# AN INTELLIGENT COST OPTIMIZED CENTRAL WAREHOUSE AND REDISTRIBUTION ROOT PLAN WITH TRUCK ALLOCATION SYSTEM IN COLOMBO REGION FOR LION BREWERY CEYLON PLC

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**Abstract**- This thesis is a case study based on Lion Brewery Ceylon PLC, Biyagama, which is a famous beer company and the market leader in Sri Lank. Company outbound logistics has been considered in this research and it is mainly focuses on distribution and redistribution process in Colombo region. A Centralized distribution strategy has been applied for the region under three ways in order to find an optimal location of new facility through determining a route plan with cost optimized truck allocation system. Current trucks have been allocated to new roots and the purpose is to find a cost optimized distribution system.

To find an optimal location, Gravity model has been used and Hamiltonian cycle was used to find an optimal path between sub clusters. Lingo software has been used to solve Hamiltonian cycle problem and linear programming model solved using MS excel solver. According to the unit cost, linear programming model result has been manually adjusted. Central warehouse capacity plan, cost comparison of existing model and proposed model including milk run and the labour cost has been embedded to this research. Finally, author has compared total cost of centralized distribution and decentralized distribution while proving a huge cost benefits/savings (21.8% savings) than decentralized distribution.

## I. INTRODUCTION

The Beer brewing industry is a sub category of alcohol brewing industry because alcohol percentage of beer is less than 10%. Beer demand (Beer culture) in Sri Lanka has a volatile market and it is steadily increasing, due to the influence of Social, Cultural, Seasonal and environment factors. Demand patterns are different from provisions to provisions. Maintain high service level brings competitive advantage in beer industry. To maintain service level there should be a master plan for the distribution and redistribution with reducing transport cost. Because of some difficulties in outbound supply chain, some companies outsource their outbound process to third party logistics providers. transport costs, capital cost and risk can be minimized by outsourcing.

There are three beer companies in Sri Lanka. Among them, Lion Brewery Ceylon PLC is the market leader. When comparing beer demand in Sri Lanka, Colombo region has the highest demand and Lion beer brands are the most popular brands in Colombo region. Lion Brewery Ceylon PLC has 18 consignment agents in Sri Lanka. Consignment agent can be defined as stock hold by one party and operate by another party. Distribution operation is done by freight link international with special design 21 Prime movers. Redistribution operation is done by Lion Brewery Ceylon PLC and there are 81 redistribution Lorries involved in redistribution operation. That means they outsourced their primary distribution and operating secondary distribution part.

The company has 25 stock keeping units (SKU) including Lion Lager, Lion Strong, Carlsberg and Carlsberg Special

Brew etc. Bottles, Cans and Kegs used for fill beer. Especially Kegs designed for the parties, events and matches. There are three agents operating in Colombo region and 16 redistribution Lorries involved in redistribution operation. Those Distributors locations are Boralasgamuwa, Colombo 6 and Colombo 13.

The researcher case study is based on Lion Brewery Ceylon PLC. Core function of the Company is manufacturing and distributing beer in domestically and internationally. According to the monthly sales, it is showing a huge growth of the Company's beer brands in Sri Lanka than other beer brands. Current Lion Brewery monthly beer sale is performed 13 million dozen.

2013/14 annual report shows a sales revenue of Rs 25804 million.

Lion Brewery manufacturing 25 Stock keeping Units including Strong, Lion Lager, Carlsberg, Carlsberg Special Brew and Stout are the most popular brands and there are few imported beer brands including Corona, Somersby etc. As well as Lion Brewery is the Diageo & Moet Hennessey agent in Sri Lanka and import Whiskey, Brandy, Vodka, Rum etc. Johnny Walker, J & B, Hennessey, Smirnoff and Dom Perignon are the popular brands among them. In past, there were three beer companies in Sri Lanka. Those were Lion Brewery Ceylon PLC, McCallum Brewery (MBL) and Asia Pacific Brewery (APBL). After, McCallum Brewery has been bought by Lion Brewery with all brand names. Now Company has only one competitor and only few competitive brands in the market. Tiger, Heineken, Anchor and Tui Beer are the most popular brands among them.

When concerning about company's total supply chain, highest budget is allocated for outbound Logistics operation. Research area is distribution and redistribution lion beer process in Colombo region

In supply chain management, logistics plays the main role. To be the market leader in the industry, need customer attraction and brands or goods should be fulfilled customer satisfaction. To maintain above two key aspects there should be an intelligent, fast, reliable and interconnected logistics system. Because logistics represent the image of the company and generally it maintains service level. To increase service level there must be a keen system. Lion Brewery Logistics can be divided in to two sectors. Those are Inbound Logistics and Outbound Logistics. Procurement, including Imports can be categorized under Inbound Logistics. The role of Procurement department is purchasing goods and raw materials in domestic and international suppliers, selecting suppliers, importing beer and etc.

Excise Department operation {Store FG in Bonded Warehouse, Clear Bond (Pay Excise Duty)}, Warehouse operation (Finished Goods store in Own Warehouse), Domestics distribution (for sale), Reverse Logistics (collects empties, Sort empties, store and feed for re production) and Export are under Outbound Logistics. After brewing beer, still it is not an asset of a company until pay the tax for the government. Finished beers are stored in covered warehouse until clear the tax and it is called bonded warehouse. There are four bonded warehouses in Lion Brewery. Two rooms are used for store Bottles and kegs and another two is used for store Cans. It is the first duty of outbound department. After paying tax, finished goods must be stored in their own warehouses and transport between Lion Brewery to warehouse also under outbound department. Domestic distribution should be very fast and there must be an on-time delivery process to keep service level. Selling beer is the main purpose of the domestic distribution.

