# IMPROVING EFFICIENCY OF A WAREHOUSE: CASE STUDY FROM A TILE MANUFACTURING COMPANY IN SRI LANKA


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## Supervisor's declaration

The above candidate has carried out research for the MBA thesis Dissertation under my supervision.

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(Supervisor:Dr. T. Sivakumar) Date

# Abstract

Warehouse operation and management is a critical part in manufacturing and service industry. This research anlysis the strategies for improving the warehouse efficiency in leading tile manufacturing organization (RPL) in Sri Lanka and how to implementing the proper inventory management system in the warehouse. The Cummulative Net Flow Analysis (Inflow-Outflow) was used for check whether warehouse capacicty was enough or not to cater the customer demand as well as Inflow quantity from the factory. And also it used 4M analysis(Man, Machine, Material, Method) with the internal warehouse processes to find that are there any errors with reference to 4Ms. In addition to that a questionnaire was given to empolyees in RPL to find the strategies which will be most significant and implementable.

**Key Words: Warehouse Efficiency,  Warehouse Layout, Forklift Routing**

## Acknowledgements

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## List of Abbreviations

| | |
|---|---|
| **First-In First-Out** | **-FIFO** |
| **Just In Time** | **-JIT** |
| **Rocell(pvt) Ltd** | **-RPL** |
| **Work in Process** | **-WIP** |
| **Stock Keeping Units** | **-SKU** |

## List of Appendices

# 1 INTRODUCTION

## 1.1 Warehouse Capacity and Operations

When considering about the supply chain's order fulfillment process, it is often the warehouse that playing a central role in making the right product available to the right customer at the right time. Warehouse is the key aspect of modern supply chains and playing a vital role in the success of manufacturing and service industry.

Warehouse and distribution facilities providing easy access to the inventory. If any warehouse can speed up its storing, picking, staging, replenishment and dispatching operations then it would create more customer satisfaction and make more profit to the organization. Businesses implementing strategies such as turn to automation, reduce operational cost, increase demand for inventory, review business pricing strategy and optimizing the supply chain for increase the inventory turnover ratio and reduce the amount of time inventory holds in the warehouse.

Often updating the inventory level and synchronizing it with the order quantity helps to avoid unnecessary slowdowns in the process. It also reduces unnecessary overtime costs and production bottlenecks.

The objectives of warehouse capacity can be more specific, such as maximum utilization of warehouse space, providing maximum flexibility to warehouse operations and increasing warehouse efficiency without increasing the resources.

The sales should indicates that how much is needed to manufacture and the capacity of the warehouse to facilitate the finished goods, raw materials and goods with WIP. The potential capacity of manufacturing and lead time need to be considered when deciding the capacity of typical warehouse.

The distribution warehouse consists of four main operations. They are receiving, storing, picking and staging. The warehouse operations should be able to timely deliver the goods to the customers, optimized distribution, leading to increased labor productivity, reduce the damages for goods in order fulfillment process, prevent goods from getting lost and increase the customer satisfaction.

## 1.2 Case Study Area

The case study organization, considered for this study, has grown into a large conglomerate business operating in sectors such as tiles, sanitary-ware, aluminium products, packaging materials, plantation, mining and even financial services. Being positioned as the largest listed company in manufacturing sector in the Colombo Securities Exchange provides evidence for the scale of the business of Rocell Pvt Ltd (RPL). Despite having diversified into many sectors, tile and sanitary-ware business is still the major contributor to the group. Having earned a combined revenue of Rs. 19.5 billion, these two sectors accounted for more than 70% of the group's net revenue for the year ended 31$^{st}$ March 2018. As 54 showrooms and 12 factory outlets in Sri Lanka and a host of international dealers to promote RPL's tile, bathwear and accessories therefore this name is trademark for functionality, originality and finesse.

## 1.3 Process Structure and Existing Layout of RPL

### 1.3.1 Process Structure of RPL

The main warehouse of RPL facilitates tiles, bathware, sanitaryware and accessories. It has eight sub warehouses and can facilitates 13,364 pallets at once. The four main operations are taken place in each sub warehouse of RPL. They are receiving, storing, staging and order picking. The process maps for storing and order picking operations are drawn in the below.

