Standards?**	
SoE14	**Is the safety of employees jeopardized due to Lack of adequate material handling equipment?**	
SoE15	**Is the safety of employees jeopardized due to Lack of adequate PPEs for employees?**	
SoE16	**Is the safety of employees jeopardized due to Information error?**	
SoE17	**Is the safety of employees jeopardized due to Lack of technological equipment to catalyze the task?**	
SoE18	**Is the safety of employees jeopardized due to Lack of maintenance personnel?**	
SoE19	**Is the safety of employees jeopardized due to Lack of Paramedics?**	
SoE20	**Is the safety of employees jeopardized due to Lack of safety training?**	
SoE21	**Is the safety of employees jeopardized due to Lack of Material Handling Training?**	
SoE22	**Is the safety of employees jeopardized due to Lack of product training?**	

7.1.3. Third Step Data Collection Questionnaire

Key for Likert Scale	
SDA (1)	Strongly Disagree
DA (2)	Disagree
N (3)	Neutral
A (4)	Agree

SA (5)	Strongly Agree

7.1.3.1. Questionnaire for Existing Human Resource

a) What is your name and affiliation with NOC

	Which lean tool can have an impact on Existing Human Resource within the warehouse	Response
EHR1	A3 Reports	
EHR2	VSM	
EHR3	Systems View	
EHR4	KPI Boards	
EHR5	Standardized Work	
EHR6	Management Style	
EHR7	Employee Involvement	
EHR8	Teamwork and Empowerment	
EHR9	TPM	
EHR10	Kaizen Events	
EHR11	PDCA	
EHR12	Technology	
EHR13	5S	
EHR14	Customer Involvement	
EHR15	Kanban	
EHR16	Layout and Zones	
EHR17	ABC Tools	
EHR18	Supplier Involvement	
EHR19	SPC	
EHR20	Quality at the Source	
EHR21	Jidoka	
EHR22	Optimized Picking Plan	
EHR23	Cross Docking	
EHR24	Heijunka	

7.1.3.2. Questionnaire for Standardization

a) What is your name and affiliation with NOC

	Can Standardization be achieved by	Response
ST1	A3 Reports	
ST2	VSM	

ST3	Systems View	
ST4	KPI Boards	
ST5	Standardized Work	
ST6	Management Style	
ST7	Employee Involvement	
ST8	Teamwork and Empowerment	
ST9	TPM	
ST10	Kaizen Events	
ST11	PDCA	
ST12	Technology	
ST13	5S	
ST14	Customer Involvement	
ST15	Kanban	
ST16	Layout and Zones	
ST17	ABC Tools	
ST18	Supplier Involvement	
ST19	SPC	
ST20	Quality at the Source	
ST21	Jidoka	
ST22	Optimized Picking Plan	
ST23	Cross Docking	
ST24	Heijunka	

7.1.3.3. Questionnaire for Storage System

a) What is your name and affiliation with NOC

	Can Storage System Improvement be achieved by	**Response**
SS1	A3 Reports	
SS2	VSM	
SS3	Systems View	
SS4	KPI Boards	
SS5	Standardized Work	
SS6	Management Style	
SS7	Employee Involvement	
SS8	Teamwork and Empowerment	
SS9	TPM	
SS10	Kaizen Events	
SS11	PDCA	

SS12	Technology	
SS13	5S	
SS14	Customer Involvement	
SS15	Kanban	
SS16	Layout and Zones	
SS17	ABC Tools	
SS18	Supplier Involvement	
SS19	SPC	
SS20	Quality at the Source	
SS21	Jidoka	
SS22	Optimized Picking Plan	
SS23	Cross Docking	
SS24	Heijunka	

7.1.3.4. Questionnaire for Training

b) What is your name and affiliation with NOC

	Which lean tool can have an impact on Training within the warehouse	**Response**
TR1	A3 Reports	
TR2	VSM	
TR3	Systems View	
TR4	KPI Boards	
TR5	Standardized Work	
TR6	Management Style	
TR7	Employee Involvement	
TR8	Teamwork and Empowerment	
TR9	TPM	
TR10	Kaizen Events	
TR11	PDCA	
TR12	Technology	
TR13	5S	
TR14	Customer Involvement	
TR15	Kanban	
TR16	Layout and Zones	
TR17	ABC Tools	
TR18	Supplier Involvement	
TR19	SPC	
TR20	Quality at the Source	

TR21	Jidoka	
TR22	Optimized Picking Plan	
TR23	Cross Docking	
TR24	Heijunka	

7.1.3.5. Questionnaire for Warehouse Design

a) What is your name and affiliation with NOC

	Can Warehouse Design Improvement be achieved by	**Response**
WD1	A3 Reports	
WD2	VSM	
WD3	Systems View	
WD4	KPI Boards	
WD5	Standardized Work	
WD6	Management Style	
WD7	Employee Involvement	
WD8	Teamwork and Empowerment	
WD9	TPM	
WD10	Kaizen Events	
WD11	PDCA	
WD12	Technology	
WD13	5S	
WD14	Customer Involvement	
WD15	Kanban	
WD16	Layout and Zones	
WD17	ABC Tools	
WD18	Supplier Involvement	
WD19	SPC	
WD20	Quality at the Source	
WD21	Jidoka	
WD22	Optimized Picking Plan	
WD23	Cross Docking	
WD24	Heijunka	

7.2. Interview Questions

7.2.1. Interview Questions for Warehouse Manager

- Are their enough warehouse employees to address the current workload at NOC?

- What type of warehousing technology does the company employ?
- What do you think is the major reason for loading and unloading delay?
- Does the warehouse have designated spaces for fast moving items, slow moving items, and drums?
- How many people handle the task of product count and inspection during loading and unloading?
- Is inventory count carried out? If yes, how often?
- How do you manage staffing needs during heavier than normal activity?
- How many people do you manage and their positions?
- Is there a maintenance team dedicated for the maintenance of the warehouse facility? If yes, what type of maintenances are carried out by the team?
- Is there a room for expansion within the vicinity of the compound?
- What happens to the shipping pallets?
- What is your method of sorting and storing inventories?
- Are there safety policies and regulations? If yes, is there a process for employees to adhere with these policies and regulations?
- What is the reason for mishandling of orders during loading?
- Is there a standard deadline for product receiving, storage, picking and shipping?

7.2.2. Interview Questions for Operations Manager

- What is the management style of the company with regards to warehousing?
- How do you monitor the performance of the warehouse employees?
- Are product, product handling and safety trainings given to employees? If yes, in what capacity? If no, why not?
- Are there any plans with regards to the expansion of the warehouse facility at NOC? If yes, in what capacity? If no, why not?
- What type of information management system does the company employ?
- How would you describe the communication between the employees in the warehouse and other department?
- Is there a schedule for loading and unloading? If yes, what is the schedule? If no, what type of system is used to manage it?

- Is there a quality and reliability standard set by the company for the warehouse? If yes, please specify the type. If no, why not?

7.3. Root Cause for Waste Tables

7.3.1. Waste of Defect

Waste Type	When?	What?	Where?	Who?	Why?
Waste of Defect	Receiving	Wrong products received, Damaged products received, Undelivered products being overlooked, Injury from Slip or Trip, Injury from manual handling, Injury from machine malfunction, Injury from hitting something Stationary	Warehouse Entry/Exit Point Warehouse Grounds and Warehouse Buildings	Product receiver Laborers Truck Drivers	• Lack of trained Personnel • Over burden of tasks on an employee • Poor warehouse ground control • Human Error • Information Error • Lack of safety Standards • Lack of safety training • Lack of adequate PPEs for employees • Lack of maintenance Personnel • Lack of Quality Standard for warehouse • Poor warehouse layout design
	Storage	Damage of products from falling, Damage of product from product handling, Damage of product, Damage of product from dirt, Damage from humidity, Damage from temperature, Injury from Slip or Trip, Injury from manual handling, Injury from machine malfunction, Injury from hitting something Stationary	Warehouse Grounds and Warehouse Buildings	Product Storage Personnel Product Carrying Labor	• Poor warehouse ground control • Poor warehouse layout design • Lack of safety Standards • Lack of safety training • Lack of adequate PPEs for employees • Poor product storage designation
	Order Picking	Damage of products from falling, Damage of product from product handling, Damage of product, Damage of product from dirt, Damage from humidity, Damage from temperature, Injury from Slip or Trip, Injury from manual handling, Injury from machine malfunction, Injury from hitting something Stationary	Warehouse Grounds and Warehouse Buildings	Order Picking Personnel Product Carrying Labor	• Poor warehouse ground control • Poor warehouse layout design • Lack of safety Standards • Lack of safety training • Lack of adequate PPEs for employees • Poor product storage designation
	Shipping	Wrong products Delivered, Damaged products Delivered, Products to be delivered being overlooked, Injury from Slip or Trip, Injury from manual handling, Injury from machine malfunction, Injury from hitting something Stationary	Warehouse Entry/Exit Point Warehouse Grounds and Warehouse Buildings	Product Shipping Personnel Laborers Truck Drivers	• Lack of trained Personnel • Over burden of tasks on an employee • Poor warehouse ground control • Human Error • Information Error • Lack of safety Standards • Lack of safety training • Lack of adequate PPEs for employees • Lack of maintenance Personnel • Lack of Quality Standard for warehouse

					• Poor warehouse layout design

7.3.2. Waste of Motion

Waste Type	When?	What?	Where?	Who?	Why?
Waste of Motion	Receiving	Walking around by the warehouse staff to search and find the equipment and tools used in the receiving process. Walking around by workers to find empty spaces for placing the unloaded items Walking around back and forth to attest and count received products long travel from product storage location to delivery truck Driving around warehouse ground to find appropriate location for product unloading	Warehouse Entry/Exit Point Warehouse Grounds and Warehouse Buildings	Product receiver Product Carrying Labor Delivery Truck Driver	• Poor design of warehouse layout • Poor product and tool storage designation • Lack of technological equipment to catalyze the task • Information error • Lack of Quality Standard • Lack of adequate personnel • Human error
	Storage	Walking around by the warehouse to find empty spaces for placing the unloaded items	Warehouse Grounds and Warehouse Buildings	Product Storage Personnel Product Carrying Labor	• Poor product and tool storage designation • Information error • Human error • Lack of adequate personnel • Poor design of warehouse layout
	Order Picking	Walking around by the warehouse to find products to be loaded for orders	Warehouse Grounds and Warehouse Buildings	Order Picking Presonnel Product Carrying Labor	• Poor product storage designation • Information error • Human error

	Shipping	Walking around by the warehouse staff to search and find the equipment and tools used in the shipping process. Walking around back and forth to attest and count products to be shipped long travel from product storage location to delivery truck Driving around warehouse ground to find appropriate location for product shipping	Warehouse Entry/Exit Point Warehouse Grounds and Warehouse Buildings	Product Shipping Personnel Product Carrying Labor Delivery Truck Driver	• Poor design of warehouse layout • Poor product and tool storage designation • Lack of technological equipment to catalyze the task • Information error • Human error • Lack of adequate personnel

7.3.3. Waste of Inventories

Waste Type	When?	What?	Where?	Who?	Why?
Waste of Inventories	Receiving	Accumulated pallets and items to be received Accumulated damaged products Injury from slip are falling pallet	Warehouse Entry/Exit Point Warehouse Grounds and Warehouse Buildings	Product receiver Operation Manager	• Poor warehouse layout design • Poor warehouse ground control • Lack of safety Standards • Lack of safety training • Lack of adequate PPEs for employees
	Storage	Too many days in hand for products Unusable pallets suffocate storage space Damaged Products case space suffocation	Warehouse Grounds and Warehouse Buildings	Product Storage Presonnel Operation Manager	• Lack of Quality Standard • Lack of optimized strategy for storage • Poor warehouse ground control • Poor warehouse layout design
	Order Picking	Damaged products become bottleneck for order picking process as they are scatterd all over the warehouse Unusable pallets become bottleneck for order picking process as they are scatterd all over the warehouse	Warehouse Grounds and Warehouse Buildings	Order Picking Presonnel Operation Manager	• Lack of Quality Standard • Lack of optimized strategy for storage • Poor warehouse ground control • Poor warehouse layout design

	Shipping	Damaged products become bottleneck for Shipping process as they are scatterd all over the warehouse Unusable pallets become bottleneck for shipping process as they are scatterd all over the warehouse Accumulated items to be shipped	Warehouse Entry/Exit Point Warehouse Grounds and Warehouse Buildings	Product Shipping Personnel Operation Manager	• Lack of Quality Standard • Lack of optimized strategy for storage • Poor warehouse ground control • Poor warehouse layout design • Lack of optimized strategy for Shipping

7.3.4. Waste of Transport

Waste Type	When?	What?	Where?	Who?	Why?
Waste of Transport	Receiving	Long movement of, Delivery Truck to, Storage Location, Long movement of material handling equipment with product to Storage Location, Multiple trip (back and forth) for large batch receivables	Warehouse Entry/Exit Point Warehouse Grounds and Warehouse Buildings	Product receiver Product Carrying Labor Delivery Truck Driver	• Poor Warehouse layout design • Poor product storage designation • Lack of adequate personnel • Lack of adequate material handling equipment • Lack of Quality Standard • Poor warehouse ground control • Lack of optimized strategy for receiving • Overcrowded warehouse ground
	Storage	Movement of material handling equipment to storage location, Movement of laborers and material handling equipment in search of storage location, Multiple trip of laborers and material handling equipment for large batch storage	Warehouse Grounds and Warehouse Buildings	Product Storage Personnel Product Carrying Labor	• Poor Warehouse layout design • Poor product storage designation • Lack of adequate personnel • Lack of optimized strategy for storage • Lack of Quality Standard • Lack of adequate material handling equipment • Overcrowded warehouse ground

	Order Picking	Laborers and Material handling equipment moving around inventory to access stock	Warehouse Grounds and Warehouse Buildings	Order Picking Presonnel Product Carrying Labor	• Poor product storage designation • Lack of optimized strategy for order picking • Lack of Quality Standard
	Shipping	Long movement of Delivery Truck from Storage Location, Long turnaround time for vehicles/ trucks, Long movement of material handling equipment with product from Storage Location, Multiple trip (back and forth) for large batch orders	Warehouse Entry/Exit Point Warehouse Grounds and Warehouse Buildings	Product Shipping Personnel Product Carrying Labor Delivery Truck Driver	• Poor Warehouse layout design • Poor product storage designation • Lack of adequate personnel • Poor warehouse ground control • Lack of Quality Standard • Lack of optimized strategy for Shipping • Lack of adequate material handling equipment • Overcrowded warehouse ground

7.3.5. Waste of Waiting Time

Waste Type	When?	What?	Where?	Who?	Why?