Reverse logistics is the difficult process in beer industry it is including empty bottles and kegs operation, pallet return process and empty creates operation. There is an empty returned policy. Distributors are liable for returning equal empty bottles which are including GRN (good receive note). As well as, they must send ERN (empty receive note) when they return their empties. If they fail to send equal empties, they should pay for the balance. The balance should be paid by distributors at the end of the month.

Empty bottles should be stored distributor wises when unloading. But Distributors are not sending their empties brand wise. It means all empties are assorted. Damage empty bottles are divided in two sectors.

- Major damages
- Minor damages

Under Major damages, if there are bottles with thinner, cement patches and bottles belong to other companies are completely destroyed.

Under Miner damages, if the bottles have small chips and those bottles are being taken for re production.

Distributor should pay for major damages because their negligence. But crates damages are not claimed by Lion Brewery.

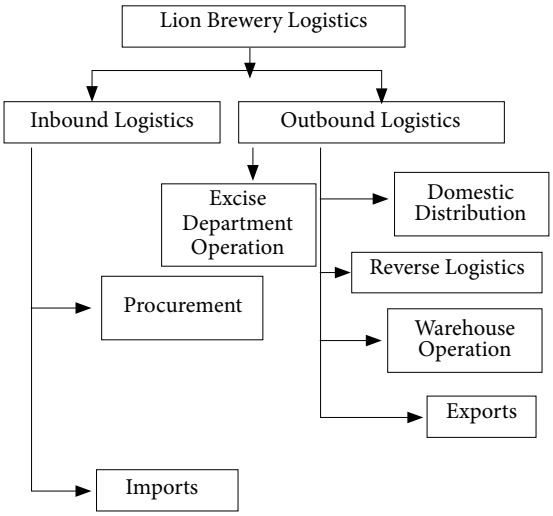



***Figure 1.1. Lion Brewery Logistics Process***
***Source: Author***

For distribution, Company has used decentralized distribution strategies and Company has 18 consignment agents in Island wide including Jaffna and Trincomalee. Those 18 agents cover 2972 outlets in Sri Lanka. Consignment agent can be simply defined as Stock hold by one party and operate by another party. That means Lion Brewery stocks hold by those 18 consignment agents and operation is done by the organization. Freight Link international has been outsourced by Lion Brewery for their distribution operation and they provide 21 specially designed Prime movers. Lion Brewery operates 81 vehicles for Redistribution process. That means, company has outsourced primary distribution part and handling secondary distribution part. It is including milk run, as well as reverse logistics part also.

### *Research Question*

How can Lion Brewery realign its distribution process by using centralized distribution strategies in Colombo Region?

When considering outlet outbreak in Sri Lanka, there are approximately 2972 outlets maintained by 18 consignment agents. But when considering distributers outbreak in district wise, there are three consignment agents operating Colombo district (Colombo Region). They are,

- Colombo 6 (Victory) – outlets 120
- Colombo 13 (Modern) – outlets 183
- Boralasgamuwa (Abeyawardhana) – outlets 189

That means, majority of distributors represent (16.56%) by the Colombo Region and there are 491 outlets

### *Research Objectives*

- Determination of centralized warehouse location and Safety stock
- Determination of a cost optimized redistribution route plan and trucks allocation system
- Identification of a capacity plan and Milk run kilometers
- Comparison of costs in existing model and proposed model

### *Description of Data*

For the purpose of this research, researcher has used secondary data from SAP ERP system and other required data has been collected from agent operation database system. As an example, monthly target demand, monthly actual demand, daily demand and all the charges of each distributor etc. this research has considered two-month daily demand because agent data base keep only two months outlet daily demand

### *Significance of the research*

Distribution and Redistribution concepts are the most important and most critical processes in outbound supply chain. In other way, redistribution shows company image and market stability. So, it should be under effective process because it is a key factor of maintaining service level. Trucks allocating process is very difficult in this field. So, there should be a keen truck allocation system while minimizing cost of transportation with

maintaining maximum service level. Trucks capacity utilization directly effect to the profit of the business. If priority is not given for redistribution process, total supply chain will break up. Currently, Lion Brewery is using decentralized distribution strategies in Colombo region because there are three distributors operating redistribution. But through this research they can allocate centralized distribution strategies and it will help to increase service level while optimizing cost, as well as cost of transportation.

Having a robust and an efficient distribution and redistribution system is the main competitive advantage of the brewery industry. Through the research, researcher finds an exact location for redistributing beers in Colombo region. And Applies a master plan for distribution system in high demand area for the purpose of gaining a cost benefit.

Centralized distribution strategies will help for

- Determining an ideal central warehouse location
- Reducing safety stock
- Smoothening redistribution root plan
- A Cost optimized redistribution Lorry allocation system

This research will guide LBCL on the importance of having an intelligent centralized warehouse with a new root plan and a truck allocation in Colombo region.

### *Methodology*

This chapter will explain the methods which are used for finding the exact location of the new facility, intelligent route plan with truck allocation while maintaining same service level of Lion Brewery Ceylon PLC. These methods will bring quantitative results to achieve objectives and these methods introduce cost optimized truck allocation method. sales data, truck rates and Return on Investment (ROI) data were used to find and build models

### *Model Development*

This research is based on mathematical approaches than statistical approaches to achieve research objectives. secondary data are used for the all mathematical models and they are taken from SAP system of Lion Brewery and agent operation data base. SAP is the intelligent Enterprise Resource Planning system and it increases efficiency and effectiveness of supply chain while updating actual information.

Finding an exact location according to the demand variation and building an optimal route plan with truck allocation will minimize overall logistics cost. Gravity model is used to find exact location and Hamiltonian cycle is used to find the optimal path of sub clusters (route plan). Linear programming is used for allocating truck in each route.