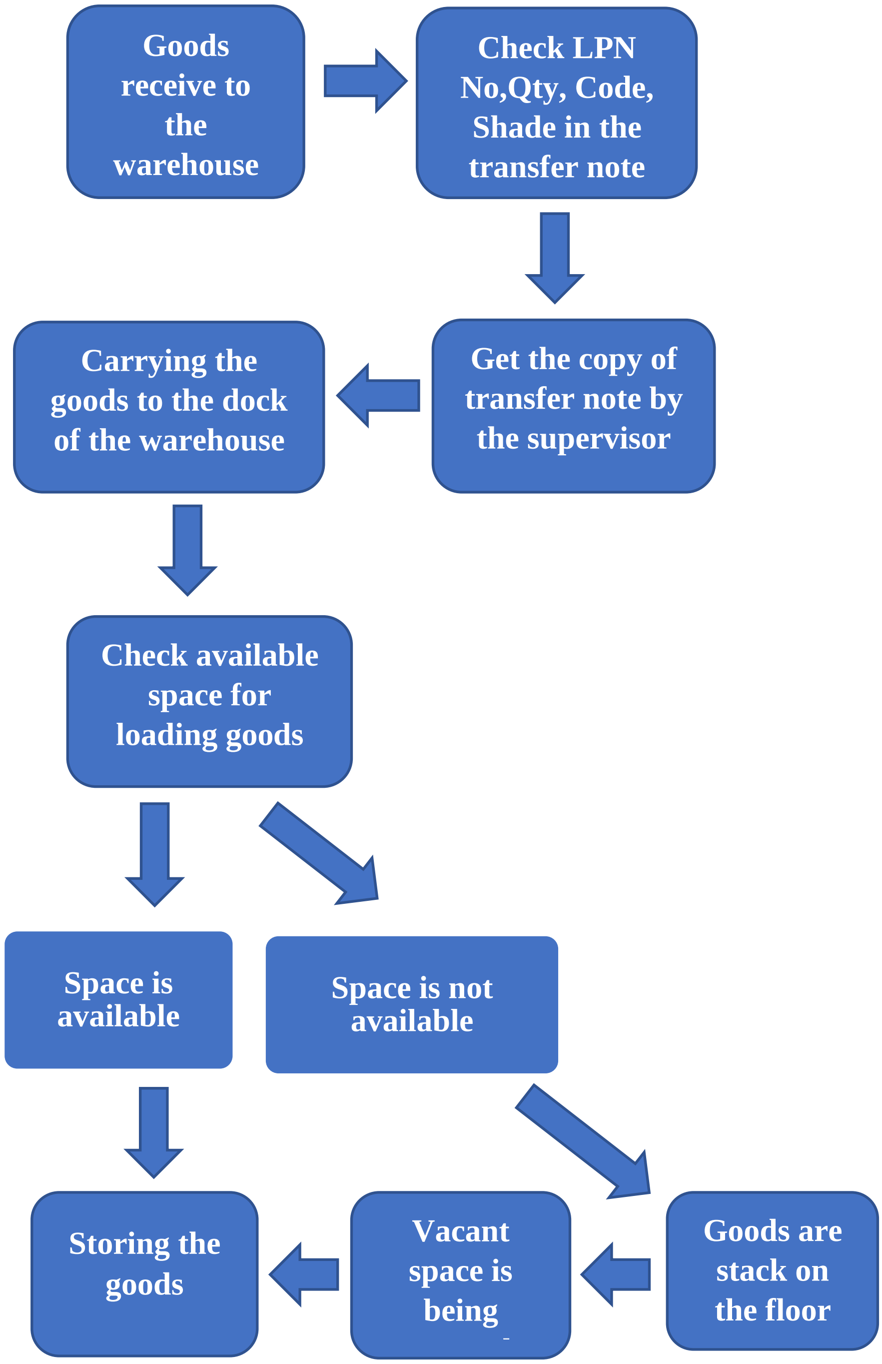


**Figure 1.1: Storing and Receiving Operation**

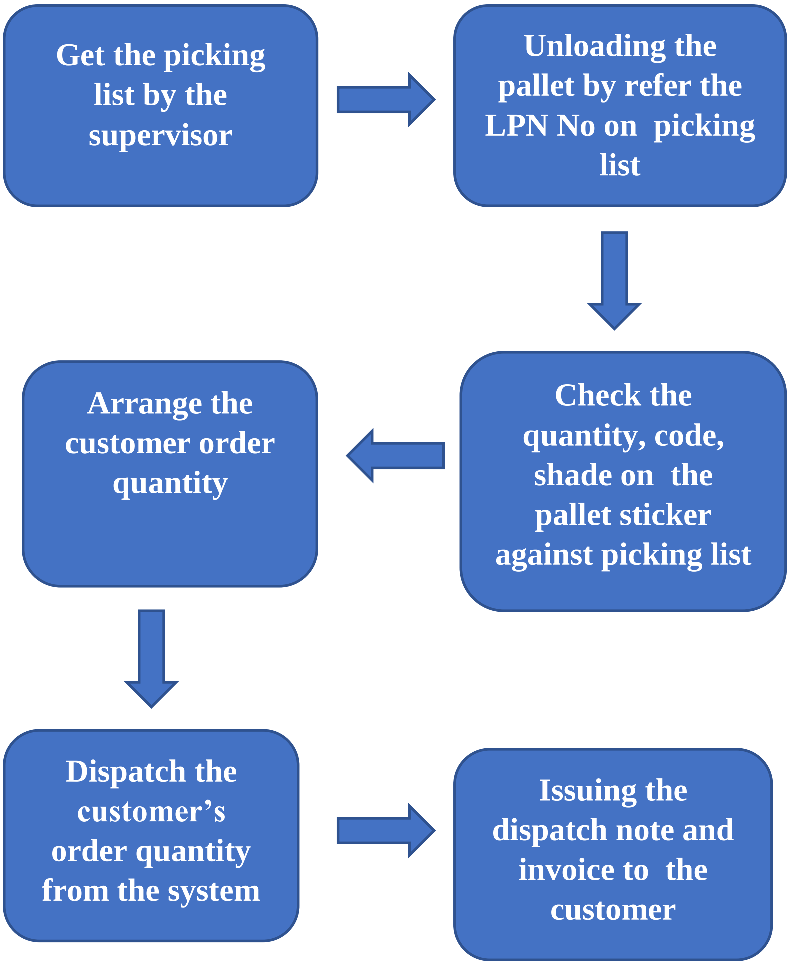


**Figure 1.2: Picking Operation**

The warehouse of RPL is storing three product categories for floor tiles and wall tiles. They are 600 in to 600, 600 in to 300 and 1200 in to 600 in cms. When considering a sub warehouse it has 12 horizontal columns and consider a horizontal column then it has twelve vertical rows and twenty-one vertical columns.

### 1.3.2 Existing Layout of RPL

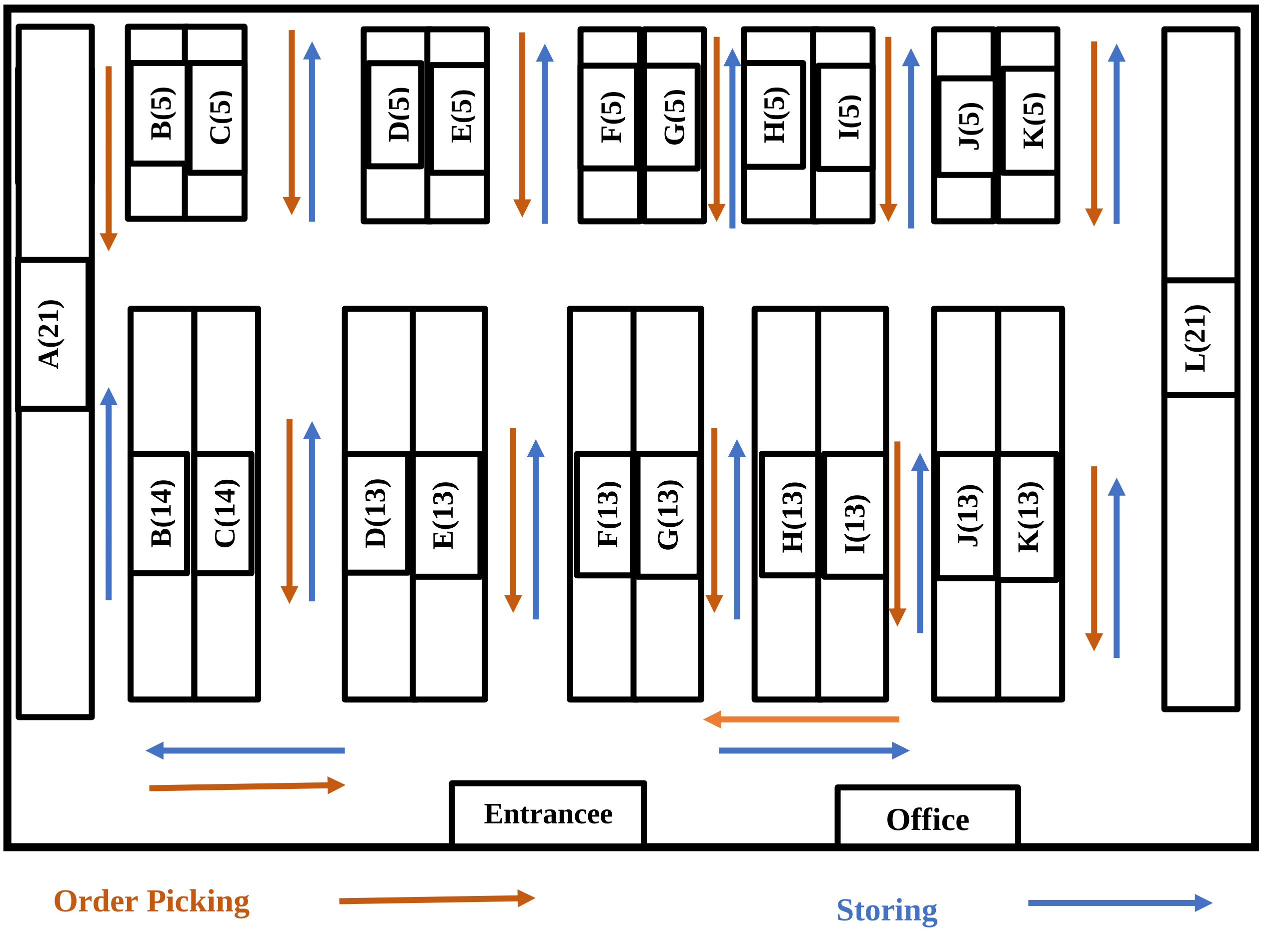


**Figure 1.3: Existing Layout of the RPL**

## 1.4 Research Problem

The warehouse of RPL has the major issue of not having a inventory management system for optimum utilization of it's warehouse capacity. The warehouse facing the following struggled with below issue. Therefore this research is focused to find a solution for below issue.

### 1.4.1 Lack of Routing Schedule for Forklift Operators

When goods are received from the factory forklift operators pick those goods and hold them in the put-away area. They don't have a proper routing schedule for entering in to put-away area and it depends on number of times goods are received to the warehouse from the factory. Therefore, checking operator is rushed during two consecutive receivings because he hasn't enough time to clear the put-away area and check the transfer note against the goods which are received. As a result, there is a high probability of making a mistake which is done by the checking operator.

In addition, inventory management system able to improve operation efficiency, consistency, quality control of the process by moving the goods at maximum speed and morale of the employees by who are earned more incentives.

## 1.5 Research Objective

In order to improve the warehouse efficiency, the main objectves of this research is to;

(a) Assess the existing warehouse operations

(b) Evaluate the factors to improve the efficiency of the warehouse

(c) Identify the least cost solution for implementation

## 1.6 Research Limitations

This research is focused only the warehouse in Meegoda of RPL because it has the issue with low efficiency in it's warehouse operations. Therefore Inflow and Outflow quantity was considered for data analysis in this research. And also sample questionnaire was given to the employees in RPL.