Waste of Waiting Time	Receiving	Warehouse personnel waiting for other truck to finish loading products to be shipped in order to start receiving operation, Waiting for the maintenance of material handling equipment, Waiting for paramedic to help injured personnel, A truck with products waiting for other truck to finalize task in order to gain passage, A truck waiting for the product receiving personnel to finish other warehousing activity and start receiving operation, Other warehouse employees and product delivery truck waiting until the warehouse personnel in charge of receiving to finish product count and attestation of products with bill of loading, A warehouse personnel in charge of receiving waiting for material handling equipment and labor	Warehouse Entry/Exit Point	Product receiver Laborers Truck Drivers	• Already occupied dock • Already occupied personnel/Over burden of tasks on an employee • Lack of maintenance personnel • Lack of Paramedics • Poor warehouse layout design • Lack of safety standards • Lack of adequate personnel • Lack of Quality Standard • Lack of adequate material Handling Equipment • Lack of technological equipment to catalyze the task • Lack of safety personnel
	Storage	Product Storage Personnel waiting for material handling equipment and labor, Product Storage Personnel waiting for the laborers to find a suitable space for storage, Storage process to halted until the product storage personnel finishes other warehousing activities, Waiting for the maintenance of material handling equipment, Waiting for paramedic to help injured personnel	Warehouse Grounds and Warehouse Buildings	Product Storage Personnel Product Carrying Labor	• Already occupied dock • Already occupied personnel/Over burden of tasks on an employee • Lack of adequate material Handling Equipment • Lack of technological equipment to catalyze the task • Lack of maintenance personnel • Poor product storage designation • Lack of Quality Standard • Lack of safety standards • Lack of Paramedics • Lack of safety personnel

	Order Picking	Waiting until the invoice order is printed to start order picking process Waiting until the ordered product is found, Product Picking Personnel waiting for the laborers to find the ordered products, Order Picking process to be halted until the product storage personnel finishes other warehousing activities	Warehouse Grounds and Warehouse Buildings	Order Picking Personnel Product Carrying Labor	• Lack of technological equipment to catalyze the task • Poor product storage designation • Already occupied personnel/Over burden of tasks on an employee • Lack of Quality Standard
	Shipping	Warehouse personnel waiting for other truck to finish receiving process in order to start shipping operation, A truck with needed for shipping waiting for other truck to finalize task in order to gain passage, A truck waiting for the product shipping personnel to finish other warehousing activity and start receiving operation, Other warehouse employees and product delivery truck waiting until the warehouse personnel in charge of shipping to finish product count and attestation with order invoice, A warehouse personnel in charge of receiving waiting for material handling equipment and labor, Waiting for the maintenance of material handling equipment Waiting for paramedic to help injured personnel	Warehouse Entry/Exit Point	Product Shipping Personnel Laborers Truck Drivers	• Already occupied dock • Already occupied personnel/Over burden of tasks on an employee • Lack of maintenance personnel • Lack of Quality Standard • Lack of Paramedics • Poor warehouse layout design • Lack of safety standards • Lack of adequate personnel • Lack of adequate material Handling Equipment • Lack of technological equipment to catalyze the task • Lack of safety personnel

7.3.6. Waste of Over Processing

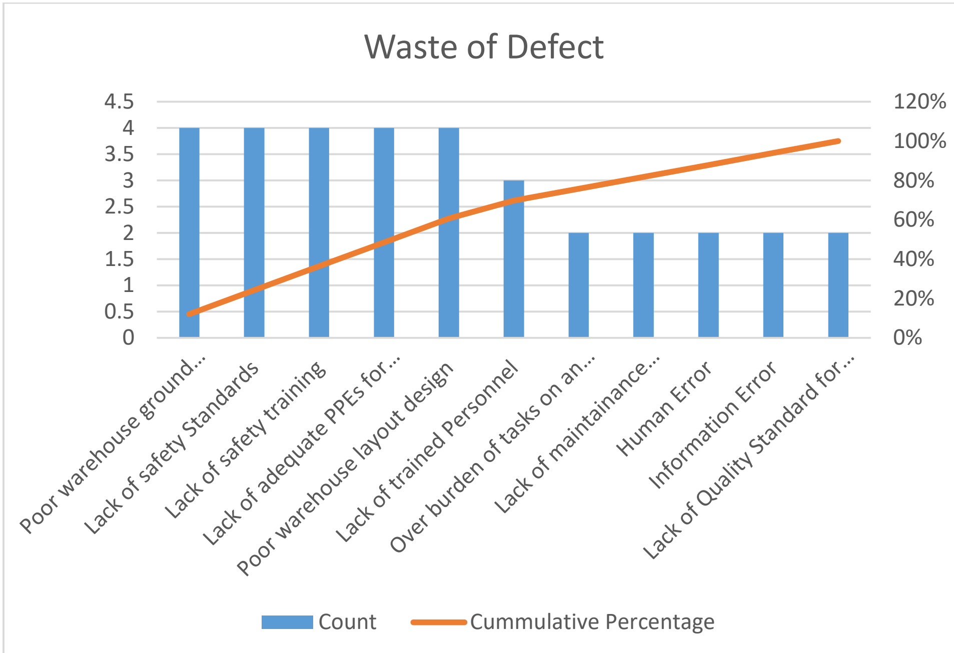
Waste Type	When?	What?	Where?	Who?	Why?
Waste of Over processing	Receiving	Checking the products with the bill of loading several times Counting product before and after receiving Unnecessary repeated checks for product quantity and quality	Warehouse Entry/Exit Point	Product receiver	• Lack of trained personnel • Lack of technological equipment to catalyze the task • Over burden of tasks on an employee • Information error • Human error • Lack of Quality Standard • Lack of adequate personnel
	Storage	Looking for space for product storage Checking the received inventory list with the products to be stored several times	Warehouse Grounds and Warehouse Buildings	Product Storage Personnel Product Carrying Labor	• Poor product storage designation • Lack of trained personnel • Lack of technological equipment to catalyze the task • Lack of Quality Standard • Information error • Human error
	Order Picking	Unnecessary repeated checks for product quantity and quality Looking where the product is stored	Warehouse Grounds and Warehouse Buildings	Order Picking Personnel Product Carrying Labor	• Poor product storage designation • Lack of trained personnel • Over burden of tasks on an employee • Lack of Quality Standard • Lack of technological equipment to catalyze the task • Information error • Human error
	Shipping	Checking the picked products with the order invoice several times Unnecessary repeated checks for product quantity and quality Counting product before and after shipping	Warehouse Entry/Exit Point Warehouse Grounds Warehouse Buildings	Product Shipping Personnel	• Lack of trained personnel • Lack of technological equipment to catalyze the task • Over burden of tasks on an employee • Lack of Quality Standard • Information error • Human error • Lack of adequate personnel

7.3.7. Waste of People

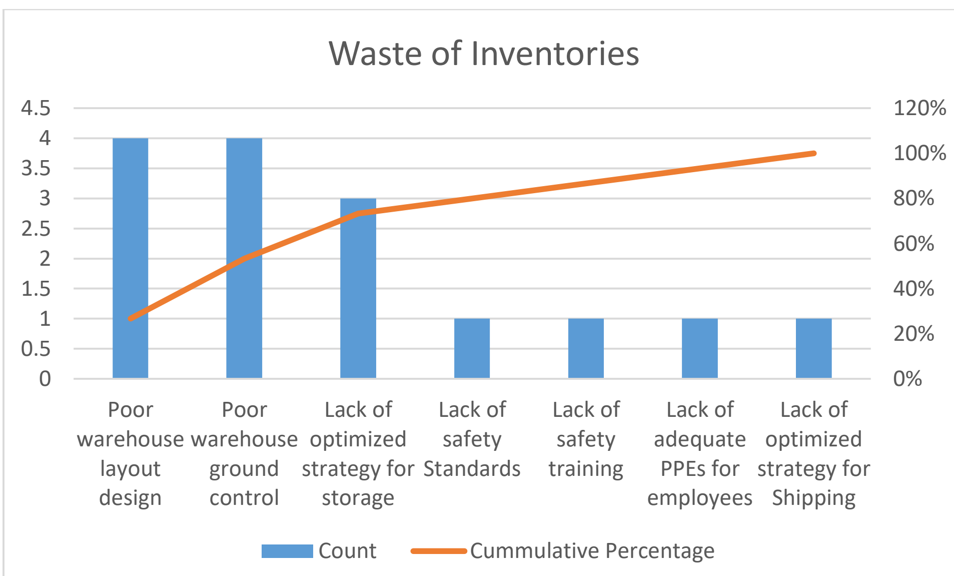
Waste Type	When?	What?	Where?	Who?	Why?
Waste of People	Receiving Storage Order Picking Shipping	Only three trained people available to undertake all activities within warehouse Periodic Product knowledge training is not given to existing or new employees Material handling training is not given to employees Safety Training is not given to employees Lack of adequate material handling maintenance and operation professional Dissatisfaction of workers Injury of workers One employee is subjected to various tasks	The whole warehouse	All warehouse employees Operations Manager	• Lack of Material Handling Training • Lack of product training • Lack of adequate personnel for loading and unloading • Lack of material handling equipment • Lack of maintenance personnel • Lack of motivators from the company for workers • Lack of safety training • Lack of adequate PPEs for employees • Lack of adequate trained personnel • Over burden of tasks on an employee