**Some limitations were concerned in this research.**

(1) Research was limited in Colombo region due to intricate of daily demand and redistribution routes.

(2) Google map was used to find clusters locations and distance between clusters.

(3) Short distance was not considered due to complexity of measure.

(4) Not considered time factor and other factors which was affected to the redistribution process

(5) All costs were fixed including transportation cost and it is based on present fuel prices. When changing fuel prices, model and prices should be updated.

(6) Distance between outlets in sub clusters was not considered.

(7) Demand is not changing rapidly.

(8) All Stock Keeping Units (cans, paint and kegs etc.) which are used to packaging consider as equal size.

(9) Reverse logistics is happening as soon as goods hand over to the outlet, empty bottles are equivalent to delivered amount and reverse logistics is not affected to this research.

(10) No any barriers while delivering goods.

(11) Allocated trucks deliver goods in allocated cluster and route and each cluster not connect each other.

This research is considering 3 distributors with 491 outlets and Figure 3.1 shows the area of the Colombo region and 3 distributors loc

***Figure 3.1. Distributors and Lion Brewery Locations in Colombo Region***
***Source: Geographical Map Sri Lanka***

### *Theoretical Frame Work*

First objective of the research is to find optimal location of central warehouse. Gravity model is the simple and mostly used interaction model in location analysis. Gravity Model considers the Newtonian gravity formula with client locations and a weight defined by the client demands, turnover or total number of clients. The outcome gives an optimized and economical location of new facility. In order to calculate in the best way all profit and inconveniencies. Research has been divided in 4 main chapters and those are the project location, stocks, transportation and warehousing. Every area has examined to find out the current situation, to estimate the possible advantages and disadvantages, and to estimate the risk of research. As a safety stock, five days safety stock policy has considered. (Geramy Bidaud.2007/08)

Optimal location has given a fixed number and the locations of the local warehouses. Solution is determined by the traditional model and it is minimized the total transportation cost. Location theory and inventory theory has considered, and numerical outcome prove that ignoring inventory costs in modeling location models might lead to inferior solution of locations. (Zvi Drezner)

"A Hamiltonian path or traceable path is a path that visits each vertex exactly once. A graph that contains a Hamiltonian path is called a traceable graph. A graph is Hamiltonian-connected if for every pair of vertices there is a Hamiltonian path between the two vertices." (Wikipedia)

Truck-Shovel is generally used for transportation. It is expensive unit process in a truck-shovel mining system. The current progress in computing technology offers the possible of refining truck-shovel production and subsequent savings. Introducing a truck allocation model has increased operational improvements by reducing waiting times and reached additional benefits through improved optimal routing. A model has presented to reduce the number of trucks allocated to a set of shovels with considering constraints. Queueing theory and linear programming has used to develop model assuming that single truck size has allocated to each shovel. To optimize the constraints, different linear programming methods have been suggested. (Soubhagya Sahoo.2012)

Research of Economic evaluation of a warehouse investment in central Europe was based on Nokian Heavy Tyres ltd and it was an ongoing project. It has comprised eminent analysis of warehouse physical location in central Europe. The goal is, build a warehouse for Nokian Heavy Tyres in central Europe through comparing private warehouse and contract warehouse. Hypothesis has been taken to get a result and to prove hypothesis using cost comparison. (Jana Machackova)

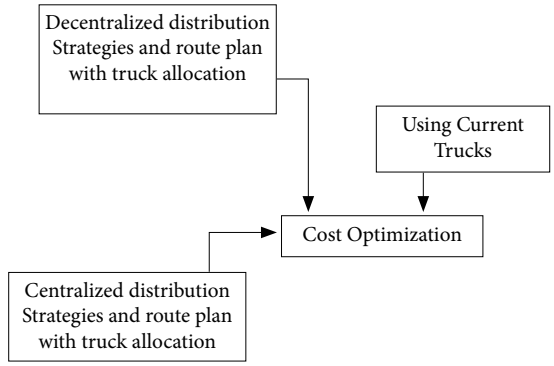



***Figure 3.2: Conceptual Frame Work***
***Source: Author***

### *Gravity Model Formula*

Gravity model is used to find optimal location and it is proposed by Geramy Bidaud (2007/08).

$$X = \frac{\sum_i^n Wi \times xCi}{\sum_i^n Wi} \quad Y = \frac{\sum_i^n Wi \times yCi}{\sum_i^n Wi}$$

n is the no of area (cluster 1,2,3……..,35)

(yCi, xCi ) is the given location coordinates with the i-th area (latitude & longitude)

Wi is the weight associated with the i-th area

(X, Y) is the unknown location co-ordinates of the new warehouse facility

***Hamiltonian Cycle – Lingo Code***

To find an optimal path between sub clusters Hamiltonian cycle sample problem is used through Lingo Software. It is based on model of Travelling Salesman problem between Atlanta to LA.

```
MODEL:
    ! Traveling Salesman Problem for the cities of
    Atlanta, Chicago, Cincinnati, Houston, LA ;
SETS:
    CITY / 1.. 5/: U; ! U( I) = sequence no. of city;
LINK( CITY, CITY):
    DIST, ! The distance matrix;
    X; ! X( I, J) = 1 if we use link I, J;
ENDSETS
    DATA: !Distance matrix, it need not be symmetric;
DIST = 0 702 454 842 2396
    702 0 324 1093 2136
    454 324 0 1137 2180
    842 1093 1137 0 1616
    2396 2136 2180 1616 0 ;
ENDDATA
    !The model:Ref. Desrochers & Laporte, OR Letters,
    Feb. 91;
    N = @SIZE( CITY);
    MIN = @SUM( LINK: DIST * X);
    @FOR( CITY( K):
    ! It must be entered;
    @SUM( CITY( I)| I #NE# K: X( I, K)) = 1;
    ! It must be departed;
    @SUM( CITY( J)| J #NE# K: X( K, J)) = 1;
    ! Weak form of the subtour breaking constraints;
    ! These are not very powerful for large problems;
    @FOR( CITY( J)| J #GT# 1 #AND# J #NE# K:
    U( J) >= U( K) + X ( K, J) -
    ( N - 2) * ( 1 - X( K, J)) +
    ( N - 3) * X( J, K)
    );
    );
    ! Make the X's 0/1;
    @FOR( LINK: @BIN( X));
    ! For the first and last stop we know...;
    @FOR( CITY( K)| K #GT# 1:
    U( K) <= N - 1 - ( N - 2) * X( 1, K);
U( K) >= 1 + ( N - 2) * X( K, 1)); END
```