# 2 LITERATURE REVIEW

## 2.1 Generalization of the Literature Review

Select the most appropiate layout for certain warehouse it needs to check whether layout can meet the required objectives for the warehouse operations (Rouwenhorst et al.2000). The definition of the warehouse design is a core factor when considering the systematic approach for decision making at strategic, tactical and operational levels. The decisions in the strategic level could be long-term impact to the warehouse operations includes the initial investment on the equipments, value stream design and selecting the type of warehouse management system. The tactical level decisions are last in between six months to one year which includes the dimensioning of storage systems, defining the layout design and choosing the right equipment's and tools. The short-term decisions are taken in the operation level which exists the conditions of the control policies and these policies should be within the constraints of strategic and tactical levels.

The requirement for defining the best layout is very important in the layout design process. There have been two types of layout models considered. The first one was facility layout model (De Koster et al.2007). It includes establishment of various operational functions (receiving, picking, storage, sorting, shipping and etc). A warehouse block layout model is defined by using the activity relationship between the cross functions. The carrying cost (travel milages) and closeness ratings have been considered as non-exclusive objectives.

The second layout model is defined as inner layout design or aisle configuration. It defined the holding place for the equipment, storage area and moving path within each cross functions areas. The definition of warehouse layout is seeking an efficient layout for the typical warehouse operations(storing and picking). In today, most of the conventional warehouses use the systematic layouts for their warehouse operations. It has parallel straight aisles with rectangular shape. The multiple block layout is adding more than one cross aisle in to the basic form of the traditional layout. There are two types of conventional layouts for order picking and storage operations with refer to selective pallet rack system. They are conventional order-picking area layout which consider only manual order picking operations and conventional storage area layout consider the unit load operations. The modest improved layouts which don’t have traditional predictions have been proposed in (Gue and Meller 2009a) and because of these layouts the storage efficiency has been increased due to less travelling time needed when store or pick a sku. The theoretical analyze of warehouse layout can be found in (Francis and white 1974) both for rectangular and non-rectangular shapes. The time for travelling between the skus, time for picking the skus and time for other activities are three components in pick an order. There is a opportunity for increasing the order picking efficiency by reducing the travel milage between the picking skus (Tompkins et al. 1996). The strategies for increasing the order picking efficiency can be divided under three operating policies they are routing, storage and batching. The picking priority and routes of travelling should be decided under the routing policies hence it caused to reduce the total travel milage when doing the picking operations. By using some constrains in storage policies cause to reduce the total travel distance with refer to the random assignment. The order batching method is another efficient method for reducing the total travel distance which includes chip in two or more customer order in to one picking order. The above methods have been already proven for improving the order picking efficiency. The performance of warehouse directly impacted by the capacity of the order picking operator, size and other criterias of the order and dimensions of the warehouse. All the processess are integrated with others therefore performance of the specific process is dependable. By using the efficient layout for the order picking will minimize the travel distance along the routes as a result reduced the operating cost and increased the customer satisfaction by reducing the response time for each customer order. When selecting most efficient layout by the warehouse designers they should consider about what are the objectives of Layout, advantages and disadvantages of the different layouts which they will have to considered.

## 2.2 Warehouse Layouts

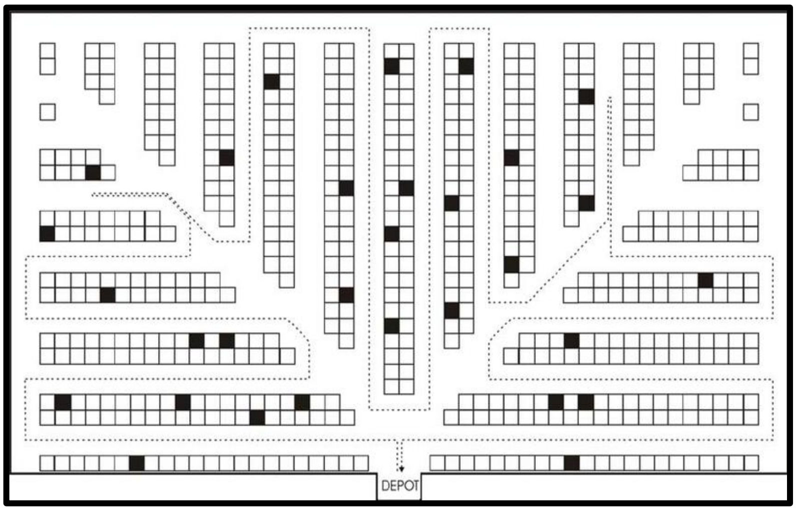


**Figure 2.1: Layout-1**

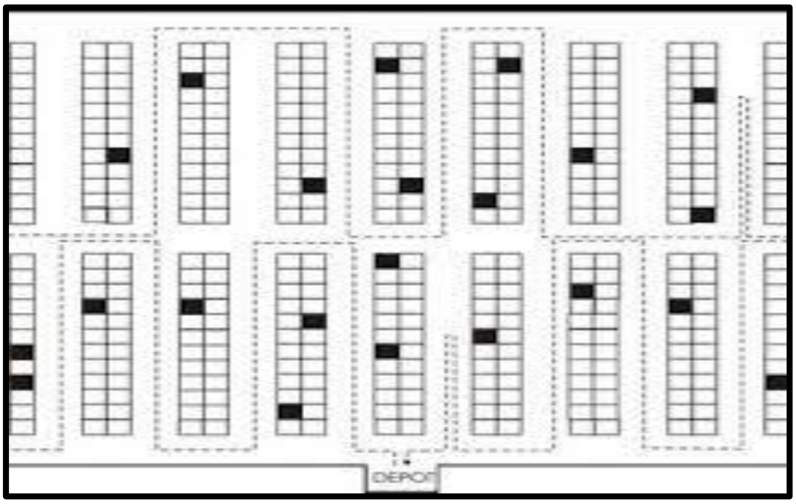

**Figure 2.2: Layout-2**

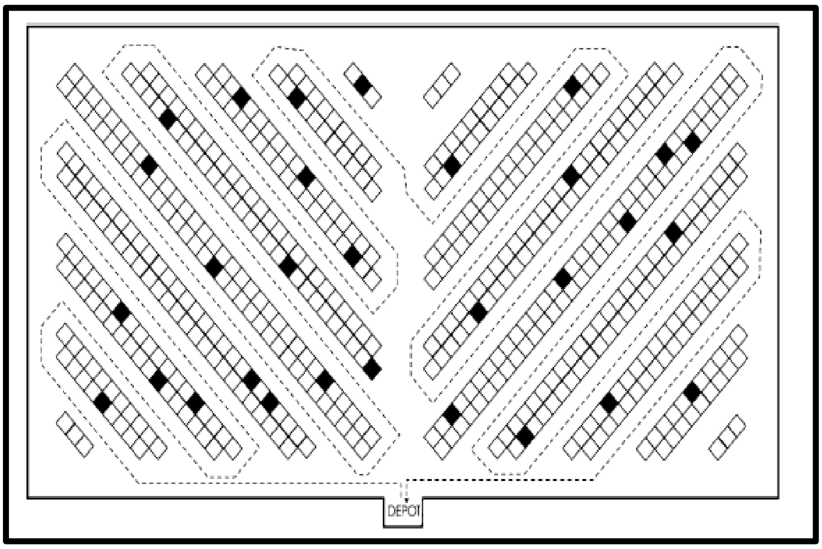


**Figure 2.3: Layout-3**

When consider Figure 2.1 the operator is moved in S-shape curve but in Figure 2.2 the operator is moved in curved lines and it is inefficient route when compare with the Figure 2.1.

When consider Figure 2.1 the warehouse layout is designed based on the quantity of goods. The goods are with less quantity can be stored in shorter columns and more quantity can be stored in longer columns. When compare with the Figure 2.2 this is efficeint layout for storing and order picking operations.

When consider the Figure 2.3 it is also designed with S-shape curve and operator can access each shelve in the warehouse. This unique feature isn’t in other two layouts Figure 2.1 and Figure 2.2.