7.4. Pareto Charts

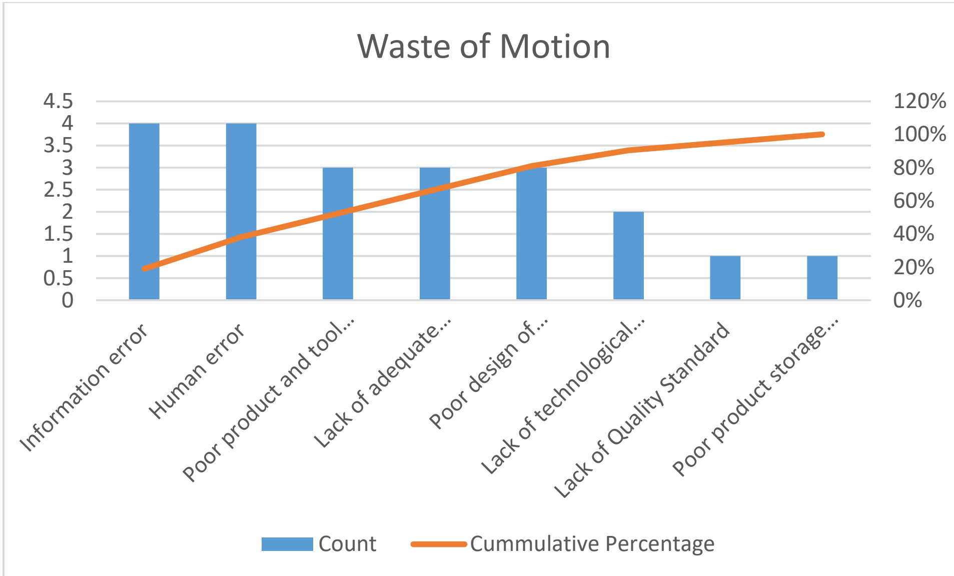
7.4.1. Pareto for Waste of Defect



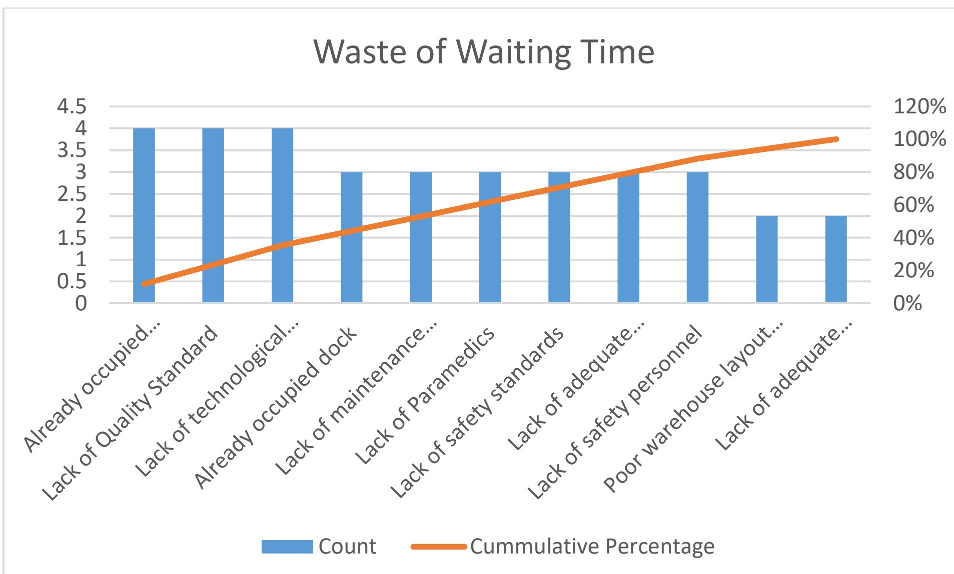
7.4.2. Pareto for Waste of Inventories



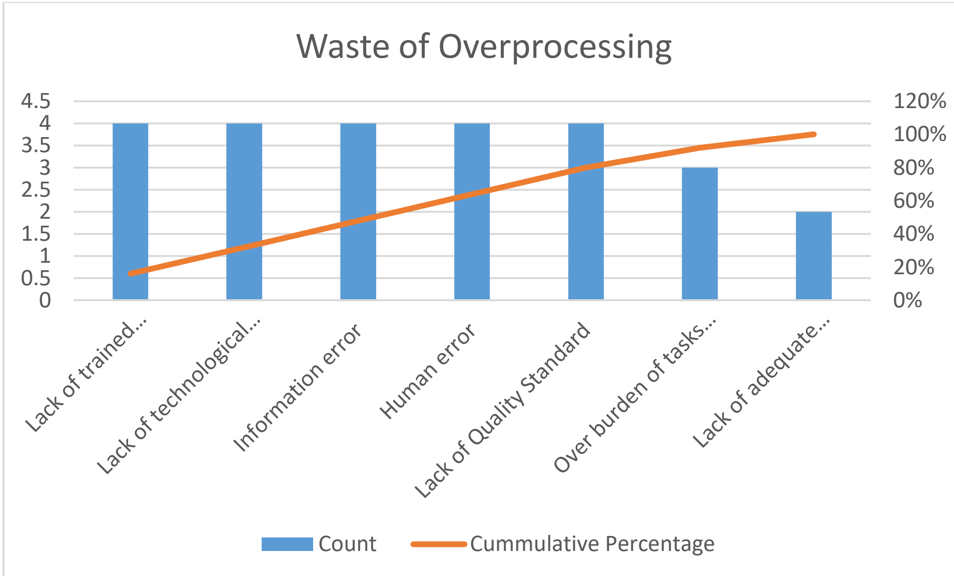
7.4.3. Pareto for Waste of Motion



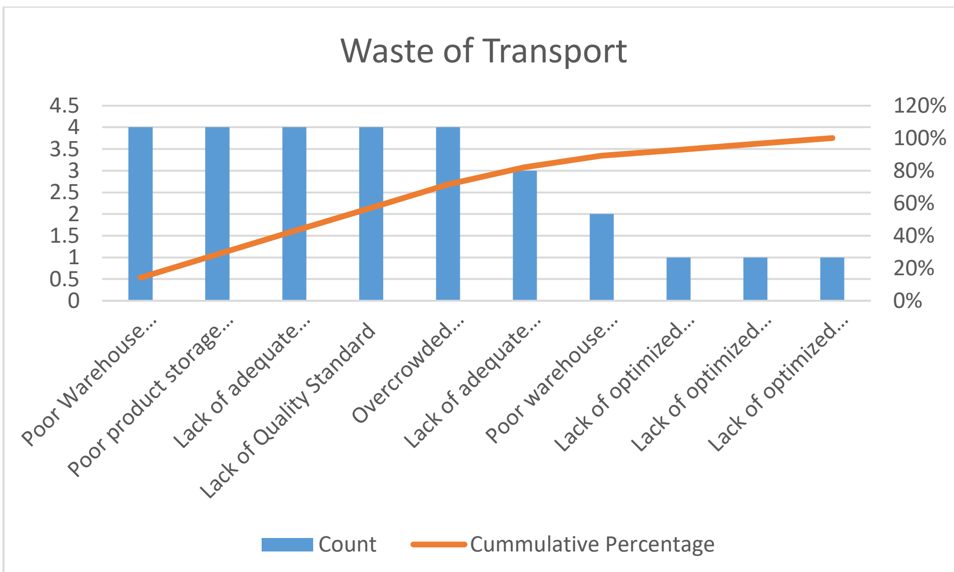
7.4.4. Pareto for Waste of Waiting Time



7.4.5. Pareto for Over Processing



7.4.6. Pareto for Waste of Transport



7.5. RII Summary

7.5.1. RII Summary for Second Step Data Collection

Keys:

- SDA (1) - Strongly Disagree
- DA (2) - Disagree
- N (3) - Neutral
- A (4) - Agree
- SA (5) - Strongly Agree
- G – Summation of Weighing Factor
- WD – Warehouse Design
- SS – Storage System
- EHR – Existing Human Resource
- ST – Standardization
- TE – Technology and Equipment
- EM – Specialized Employment
- TR – Training

11.5.1.1. RII for Damage of Product

	SDA (1)	DA (2)	N (3)	A (4)	SA (5)	Total	G	RII
WD			5	14	54	73	341	93%
SS				**12**	**61**	**73**	**353**	**96.7%**
EHR				73		73	292	80%
ST				63	10	73	302	83%
TE		69	4			73	150	41%
EM	58	13	2			73	90	25%
TR				**11**	**62**	**73**	**354**	**97.0%**

11.5.1.2. RII for Equipment Failure

	SDA (1)	DA (2)	N (3)	A (4)	SA (5)	Total	G	RII
WD			2	16	55	73	345	95%
SS	54	18	1			73	93	25%
EHR			9	62	2	73	285	78%

ST				**9**	**64**	**73**	**356**	**98%**
TE			10	58	5	73	287	79%
EM		60	13			73	159	44%
TR		3	64	6		73	222	61%

11.5.1.3. RII for Inventory Count Mistake

	SDA (1)	DA (2)	N (3)	A (4)	SA (5)	Total	G	RII
WD	61	12				73	85	23%
SS	1	38	34			73	179	49%
EHR				**14**	**59**	**73**	**351**	**96%**
ST	50	19				69	88	26%
TE	1	68	3	1		73	150	41%
EM	56	17				73	90	25%
TR	1	49	23			73	168	46%

11.5.1.4. RII for Insufficient Storage Space

	SDA (1)	DA (2)	N (3)	A (4)	SA (5)	Total	G	RII
WD				23	50	73	342	94%
SS				**11**	**62**	**73**	**354**	**97%**
EHR		66	7			73	153	42%
ST	64	9				73	82	22%
TE	1	68	3	1		73	150	41%
EM	56	17				73	90	25%
TR	59	12	2			73	89	24%

11.5.1.5. RII for Late Delivery

	SDA (1)	DA (2)	N (3)	A (4)	SA (5)	Total	G	RII
WD				**9**	**64**	**73**	**356**	**98%**
SS				35	38	73	330	90%
EHR				13	60	73	352	96%
ST				46	27	73	319	87%
TE			4	60	9	73	297	81%
EM			50	23		73	242	66%
TR			7	50	16	73	301	82%

11.5.1.6. RII for Safety of Employees

	SDA (1)	DA (2)	N (3)	A (4)	SA (5)	Total	G	RII
WD				34	39	73	331	91%
SS	9	56	8			73	145	40%
EHR				31	42	73	334	92%
ST				26	47	73	339	93%
TE				32	41	73	333	91%
EM		1	20	52		73	270	74%
TR				**16**	**57**	**73**	**349**	**96%**

7.5.2. RII Summary for Third Step Data Collection

Keys:

- SDA (1) - Strongly Disagree
- DA (2) - Disagree
- N (3) - Neutral
- A (4) - Agree
- SA (5) - Strongly Agree
- G – Summation of Weighing Factor
- VM – Visual Management Lean Tools
- HRM – HR Management Lean Tools
- CI – Continuous Improvement Lean tools
- DM – Demand Management Lean Tools
- LM – Layout Management Lean Tools
- PPM – Product and Process Management Lean Tools
- FM – Flow Management Lean Tools

7.5.2.1. RII for Existing Human Resource

Lean Tools	SDA (1)	DA (2)	N (3)	A (4)	SA (5)	Total	G	RII
VM				46	27	73	319	87%
HRM				**10**	**63**	**73**	**355**	**97%**
CI				25	48	73	340	93%
DM	43	21	9			73	112	31%
LM	43	30				73	103	28%
PPM	10	63				73	136	37%
FM			18	55		73	274	75%

7.5.2.2. RII for Standardization

Lean Tools	SDA (1)	DA (2)	N (3)	A (4)	SA (5)	Total	G	RII
VM				18	55	73	347	95%
HRM			6	61	6	73	292	80%
CI				13	60	73	352	96%
DM	50	18	5			73	101	28%
LM		11	53	9		73	217	59%
PPM				**10**	**63**	**73**	**355**	**97%**
FM	7	56	10			73	149	41%

7.5.2.3. 6.5.2.3 RII for Storage System

Lean Tools	SDA (1)	DA (2)	N (3)	A (4)	SA (5)	Total	G	RII
VM	51	22				73	95	26%
HRM			17	56		73	275	75%
CI				**12**	**61**	**73**	**353**	**97%**
DM	53	20				73	93	25%
LM				27	46	73	338	93%
PPM	49	22	2			73	99	27%
FM			9	54	10	73	293	80%

7.5.2.4. RII for Training Issues

Lean Tools	SDA (1)	DA (2)	N (3)	A (4)	SA (5)	Total	G	RII
VM			23	46	4	73	273	75%
HRM				25	48	73	340	93%
CI				**18**	**55**	**73**	**347**	**95%**
DM			25	48		73	267	73%
LM	35	38				73	111	30%
PPM		54	19			73	165	45%
FM	46	27				73	100	27%

7.5.2.5. RII for Warehouse Design

Lean Tools	SDA (1)	DA (2)	N (3)	A (4)	SA (5)	Total	G	RII
VM	51	21	1			73	96	26%
HRM			62	11		73	230	63%
CI				**12**	**61**	**73**	**353**	**97%**
DM	45	28				73	101	28%
LM				27	46	73	338	93%
PPM	48	25				73	98	27%
FM	51	14	8			73	103	28%

7.6. Validity Summary

7.6.1. Second Step Data Collection Validity Summary

7.6.1.1. 6.6.1.1 Validity for Damage of Product

		DoP1	DoP2	DoP3	DoP4	DoP5	DoP6	DoP7	DoP8	DoP9	DoP10	DoP11	DoP12	DoP13	DoP14	DoP15	DoP16	DoP17	DoP18	DoP19	DoP20	DoP21	DoP22	Total_Score
DoP1	Pearson Correlation	1	.895**	.910**	0.156	.234*	.318**	0.192	0.088	0.146	0.164	.260*	0.149	0.155	-0.194	0.072	0.059	-0.065	-0.038	0.100	-0.108	-0.100	-0.091	.659**
DoP2	Pearson Correlation	.895**	1	.949**	0.210	.234*	.318**	0.192	0.039	0.204	0.228	.321**	0.149	0.155	-0.194	0.072	0.004	-0.065	0.050	0.194	-.231*	-0.212	-0.219	.665**
DoP3	Pearson Correlation	.910**	.949**	1	0.208	.294*	.328**	0.187	-0.018	0.132	0.140	.249*	0.144	0.142	-.238*	0.061	0.043	-0.090	0.025	0.183	-0.224	-0.198	-0.212	.636**
DoP4	Pearson Correlation	0.156	0.210	0.208	1	.786**	.748**	0.070	0.051	0.118	-0.104	0.070	0.138	0.203	-0.065	0.130	0.155	0.130	0.074	-0.067	-0.025	0.011	-0.005	.486**
DoP5	Pearson Correlation	.234*	.234*	.294*	.786**	1	.786**	0.060	0.075	0.137	-0.093	0.087	0.132	0.194	-0.078	0.125	0.149	0.125	0.062	-0.084	0.087	0.116	0.110	.557**
DoP6	Pearson Correlation	.318**	.318**	.328**	.748**	.786**	1	0.070	0.126	0.206	-0.005	0.165	0.138	0.104	-0.065	0.025	0.071	0.025	0.074	-0.067	-0.025	0.011	-0.005	.555**
DoP7	Pearson Correlation	0.192	0.192	0.187	0.070	0.060	0.070	1	-.552**	0.163	0.140	0.148	0.078	-0.012	-0.114	-0.090	0.110	-0.090	0.032	0.033	-0.220	-0.163	-0.115	0.136
DoP8	Pearson Correlation	0.088	0.039	-0.018	0.051	0.075	0.126	-.552**	1	.574**	.539**	.494**	-0.067	-0.011	0.104	0.163	-0.031	0.163	0.019	-0.044	0.071	0.152	0.011	.352**
DoP9	Pearson	0.146	0.204	0.132	0.118	0.137	0.206	0.163	.574**	1	.648**	.605**	-0.016	-0.023	0.030	0.119	0.053	0.119	0.049	0.051	-0.196	-0.045	-0.185	.466**

	Correlation																							
DoP10	Pearson Correlation	0.164	0.228	0.140	-0.104	-0.093	-0.005	0.140	.539**	.648**	1	.612**	-0.050	-0.073	0.130	0.102	0.023	0.102	0.085	0.090	-0.056	0.008	-0.043	.427**
DoP11	Pearson Correlation	.260*	.321**	.249*	0.070	0.087	0.165	0.148	.494**	.605**	.612**	1	-0.037	-0.055	0.007	0.108	0.034	0.108	0.175	0.103	-0.177	-0.108	-0.168	.503**
DoP12	Pearson Correlation	0.149	0.149	0.144	0.138	0.132	0.138	0.078	-0.067	-0.016	-0.050	-0.037	1	.681**	-0.088	-0.070	-0.083	-0.070	.325**	.345**	0.114	0.132	0.108	.356**
DoP13	Pearson Correlation	0.155	0.155	0.142	0.203	0.194	0.104	-0.012	-0.011	-0.023	-0.073	-0.055	.681**	1	-0.130	0.022	-0.023	0.022	.237*	.251*	0.168	0.093	0.159	.372**
DoP14	Pearson Correlation	-0.194	-0.194	-.238*	-0.065	-0.078	-0.065	-0.114	0.104	0.030	0.130	0.007	-0.088	-0.130	1	0.062	0.131	0.062	-0.135	-0.044	0.137	0.040	0.130	-0.014
DoP15	Pearson Correlation	0.072	0.072	0.061	0.130	0.125	0.025	-0.090	0.163	0.119	0.102	0.108	-0.070	0.022	0.062	1	.663**	.867**	-0.106	-0.113	-0.131	-0.092	-0.146	.302**
DoP16	Pearson Correlation	0.059	0.004	0.043	0.155	0.149	0.071	0.110	-0.031	0.053	0.023	0.034	-0.083	-0.023	0.131	.663**	1	.663**	-0.127	-0.134	-.251*	-0.196	-.273*	0.211
DoP17	Pearson Correlation	-0.065	-0.065	-0.090	0.130	0.125	0.025	-0.090	0.163	0.119	0.102	0.108	-0.070	0.022	0.062	.867**	.663**	1	0.066	-0.113	-0.131	-0.092	-0.146	.252*
DoP18	Pearson Correlation	-0.038	0.050	0.025	0.074	0.062	0.074	0.032	0.019	0.049	0.085	0.175	.325**	.237*	-0.135	-0.106	-0.127	0.066	1	.765**	-0.057	-0.079	-0.076	.311**
DoP19	Pearson Correlation	0.100	0.194	0.183	-0.067	-0.084	-0.067	0.033	-0.044	0.051	0.090	0.103	.345**	.251*	-0.044	-0.113	-0.134	-0.113	.765**	1	-0.061	-.233*	-0.081	.296*

DoP20	Pearson Correlation	-0.108	-.231*	-0.224	-0.025	0.087	-0.025	-0.220	0.071	-0.196	-0.056	-0.177	0.114	0.168	0.137	-0.131	-.251*	-0.131	-0.057	-0.061	1	.865**	.946**	0.113
DoP21	Pearson Correlation	-0.100	-0.212	-0.198	0.011	0.116	0.011	-0.163	0.152	-0.045	0.008	-0.108	0.132	0.093	0.040	-0.092	-0.196	-0.092	-0.079	-.233*	.865**	1	.818**	0.142
DoP22	Pearson Correlation	-0.091	-0.219	-0.212	-0.005	0.110	-0.005	-0.115	0.011	-0.185	-0.043	-0.168	0.108	0.159	0.130	-0.146	-.273*	-0.146	-0.076	-0.081	.946**	.818**	1	0.114
Total_Score	Pearson Correlation	.659**	.665**	.636**	.486**	.557**	.555**	0.136	.352**	.466**	.427**	.503**	.356**	.372**	-0.014	.302**	0.211	.252*	.311**	.296*	0.113	0.142	0.114	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