***Linear Programming Model***

To find a truck a truck allocation for each path, linear programming model is developed.

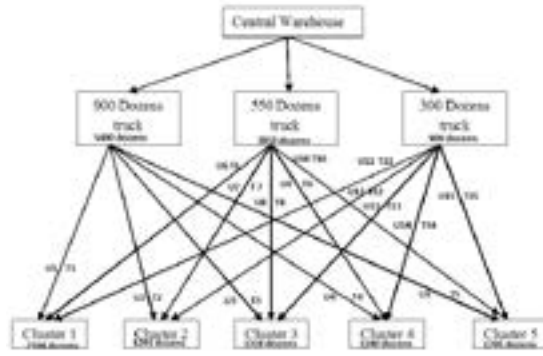



***Figure 3.3. Truck allocation Structure***
***Source: Author***

Figure 3.3 is showing truck allocation model structure of each size. Three sizes of trucks are used for redistribution

U1- No of Units/ Dozens delivers from 900 dozens trucks for Cluster 1

U2- No of Units/ Dozens delivers from 900 dozens trucks for Cluster 2

U3- No of Units/ Dozens delivers from 900 dozens trucks for Cluster 3

U4- No of Units/ Dozens delivers from 900 dozens trucks for Cluster 4

U5- No of Units/ Dozens delivers from 900 dozens trucks for Cluster 5

U6- No of Units/ Dozens delivers from 550 dozens trucks for Cluster 1

U7- No of Units/ Dozens delivers from 550 dozens trucks for Cluster 2

U8- No of Units/ Dozens delivers from 550 dozens trucks for Cluster 3

U9- No of Units/ Dozens delivers from 550 dozens trucks for Cluster 4

U10- No of Units/ Dozens delivers from 550 dozens trucks for Cluster 5

U11- No of Units/ Dozens delivers from 300 dozens trucks for Cluster 1

U12- No of Units/ Dozens delivers from 300 dozens trucks for Cluster 2

U13- No of Units/ Dozens delivers from 300 dozens trucks for Cluster 3

U14- No of Units/ Dozens delivers from 300 dozens trucks for Cluster 4

U15- No of Units/ Dozens delivers from 300 dozens trucks for Cluster 5

T1– Unit/Dozen Cost of 900 dozens trucks for Cluster 1

T2– Unit/Dozen Cost of 900 dozens trucks for Cluster 2

T3– Unit/Dozen Cost of 900 dozens trucks for Cluster 3

T4– Unit/Dozen Cost of 900 dozens trucks for Cluster 4

T5– Unit/Dozen Cost of 900 dozens trucks for Cluster 5

T6– Unit/Dozen Cost of 550 dozens trucks for Cluster 1

T7– Unit/Dozen Cost of 550 dozens trucks for Cluster 2

T8– Unit/Dozen Cost of 550 dozens trucks for Cluster 3

T9– Unit/Dozen Cost of 550 dozens trucks for Cluster 4

T10– Unit/Dozen Cost of 550 dozens trucks for Cluster 5

T11– Unit/Dozen Cost of 300 dozens trucks for Cluster 1

T12– Unit/Dozen Cost of 300 dozens trucks for Cluster 2

T13– Unit/Dozen Cost of 300 dozens trucks for Cluster 3

T14– Unit/Dozen Cost of 300 dozens trucks for Cluster 4

T15– Unit/Dozen Cost of 300 dozens trucks for Cluster 5

Objective Function = U1T1+U2T2+ U3T3+U4T4+ U5T5+U6T6+ U7T7+U8T8+ U9T9+U10T10+ U11T11+U12T12+ U13T13+U14T14+ U15T15

**Constrains;**

U1+U6+U11 ≥ Cluster 1 demand

U2+U7+U12 ≥ Cluster 1 demand

U3+U8+U13 ≥ Cluster 1 demand

U4+U9+U14 ≥ Cluster 1 demand

U5+U10+U15 ≥ Cluster 1 demand

U1+U2+U3+U4+U5 ≤ 900 dozens trucks total capacity

U6+U7+U8+U9+U10 ≤ 550 dozens trucks total capacity

U11+U12+U13+U14+U15 ≤ 300 dozens trucks total capacity

Non Negative Constrain; U1:U15 ≥ 0

### *Research Techniques*

Supply chain optimization models have economical value but solving models taking more times and it is difficult

to do manually. Because of that, companies have to pay more to get solution from logistics service providers. As a result of that, some softwares were developed to solve mathematical models. Lingo and Excel are software's to design and solve nonlinear, linear and integer optimization models. It is consisted of objective functions, variables and constrains.

In Lingo, several set of looping functions are included to use in Lingo models. Those functions are as follows:

@FOR – generates constraints over members of a set.

@SUM – sums an expression over all members of the set.

@MIN – computes the minimum of an expression over all members of the set.

@MAX – computes the maximum of an expression over all members of the set.