And it is recommended that layout-3 will be the best layout for warehouse in RPL.(Goran Dukic and Tihomir Opetuk -1985)

# 3 RESEARCH METHODOLOGY

## 3.1 Analysis Cumulative Net Flow(Inflow-Outflow)

The Inflow and Outflow quantity was analyzed in each month from 2014 to 2018 which was transferred through the warehouse in terms of tiles then calculated the Net Flow by got the difference of Inflow and Outflow quantity. Then Cumulative Net Flow was calculated.Finally, Cumulative Net Flow (in terms of tiles) was converted in to pallets and which was graphically represented in the graph(Figure 4.2). According to the graph, the actual number of pallets was below the maximum warehouse capacity of 13364(in pallets) with in the time period of 2014 to 2018. Therefore, RPL has enough warehouse capacity for cater the customer demand and vendor(factory) Inflow but it's warehouse capacity wasn't fully utilized

## 3.2 Conduct a Questionnaire for Employees in RPL

The questionnaire was given to employees which included thirteen questions to analyze how these questions will be affected to the business in terms of importance level and whether will it be implemented or not to the business as a long term business strategy. The fifteen respondents were answered to the questionnaire and which included six store keepers and nine forklift operators. Firstly it was defined the weighted scale for each response Table 4.3. Then number of responses given were analyzed by each respondent to each question Table 4.2. Finally, it was multiplied the weighted scale in to number of responses for each question Figure 4.3. It was further analyzed the weighted score for each question Table 4.5 and according to this analysis the question one was scored highest marks (weighted score) out of the thirteen questions.

## 3.3 Assign Standard Routing for Forklift Operators

It will be used Hungarian Method in Operation Research for assign standard routing for forklift operators to enter in to put-away area. The typical operation activities which is done by the forklift operator in the storing operation are mentioned in the below.

I. Pick the sku from the loading bay(Operation Activity1)

II. Transfer the sku(which is already picked) from the loading bay in to put-away area(Operation Activity2)

III. Transfer the sku from the put-away area in to storing racks(Operation Activity3)

### 3.4 Data Collection Process

The sample questionnaire was given to the employees who work in RPL which included thirteen questions. The questions were categorized under two segments they were how significant them in to the business and difficulty level when they will be implemented in to the business. The fifteen responses were given for this sample questionnaire.

**Table 3.1: Sample Questionnaire**

| Importance | Not Important | Slightly Important | Moderately Important | Important | Extremely Important | No Idea |
|---|---|---|---|---|---|---|
| (1) Standardization of the Method | | | | | | |
| 1.1 Applying a standard turn for each transporter to | | | | | | |
| 1.2 Require vendor receiving appointments | | | | | | |
| 1.3 Calculate resource and space requirements based on expected receipts and current backlogs | | | | | | |
| 1.4 Communicate effectively and often to employees by the managers | | | | | | |
| Total No of Responses | | | | | | |
| (2) Redesign the layout with high accessibility | | | | | | |
| 2.1 Use labels effectively for inventory location | | | | | | |
| 2.2 Make sure for proper upkeep the warehouse | | | | | | |
| 2.3 Organize the picking stations logically | | | | | | |
| 2.4 Put high volume items close to shipping areas | | | | | | |
| 2.5 Conduct an ABC analysis, which causes for categorizing the inventory by value | | | | | | |
| 2.6 Keep the inventory together as much as possible | | | | | | |
| Total No of Responses | | | | | | |
| (3) Introducing advance technologies for warehouse | | | | | | |
| 3.1 Invest in a warehouse management system | | | | | | |
| 3.2 By using Barcodes and RFID tags for the data | | | | | | |
| 3.3 Capture the inventory picking frequency by using | | | | | | |
| Total No of Responses | | | | | | |

| Implementability | | | | | |
|---|---|---|---|---|---|
| | Very Easy | Easy | No idea | Difficult | Very difficult |
| (1) Standardization of the Method | | | | | |
| 1.1 Applying a standard turn for each transporter to enter the loading dock | | | | | |
| 1.2 Require vendor receiving appointments | | | | | |
| 1.3 Calculate resource and space requirements based on expected receipts and current backlogs | | | | | |
| 1.4 Communicate effectively and often to employees by the managers | | | | | |
| Total No of Responses | | | | | |
| (2) Redesign the layout with high accessibility | | | | | |
| 2.1 Use labels effectively for inventory location | | | | | |
| 2.2 Make sure for proper upkeep the warehouse | | | | | |
| 2.3 Organize the picking stations logically | | | | | |
| 2.4 Put high volume items close to shipping areas | | | | | |
| 2.5 Conduct an ABC analysis, which causes for categorizing the inventory by value | | | | | |
| 2.6 Keep the inventory together as much as possible | | | | | |
| Total No of Responses | | | | | |
| (3) Introducing advance technologies for warehouse operations | | | | | |
| 3.1 Invest in a warehouse management system | | | | | |
| 3.2 By using Barcodes and RFID tags for the data | | | | | |
| 3.3 Capture the inventory picking frequency by using the asset tracking system | | | | | |
| Total No of Responses | | | | | |

# 4 DATA ANALYSIS

## 4.1 Analysis Cumulative Net Flow

The Inflow and Outflow quantity in the warehouse was collected for each month for five years(2014 to 2018) and then analyzed the Net Flow and Cummulative Net Flow for each month. These data were obtained from the ERP system of the RPL.

**Table 4.1: Cumulative Net Flow**

| Year | Month | Inflow Qty(in Tiles) | Outflow Qty(in Tiles) | Net Flow (In-Out) in Tiles | Cum. Net Flow in Tiles | No of Pallets |
|---|---|---|---|---|---|---|
| 2014 | Jan | 2161 | -2030 | 131 | 131 | 2131 |
| 2014 | Feb | 2124 | -1248 | 876 | 1007 | 3007 |
| 2014 | Mar | 2795 | -2241 | 554 | 1561 | 3561 |
| 2014 | Apr | 1337 | -1671 | -334 | 1227 | 3227 |
| 2014 | May | 1077 | -1177 | -100 | 1127 | 3127 |
| 2014 | Jun | 1076 | -1267 | -191 | 936 | 2936 |
| 2014 | Jul | 1285 | -1392 | -107 | 829 | 2829 |
| 2014 | Aug | 1951 | -1652 | 299 | 1128 | 3128 |
| 2014 | Sep | 1520 | -1475 | 45 | 1173 | 3173 |
| 2014 | Oct | 2400 | -2065 | 335 | 1508 | 3508 |
| 2014 | Nov | 1990 | -1702 | 288 | 1796 | 3796 |
| 2014 | Dec | 2317 | -3063 | -746 | 1050 | 3050 |
| 2015 | Jan | 2731 | -2414 | 317 | 1367 | 3367 |
| 2015 | Feb | 2120 | -1657 | 463 | 1830 | 3830 |
| 2015 | Mar | 2439 | -2868 | -429 | 1401 | 3401 |
| 2015 | Apr | 1232 | -1937 | -705 | 696 | 2696 |
| 2015 | May | 1247 | -1749 | -502 | 194 | 2194 |
| 2015 | Jun | 2607 | -2244 | 363 | 557 | 2557 |
| 2015 | Jul | 2442 | -2007 | 435 | 992 | 2992 |
| 2015 | Aug | 2834 | -2182 | 652 | 1644 | 3644 |
| 2015 | Sep | 2479 | -2147 | 332 | 1976 | 3976 |
| 2015 | Oct | 1223 | -1673 | -450 | 1526 | 3526 |
| 2015 | Nov | 2575 | -1850 | 725 | 2251 | 4251 |
| 2015 | Dec | 2904 | -3260 | -356 | 1895 | 3895 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2016 | Jan | 2063 | -2090 | -27 | 1868 | 3868 |
| 2016 | Feb | 2239 | -1955 | 284 | 2152 | 4152 |
| 2016 | Mar | 2777 | -3159 | -382 | 1770 | 3770 |
| 2016 | Apr | 1948 | -2070 | -122 | 1648 | 3648 |
| 2016 | May | 2176 | -1858 | 318 | 1966 | 3966 |
| 2016 | Jun | 3105 | -2072 | 1033 | 2999 | 4999 |
| 2016 | Jul | 2165 | -2144 | 21 | 3020 | 5020 |
| 2016 | Aug | 1555 | -2022 | -467 | 2553 | 4553 |
| 2016 | Sep | 2433 | -2188 | 245 | 2798 | 4798 |
| 2016 | Oct | 2826 | -2256 | 570 | 3368 | 5368 |
| 2016 | Nov | 3043 | -2930 | 113 | 3481 | 5481 |
| 2016 | Dec | 3560 | -4012 | -452 | 3029 | 5029 |
| 2017 | Jan | 2757 | -2650 | 107 | 3136 | 5136 |
| 2017 | Feb | 2433 | -2080 | 353 | 3489 | 5489 |
| 2017 | Mar | 3773 | -3907 | -134 | 3355 | 5355 |
| 2017 | Apr | 1741 | -493 | 1248 | 4603 | 6603 |
| 2017 | May | 3497 | -2050 | 1447 | 6050 | 8050 |
| 2017 | Jun | 3538 | -2272 | 1266 | 7316 | 9316 |
| 2017 | Jul | 2909 | -2335 | 574 | 7890 | 9890 |
| 2017 | Aug | 2536 | -2532 | 4 | 7894 | 9894 |
| 2017 | Sep | 3110 | -2533 | 577 | 8471 | 10471 |
| 2017 | Oct | 2292 | -2406 | -114 | 8357 | 10357 |
| 2017 | Nov | 3403 | -3462 | -59 | 8298 | 10298 |
| 2017 | Dec | 3856 | -5075 | -1219 | 7079 | 9079 |
| 2018 | Jan | 3923 | -4160 | -237 | 6842 | 8842 |
| 2018 | Feb | 3272 | -2810 | 462 | 7304 | 9304 |
| 2018 | Mar | 3338 | -4810 | -1472 | 5832 | 7832 |
| 2018 | Apr | 2641 | -2563 | 78 | 5910 | 7910 |
| 2018 | May | 3036 | -2510 | 526 | 6436 | 8436 |
| 2018 | Jun | 3713 | -2714 | 999 | 7434 | 9434 |
| 2018 | Jul | 3070 | -3051 | 20 | 7454 | 9454 |
| 2018 | Aug | 4045 | -3456 | 589 | 8043 | 10043 |
| 2018 | Sep | 2848 | -2778 | 70 | 8113 | 10113 |
| 2018 | Oct | 3266 | -3154 | 111 | 8224 | 10224 |
| 2018 | Nov | 3091 | -3153 | -62 | 8162 | 10162 |
| 2018 | Dec | 1543 | -2085 | -542 | 7620 | 9620 |