7.6.1.2. Validity for Equipment Failure

		EF 1	EF 2	EF 3	EF 4	EF 5	EF 6	EF 7	EF 8	EF 9	EF 10	EF 11	EF 12	EF 13	EF 14	EF 15	EF 16	EF 17	EF 18	EF 19	EF 20	EF 21	EF 22	Total_Score
EF1	Pearson Correlation	1	.792**	.813**	0.001	0.123	0.108	0.048	0.076	0.091	0.030	0.091	0.005	0.050	-0.092	-0.134	-0.085	-0.085	-0.138	-0.096	-0.176	-0.105	-0.139	.344**
EF2	Pearson Correlation	.792**	1	.838**	0.065	0.182	0.174	0.037	0.007	0.086	0.086	0.026	-0.072	-0.026	-0.155	-0.139	-0.088	-0.088	0.006	0.010	-0.109	-0.043	-0.056	.390**
EF3	Pearson Correlation	.813**	.838**	1	0.102	0.217	0.214	0.048	0.012	0.030	0.030	0.030	0.005	0.050	-0.092	-0.134	-0.085	-0.085	-0.005	0.006	-0.176	-0.163	-0.139	.392**
EF4	Pearson Correlation	0.001	0.065	0.102	1	.652**	.773**	0.001	-0.024	-0.106	-0.106	-0.041	0.040	0.127	-0.106	-0.168	-0.220	-0.160	0.102	-0.050	0.061	-0.006	0.152	.290*

EF5	Pearson Correlation	0.123	0.182	0.217	.652**	1	.690**	0.022	-0.012	-0.091	-0.091	-0.030	0.127	0.143	-0.091	-0.144	-0.197	-0.141	0.138	0.146	-0.076	-0.129	-0.025	.350**
EF6	Pearson Correlation	0.108	0.174	0.214	.773**	.690**	1	0.001	-0.026	-0.113	-0.113	-0.044	0.042	0.061	-0.113	-0.178	-.233*	-0.169	0.108	0.120	0.065	-0.006	-0.026	.338**
EF7	Pearson Correlation	0.048	0.037	0.048	0.001	0.022	0.001	1	.781**	.758**	.758**	.758**	0.104	0.184	0.023	-0.017	0.021	0.021	0.096	0.004	-0.038	-0.035	-0.105	.496**
EF8	Pearson Correlation	0.076	0.007	0.012	-0.024	-0.012	-0.026	.781**	1	.877**	.877**	.960**	0.084	0.074	0.132	0.026	0.045	0.045	0.006	-0.029	0.028	0.026	0.009	.551**
EF9	Pearson Correlation	0.091	0.086	0.030	-0.106	-0.091	-0.113	.758**	.877**	1	.921**	.921**	0.095	0.087	0.210	0.177	0.195	0.195	-0.009	-0.034	0.022	0.021	0.007	.595**
EF10	Pearson Correlation	0.030	0.086	0.030	-0.106	-0.091	-0.113	.758**	.877**	.921**	1	.842**	0.009	0.003	0.210	0.177	0.195	0.195	-0.009	-0.034	0.022	0.021	0.007	.559**
EF11	Pearson Correlation	0.091	0.026	0.030	-0.041	-0.030	-0.044	.758**	.960**	.921**	.842**	1	0.095	0.087	0.131	0.033	0.048	0.048	-0.009	-0.034	0.022	0.021	0.007	.550**
EF12	Pearson Correlation	0.005	-0.072	0.005	0.040	0.127	0.042	0.104	0.084	0.095	0.009	0.095	1	.774**	0.095	0.045	0.089	0.089	0.029	0.018	-0.204	-0.106	0.021	.262*
EF13	Pearson Correlation	0.050	-0.026	0.050	0.127	0.143	0.061	0.184	0.074	0.087	0.003	0.087	.774**	1	0.171	0.036	0.081	0.081	-0.046	-0.115	-0.193	-0.099	0.022	.285*
EF14	Pearson Correlation	-0.092	-0.155	-0.092	-0.106	-0.091	-0.113	0.023	0.132	0.210	0.210	0.131	0.095	0.171	1	.828**	.856**	.929**	-0.009	-0.034	0.104	0.172	0.114	.487**
EF15	Pearson Correlation	-0.134	-0.139	-0.134	-0.168	-0.144	-0.178	-0.017	0.026	0.177	0.177	0.033	0.045	0.036	.828**	1	.836**	.904**	0.033	-0.014	0.108	0.169	0.108	.401**

EF16	Pearson Correlation	-0.085	-0.088	-0.085	-0.220	-0.197	-.233*	0.021	0.045	0.195	0.195	0.048	0.089	0.081	.856**	.836**	1	.932**	-0.089	-0.093	0.173	.230*	0.106	.419**
EF17	Pearson Correlation	-0.085	-0.088	-0.085	-0.160	-0.141	-0.169	0.021	0.045	0.195	0.195	0.048	0.089	0.081	.929**	.904**	.932**	1	-0.009	-0.032	0.097	0.160	0.106	.461**
EF18	Pearson Correlation	-0.138	0.006	-0.005	0.102	0.138	0.108	0.096	0.006	-0.009	-0.009	-0.009	0.029	-0.046	-0.009	0.033	-0.089	-0.009	1	.840**	-0.063	-0.059	-0.021	0.229
EF19	Pearson Correlation	-0.096	0.010	0.006	-0.050	0.146	0.120	0.004	-0.029	-0.034	-0.034	-0.034	0.018	-0.115	-0.034	-0.014	-0.093	-0.032	.840**	1	-0.094	-0.087	-0.097	0.169
EF20	Pearson Correlation	-0.176	-0.109	-0.176	0.061	-0.076	0.065	-0.038	0.028	0.022	0.022	0.022	-0.204	-0.193	0.104	0.108	0.173	0.097	-0.063	-0.094	1	.925**	.655**	0.217
EF21	Pearson Correlation	-0.105	-0.043	-0.163	-0.006	-0.129	-0.006	-0.035	0.026	0.021	0.021	0.021	-0.106	-0.099	0.172	0.169	.230*	0.160	-0.059	-0.087	.925**	1	.606**	.261*
EF22	Pearson Correlation	-0.139	-0.056	-0.139	0.152	-0.025	-0.026	-0.105	0.009	0.007	0.007	0.007	0.021	0.022	0.114	0.108	0.106	0.106	-0.021	-0.097	.655**	.606**	1	0.228
Total_Score	Pearson Correlation	.344**	.390**	.392**	.290*	.350**	.338**	.496**	.551**	.595**	.559**	.550**	.262*	.285*	.487**	.401**	.419**	.461**	0.229	0.169	0.217	.261*	0.228	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

7.6.1.3. Validity for Inventory Count Mistake

		ICM1	ICM2	ICM3	ICM4	ICM5	ICM6	ICM7	ICM8	ICM9	ICM10	ICM11	ICM12	ICM13	ICM14	ICM15	ICM16	ICM17	ICM18	ICM19	ICM20	ICM21	ICM22	Total_Score
ICM1	Pearson Correlation	1	.805**	.717**	-0.012	0.046	0.032	-0.201	-0.201	-.252*	-0.201	-0.100	0.151	0.042	-0.038	-0.037	0.019	0.215	0.041	-0.040	0.215	0.198	0.170	.309**
ICM2	Pearson Correlation	.805**	1	.749**	-0.036	0.134	0.060	-0.222	-0.140	-.273*	-0.222	-0.120	0.175	0.063	-0.082	-0.022	-0.022	0.212	0.058	0.058	.238*	0.156	0.073	.315**
ICM3	Pearson Correlation	.717**	.749**	1	-0.139	-0.012	-0.135	-0.038	0.037	-0.077	-0.038	0.053	.274*	0.108	-0.036	0.018	0.018	0.117	-0.037	0.038	0.140	0.006	0.037	.319**
ICM4	Pearson Correlation	-0.012	-0.036	-0.139	1	.613**	.629**	0.062	-0.010	-0.034	-0.010	0.106	-0.179	-0.164	-0.216	-0.157	-0.157	-0.004	-0.133	-0.062	.450**	.464**	.712**	.372**
ICM5	Pearson Correlation	0.046	0.134	-0.012	.613**	1	.841**	0.085	0.023	-0.031	0.023	0.109	-0.161	-.232*	-0.067	-0.021	0.022	-0.031	-0.147	-0.023	.771**	.594**	.286*	.529**
ICM6	Pearson Correlation	0.032	0.060	-0.135	.629**	.841**	1	0.036	0.036	-0.020	0.036	0.061	-0.177	-.246*	-0.034	0.010	0.053	-0.026	-0.221	-0.097	.606**	.774**	.311**	.501**
ICM7	Pearson Correlation	-0.201	-0.222	-0.038	0.062	0.085	0.036	1	.748**	.827**	.832**	.878**	0.024	0.070	0.007	0.065	0.065	-0.116	-0.077	0.007	0.007	-0.046	-0.041	.433**
ICM8	Pearson Correlation	-0.201	-0.140	0.037	-0.010	0.023	0.036	.748**	1	.827**	.832**	.796**	0.098	0.147	0.129	0.182	0.182	-0.022	-0.161	0.007	-0.060	-0.046	-0.109	.478**
ICM9	Pearson Correlation	-.252*	-.273*	-0.077	-0.034	-0.031	-0.020	.827**	.827**	1	.915**	.705**	-0.021	0.031	0.036	0.096	0.096	-0.106	-0.118	-0.029	-0.102	-0.089	-0.114	.344**

ICM10	Pearson Correlation	-0.201	-0.222	-0.038	-0.010	0.023	0.036	.832**	.832**	.915**	1	.796**	0.024	0.070	0.068	0.123	0.123	-0.116	-0.077	0.007	-0.060	-0.046	-0.109	.433**
ICM11	Pearson Correlation	-0.100	-0.120	0.053	0.106	0.109	0.061	.878**	.796**	.705**	.796**	1	0.117	0.163	0.082	0.136	0.136	-0.029	-0.058	0.024	0.025	-0.026	-0.007	.545**
ICM12	Pearson Correlation	0.151	0.175	.274*	-0.179	-0.161	-0.177	0.024	0.098	-0.021	0.024	0.117	1	.795**	0.068	0.065	0.065	-0.107	-0.173	-0.098	-0.105	-0.121	-0.082	0.186
ICM13	Pearson Correlation	0.042	0.063	0.108	-0.164	-.232*	-.246*	0.070	0.147	0.031	0.070	0.163	.795**	1	0.157	0.151	0.151	-0.038	-0.070	0.007	-0.137	-0.151	-0.023	0.215
ICM14	Pearson Correlation	-0.038	-0.082	-0.036	-0.216	-0.067	-0.034	0.007	0.129	0.036	0.068	0.082	0.068	0.157	1	.916**	.958**	-0.161	-0.129	-0.068	-0.023	0.012	-0.141	.380**
ICM15	Pearson Correlation	-0.037	-0.022	0.018	-0.157	-0.021	0.010	0.065	0.182	0.096	0.123	0.136	0.065	0.151	.916**	1	.959**	-0.154	-0.123	-0.006	0.024	0.058	-0.135	.464**
ICM16	Pearson Correlation	0.019	-0.022	0.018	-0.157	0.022	0.053	0.065	0.182	0.096	0.123	0.136	0.065	0.151	.958**	.959**	1	-0.154	-0.182	-0.065	0.071	0.104	-0.088	.495**
ICM17	Pearson Correlation	0.215	0.212	0.117	-0.004	-0.031	-0.026	-0.116	-0.022	-0.106	-0.116	-0.029	-0.107	-0.038	-0.161	-0.154	-0.154	1	0.022	-0.072	0.049	0.054	0.073	0.037
ICM18	Pearson Correlation	0.041	0.058	-0.037	-0.133	-0.147	-0.221	-0.077	-0.161	-0.118	-0.077	-0.058	-0.173	-0.070	-0.129	-0.123	-0.182	0.022	1	.832**	-0.142	-0.221	-0.163	-0.082
ICM19	Pearson Correlation	-0.040	0.058	0.038	-0.062	-0.023	-0.097	0.007	0.007	-0.029	0.007	0.024	-0.098	0.007	-0.068	-0.006	-0.065	-0.072	.832**	1	-0.075	-0.154	-0.163	0.088
ICM20	Pearson Correlation	0.215	.238*	0.140	.450**	.771**	.606**	0.007	-0.060	-0.102	-0.060	0.025	-0.105	-0.137	-0.023	0.024	0.071	0.049	-0.142	-0.075	1	.814**	.606**	.592**

ICM21	Pearson Correlation	0.198	0.156	0.006	.464**	.594**	.774**	-0.046	-0.046	-0.089	-0.046	-0.026	-0.121	-0.151	0.012	0.058	0.104	0.054	-0.221	-0.154	.814**	1	.626**	.557**
ICM22	Pearson Correlation	0.170	0.073	0.037	.712**	.286*	.311**	-0.041	-0.109	-0.114	-0.109	-0.007	-0.082	-0.023	-0.141	-0.135	-0.088	0.073	-0.163	-0.163	.606**	.626**	1	.370**
Total_Score	Pearson Correlation	.309**	.315**	.319**	.372**	.529**	.501**	.433**	.478**	.344**	.433**	.545**	0.186	0.215	.380**	.464**	.495**	0.037	-0.082	0.088	.592**	.557**	.370**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