There are four Lingo variables domain functions are used to override the default domain for given variables. Those variable domain functions are as follows:

@GIN – any positive integer value

@BIN – a binary value (ie, 0 or 1)

@FREE – any positive or negative real value

@BND – any value within the specified bounds

Lingo user manual describes all features of lingo software and it is user friendly software.

MS Excel is spreadsheet application and it is including features of calculating programming and graphing tool etc. Solver is powerful tool of solving optimization problems in linear, nonlinear and integer programs. Thus, above software's are justified as an effective tool for this research.

### *Analyse of the research*

Lion Brewery Ceylon PLC is the beer market leader in Sri Lanka since 1881 and Lion Lager, Strong, stout and world-famous Carlsberg beer brewer in Sri Lanka. According to the monthly sales data which are collected from SAP ERP system and agent operation data base it is showing small variation but not too much in Colombo region. There are 18 distributors operate in Sri Lanka and among them, three distributors operate in Colombo region. Following table is given average monthly sales in Colombo region distributors.

**Table 4.1. Average sales of Colombo region**

| Distributor | Average Monthly Demand (Dozens) | Average Daily Demand (Dozens) | Daily Total Average Demand (Dozens) |
|---|---|---|---|
| Colombo 06 | 46495 | 1788 | |
| Colombo 13 | 66858 | 2571 | 7754 |
| Boralasgamuwa | 88251 | 3394 | |

***Source: Author***

Table 4.1 is explaining average monthly sales of Colombo 6, Colombo 13 and Boralasgamuwa distributors. Daily sales of Colombo region are 7754 dozen.

### *Location Analysis - Gravity Model*

When implementing central warehouse strategies in Colombo region, an exact location was found according to the demand. To find a location, Gravity model was used. Colombo region is divided into 35 demand regions. And those regions were divided into five main clusters according to the geographical situation. Following table is giving five main clusters under 35 demand regions in Colombo with daily demand

According to Table 4.2 with clusters and demand, weights are allocated with demand. As a weight, demand between 0 to 50 dozen is concerned as 1. That means weight of demand range is equal to 1. Thus, in order to 2,3,4,5,6,7,8,9,10,11,12, and 13 weights are allocated to demand range between 50 to 100, 100 to 150, 150 to 200, 200 to 250, 250 to 300,300 to 350, 350 to 400, 400 to 450, 450 to 500, 500 to 550, 550 to 600, 600 to 650, 650 to 700 dozen. Latitude and longitude is taken from Google map to solve the equation and due to small variance of latitude has to concern at least seven decimals and longitude has to concern five decimals.

**Table 4.2. Colombo Region Daily Demand in Clusters wise**

| Cluster 1 | | Cluster 2 | | Cluster 3 | | Cluster 4 | | Cluster 5 | |
|---|---|---|---|---|---|---|---|---|---|
| **Area** | **Average Demand** | **Area** | **Average Demand** | **Area** | **Average Demand** | **Area** | **Average Demand** | **Area** | **Average Demand** |
| Colombo 1 | 103 | Colombo 2 | 289 | Battaranulla | 225 | Kottawa | 61 | Boralasg-amuwa | 124 |
| Colombo 9 | 368 | Colombo 3 | 249 | Thalawath-ugoda | 139 | Pannipitiya | 235 | Dehiwala | 361 |
| Colombo 11 | 633 | Colombo 4 | 71 | Malabe | 167 | Maharagama | 245 | Mt. Lavinia | 122 |
| Colombo 12 | 212 | Colombo 5 | 301 | Kaduwela | 103 | Nugegoda | 244 | Rathmalana | 110 |
| Colombo 13 | 357 | Colombo 7 | 58 | Athurugiriya | 185 | Homagama | 169 | Moratuwa | 463 |
| Colombo 14 | 211 | Colombo 8 | 160 | Gothatuwa | 291 | Padukka | 76 | Piliyandala | 339 |
| Colombo 15 | 220 | Colombo 10 | 170 | Rajagiriya | 208 | Hanwella | 210 | Colombo 6 | 277 |

***Source: Author***

Find an exact location of central warehouse, Gravity model equation has been used. Table 4.3 is given exact location of the central warehouse and it is situated in latitude 6.887700861 and longitude 79.90165817.

### *Route Analysis - Hamiltonian Cycle*

The second step of the research is to find a route plan with optimal path is done by using lingo software. Lingo is a software which is made for easy to solve linear and nonlinear optimization problems. Through that, Hamiltonian cycle sample model is adjusted to this research and it is solved by using Lingo software. Hamiltonian cycle is given optimal path to each main cluster. Adjusted Hamiltonian cycle sample problem is given bellow. After solving model, when value is showed 1, it is taken as a path.

***Figure 4.1: Hamiltonian Cycle Problem in Cluster 1***

**MODEL:**

! Traveling Salesman Problem for the cities of

New Facility, Colombo 01, Colombo 09, Colombo 11, Colombo 12, Colombo 13, Colombo 14, Colombo 15;

**SETS:**

CITY / 1.. 8/: U; ! U( I) = sequence no. of city;

LINK( CITY, CITY):

DIST, ! The distance matrix;

X; ! X( I, J) = 1 if we use link I, J;

**ENDSETS**

**DATA:** !Distance matrix (rows -- New Facility, Colombo 01, Colombo 09, Colombo 11, Colombo 12, Colombo 13,Colombo 14,Colombo 15)(columns -- New Facility, Colombo 01, Colombo 09, Colombo 11, Colombo 12, Colombo 13,Colombo 14,Colombo 15 ), it need not be symmetric;