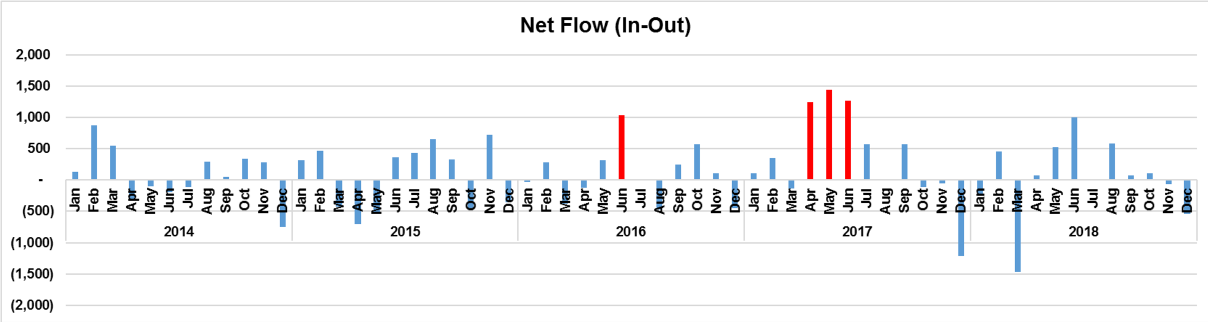


**Figure 4.1: Net Flow(In-Out)**

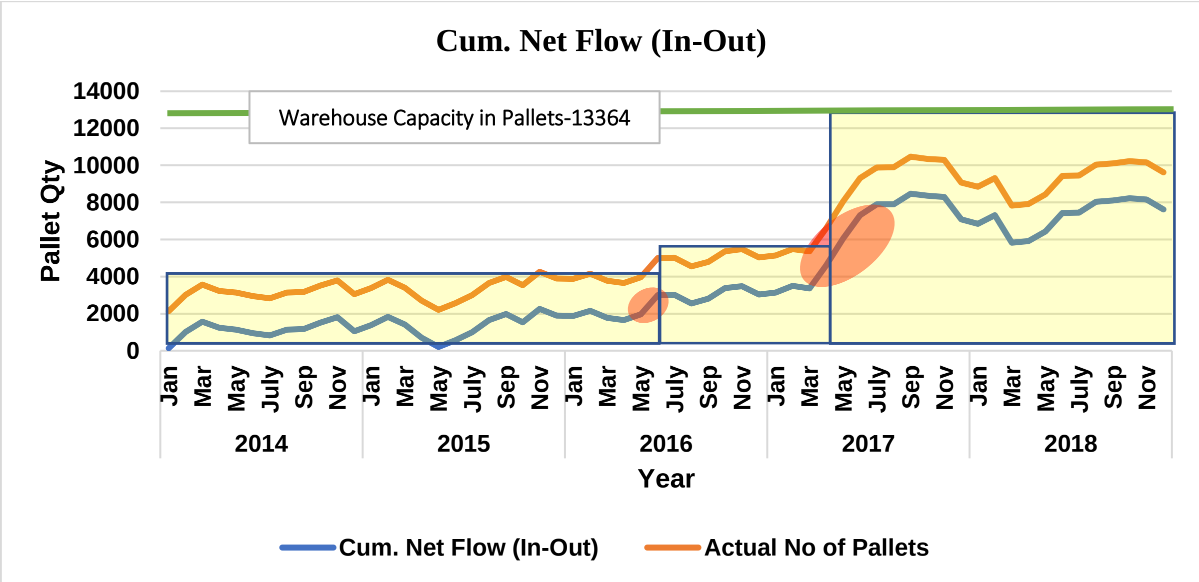


**Figure 4.2: Cumulative Net Flow(In-Out)**

According to Figure 4.1, Inflow quantity was more than Outflow quantity in most months during that time period. The maximum number of Inflow quantities were in 2015,2017 and 2018 . The maximum number of Outflow quantities were in 2014,2015 and 2016. The Average Inflow quantity was 500 tiles and Average Outflow quantity was below 500 tiles.

According to the Figure 4.2, there was drastic increment for both graphs from March 2017 to Aug 2017 because warehouse capacity was expanded and except that time period there was not any significant variation for both graphs.The maximum number of pallet quantity was 10471 and maximum Cumulative Net Flow was 8471 which was occurred in September 2017. The actual number of pallet quantity was always behind the maximum warehouse capacity of 13364 pallets.

## 4.2 Questionnaire Related Summary and Findings

The questionnaire was conducted for fifteen employees who work in RPL and thirteen questions were provided. The analysis of the questionnaire is below mentioned.

### 4.2.1 Analysis No of Responses for Questions

**Table 4.2: No of Responses for Questions**

| | Ques1(standard turn) | | | | | Ques2(vendor's docs) | | | | | Ques3(cal resources) | | | | | Ques4(communication) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult |
| Extremely Important | 0 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 3 | 0 | 6 | 5 | 0 | 0 | 0 |
| Important | 0 | 3 | 0 | 4 | 0 | 0 | 6 | 2 | 2 | 2 | 0 | 2 | 0 | 4 | 1 | 3 | 1 | 0 | 0 | 0 |
| Moderately Important | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Slightly Important | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Not Important | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Ques5(use labels) | | | | | Ques6(proper upkeep) | | | | | Ques7(org picking sta) | | | | | Ques8(high vol items) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult |
| 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 4 | 1 | 1 | 4 | 0 | 2 | 1 | 0 | 3 | 0 | 1 | 0 |
| 2 | 10 | 0 | 1 | 1 | 2 | 6 | 0 | 0 | 0 | 0 | 4 | 0 | 1 | 0 | 0 | 6 | 1 | 3 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Ques9(ABC analysis) | | | | | Ques10(inv together) | | | | | Ques11(invest WMS) | | | | | Ques12(RFID,Barco) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult |
| 0 | 1 | 0 | 3 | 0 | 0 | 2 | 0 | 6 | 1 | 0 | 2 | 0 | 3 | 0 | 0 | 1 | 0 | 5 | 1 |
| 0 | 4 | 1 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 3 | 1 | 5 | 1 | 0 | 0 | 1 | 5 | 2 |
| 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Ques13(inv picking freq) | | | | |
|---|---|---|---|---|
| Very Eassy | Eassy | No Idea | Difficult | Very Difficult |
| 0 | 4 | 0 | 2 | 0 |
| 0 | 2 | 0 | 3 | 2 |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 |

This questionnaire was tested on whether these thirteen questions will be important to the business or not and whether it can be implemented or not to the business as a long term strategy. The fifteen responses were given for each question.