7.6.1.4. Validity for Insufficient Storage Space

		ISS 1	ISS 2	ISS 3	ISS 4	ISS 5	ISS 6	ISS 7	ISS 8	ISS 9	ISS 10	ISS 11	ISS 12	ISS 13	ISS 14	ISS 15	ISS 16	ISS 17	ISS 18	ISS 19	ISS 20	ISS 21	ISS 22	Total_Score
ISS1	Pearson Correlation	1	.763**	.781**	-0.013	-0.062	0.110	-0.003	-0.085	-0.003	-0.003	-0.019	-0.044	0.038	-0.143	-0.086	0.009	-0.086	-.385**	-.385**	0.065	-0.076	0.065	0.190
ISS2	Pearson Correlation	.763**	1	.793**	0.025	-0.034	0.055	-0.039	-0.127	-0.039	-0.039	-0.058	-0.074	-0.074	0.020	0.068	0.061	0.068	-.313**	-.313**	0.055	-0.019	0.055	.249*
ISS3	Pearson Correlation	.781**	.793**	1	0.060	0.004	0.095	0.011	-0.096	0.011	0.011	-0.005	-0.031	-0.113	-0.075	-0.021	0.164	-0.021	-.294*	-.294*	-0.045	-0.117	0.016	.241*
ISS4	Pearson Correlation	-0.013	0.025	0.060	1	.898**	.754**	0.064	0.007	0.064	0.064	0.057	0.168	0.056	0.053	-0.018	0.020	-0.018	0.104	0.104	0.100	0.036	0.100	.408**
ISS5	Pearson Correlation	-0.062	-0.034	0.004	.898**	1	.753**	0.094	-0.023	0.094	0.094	0.088	0.084	-0.020	0.019	-0.045	0.001	-0.045	0.134	0.134	0.049	-0.003	0.049	.361**

ISS6	Pearson Correlation	0.110	0.055	0.095	.754**	.753**	1	0.112	-0.045	0.112	0.112	0.107	0.010	-0.080	-0.125	-0.175	0.075	-0.175	0.070	0.070	0.140	0.090	0.140	.359**
ISS7	Pearson Correlation	-0.003	-0.039	0.011	0.064	0.094	0.112	1	-.522**	1.000**	1.000**	.983**	-0.019	-0.019	-0.118	-0.150	0.108	-0.150	0.026	0.079	0.190	0.149	0.190	.665**
ISS8	Pearson Correlation	-0.085	-0.127	-0.096	0.007	-0.023	-0.045	-.522**	1	-.522**	-.522**	-.554**	0.009	0.009	0.194	0.186	-0.090	0.186	0.061	0.061	-.292*	-.247*	-.292*	-.295*
ISS9	Pearson Correlation	-0.003	-0.039	0.011	0.064	0.094	0.112	1.000**	-.522**	1	1.000**	.983**	-0.019	-0.019	-0.118	-0.150	0.108	-0.150	0.026	0.079	0.190	0.149	0.190	.665**
ISS10	Pearson Correlation	-0.003	-0.039	0.011	0.064	0.094	0.112	1.000**	-.522**	1.000**	1	.983**	-0.019	-0.019	-0.118	-0.150	0.108	-0.150	0.026	0.079	0.190	0.149	0.190	.665**
ISS11	Pearson Correlation	-0.019	-0.058	-0.005	0.057	0.088	0.107	.983**	-.554**	.983**	.983**	1	-0.010	-0.010	-0.112	-0.146	0.108	-0.146	0.038	0.094	0.209	0.166	0.209	.661**
ISS12	Pearson Correlation	-0.044	-0.074	-0.031	0.168	0.084	0.010	-0.019	0.009	-0.019	-0.019	-0.010	1	.786**	0.068	0.065	-0.010	0.065	0.165	0.165	-0.033	-0.053	-0.033	0.221
ISS13	Pearson Correlation	0.038	-0.074	-0.113	0.056	-0.020	-0.080	-0.019	0.009	-0.019	-0.019	-0.010	.786**	1	0.137	0.131	0.096	0.131	0.165	0.165	-0.114	-0.127	-0.114	0.200
ISS14	Pearson Correlation	-0.143	0.020	-0.075	0.053	0.019	-0.125	-0.118	0.194	-0.118	-0.118	-0.112	0.068	0.137	1	.916**	-0.161	.958**	0.054	0.054	-0.176	-.235*	-0.227	.294*
ISS15	Pearson Correlation	-0.086	0.068	-0.021	-0.018	-0.045	-0.175	-0.150	0.186	-0.150	-0.150	-0.146	0.065	0.131	.916**	1	-0.154	.959**	-0.006	0.052	-0.168	-0.225	-0.218	.269*
ISS16	Pearson Correlation	0.009	0.061	0.164	0.020	0.001	0.075	0.108	-0.090	0.108	0.108	0.108	-0.010	0.096	-0.161	-0.154	1	-0.154	-0.072	-0.072	-0.135	-0.038	-0.055	0.091

ISS17	Pearson Correlation	-0.086	0.068	-0.021	-0.018	-0.045	-0.175	-0.150	0.186	-0.150	-0.150	-0.146	0.065	0.131	.958**	.959**	-0.154	1	-0.006	0.052	-0.168	-0.225	-0.218	.275*
ISS18	Pearson Correlation	-.385**	-.313**	-.294*	0.104	0.134	0.070	0.026	0.061	0.026	0.026	0.038	0.165	0.165	0.054	-0.006	-0.072	-0.006	1	.832**	0.051	0.020	0.051	0.182
ISS19	Pearson Correlation	-.385**	-.313**	-.294*	0.104	0.134	0.070	0.079	0.061	0.079	0.079	0.094	0.165	0.165	0.054	0.052	-0.072	0.052	.832**	1	0.051	0.020	0.051	.238*
ISS20	Pearson Correlation	0.065	0.055	-0.045	0.100	0.049	0.140	0.190	-.292*	0.190	0.190	0.209	-0.033	-0.114	-0.176	-0.168	-0.135	-0.168	0.051	0.051	1	.838**	.939**	.411**
ISS21	Pearson Correlation	-0.076	-0.019	-0.117	0.036	-0.003	0.090	0.149	-.247*	0.149	0.149	0.166	-0.053	-0.127	-.235*	-0.225	-0.038	-0.225	0.020	0.020	.838**	1	.838**	.295*
ISS22	Pearson Correlation	0.065	0.055	0.016	0.100	0.049	0.140	0.190	-.292*	0.190	0.190	0.209	-0.033	-0.114	-0.227	-0.218	-0.055	-0.218	0.051	0.051	.939**	.838**	1	.403**
Total_Score	Pearson Correlation	0.190	.249*	.241*	.408**	.361**	.359**	.665**	-.295*	.665**	.665**	.661**	0.221	0.200	.294*	.269*	0.091	.275*	0.182	.238*	.411**	.295*	.403**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

7.6.1.5. Validity for Late Delivery

		LD 1	LD 2	LD 3	LD 4	LD 5	LD 6	LD 7	LD 8	LD 9	LD 10	LD 11	LD 12	LD 13	LD 14	LD 15	LD 16	LD 17	LD 18	LD 19	LD 20	LD 21	LD 22	Total_ Score
LD1	Pearson Correlation	1	.532**	.639**	-0.135	-0.135	-0.123	-0.136	-0.227	-.247*	-0.123	-0.045	-0.132	-0.147	0.153	0.092	0.123	0.105	-0.070	0.087	0.196	.253*	0.194	.238*
LD2	Pearson Correlation	.532**	1	.754**	-0.135	-0.135	-0.195	-0.136	-0.136	-0.160	-0.123	-0.136	0.097	0.084	0.153	0.092	0.200	0.105	-0.070	0.002	0.133	0.134	0.074	.261*
LD3	Pearson Correlation	.639**	.754**	1	-0.142	-0.142	-0.133	-0.171	-0.171	-0.186	-0.163	-0.171	0.059	0.049	0.157	0.163	0.187	0.170	-0.140	-0.014	.253*	.275*	0.202	.322**
LD4	Pearson Correlation	-0.135	-0.135	-0.142	1	.889**	.862**	-0.023	-0.093	-0.015	-0.135	-0.093	-0.009	0.024	0.055	0.022	0.122	0.092	-0.095	-0.151	-0.076	-0.084	-0.176	.293*
LD5	Pearson Correlation	-0.135	-0.135	-0.142	.889**	1	.862**	-0.023	-0.093	-0.015	-0.135	-0.093	0.050	0.142	-0.013	-0.054	0.063	-0.022	-0.095	-0.151	-0.028	-0.084	-0.130	.293*
LD6	Pearson Correlation	-0.123	-0.195	-0.133	.862**	.862**	1	-0.010	-0.080	-0.068	-0.123	-0.080	-0.028	0.064	-0.017	-0.048	0.056	0.029	-0.055	-0.101	-0.132	-0.181	-0.227	0.223
LD7	Pearson Correlation	-0.136	-0.136	-0.171	-0.023	-0.023	-0.010	1	.735**	.751**	.774**	.912**	0.119	0.106	-0.020	-0.111	-0.020	-0.105	-0.194	-0.226	-0.042	-0.096	-0.096	.365**
LD8	Pearson Correlation	-0.227	-0.136	-0.171	-0.093	-0.093	-0.080	.735**	1	.835**	.865**	.735**	0.193	0.181	-0.020	-0.111	-0.020	-0.105	-0.119	-0.143	-0.164	-0.212	-0.212	.298*

LD9	Pearson Correlation	-.247*	-0.160	-0.186	-0.015	-0.015	-0.068	.751**	.835**	1	.792**	.751**	0.159	0.145	-0.010	-0.121	-0.002	-0.085	-0.140	-0.178	-.252*	-.301**	-.301**	.251*
LD10	Pearson Correlation	-0.123	-0.123	-0.163	-0.135	-0.135	-0.123	.774**	.865**	.792**	1	.865**	0.173	0.162	-0.026	-0.106	-0.030	-0.116	-0.147	-0.167	-.241*	-.283*	-.283*	.250*
LD11	Pearson Correlation	-0.045	-0.136	-0.171	-0.093	-0.093	-0.080	.912**	.735**	.751**	.865**	1	0.119	0.106	-0.020	-0.111	-0.020	-0.105	-0.194	-0.226	-0.103	-0.154	-0.154	.321**
LD12	Pearson Correlation	-0.132	0.097	0.059	-0.009	0.050	-0.028	0.119	0.193	0.159	0.173	0.119	1	.781**	0.122	-0.002	.253*	0.082	-0.098	-0.179	-0.048	-0.015	-0.063	.372**
LD13	Pearson Correlation	-0.147	0.084	0.049	0.024	0.142	0.064	0.106	0.181	0.145	0.162	0.106	.781**	1	0.054	-0.091	0.200	0.029	-0.016	-0.095	0.011	-0.010	-0.010	.405**
LD14	Pearson Correlation	0.153	0.153	0.157	0.055	-0.013	-0.017	-0.020	-0.020	-0.010	-0.026	-0.020	0.122	0.054	1	.504**	.841**	.814**	-.239*	-.237*	0.020	0.092	0.092	.484**
LD15	Pearson Correlation	0.092	0.092	0.163	0.022	-0.054	-0.048	-0.111	-0.111	-0.121	-0.106	-0.111	-0.002	-0.091	.504**	1	.467**	.522**	-0.009	-0.054	0.065	0.100	0.100	.316**
LD16	Pearson Correlation	0.123	0.200	0.187	0.122	0.063	0.056	-0.020	-0.020	-0.002	-0.030	-0.020	.253*	0.200	.841**	.467**	1	.728**	-0.116	-0.215	0.027	0.007	0.104	.560**
LD17	Pearson Correlation	0.105	0.105	0.170	0.092	-0.022	0.029	-0.105	-0.105	-0.085	-0.116	-0.105	0.082	0.029	.814**	.522**	.728**	1	-0.153	-0.125	0.034	0.105	0.058	.439**
LD18	Pearson Correlation	-0.070	-0.070	-0.140	-0.095	-0.095	-0.055	-0.194	-0.119	-0.140	-0.147	-0.194	-0.098	-0.016	-.239*	-0.009	-0.116	-0.153	1	.812**	-0.040	-0.010	-0.010	-0.013
LD19	Pearson Correlation	0.087	0.002	-0.014	-0.151	-0.151	-0.101	-0.226	-0.143	-0.178	-0.167	-0.226	-0.179	-0.095	-.237*	-0.054	-0.215	-0.125	.812**	1	-0.101	-0.034	-0.088	-0.089

LD20	Pearson Correlation	0.196	0.133	.253*	-0.076	-0.028	-0.132	-0.042	-0.164	-.252*	-.241*	-0.103	-0.048	0.011	0.020	0.065	0.027	0.034	-0.040	-0.101	1	.789**	.869**	.425**
LD21	Pearson Correlation	.253*	0.134	.275*	-0.084	-0.084	-0.181	-0.096	-0.212	-.301**	-.283*	-0.154	-0.015	-0.010	0.092	0.100	0.007	0.105	-0.010	-0.034	.789**	1	.848**	.420**
LD22	Pearson Correlation	0.194	0.074	0.202	-0.176	-0.130	-0.227	-0.096	-0.212	-.301**	-.283*	-0.154	-0.063	-0.010	0.092	0.100	0.104	0.058	-0.010	-0.088	.869**	.848**	1	.376**
Total_ Score	Pearson Correlation	.238*	.261*	.322**	.293*	.293*	0.223	.365**	.298*	.251*	.250*	.321**	.372**	.405**	.484**	.316**	.560**	.439**	-0.013	-0.089	.425**	.420**	.376**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

7.6.1.6. Validity for Safety of Employees

		SoE1	SoE2	SoE3	SoE4	SoE5	SoE6	SoE7	SoE8	SoE9	SoE10	SoE11	SoE12	SoE13	SoE14	SoE15	SoE16	SoE17	SoE18	SoE19	SoE20	SoE21	SoE22	Total_ Score
SoE1	Pearson Correlation	1	.754**	.786**	0.029	0.080	0.023	-0.209	-0.151	-0.095	-0.150	-0.041	-0.095	-0.067	.238*	0.185	.237*	.238*	-0.138	-0.174	0.025	0.056	0.059	.335**
SoE2	Pearson Correlation	.754**	1	.817**	-0.084	-0.028	-0.089	-0.174	-0.117	-0.061	-0.119	0.041	-0.065	-0.032	.270*	0.219	0.123	.270*	-0.208	-0.192	0.140	0.167	0.177	.364**
SoE3	Pearson Correlation	.786**	.817**	1	0.026	0.084	0.049	-0.069	-0.006	0.050	-0.001	0.125	-0.051	-0.037	.278*	0.219	0.225	.278*	-0.172	-0.157	0.021	0.055	0.118	.476**
SoE4	Pearson	0.029	-0.084	0.026	1	.947**	.714**	0.198	0.139	0.139	.254*	0.199	-0.031	-0.094	-0.205	-0.209	-0.126	-0.148	0.072	0.019	-0.119	-0.050	-0.122	.368**