DIST = 0 13.4 9.7 11.9 11.6 12 11.6 14.2
13.4 0 6.3 1.9 3.1 3.2 6.4 6.5
9.7 6.3 0 4.8 4.4 4.8 3.2 5.8
11.9 1.9 4.8 0 1.4 1.3 3.3 4.8
11.6 3.1 4.4 1.4 0 1 2.6 4.6
12 3.2 4.8 1.3 1 0 2.5 4.1
11.6 6.4 3.2 3.3 2.6 2.5 0 3.2
14. 6.5 5.8 4.8 4.6 4.1 3.2 0 ;

**Table 4.3: Gravity Model MS Excel Work Sheet**

| Cluster | ADD | WAD | Latitude | Longitude | Latitude* WAD | Longitude* WAD |
|---|---|---|---|---|---|---|
| Colombo 1 | 103 | 3 | 6.9556 | 79.88477 | 20.8670727 | 239.6543175 |
| Colombo 2 | 289 | 6 | 6.9215 | 79.86485 | 41.529183 | 479.1891198 |
| Colombo 3 | 249 | 5 | 6.9215 | 79.86485 | 34.6076525 | 399.3242665 |
| Colombo 4 | 71 | 2 | 6.92153 | 79.86485 | 13.843061 | 159.7297066 |
| Colombo 5 | 301 | 7 | 6.8703 | 79.86456 | 48.092457 | 559.051899 |
| Colombo 6 | 277 | 6 | 6.8756 | 79.87118 | 41.2540206 | 479.2270506 |
| Colombo 7 | 58 | 2 | 6.9215 | 79.86485 | 13.843061 | 159.7297066 |
| Colombo 8 | 160 | 4 | 6.9124 | 79.87895 | 27.6497288 | 319.5157828 |
| Colombo 9 | 368 | 8 | 6.9044 | 79.85992 | 55.235592 | 638.879328 |
| Colombo 10 | 170 | 4 | 6.9301 | 79.86257 | 27.7204308 | 319.4502816 |
| Colombo 11 | 633 | 13 | 6.9380 | 79.85253 | 90.1948008 | 1038.082884 |
| Colombo 12 | 212 | 5 | 6.9377 | 79.86185 | 34.688955 | 399.309245 |
| Colombo 13 | 357 | 8 | 6.9480 | 79.86084 | 55.5844048 | 638.8867048 |
| Colombo 14 | 211 | 5 | 6.9507 | 79.87167 | 34.7537645 | 399.3583635 |
| Colombo 15 | 220 | 5 | 6.9679 | 79.86885 | 34.839867 | 399.344248 |
| Athurugiriya | 185 | 4 | 6.8734 | 79.99814 | 27.4936856 | 319.992562 |
| Battaramulla | 225 | 5 | 6.9000 | 79.92049 | 34.500296 | 399.6024705 |
| Boralasgamuw | 124 | 3 | 6.8339 | 79.90818 | 20.5017489 | 239.7245331 |
| Dehiwala | 361 | 8 | 6.8528 | 79.86912 | 54.8229576 | 638.9529824 |
| Gothatuwa | 291 | 6 | 6.9255 | 79.90553 | 41.553021 | 479.4331638 |
| Hanwella | 210 | 5 | 6.8915 | 80.08523 | 34.4578175 | 400.426129 |
| Homagama | 169 | 4 | 6.8450 | 80.00621 | 27.380368 | 320.0248516 |
| Kaduwela | 103 | 3 | 6.9299 | 79.98355 | 20.7897939 | 239.9506569 |
| Kottawa | 61 | 2 | 6.8396 | 79.96432 | 13.6793744 | 159.928645 |
| Maharagama | 245 | 5 | 6.8503 | 79.92474 | 34.251845 | 399.62371 |
| Malabe | 167 | 4 | 6.9043 | 79.96543 | 27.6172828 | 319.8617292 |
| Moratuwa | 463 | 10 | 6.7674 | 79.88827 | 67.674157 | 798.882677 |
| Mt. Lavinia | 122 | 3 | 6.8391 | 79.86623 | 20.5175985 | 239.5986999 |
| Nugegoda | 244 | 5 | 6.8656 | 79.90714 | 34.3280975 | 399.535686 |
| Padukka | 76 | 2 | 6.8436 | 80.10119 | 13.6872864 | 160.2023792 |
| Pannipitiya | 235 | 5 | 6.8382 | 79.95782 | 34.191483 | 399.789092 |
| Piliyandala | 339 | 7 | 6.7915 | 79.93651 | 47.540773 | 559.5555826 |
| Rajagiriya | 208 | 5 | 6.9119 | 79.89571 | 34.5595735 | 399.4785665 |
| Rathmalana | 110 | 3 | 6.8237 | 79.88988 | 20.471148 | 239.669646 |
| Thalawathugoda | 139 | 3 | 6.8750 | 79.94117 | 20.6252916 | 239.8235127 |
| Total | | 175 | | | 1205.347651 | 13982.79018 |
| | | | | | 6.887700 | 79.90165 |