### 4.2.2 Define Weighted Scale for Different Segments

**Table 4.3: Weighted Scale for Different Segments**

| | | Very Eassy | Eassy | No Idea | Difficult | Very Difficult |
|---|---|---|---|---|---|---|
| | | 5 | 4 | 3 | 2 | 1 |
| **Extremely Important** | 5 | *25* | *20* | *15* | *10* | *5* |
| **Important** | 4 | *20* | *16* | *12* | *8* | *4* |
| **Moderately Important** | 3 | *15* | *12* | *9* | *6* | *3* |
| **Slightly Important** | 2 | *10* | *8* | *6* | *4* | *2* |
| **Not Important** | 1 | *5* | *4* | *3* | *2* | *1* |

The highest priority was given to the segments which were extremely important and very easy to implement because the purpose of the questionnaire was find out the strategies which will be most important and convenient when they will be implemented in to warehouse operations. The weighted scale was defined by multiplying two different segments.The scale was defined from 1 to 5 for both segments.

### 4.2.3 Analysis Weighted Score against Importance and Easy

**Table 4.4: Weighted Score Vs Importance and Easy**

| Weighted Score (Importance Vs Easy Vs Questions) | | Ques1(standard turn) | | | | | Ques2(vendor's docs) | | | | | Ques3(cal resources) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult |
| 5 | Extremely Important | 0 | 60 | 0 | 10 | 0 | 0 | 20 | 0 | 20 | 0 | 0 | 5 | 0 | 15 | 0 |
| 4 | Important | 0 | 48 | 0 | 32 | 0 | 0 | 96 | 24 | 16 | 8 | 0 | 8 | 0 | 16 | 4 |
| 3 | Moderately Important | 0 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 |
| 2 | Slightly Important | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | Not Important | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Ques4(communication) | | | | | Ques5(use labels) | | | | | Ques6(proper upkeep) | | | | | Ques7(org picking sta) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult |
| 30 | 25 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 5 | 5 | 0 | 20 | 5 | 5 | 20 | 0 | 10 | 5 |
| 12 | 4 | 0 | 0 | 0 | 8 | 40 | 0 | 4 | 4 | 8 | 24 | 0 | 0 | 0 | 0 | 16 | 0 | 4 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Ques8(high vol items) | | | | | Ques9(ABC analysis) | | | | | Ques10(inv together) | | | | | Ques11(invest WMS) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult |
| 0 | 15 | 0 | 5 | 0 | 0 | 5 | 0 | 15 | 0 | 0 | 10 | 0 | 30 | 5 | 0 | 10 | 0 | 15 | 0 |
| 0 | 24 | 4 | 12 | 0 | 0 | 16 | 4 | 16 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 12 | 4 | 20 | 4 |
| 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

| Ques12(RFID,Barco) | | | | | Ques13(inv picking freq) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Very Eassy | Eassy | No Idea | Difficult | Very Difficult | Very Eassy | Eassy | No Idea | Difficult | Very Difficult |
| 0 | 5 | 0 | 25 | 5 | 0 | 20 | 0 | 10 | 0 |
| 0 | 0 | 4 | 20 | 8 | 0 | 8 | 0 | 12 | 8 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The weighted score was calculated by multiplying no of responses for questions Table 4.2 in to weighted scale for different segments Table 4.3. The result is mentioned in the below.

**Table 4.5: Weighted Score Vs Questions**

| Weighted Score Vs Questions | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 |
| | 194 | 184 | 60 | 71 | 61 | 67 | 66 | 60 | 62 | 62 | 65 | 67 | 61 |
| Rank | 1 | 2 | 12 | 3 | 10 | 4 | 6 | 12 | 8 | 8 | 7 | 4 | 10 |

The highest score was scored by question one and second highest score was scored by question two. And lowest score was scored by questions three and eight.

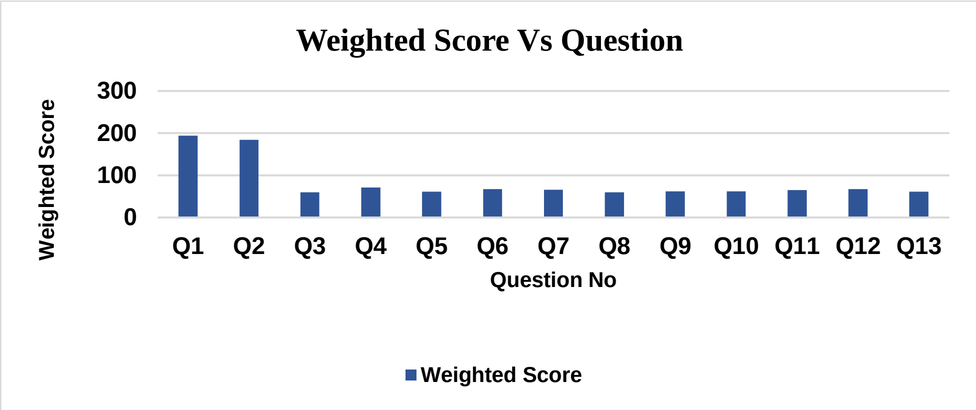


**Figure 4.4: Weighted Score Vs Question**

The weighted score was constant for the first two questions after that there was a drastic decrement in between the questions two and three then it was constant again Figure 4.4.

### 4.2.4 Analysis Weighted Score against Importance

**Table 4.6: Weighted Score Vs Importance**

| Weighted Score (Importance Vs Questions) | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 |
| Importance | 5 | Extremely Important | 70 | 40 | 20 | 55 | 5 | 35 | 40 | 20 | 20 | 45 | 25 | 35 | 30 |
| | 4 | Important | 80 | 144 | 28 | 16 | 56 | 32 | 20 | 40 | 36 | 8 | 40 | 32 | 28 |
| | 3 | Moderately Important | 36 | 0 | 12 | 0 | 0 | 0 | 6 | 0 | 6 | 6 | 0 | 0 | 3 |
| | 2 | Slightly Important | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| | 1 | Not Important | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

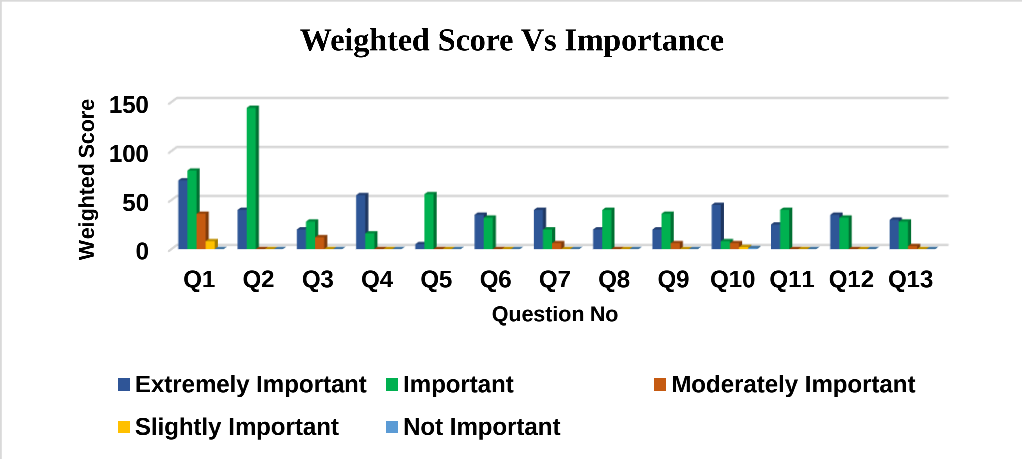


**Figure 4.5: Weighted Score Vs Importance**

The highest weighted scores were scored by the question two and one respectively. The lowest score was scored by question three and eight. The scores of other questions were below 75. The weighted score was drastically decreased from question two to three. After that weighted score was constant till the thirteen question.