	Correlation																							
SoE5	Pearson Correlation	0.080	-0.028	0.084	.947**	1	.714**	0.146	0.143	0.143	.303**	.241*	-0.078	-0.132	-0.186	-0.186	-0.112	-0.132	0.033	-0.018	-0.142	-0.078	-0.144	.376**
SoE6	Pearson Correlation	0.023	-0.089	0.049	.714**	.714**	1	0.145	0.184	0.184	0.222	0.180	-0.056	-0.078	-0.150	-0.138	-0.085	-0.150	-0.103	-0.156	-0.068	-0.135	-0.125	.302**
SoE7	Pearson Correlation	-0.209	-0.174	-0.069	0.198	0.146	0.145	1	.886**	.770**	.834**	.756**	-.240*	-.254*	-.256*	-.274*	-0.032	-0.199	0.094	0.121	0.048	0.088	0.006	.458**
SoE8	Pearson Correlation	-0.151	-0.117	-0.006	0.139	0.143	0.184	.886**	1	.886**	.832**	.801**	-.231*	-.237*	-0.131	-0.144	-0.025	-0.074	0.162	0.082	0.083	0.055	0.044	.565**
SoE9	Pearson Correlation	-0.095	-0.061	0.050	0.139	0.143	0.184	.770**	.886**	1	.832**	.801**	-.231*	-0.180	-0.018	-0.030	-0.025	0.039	0.057	-0.030	-0.050	-0.075	-0.024	.557**
SoE10	Pearson Correlation	-0.150	-0.119	-0.001	.254*	.303**	0.222	.834**	.832**	.832**	1	.847**	-.279*	-.279*	-0.121	-0.131	-0.018	-0.065	0.020	0.045	-0.014	0.023	-0.053	.542**
SoE11	Pearson Correlation	-0.041	0.041	0.125	0.199	.241*	0.180	.756**	.801**	.801**	.847**	1	-.260*	-.236*	-0.039	-0.039	0.002	0.016	0.017	-0.064	0.090	0.183	0.059	.629**
SoE12	Pearson Correlation	-0.095	-0.065	-0.051	-0.031	-0.078	-0.056	-.240*	-.231*	-.231*	-.279*	-.260*	1	.755**	-0.001	0.106	0.107	-0.001	0.140	0.119	-0.110	-0.136	-0.082	0.037
SoE13	Pearson Correlation	-0.067	-0.032	-0.037	-0.094	-0.132	-0.078	-.254*	-.237*	-0.180	-.279*	-.236*	.755**	1	-0.108	-0.065	0.093	-0.108	0.182	0.102	-0.035	-0.124	-0.077	-0.004
SoE14	Pearson Correlation	.238*	.270*	.278*	-0.205	-0.186	-0.150	-.256*	-0.131	-0.018	-0.121	-0.039	-0.001	-0.108	1	.832**	0.220	.944**	-0.137	-0.066	0.051	0.023	0.081	.321**

SoE15	Pearson Correlation	0.185	0.219	0.219	-0.209	-0.186	-0.138	-.274*	-0.144	-0.030	-0.131	-0.039	0.106	-0.065	.832**	1	0.216	.832**	-0.208	-0.142	0.016	-0.010	0.044	.265*
SoE16	Pearson Correlation	.237*	0.123	0.225	-0.126	-0.112	-0.085	-0.032	-0.025	-0.025	-0.018	0.002	0.107	0.093	0.220	0.216	1	0.220	-0.035	0.078	-0.074	-0.069	-0.080	0.182
SoE17	Pearson Correlation	.238*	.270*	.278*	-0.148	-0.132	-0.150	-0.199	-0.074	0.039	-0.065	0.016	-0.001	-0.108	.944**	.832**	0.220	1	-0.137	-0.066	0.051	0.023	0.081	.375**
SoE18	Pearson Correlation	-0.138	-0.208	-0.172	0.072	0.033	-0.103	0.094	0.162	0.057	0.020	0.017	0.140	0.182	-0.137	-0.208	-0.035	-0.137	1	.768**	0.133	0.110	0.220	.256*
SoE19	Pearson Correlation	-0.174	-0.192	-0.157	0.019	-0.018	-0.156	0.121	0.082	-0.030	0.045	-0.064	0.119	0.102	-0.066	-0.142	0.078	-0.066	.768**	1	0.027	0.069	0.182	0.204
SoE20	Pearson Correlation	0.025	0.140	0.021	-0.119	-0.142	-0.068	0.048	0.083	-0.050	-0.014	0.090	-0.110	-0.035	0.051	0.016	-0.074	0.051	0.133	0.027	1	.738**	.727**	.302**
SoE21	Pearson Correlation	0.056	0.167	0.055	-0.050	-0.078	-0.135	0.088	0.055	-0.075	0.023	0.183	-0.136	-0.124	0.023	-0.010	-0.069	0.023	0.110	0.069	.738**	1	.696**	.313**
SoE22	Pearson Correlation	0.059	0.177	0.118	-0.122	-0.144	-0.125	0.006	0.044	-0.024	-0.053	0.059	-0.082	-0.077	0.081	0.044	-0.080	0.081	0.220	0.182	.727**	.696**	1	.337**
Total_Score	Pearson Correlation	.335**	.364**	.476**	.368**	.376**	.302**	.458**	.565**	.557**	.542**	.629**	0.037	-0.004	.321**	.265*	0.182	.375**	.256*	0.204	.302**	.313**	.337**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

7.6.2. Third Step Data Collection Validity Summary

7.6.2.1. Validity for Existing Human Resource (Human Capital)

		HR1	HR2	HR3	HR4	HR5	HR6	HR7	HR8	HR9	HR10	HR11	HR12	HR13	HR14	HR15	HR16	HR17	HR18	HR19	HR20	HR21	HR22	HR23	HR24	Total_Score
HR1	Pearson Correlation	1	.775**	.797**	.866**	1.000**	0.130	0.122	0.072	0.094	-0.033	-.237*	-0.098	-0.126	-0.047	-0.033	-0.016	0.060	-0.210	-.246*	-.288*	-.292*	-0.015	0.012	0.072	.348**
HR2	Pearson Correlation	.775**	1	.863**	.784**	.775**	0.143	0.088	-0.020	0.104	-0.056	-0.145	-0.117	-0.116	-0.006	-0.049	0.031	0.032	-0.092	-0.132	-0.166	-0.159	-0.056	0.061	0.050	.365**
HR3	Pearson Correlation	.797**	.863**	1	.753**	.797**	0.132	0.076	-0.033	0.088	-0.135	-0.224	-0.196	-0.194	0.086	0.048	0.108	0.111	-0.105	-0.144	-0.179	-0.173	-0.135	-0.017	-0.033	.351**
HR4	Pearson Correlation	.866**	.784**	.753**	1	.866**	0.020	0.038	-0.004	0.041	-0.005	-0.177	-0.039	-0.081	-0.073	-0.051	-0.060	0.006	-0.142	-0.180	-0.217	-0.215	-0.059	-0.014	-0.074	.313**
HR5	Pearson Correlation	1.000**	.775**	.797**	.866**	1	0.130	0.122	0.072	0.094	-0.033	-.237*	-0.098	-0.126	-0.047	-0.033	-0.016	0.060	-0.210	-.246*	-.288*	-.292*	-0.015	0.012	0.072	.348**
HR6	Pearson Correlation	0.130	0.143	0.132	0.020	0.130	1	.752**	.717**	.604**	0.011	0.013	0.002	0.048	0.078	0.166	0.047	0.068	0.038	-0.056	-0.069	-0.093	0.036	-0.013	0.110	.349**
HR7	Pearson Correlation	0.122	0.088	0.076	0.038	0.122	.752**	1	.683**	.481**	-0.059	-0.073	-0.012	0.041	-0.089	0.072	-0.102	-0.001	-0.013	0.004	0.083	0.046	0.132	-0.007	0.137	.282*
HR8	Pearson Correlation	0.072	-0.020	-0.033	-0.004	0.072	.717**	.683**	1	.690**	-0.002	-0.026	-0.040	0.088	0.077	.242*	0.072	0.170	-0.028	-0.108	-0.122	-0.061	0.187	0.044	0.116	.333**
HR9	Pearson Correlation	0.094	0.104	0.088	0.041	0.094	.604**	.481**	.690**	1	0.128	0.137	0.055	0.123	0.078	0.220	0.094	0.190	0.175	0.026	0.004	-0.036	.313**	0.159	0.206	.455**

HR10	Pearson Correlation	-0.033	-0.056	-0.135	-0.005	-0.033	0.011	-0.059	-0.002	0.128	1	.743**	.721**	.625**	0.140	0.058	0.220	0.190	.616**	.578**	.453**	.382**	0.175	0.220	0.075	.550**
HR11	Pearson Correlation	-.237*	-0.145	-0.224	-0.177	-.237*	0.013	-0.073	-0.026	0.137	.743**	1	.741**	.677**	0.087	-0.008	0.116	0.101	.562**	.534**	.486**	.403**	0.046	0.071	0.045	.413**
HR12	Pearson Correlation	-0.098	-0.117	-0.196	-0.039	-0.098	0.002	-0.012	-0.040	0.055	.721**	.741**	1	.830**	0.070	0.012	0.078	0.122	.395**	.441**	.546**	.458**	0.093	0.112	0.031	.463**
HR13	Pearson Correlation	-0.126	-0.116	-0.194	-0.081	-0.126	0.048	0.041	0.088	0.123	.625**	.677**	.830**	1	0.103	0.054	0.115	0.154	.381**	.422**	.537**	.528**	0.098	0.132	0.088	.489**
HR14	Pearson Correlation	-0.047	-0.006	0.086	-0.073	-0.047	0.078	-0.089	0.077	0.078	0.140	0.087	0.070	0.103	1	.826**	.895**	.692**	0.223	0.203	0.125	0.077	0.099	0.101	0.077	.547**
HR15	Pearson Correlation	-0.033	-0.049	0.048	-0.051	-0.033	0.166	0.072	.242*	0.220	0.058	-0.008	0.012	0.054	.826**	1	.779**	.807**	0.153	0.132	0.101	0.045	0.149	0.014	0.045	.538**
HR16	Pearson Correlation	-0.016	0.031	0.108	-0.060	-0.016	0.047	-0.102	0.072	0.094	0.220	0.116	0.078	0.115	.895**	.779**	1	.825**	.253*	.233*	0.098	0.072	0.115	0.073	0.072	.571**
HR17	Pearson Correlation	0.060	0.032	0.111	0.006	0.060	0.068	-0.001	0.170	0.190	0.190	0.101	0.122	0.154	.692**	.807**	.825**	1	0.198	0.175	0.122	0.098	0.147	-0.011	0.098	.589**
HR18	Pearson Correlation	-0.210	-0.092	-0.105	-0.142	-0.210	0.038	-0.013	-0.028	0.175	.616**	.562**	.395**	.381**	0.223	0.153	.253*	0.198	1	.846**	.701**	.535**	.327**	.336**	.253*	.548**
HR19	Pearson Correlation	-.246*	-0.132	-0.144	-0.180	-.246*	-0.056	0.004	-0.108	0.026	.578**	.534**	.441**	.422**	0.203	0.132	.233*	0.175	.846**	1	.846**	.670**	0.186	0.209	0.087	.479**
HR20	Pearson Correlation	-.288*	-0.166	-0.179	-0.217	-.288*	-0.069	0.083	-0.122	0.004	.453**	.486**	.546**	.537**	0.125	0.101	0.098	0.122	.701**	.846**	1	.817**	.242*	.256*	0.159	.449**

HR21	Pearson Correlation	-.292*	-0.159	-0.173	-0.215	-.292*	-0.093	0.046	-0.061	-0.036	.382**	.403**	.458**	.528**	0.077	0.045	0.072	0.098	.535**	.670**	.817**	1	.266*	.269*	0.205	.383**
HR22	Pearson Correlation	-0.015	-0.056	-0.135	-0.059	-0.015	0.036	0.132	0.187	.313**	0.175	0.046	0.093	0.098	0.099	0.149	0.115	0.147	.327**	0.186	.242*	.266*	1	.807**	.663**	.429**
HR23	Pearson Correlation	0.012	0.061	-0.017	-0.014	0.012	-0.013	-0.007	0.044	0.159	0.220	0.071	0.112	0.132	0.101	0.014	0.073	-0.011	.336**	0.209	.256*	.269*	.807**	1	.568**	.394**
HR24	Pearson Correlation	0.072	0.050	-0.033	-0.074	0.072	0.110	0.137	0.116	0.206	0.075	0.045	0.031	0.088	0.077	0.045	0.072	0.098	.253*	0.087	0.159	0.205	.663**	.568**	1	.362**
Total_Score	Pearson Correlation	.348**	.365**	.351**	.313**	.348**	.349**	.282*	.333**	.455**	.550**	.413**	.463**	.489**	.547**	.538**	.571**	.589**	.548**	.479**	.449**	.383**	.429**	.394**	.362**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

7.6.2.2. Validity for Standardization

		ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8	ST 9	ST 10	ST 11	ST 12	ST 13	ST 14	ST15	ST 16	ST 17	ST 18	ST 19	ST 20	ST 21	ST 22	ST 23	ST 24	Total_Score
ST1	Pearson Correlation	1	.763**	.787**	.839**	1.000**	0.074	0.074	0.022	0.130	.252*	.281*	.335**	0.201	0.003	0.064	0.107	0.123	.455**	.312**	.368**	0.226	-.367**	-.272*	-.286*	.636**
ST2	Pearson Correlation	.763**	1	.847**	.784**	.763**	0.066	0.000	-0.002	0.040	0.117	0.133	0.176	0.062	0.042	0.188	0.143	.270*	.303**	0.180	0.225	0.088	-0.207	-0.208	-.318**	.566**