***Source: Author***

**ENDDATA**

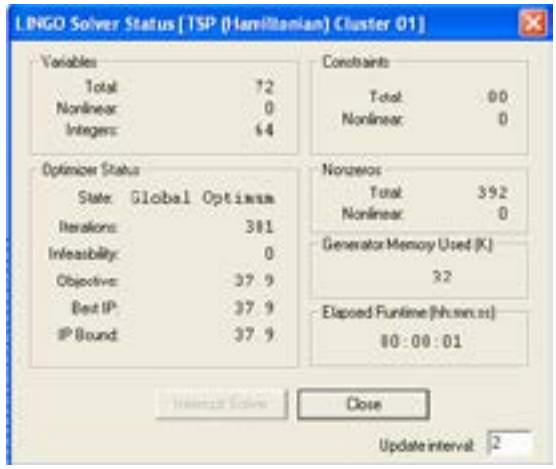
```
!The model:Ref. Desrochers & Laporte, OR Letters,
Feb. 91;
N = @SIZE( CITY);
MIN = @SUM( LINK: DIST * X);
@FOR( CITY( K):
!  It must be entered;
@SUM( CITY( I)| I #NE# K: X( I, K)) = 1;
!  It must be departed;
@SUM( CITY( J)| J #NE# K: X( K, J)) = 1;
! Weak form of the subtour breaking constraints;
! These are not very powerful for large problems;
@FOR( CITY( J)| J #GT# 1 #AND# J #NE# K:
    U( J) >= U( K) + X ( K, J) -
    ( N - 2) * ( 1 - X( K, J)) +
    ( N - 3) * X( J, K)
 );
);
! Make the X's 0/1;
@FOR( LINK: @BIN( X));
! For the first and last stop we know...;
@FOR( CITY( K)| K #GT# 1:
 U( K) <= N - 1 - ( N - 2) * X( 1, K);
 U( K) >= 1  + ( N - 2) * X( K, 1)
);
```

**END**

Figure 4.1 is showing Lingo model of Cluster 1 Hamiltonian cycle problem. Distance matrix, rows and columns are representing sub clusters and above matrix are showing cluster 1 sub clusters.

In other hand rows and columns are showing distance between each sub clusters.In order to above model, other four clusters also adjusted and solve using Lingo software. According to Hamiltonian cycle has given optimal paths and those are given bellow.

***Figure 4.3. Lingo Solver window***
***Source : Author***




Global optimal solution found – Cluster 1

| | | |
|---|---|---|
| Objective value | : | 37.90000 |
| Branch count | : | 9 |

***Figure 4.2: Lingo Solver Status and Global Optimal Solution of Cluster 1***

| Variable | Value | Reduced Cost |
|---|---|---|
| X( 1, 1) | 0.0000000 | 0.0000000 |
| X( 1, 2) | 1.000000 | 13.40000 |
| X( 1, 3) | 0.0000000 | 9.700000 |
| X( 1, 4) | 0.0000000 | 11.90000 |
| X( 1, 5) | 0.0000000 | 11.60000 |
| X( 1, 6) | 0.0000000 | 12.00000 |
| X( 1, 7) | 0.0000000 | 11.60000 |
| X( 1, 8) | 0.0000000 | 14.20000 |
| X( 2, 1) | 0.0000000 | 13.40000 |
| X( 2, 2) | 0.0000000 | 0.0000000 |
| X( 2, 3) | 0.0000000 | 6.300000 |
| X( 2, 4) | 1.000000 | 1.900000 |
| X( 2, 5) | 0.0000000 | 3.100000 |

| Variable | Value | Reduced Cost |
|---|---|---|
| X( 2, 6) | 0.0000000 | 3.200000 |
| X( 2, 7) | 0.0000000 | 6.400000 |
| X( 2, 8) | 0.0000000 | 6.500000 |
| X( 3, 1) | 1.000000 | 9.700000 |
| X( 3, 2) | 0.0000000 | 6.300000 |
| X( 3, 3) | 0.0000000 | 0.0000000 |
| X( 3, 4) | 0.0000000 | 4.800000 |
| X( 3, 5) | 0.0000000 | 4.400000 |
| X( 3, 6) | 0.0000000 | 4.800000 |
| X( 3, 7) | 0.0000000 | 3.200000 |
| X( 3, 8) | 0.0000000 | 5.800000 |
| X( 4, 1) | 0.0000000 | 11.90000 |
| X( 4, 2) | 0.0000000 | 1.900000 |
| X( 4, 3) | 0.0000000 | 4.800000 |
| X( 4, 4) | 0.0000000 | 0.0000000 |
| X( 4, 5) | 1.000000 | 1.400000 |
| X( 4, 6) | 0.0000000 | 1.300000 |
| X( 4, 7) | 0.0000000 | 3.300000 |
| X( 4, 8) | 0.0000000 | 4.800000 |
| X( 5, 1) | 0.0000000 | 11.60000 |
| X( 5, 2) | 0.0000000 | 3.100000 |
| X( 5, 3) | 0.0000000 | 4.400000 |
| X( 5, 4) | 0.0000000 | 1.400000 |
| X( 5, 5) | 0.0000000 | 0.0000000 |
| X( 5, 6) | 1.000000 | 1.000000 |
| X( 5, 7) | 0.0000000 | 2.600000 |
| X( 5, 8) | 0.0000000 | 4.600000 |
| X( 6, 1) | 0.0000000 | 12.00000 |
| X( 6, 2) | 0.0000000 | 3.200000 |
| X( 6, 3) | 0.0000000 | 4.800000 |
| X( 6, 4) | 0.0000000 | 1.300000 |
| X( 6, 5) | 0.0000000 | 1.000000 |

| Variable | Value | Reduced Cost |
|---|---|---|
| X( 6, 6) | 0.0000000 | 0.0000000 |
| X( 6, 7) | 0.0000000 | 2.500000 |
| X( 6, 8) | 1.000000 | 4.100000 |
| X( 7, 1) | 0.0000000 | 11.60000 |
| X( 7, 2) | 0.0000000 | 6.400000 |
| X( 7, 3) | 1.000000 | 3.200000 |
| X( 7, 4) | 0.0000000 | 3.300000 |
| X( 7, 5) | 0.0000000 | 2.600000 |
| X( 7, 6) | 0.0000000 | 2.500000 |
| X( 7, 7) | 0.0000000 | 0.0000000 |
| X( 7, 8) | 0.0000000 | 3.200000 |
| X( 8, 1) | 0.0000000 | 14.00000 |
| X( 8, 2) | 0.0000000 | 6.500000 |
| X( 8, 3) | 0.0000000 | 5.800000 |
| X( 8, 4) | 0.0000000 | 4.800000 |
| X( 8, 5) | 0.0000000 | 4.600000 |
| X( 8, 6) | 0.0000000 | 4.100000 |
| X( 8, 7) | 1.000000 | 3.200000 |
| X( 8, 8) | 0.0000000 | 0.0000000 |

Figure 4.2 is showing Lingo solver status menu and paths between sub clusters in Cluster 1. In value column, it is showing two values (0 and 1). When value is 1, parallel variable column is showing path between two clusters. In order to optimal path of cluster 1 is New Facility, Colombo 1, Colombo 11, Colombo 12, Colombo 13, Colombo 15, Colombo 14 and Colombo 9.