### 4.2.5 Analysis Weighted Score against Easy

**Table 4.7: Weighted Score Vs Easy**

| Weighted Score (Easy Vs Questions) | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 |
| Easy | 5 | Very Eassy | 0 | 0 | 0 | 42 | 8 | 13 | 5 | 0 | 3 | 0 | 0 | 0 | 0 |
| | 4 | Eassy | 152 | 116 | 13 | 29 | 45 | 29 | 39 | 39 | 21 | 10 | 22 | 5 | 28 |
| | 3 | No Idea | 0 | 24 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 0 | 4 | 4 | 0 |
| | 2 | Difficult | 42 | 36 | 43 | 0 | 4 | 20 | 17 | 17 | 34 | 47 | 35 | 45 | 25 |
| | 1 | Very Difficult | 0 | 8 | 4 | 0 | 4 | 5 | 5 | 0 | 0 | 5 | 4 | 13 | 8 |

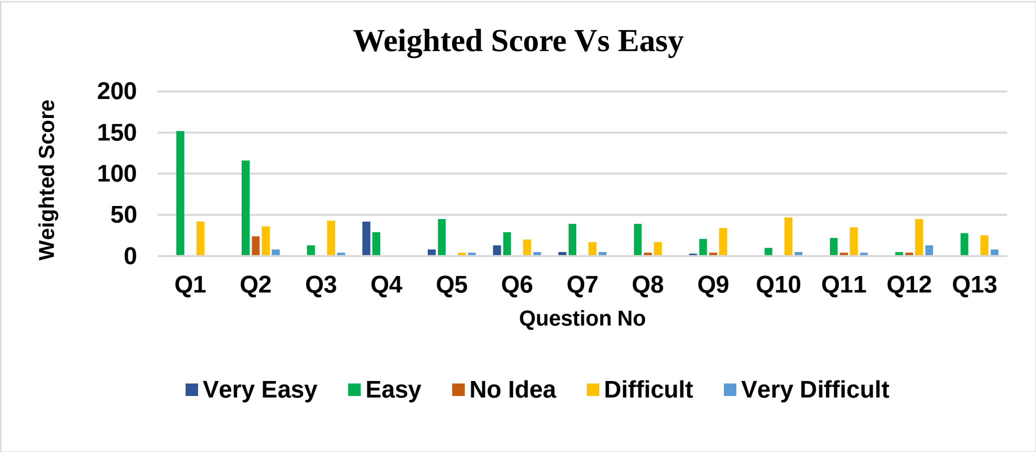


**Figure 4.6: Weighted Score Vs Easy**

According to the Figure 4.6 the highest scores were scored by question one and two respectively. And other questions were scored marks which below 50. In order to achieve the research objective of identify the least cost solution for implementation in RPL which can be used the strategy of applying a standard routing for forklift operators to enter in to put-away area because warehouse has enough machineries(forklifts) and employees who have sound technical knowledge and enough working experiences.

### 4.2.6 Analysis Weighted Score for Importance against Question Category

The following analysis was done for weighted score for importance against question category. And category-A means that standardization of the method, B means redesign the layout with high accessibility and C was for introducing advance technologies for warehouse operations.

**Table 4.8: Score for Importance Vs Question Category**

| Weighted Score (Importance Vs Questions-Category) | | | 1 | 2 | 3 |
|---|---|---|---|---|---|
| | | | A | B | C |
| Importance | 5 | Extremely Important | 185 | 165 | 90 |
| | 4 | Important | 268 | 192 | 100 |
| | 3 | Moderately Important | 48 | 18 | 3 |
| | 2 | Slightly Important | 8 | 2 | 0 |
| | 1 | Not Important | 0 | 1 | 0 |

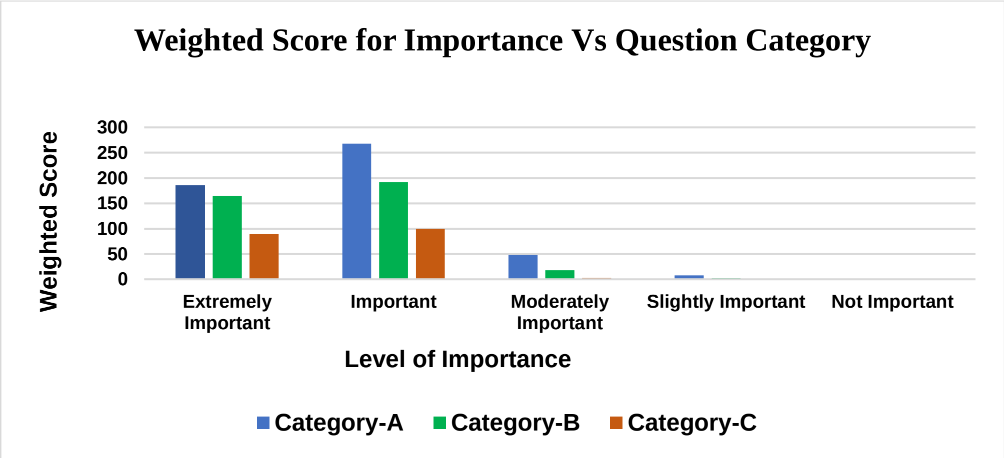


**Figure 4.7: Weighted Score for Importance Vs Question Category**

### 4.2.7 Analysis Weighted Score for Easy against Question Category

**Table 4.9: Weighted Score for Easy Vs Question Category**

| Weighted Score (Easy Vs Questions-Category) | | | 1 | 2 | 3 |
|---|---|---|---|---|---|
| | | | A | B | C |
| Easy | 5 | Very Eassy | 42 | 29 | 0 |
| | 4 | Eassy | 310 | 183 | 55 |
| | 3 | No Idea | 24 | 8 | 8 |
| | 2 | Difficult | 121 | 139 | 105 |
| | 1 | Very Difficult | 12 | 19 | 25 |

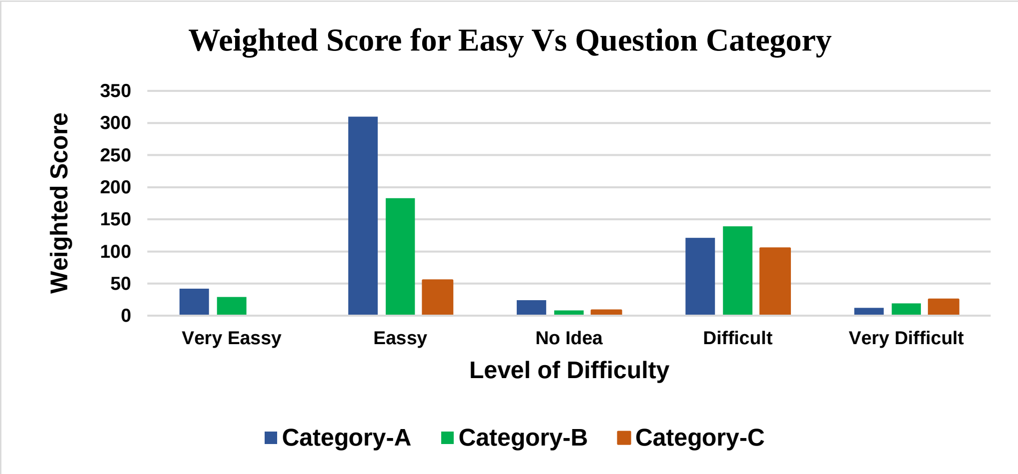


**Figure 4.8: Weighted Score for Easy Vs Question Category**

According to Figure 4.7 and Figure 4.8,both standardization of method (Category-A) and redesign the layout with high accessibility(Category-B) will be competitive strategies for RPL instead of introduce advance technologies for its warehouse operations(Category-C).

This would be happened because RPL has to invest huge capital investment if they would migrate to advance technology as its core business strategy. For example,when introducing warehouse management system, asset tracking system, barcode system or RFID tags for typical warehouse operations. And also, it requires expert knowledge for knowledge transferring to the top management, training and brainstorming the current employees for adhere to new technology, troubleshooting and other system updates for familiarize with the new system.

Under the standardization of the method(CategoryA), routing standardization for forklift operators(question1) has already been most critical and important requirement for warehouse of the RPL. This will cause the reduction of idle time of the forklift operators and eliminate the checking errors which was done by the checking operator.The total of Inflow and stored pallets should not be exceeded the warehouse capacity of 13364 pallets and base on that figure it should allocate the space requirement in the warehouse. The communication network between the management and employees is also vital for RPL to achieve the organization goals.