ST3	Pearson Correlation	.787**	.847**	1	.748**	.787**	0.133	0.133	0.065	0.120	0.132	0.149	0.193	0.077	-0.067	0.084	0.145	0.226	.319**	0.194	.240*	0.103	-.267*	-.260*	-.400**	.554**
ST4	Pearson Correlation	.839**	.784**	.748**	1	.839**	0.136	0.068	0.072	0.143	0.162	0.183	0.229	0.109	-0.008	0.052	0.150	0.137	.353**	0.224	.273*	0.135	-.334**	-.262*	-.286*	.572**
ST5	Pearson Correlation	1.000**	.763**	.787**	.839**	1	0.074	0.074	0.022	0.130	.252*	.281*	.335**	0.201	0.003	0.064	0.107	0.123	.455**	.312**	.368**	0.226	-.367**	-.272*	-.286*	.636**
ST6	Pearson Correlation	0.074	0.066	0.133	0.136	0.074	1	.857**	.762**	.451**	-0.082	-0.155	-0.076	-0.155	0.100	0.096	0.000	0.056	0.084	-0.087	-0.084	-0.079	-0.184	-0.168	-0.075	.291*
ST7	Pearson Correlation	0.074	0.000	0.133	0.068	0.074	.857**	1	.762**	.376**	0.000	0.000	0.000	0.000	0.100	0.096	-0.058	0.000	0.084	0.087	0.084	0.079	-0.184	-0.168	-0.075	.341**
ST8	Pearson Correlation	0.022	-0.002	0.065	0.072	0.022	.762**	.762**	1	.481**	-0.201	-0.121	-0.195	-0.046	0.100	0.098	-0.002	0.090	-0.040	-0.123	-0.122	0.033	-.236*	-0.224	-0.043	.232*
ST9	Pearson Correlation	0.130	0.040	0.120	0.143	0.130	.451**	.376**	.481**	1	0.105	0.159	0.144	0.159	0.029	0.035	0.114	0.170	0.209	0.045	0.032	0.091	-0.056	-0.083	-0.129	.391**
ST10	Pearson Correlation	.252*	0.117	0.132	0.162	.252*	-0.082	0.000	-0.201	0.105	1.000	.915**	.792**	.649**	0	-0.1753357	0.055	-0.027	.760**	.805**	.663**	.592**	-0.058	-0.034	-0.105	.557**
ST11	Pearson Corr	.281*	0.133	0.149	0.183	.281*	-0.155	0.000	-0.121	0.159	.915**	1.000	.796**	.664**	0	-0.1795571	0.050	0.021	.781**	.828**	.689**	.613**	-0.119	-0.098	-0.159	.569**

	elation																									
ST12	Pearson Correlation	.335**	0.176	0.193	0.229	.335**	-0.076	0.000	-0.195	0.144	.792**	.796**	1.000	.796**	0	-0.1565838	0.048	-0.044	.658**	.702**	.837**	.751**	-0.181	-0.157	-0.224	.583**
ST13	Pearson Correlation	0.201	0.062	0.077	0.109	0.201	-0.155	0.000	-0.046	0.159	.649**	.664**	.796**	1.000	0	-0.1275426	0.050	-0.039	.506**	.639**	.781**	.872**	-0.186	-0.158	-.240*	.506**
ST14	Pearson Correlation	0.003	0.042	-0.067	-0.008	0.003	0.100	0.100	0.100	0.029	-0.192	-0.198	-0.121	-0.036	1	.750**	0.137	0.033	-0.102	-0.066	-0.043	-0.112	0.028	0.120	0.023	.253*
ST15	Pearson Correlation	0.064	0.188	0.084	0.052	0.064	0.096	0.096	0.098	0.035	-0.175	-0.180	-0.157	-0.128	.750**	1	0.093	0.073	-0.089	-0.055	-0.089	-0.204	0.026	0.042	0.116	.285*
ST16	Pearson Correlation	0.107	0.143	0.145	0.150	0.107	0.000	-0.058	-0.002	0.114	0.055	0.050	0.048	0.050	0.137	0.093	1	.812**	0.058	0.061	0.058	0.052	-0.100	-0.093	-0.176	.336**
ST17	Pearson Correlation	0.123	.270*	0.226	0.137	0.123	0.056	0.000	0.090	0.170	-0.027	0.021	-0.044	-0.039	0.033	0.073	.812**	1	0.045	-0.014	-0.021	-0.033	-0.090	-0.145	-0.170	.316**
ST18	Pearson Correlation	.455**	.303**	.319**	.353**	.455**	0.084	0.084	-0.040	0.209	.760**	.781**	.658**	.506**	-0.102	-0.089	0.058	0.045	1	.846**	.701**	.535**	-0.206	-0.165	-.298*	.656**
ST19	Pearson Correlation	.312**	0.180	0.194	0.224	.312**	-0.087	0.087	-0.123	0.045	.805**	.828**	.702**	.639**	-0.066	-0.055	0.061	-0.014	.846**	1	.846**	.670**	-0.064	-0.031	-0.137	.647**

ST20	Pearson Correlation	.368**	0.225	.240*	.273*	.368**	-0.084	0.084	-0.122	0.032	.663**	.689**	.837**	.781**	-0.043	-0.089	0.058	-0.021	.701**	.846**	1	.817**	-0.133	-0.099	-0.209	.647**
ST21	Pearson Correlation	0.226	0.088	0.103	0.135	0.226	-0.079	0.079	0.033	0.091	.592**	.613**	.751**	.872**	-0.112	-0.204	0.052	-0.033	.535**	.670**	.817**	1	-0.192	-0.160	-.258*	.506**
ST22	Pearson Correlation	-.367**	-0.207	-.267*	-.334**	-.367**	-0.184	-0.184	-.236*	-0.056	-0.058	-0.119	-0.181	-0.186	0.028	0.026	-0.100	-0.090	-0.206	-0.064	-0.133	-0.192	1	.866**	.637**	-0.054
ST23	Pearson Correlation	-.272*	-0.208	-.260*	-.262*	-.272*	-0.168	-0.168	-0.224	-0.083	-0.034	-0.098	-0.157	-0.158	0.120	0.042	-0.093	-0.145	-0.165	-0.031	-0.099	-0.160	.866**	1	.612**	0.005
ST24	Pearson Correlation	-.286*	-.318**	-.400**	-.286*	-.286*	-0.075	-0.075	-0.043	-0.129	-0.105	-0.159	-0.224	-.240*	0.023	0.116	-0.176	-0.170	-.298*	-0.137	-0.209	-.258*	.637**	.612**	1	-0.116
Total_Score	Pearson Correlation	.636**	.566**	.554**	.572**	.636**	.291*	.341**	.232*	.391**	.557**	.569**	.583**	.506**	.253*	.285*	.336**	.316**	.656**	.647**	.647**	.506**	-0.054	0.005	-0.116	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

7.6.2.3. Validity for Storage System

		SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10	SS11	SS12	SS13	SS14	SS15	SS16	SS17	SS18	SS19	SS20	SS21	SS22	SS23	SS24	Total_Score

SS1	Pearson Correlation	1	.733**	.736**	.633**	.711**	0.036	0.036	0.036	-0.002	-0.093	-0.066	-0.025	-0.093	0.211	.272*	0.010	-0.078	0.203	0.175	-0.087	0.004	-0.222	-.259*	-.249*	.451**
SS2	Pearson Correlation	.733**	1	.714**	.884**	.743**	0.139	0.139	0.139	0.010	-0.001	0.094	0.139	-0.001	0.199	.267*	-0.113	-0.215	0.091	0.061	-0.133	-0.024	-.244*	-.286*	-.273*	.477**
SS3	Pearson Correlation	.736**	.714**	1	.716**	.699**	0.078	0.078	0.078	0.014	0.012	0.039	0.138	0.012	0.164	.285*	-0.028	-0.171	0.201	0.162	0.001	0.122	-0.219	-.256*	-.341**	.513**
SS4	Pearson Correlation	.633**	.884**	.716**	1	.696**	0.168	0.168	0.168	0.021	0.026	0.124	0.168	0.026	0.165	.299*	-0.063	-0.166	0.108	0.068	-0.118	0.006	-.242*	-.230*	-.269*	.510**
SS5	Pearson Correlation	.711**	.743**	.699**	.696**	1	0.089	0.089	0.089	-0.008	0.029	0.043	0.155	0.029	0.108	0.174	-0.013	-0.106	0.085	0.070	-0.124	-0.038	-.235*	-0.224	-0.212	.460**
SS6	Pearson Correlation	0.036	0.139	0.078	0.168	0.089	1	1.000**	1.000**	0.212	0.061	0.061	0.157	0.061	-0.080	-0.157	0.051	0.016	0.020	0.105	-0.041	0.013	0.015	-0.046	0.062	.422**
SS7	Pearson Correlation	0.036	0.139	0.078	0.168	0.089	1.000**	1	1.000**	0.212	0.061	0.061	0.157	0.061	-0.080	-0.157	0.051	0.016	0.020	0.105	-0.041	0.013	0.015	-0.046	0.062	.422**
SS8	Pearson Correlation	0.036	0.139	0.078	0.168	0.089	1.000**	1.000**	1	0.212	0.061	0.061	0.157	0.061	-0.080	-0.157	0.051	0.016	0.020	0.105	-0.041	0.013	0.015	-0.046	0.062	.422**
SS9	Pearson Corr	-0.002	0.010	0.014	0.021	-0.008	0.212	0.212	0.212	1	-0.101	-0.118	-0.114	-0.101	0.114	-0.049	0.101	-0.027	0.114	0.138	0.136	0.104	0.006	-0.123	0.000	0.144

	elation																										
SS10	Pearson Correlation	-0.093	-0.001	0.012	0.026	0.029	0.061	0.061	0.061	-0.101	1.000	.609**	.555**	1.000**	0	0.0214262	0.074	0.031	-0.036	0.043	-0.051	0.174	0.013	0.012	0.000	.363**
SS11	Pearson Correlation	-0.066	0.094	0.039	0.124	0.043	0.061	0.061	0.061	-0.118	.609**	1.000	.738**	.609**	0	0.1648101	-0.041	-0.140	-0.018	-0.031	0.094	0.158	-0.109	-0.104	-0.182	.321**
SS12	Pearson Correlation	-0.025	0.139	0.138	0.168	0.155	0.157	0.157	0.157	-0.114	.555**	.738**	1.000	.555**	0	-0.0031513	-0.014	-0.116	-0.093	-0.001	0.017	0.079	-0.049	-0.107	-0.124	.350**
SS13	Pearson Correlation	-0.093	-0.001	0.012	0.026	0.029	0.061	0.061	0.061	-0.101	1.000**	.609**	.555**	1.000	0	0.0214262	0.074	0.031	-0.036	0.043	-0.051	0.174	0.013	0.012	0.000	.363**
SS14	Pearson Correlation	0.211	0.199	0.164	0.165	0.108	-0.080	-0.080	-0.080	0.114	0.021	0.090	-0.003	0.021	1	.770**	-0.051	-0.016	0.037	0.211	-0.132	-0.145	-0.142	-0.135	-0.124	0.225
SS15	Pearson Correlation	.272*	.267*	.285*	.299*	0.174	-0.157	-0.157	-0.157	-0.049	0.021	0.165	-0.003	0.021	.770**	1	-0.117	-0.083	0.150	0.211	-0.017	-0.013	-0.142	-0.075	-0.124	.297*
SS16	Pearson Correlation	0.010	-0.113	-0.028	-0.063	-0.013	0.051	0.051	0.051	0.101	0.074	-0.041	-0.014	0.074	-0.051	-0.117	1	.832**	0.037	-0.012	0.072	-0.020	0.077	0.177	0.159	.274*
SS17	Pearson Correlation	-0.078	-0.215	-0.171	-0.166	-0.106	0.016	0.016	0.016	-0.027	0.031	-0.140	-0.116	0.031	-0.016	-0.083	.832**	1	-0.091	-0.095	-0.064	-0.163	0.186	.282*	.321**	0.150

SS18	Pearson Correlation	0.203	0.0906805	0.201	0.107569	0.0853853	0.020	0.020	0.020	0.114	-0.036	-0.018	-0.093	-0.036	0.037	0.150	0.037	-0.091	1.000	.723**	.663**	.848**	0	-0.0589003	-0.0917597	.516**
SS19	Pearson Correlation	0.175	0.0611026	0.162	0.0683228	0.0698394	0.105	0.105	0.105	0.138	0.043	-0.031	-0.001	0.043	0.211	0.211	-0.012	-0.095	.723**	1.000	.511**	.662**	0	-0.0170536	-0.042508	.543**
SS20	Pearson Correlation	-0.087	-0.133304	0.001	-0.1182193	-0.1240206	-0.041	-0.041	-0.041	0.136	-0.051	0.094	0.017	-0.051	-0.132	-0.017	0.072	-0.064	.663**	.511**	1.000	.763**	0	-0.0623327	-0.0932227	.298*
SS21	Pearson Correlation	0.004	-0.0239685	0.122	0.0055077	-0.0380145	0.013	0.013	0.013	0.104	0.174	0.158	0.079	0.174	-0.145	-0.013	-0.020	-0.163	.848**	.662**	.763**	1.000	0	-0.1170228	-0.1600751	.441**
SS22	Pearson Correlation	-0.222	-.244*	-0.219	-.242*	-.235*	0.015	0.015	0.015	0.006	0.013	-0.109	-0.049	0.013	-0.142	-0.142	0.077	0.186	-0.015	0.026	-0.066	-0.068	1	.901**	.872**	0.191
SS23	Pearson Correlation	-.259*	-.286*	-.256*	-.230*	-0.224	-0.046	-0.046	-0.046	-0.123	0.012	-0.104	-0.107	0.012	-0.135	-0.075	0.177	.282*	-0.059	-0.017	-0.062	-0.117	.901**	1	.879**	0.163
SS24	Pearson Correlation	-.249*	-.273*	-.341**	-.269*	-0.212	0.062	0.062	0.062	0.000	0.000	-0.182	-0.124	0.000	-0.124	-0.124	0.159	.321**	-0.092	-0.043	-0.093	-0.160	.872**	.879**	1	0.155
Total_Score	Pearson Correlation	.451**	.477**	.513**	.510**	.460**	.422**	.422**	.422**	0.144	.363**	.321**	.350**	.363**	0.225	.297*	.274*	0.150	.516**	.543**	.298*	.441**	0.191	0.163	0.155	1

**. Correlation is significant at the 0.01 level (2-tailed).

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7.6.2.4. Validity for Training

		TR 1	TR 2	TR 3	TR 4	TR 5	TR 6	TR 7	TR 8	TR 9	TR 10	TR 11	TR 12	TR 13	TR 14	TR 15	TR 16	TR 17	TR 18	TR 19	TR 20	TR 21	TR 22	TR 23	TR 24	Total_Score
TR1	Pearson Correlation	1	.831**	.846**	.898**	1.000**	-.425**	-.358**	-.390**	-.285*	0.033	0.032	0.101	0.003	-0.202	-0.191	0.108	-0.006	-0.076	-0.108	-0.150	-0.133	0.008	-0.005	-0.095	.472**
TR2	Pearson Correlation	.831**	1	.905**	.843**	.831**	-.350**	-.262*	-.233*	-0.186	0.044	0.073	0.091	0.029	-0.215	-.247*	0.151	0.060	-0.026	-0.063	-0.097	-0.077	-0.003	0.028	-0.050	.560**
TR3	Pearson Correlation	.846**	.905**	1	.821**	.846**	-.433**	-.292*	-.265*	-0.218	0.111	0.138	0.157	0.096	-0.151	-0.184	0.131	0.038	0.013	-0.022	-0.058	-0.039	0.025	0.010	-0.022	.608**
TR4	Pearson Correlation	.898**	.843**	.821**	1	.898**	-.387**	-.337**	-.361**	-.260*	0.018	0.004	0.073	-0.002	-.238*	-0.224	0.116	-0.032	-0.055	-0.093	-0.130	-0.110	-0.042	-0.058	-0.141	.436**
TR5	Pearson Correlation	1.000**	.831**	.846**	.898**	1	-.425**	-.358**	-.390**	-.285*	0.033	0.032	0.101	0.003	-0.202	-0.191	0.108	-0.006	-0.076	-0.108	-0.150	-0.133	0.008	-0.005	-0.095	.472**
TR6	Pearson Correlation	-.425**	-.350**	-.433**	-.387**	-.425**	1	.827**	.758**	.697**	-0.062	-0.078	-0.123	-0.018	0.048	0.007	-0.009	0.107	-0.050	-0.028	-0.006	0.016	-0.147	-0.048	-0.028	0.068
TR7	Pearson Correlation	-.358**	-.262*	-.292*	-.337**	-.358**	.827**	1	.766**	.708**	0.072	0.034	-0.066	-0.009	0.131	0.038	-0.019	0.102	-0.046	-0.032	-0.072	-0.046	-0.108	-0.073	0.007	0.187
TR8	Pearson Correlation	-.390**	-.233*	-.265*	-.361**	-.390**	.758**	.766**	1	.701**	0.039	0.073	0.033	0.090	0.002	-0.096	-0.014	0.104	0.115	0.071	0.094	0.050	-0.039	-0.002	0.019	.251*
TR9	Pearson Correlation	-.285*	-0.186	-0.218	-.260*	-.285*	.697**	.708**	.701**	1	0.105	0.073	0.033	-0.048	0.002	-0.096	-0.072	0.104	-0.146	-0.064	-0.039	-0.015	-0.215	-0.178	-0.098	0.141
TR10	Pearson	0.033	0.044	0.111	0.018	0.033	-0.062	0.072	0.039	0.105	1	.732**	.690**	.542**	-0.059	0.023	0.136	0.056	-.240*	-0.211	-0.189	-0.168	0.010	-0.072	-0.055	.351**

	Correlation																									
TR11	Pearson Correlation	0.032	0.073	0.138	0.004	0.032	-0.078	0.034	0.073	0.073	.732**	1	.770**	.735**	-0.088	-0.070	0.177	0.170	-0.155	-0.203	-.248*	-0.155	0.106	0.088	0.045	.450**
TR12	Pearson Correlation	0.101	0.091	0.157	0.073	0.101	-0.123	-0.066	0.033	0.033	.690**	.770**	1	.761**	-.252*	-0.173	0.212	0.143	-.244*	-.294*	-0.198	-0.106	0.021	-0.059	-0.103	.354**
TR13	Pearson Correlation	0.003	0.029	0.096	-0.002	0.003	-0.018	-0.009	0.090	-0.048	.542**	.735**	.761**	1	-0.077	-0.063	0.149	0.125	-0.139	-.256*	-.235*	-0.214	0.227	0.146	0.092	.397**
TR14	Pearson Correlation	-0.202	-0.215	-0.151	-.238*	-0.202	0.048	0.131	0.002	0.002	-0.059	-0.088	-.252*	-0.077	1	.855**	-.699**	-.574**	-0.046	-0.032	-0.137	-0.174	-0.050	0.043	-0.050	-0.187
TR15	Pearson Correlation	-0.191	-.247*	-0.184	-0.224	-0.191	0.007	0.038	-0.096	-0.096	0.023	-0.070	-0.173	-0.063	.855**	1	-.558**	-.606**	-0.063	-0.048	-0.088	-0.128	-0.074	0.021	-0.074	-0.200
TR16	Pearson Correlation	0.108	0.151	0.131	0.116	0.108	-0.009	-0.019	-0.014	-0.072	0.136	0.177	0.212	0.149	-.699**	-.558**	1	.811**	-0.100	-0.175	-0.073	0.026	-0.062	-0.094	-0.006	0.199
TR17	Pearson Correlation	-0.006	0.060	0.038	-0.032	-0.006	0.107	0.102	0.104	0.104	0.056	0.170	0.143	0.125	-.574**	-.606**	.811**	1	-0.148	-0.155	-0.119	-0.023	-0.073	-0.102	-0.017	0.147
TR18	Pearson Correlation	-0.076	-0.026	0.013	-0.055	-0.076	-0.050	-0.046	0.115	-0.146	-.240*	-0.155	-.244*	-0.139	-0.046	-0.063	-0.100	-0.148	1	.855**	.747**	.573**	0.156	0.174	0.220	.279*
TR19	Pearson Correlation	-0.108	-0.063	-0.022	-0.093	-0.108	-0.028	-0.032	0.071	-0.064	-0.211	-0.203	-.294*	-.256*	-0.032	-0.048	-0.175	-0.155	.855**	1	.888**	.707**	0.083	0.099	0.215	.240*
TR20	Pearson Correlation	-0.150	-0.097	-0.058	-0.130	-0.150	-0.006	-0.072	0.094	-0.039	-0.189	-.248*	-0.198	-.235*	-0.137	-0.088	-0.073	-0.119	.747**	.888**	1	.820**	0.055	0.072	0.185	0.212

TR21	Pearson Correlation	-0.133	-0.077	-0.039	-0.110	-0.133	0.016	-0.046	0.050	-0.015	-0.168	-0.155	-0.106	-0.214	-0.174	-0.128	0.026	-0.023	.573**	.707**	.820**	1	0.029	0.046	0.156	0.223
TR22	Pearson Correlation	0.008	-0.003	0.025	-0.042	0.008	-0.147	-0.108	-0.039	-0.215	0.010	0.106	0.021	0.227	-0.050	-0.074	-0.062	-0.073	0.156	0.083	0.055	0.029	1	.799**	.771**	.348**
TR23	Pearson Correlation	-0.005	0.028	0.010	-0.058	-0.005	-0.048	-0.073	-0.002	-0.178	-0.072	0.088	-0.059	0.146	0.043	0.021	-0.094	-0.102	0.174	0.099	0.072	0.046	.799**	1	.799**	.370**
TR24	Pearson Correlation	-0.095	-0.050	-0.022	-0.141	-0.095	-0.028	0.007	0.019	-0.098	-0.055	0.045	-0.103	0.092	-0.050	-0.074	-0.006	-0.017	0.220	0.215	0.185	0.156	.771**	.799**	1	.365**
Total_Score	Pearson Correlation	.472**	.560**	.608**	.436**	.472**	0.068	0.187	.251*	0.141	.351**	.450**	.354**	.397**	-0.187	-0.200	0.199	0.147	.279*	.240*	0.212	0.223	.348**	.370**	.365**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

7.6.2.5. Validity for Warehouse Design

		WD1	WD2	WD3	WD4	WD5	WD6	WD7	WD8	WD9	WD10	WD11	WD12	WD13	WD14	WD15	WD16	WD17	WD18	WD19	WD20	WD21	WD22	WD23	WD24	Total_Score
WD1	Pearson Correlation	1	.676**	.778**	.693**	.792**	-0.022	-0.118	-0.137	-0.074	-0.025	-0.159	-0.066	-0.164	0.098	0.157	-0.148	-.238*	-0.105	-0.047	-0.177	-0.049	-0.120	-0.079	0.005	.385**
WD2	Pearson Correlation	.676**	1	.652**	.708**	.665**	-0.157	-0.179	-0.071	0.119	0.069	-0.186	-0.075	-0.106	-0.031	0.034	-.235*	-.328**	-0.214	-0.172	-.284*	-0.163	0.004	0.094	0.176	.340**
WD3	Pearson	.778**	.652**	1	.669**	.768**	0.043	-0.128	-0.147	-0.076	-0.011	-0.145	0.010	-0.088	.242*	.365**	-0.177	-.268*	-0.122	-0.067	-0.194	-0.067	-0.134	-0.094	-0.010	.420**

	Correlation																									
WD4	Pearson Correlation	.693**	.708**	.669**	1	.730**	-0.123	-0.221	-.239*	0.150	-0.060	-.276*	-0.162	-0.138	0.176	.245*	-0.162	-.313**	-0.147	-0.147	-0.165	-0.089	-0.155	-0.114	-0.026	.284*
WD5	Pearson Correlation	.792**	.665**	.768**	.730**	1	-0.103	-0.201	-0.219	0.159	-0.027	-0.167	-0.069	-0.110	0.103	0.166	-0.156	-.251*	-0.052	-0.050	-0.129	0.006	-0.048	-0.007	0.082	.437**
WD6	Pearson Correlation	-0.022	-0.157	0.043	-0.123	-0.103	1	.723**	.576**	-0.047	0.220	0.194	0.135	0.146	-0.036	-0.001	0.181	0.161	0.145	0.025	0.048	0.060	-0.163	-0.180	-0.117	.239*
WD7	Pearson Correlation	-0.118	-0.179	-0.128	-0.221	-0.201	.723**	1	.846**	-0.050	0.141	0.205	0.152	0.163	-0.143	-0.193	0.129	0.107	0.031	-0.085	-0.062	-0.050	-0.012	-0.036	0.026	0.169
WD8	Pearson Correlation	-0.137	-0.071	-0.147	-.239*	-0.219	.576**	.846**	1	-0.052	0.157	0.216	.254*	0.179	-0.164	-0.211	0.157	0.133	0.004	-0.034	-0.086	-0.074	0.074	0.046	0.055	0.217
WD9	Pearson Correlation	-0.074	0.119	-0.076	0.150	0.159	-0.047	-0.050	-0.052	1	0.065	0.057	0.067	0.070	-0.085	-0.077	0.101	0.096	0.168	0.154	0.163	0.168	.274*	.258*	.261*	.334**
WD10	Pearson Correlation	-0.025	0.069	-0.011	-0.060	-0.027	0.220	0.141	0.157	0.065	1	.637**	.587**	.633**	-0.217	-0.062	-0.014	-0.050	0.179	0.154	0.056	0.110	-0.116	-0.080	-0.091	.343**
WD11	Pearson Correlation	-0.159	-0.186	-0.145	-.276*	-0.167	0.194	0.205	0.216	0.057	.637**	1	.690**	.742**	-0.162	0.017	-0.207	-0.182	.267*	0.229	0.132	0.193	-0.032	-0.099	-0.109	.270*
WD12	Pearson Correlation	-0.066	-0.075	0.010	-0.162	-0.069	0.135	0.152	.254*	0.067	.587**	.690**	1	.675**	-0.056	0.099	-0.106	-0.205	.333**	.241*	0.212	.265*	-0.096	-0.060	-0.115	.395**
WD13	Pearson Correlation	-0.164	-0.106	-0.088	-0.138	-0.110	0.146	0.163	0.179	0.070	.633**	.742**	.675**	1	-0.098	0.117	-0.131	-0.163	0.216	0.131	0.099	0.149	-0.032	-0.084	-0.095	.317**

WD14	Pearson Correlation	0.098	-0.031	.242*	0.176	0.103	-0.036	-0.143	-0.164	-0.085	-0.217	-0.162	-0.056	-0.098	1	.721**	0.036	0.055	-0.013	-0.075	-0.034	-0.136	-0.149	-0.185	-0.091	0.102
WD15	Pearson Correlation	0.157	0.034	.365**	.245*	0.166	-0.001	-0.193	-0.211	-0.077	-0.062	0.017	0.099	0.117	.721**	1	-0.040	-0.016	0.112	-0.008	-0.034	-0.078	-0.191	-0.097	-0.126	.247*
WD16	Pearson Correlation	-0.148	-.235*	-0.177	-0.162	-0.156	0.181	0.129	0.157	0.101	-0.014	-0.207	-0.106	-0.131	0.036	-0.040	1	.832**	0.011	0.084	0.094	0.070	0.036	-0.071	0.029	0.149
WD17	Pearson Correlation	-.238*	-.328**	-.268*	-.313**	-.251*	0.161	0.107	0.133	0.096	-0.050	-0.182	-0.205	-0.163	0.055	-0.016	.832**	1	0.032	0.100	0.055	0.032	0.086	-0.027	-0.003	0.062
WD18	Pearson Correlation	-0.105	-0.214	-0.122	-0.147	-0.052	0.145	0.031	0.004	0.168	0.179	.267*	.333**	0.216	-0.013	0.112	0.011	0.032	1	.732**	.785**	.814**	-0.134	-0.089	-0.197	.415**
WD19	Pearson Correlation	-0.047	-0.172	-0.067	-0.147	-0.050	0.025	-0.085	-0.034	0.154	0.154	0.229	.241*	0.131	-0.075	-0.008	0.084	0.100	.732**	1	.703**	.853**	-0.015	0.021	-0.083	.441**
WD20	Pearson Correlation	-0.177	-.284*	-0.194	-0.165	-0.129	0.048	-0.062	-0.086	0.163	0.056	0.132	0.212	0.099	-0.034	-0.034	0.094	0.055	.785**	.703**	1	.785**	-0.024	-0.065	-0.172	.301**
WD21	Pearson Correlation	-0.049	-0.163	-0.067	-0.089	0.006	0.060	-0.050	-0.074	0.168	0.110	0.193	.265*	0.149	-0.136	-0.078	0.070	0.032	.814**	.853**	.785**	1	-0.093	-0.048	-0.157	.407**
WD22	Pearson Correlation	-0.120	0.004	-0.134	-0.155	-0.048	-0.163	-0.012	0.074	.274*	-0.116	-0.032	-0.096	-0.032	-0.149	-0.191	0.036	0.086	-0.134	-0.015	-0.024	-0.093	1	.824**	.809**	.357**
WD23	Pearson Correlation	-0.079	0.094	-0.094	-0.114	-0.007	-0.180	-0.036	0.046	.258*	-0.080	-0.099	-0.060	-0.084	-0.185	-0.097	-0.071	-0.027	-0.089	0.021	-0.065	-0.048	.824**	1	.855**	.380**
WD24	Pearson Correlation	0.005	0.176	-0.010	-0.026	0.082	-0.117	0.026	0.055	.261*	-0.091	-0.109	-0.115	-0.095	-0.091	-0.126	0.029	-0.003	-0.197	-0.083	-0.172	-0.157	.809**	.855**	1	.411**

Total_Score	Pearson Correlation	.385**	.340**	.420**	.284*	.437**	.239*	0.169	0.217	.334**	.343**	.270*	.395**	.317**	0.102	.247*	0.149	0.062	.415**	.441**	.301**	.407**	.357**	.380**	.411**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).