## 4.3 Analysis of Assign the Operation Activities

The Cost Metrix for how to assigning the operation activities(assigning standard routing for forklift operators) is below mentioned.

**Table 5.0: Cost Metrix for Assigning Operation Activities**

| Ope Activity / Operators | OA1 | OA2 | OA3 | …….j | …….n |
|---|---|---|---|---|---|
| 1 | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{1j}$ | $C_{1n}$ |
| 2 | $C_{21}$ | $C_{22}$ | $C_{23}$ | $C_{2j}$ | $C_{2n}$ |
| 3 | $C_{31}$ | $C_{32}$ | $C_{33}$ | $C_{3j}$ | $C_{3n}$ |
| . | . | . | . | .......... | .......... |
| . | . | . | . | .......... | .......... |
| . | . | . | . | …….. | …….. |
| . | . | . | . | …….. | …….. |
| i | $C_{i1}$ | $C_{i2}$ | $C_{i3}$ | $C_{ij}$ | $C_{in}$ |
| . | . | . | . | .......... | .......... |
| . | . | . | . | .......... | .......... |
| . | . | . | . | .......... | .......... |
| . | . | . | . | .......... | .......... |
| n | $C_{n1}$ | $C_{n2}$ | $C_{n3}$ | $C_{nj}$ | $C_{nn}$ |

According to Table 5.0, there are n jobs and n operators are available with differnet skills. And $C_{ij}$ is cost relates for $j^{th}$ work which is done by the $i^{th}$ operator. The each operation activity needs to be assigned for the operators with minimum cost to be completed. The operation activities are defined as OA1 to OAn and operators as OP1 to OPn.

Minimize Z(Cost) = $\sum_{i=1}^{n} Cij \sum_{j=1}^{n} Xij$ ; [i=1,2,3,….,n ; j=1,2,3,…..,n]

Where $X_{ij}$ =
- 1; if $i^{th}$ operator is assigned to $j^{th}$ operation activity
- 0; if $i^{th}$ operator is not assigned to $j^{th}$ operation activity

With the restrictions of

I. $\sum_{i=1}^{n} Xij$=1; j=1,2,3,………,n ; $i^{th}$ operator will do only one operation activity

II. $\sum_{j=1}^{n} Xij$=1; i=1,2,3,………,n ; $j^{th}$ operation activity will be done by only one operator

According to this Hungarian Method the number of forklift operators should be equal to number of operation activities. Therefore three forklift operators will be assigned for operation activities in the storing operation.

The cost for $j^{th}$ operation activity is done by the $i^{th}$ operator($C_{ij}$) defined as below mentioned.

Cost(Z) = Fuel Cost per Day+ Electricity Cost per Day+ Avg Labor Cost per Day

The typical example of Cost Metrix for how to assigned the operation activities for the forklift operators is below mentioned.

**Table 5.1: Cost Metrix**

| Operators / Ope Activity | OP1 | OP2 | OP3 |
|---|---|---|---|
| **OA1** | **8** | **10** | **17** |
| **OA2** | **3** | **8** | **5** |
| **OA3** | **10** | **12** | **11** |

**(Row Reduction)**

| Operators / Ope Activity | OP1 | OP2 | OP3 |
|---|---|---|---|
| **OA1** | **0** | **2** | **9** |
| **OA2** | **0** | **5** | **2** |
| **OA3** | **0** | **2** | **1** |

**(Column Reduction)**

| Operators / Ope Activity | OP1 | OP2 | OP3 |
|---|---|---|---|
| OA1 | 0 | 0 | 8 |
| OA2 | 0 | 3 | 1 |
| OA3 | 0 | 0 | 0 |

**(Assigned the zero in each row and crossed out the other zeros in same row and same column)**

| Operators / Ope Activity | OP1 | OP2 | OP3 |
|---|---|---|---|
| OA1 | ~~0~~ | 0 | 8 |
| OA2 | 0 | 3 | 1 |
| OA3 | ~~0~~ | ~~0~~ | 0 |

The operation activities are assigned for the forklift operators as below mentioned.

- **Operation Activity1 for 2nd forklift operator**
- **Operation Activity2 for 1st forklift operator**
- **Operation Activity3 for 3rd forklift operator**

According to the Table 5.1, the total minimum cost for assigned the operation activities for the forklift operators is 24(10+3+11).

# 5 CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

The main warehouse of RPL has eight sub warehouses and has a capacity of 13,364 pallets at once. The factories of RPL have been operating continuously due to minimize the operating cost of the machines excepts 10 days of shut down in the month of April for its maintenance purposes. In that operating period warehouse has more supply than its demand (Inflow Rate is higher than Outflow Rate).

In order to achieve research objectives, the Cumulative Net Flow was analyzed. According to Cumulative Net Flow analysis it was emphasized that warehouse capacity was enough for cater the customer demand and Input quantity from the factory. Then analyzed their 4Ms (Man, Machinery, Method and Material) further. They already have technically sound employees and enough sophisticated modern forklifts. Then issue may be in Material or Method. This is a storing and distribution warehouse therefore Material should not be considered.The Method is left and questionnaire was given to employees who work in RPL to evaluate the factors to improve the warehouse efficiency.The questionnaire was categorized under the standardization of the method, redesign the layout with high accessibility and introducing new technology for warehouse operations. According to the questionnaire analysis, It was concluded that requirement for standard routing for forklift operators to enter in to put-away area(question1) was most important and can be easily applicable to the warehouse operations in RPL. In addition to that require the vendor receiving appointments was also vital. Then specific method was required for how to implement the standard routing process for forklift operators to enter in to put-away area with minimum cost effect. Firstly, it was required to identify the relevant Cost Metrix which relates to each operation activity was done by the each forklift operator Table 5.1. The Hungarian Method was used to assigned the operation activities for each forklift operator. In the Hungarian Method, one operator can do only one operation activity and one operation activity can be done by the one operator.

In the nutshell according to Cummulative Net Flow analysis there wasn’t any issue with the capacity of the warehouse then it was needed to improve the warehouse efficiency for maximum utilization its existing warehouse capacity. Then it was required to find what factors can caused to improve the warehouse efficiency and it was done by conducting a questionnaire. According to that standard routing for forklift operators should be done as a core business strategy. Then used the Hungarian Method to assigned the each operation activity to each forklift operator with consideration of the cost which was minimum.

### 5.2 Recommendations

By using Hungarian Method for assigned the each operation activity for each forklift operator will be competitive strategy because each operation activity will be done with the minimum cost. There won't be any idle time with the forklift operators because all of them should be involved with the operation activities. By implementing this standard routing schedule for forklift operators will be caused for eliminate the packing mistakes which will be done by the packing operator because there will be considerable time gaps in between consecutive arrivals in to the put-away area. And it will be affected for run the process flow smoothely and orderly than ever because all the operation activities in the storing operation will be well organized in timely manner. Moreover standard routing for forklift operators will be cut off the lean wastages in terms of unnecessary transport, unnecessary motions, waiting, over processing and defects of the packing operation. Therefore this will be a competitive advantage in terms of cost cutting in the warehouse operations in the future.

At last but not least implementation of standard routing for forklift operators will be bigger impact for fully optimizing the existing warehouse capacity and improving the warehouse efficiency of  RPL drastically by using the existing resources.

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# Appendix-A

## Sample Questionnaire

| *How Important to the Business* | Not Important | Slightly Important | Moderately Important | Important | Extremely Important | No Idea |
|---|---|---|---|---|---|---|
| (1) Standardization of the Method | 0 | 1 | 7 | 30 | 22 | 0 |
| (2) Redesign the layout with high accessibility | 1 | 1 | 6 | 48 | 33 | 1 |
| (3) Introducing advance technologies for warehouse operations | 0 | 0 | 1 | 25 | 18 | 1 |

| *When Implementing in to the Business* | Very Easy | Easy | No idea | Difficult | Very difficult |
|---|---|---|---|---|---|
| **(1) Standardization of the Method** | 9 | 26 | 2 | 20 | 3 |
| **(2) Redesign the layout with high accessibility** | 7 | 43 | 2 | 34 | 4 |
| **(3) Introducing advance technologies for warehouse operations** | 0 | 12 | 2 | 24 | 7 |