In order to the solution of each Clusters Optimal paths with distance are given bellow.

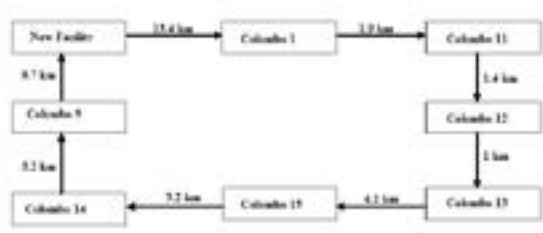


***Figure 4.7. Cluster 1 – Optimal Path and Distance***
***Source: Author***

According to Figure 4.7 is showing optimal path and distance between sub clusters of Cluster 1.

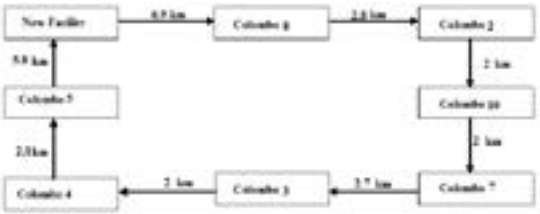


*Figure 4.8. Cluster 2 – Optimal Path and Distance*
*Source: Author*

According to Figure 4.8 is showing optimal path and distance between sub clusters of Cluster 2.

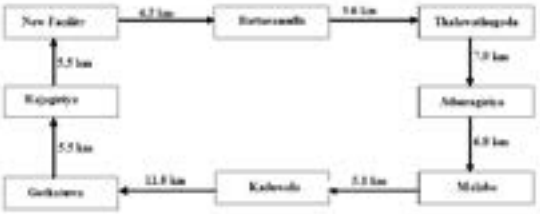


*Figure 4.9. Cluster 3 – Optimal Path and Distance*
*Source: Author*

According to Figure 4.9 is showing optimal path and distance between sub clusters of Cluster 3.

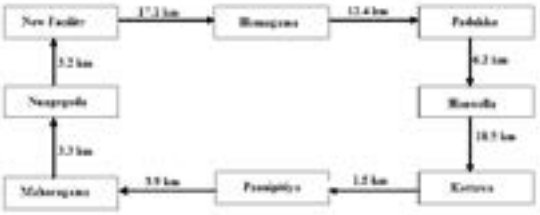


*Figure 4.10. Cluster 4 – Optimal Path and Distance*
*Source: Author*

According to Figure 4.10 is showing optimal path and distance between sub clusters of Cluster 4.

*Figure 4.11. Cluster 5 – Optimal Path and Distance*
*Source: Author*

According to Figure 4.11 is showing optimal path and distance between sub clusters of Cluster 5.

After finding optimal path of each main cluster, total milk run is calculated

**Table 4.4. Daily Milk Run Kilometres**

| Cluster | Daily Milk Run km |
|---|---|
| 1 | 38 |
| 2 | 27 |
| 3 | 51 |
| 4 | 66 |
| 5 | 38 |
| Total | 220 |

***Source: Author***

According to the optimal path, Table 4.4 is given daily milk run total kilometers.

### *Truck Allocation Model – Linear Programming Model*

After finding optimal path, next step of the research is allocating redistribution trucks to the root. To solve mathematical model MS Excel is used to this research. MS excel has so many functions to solve problems. In this research MS Excel Solver is used to run mathematical model and Table 4.9 is showing MS Excel worksheet and result of optimal truck allocation. Figure 4.12 is showing solver parameters


*Figure 4.12. Solver Parameters*
*Source: Author*

**Table 4.5. Linear Programming Model MS Excel work sheet**

| Description | Dozens(unit) | | Transport Cost per dozen (Rs) | |
|---|---|---|---|---|
| No of units via 900 dozen trucks for cluster 1 | U1 | 777 | T1 | 2.04 |
| No of units via 900 dozen trucks for cluster 2 | U2 | 583 | T2 | 1.88 |
| No of units via 900 dozen trucks for cluster 3 | U3 | 492 | T3 | 4.28 |
| No of units via 900 dozen trucks for cluster 4 | U4 | 468 | T4 | 5.88 |
| No of units via 900 dozen trucks for cluster 5 | U5 | 678 | T5 | 2.31 |
| No of units via 550 dozen trucks for cluster 1 | U6 | 959 | T6 | 1.65 |
| No of units via 550 dozen trucks for cluster 2 | U7 | 649 | T7 | 1.69 |
| No of units via 550 dozen trucks for cluster 3 | U8 | 708 | T8 | 2.97 |
| No of units via 550 dozen trucks for cluster 4 | U9 | 681 | T9 | 4.04 |
| No of units via 550 dozen trucks for cluster 5 | U10 | 854 | T10 | 1.84 |
| No of units via 300 dozen trucks for cluster 1 | U11 | 369 | T11 | 4.29 |
| No of units via 300 dozen trucks for cluster 2 | U12 | 59 | T12 | 18.62 |
| No of units via 300 dozen trucks for cluster 3 | U13 | 118 | T13 | 17.84 |
| No of units via 300 dozen trucks for cluster 4 | U14 | 91 | T14 | 30.33 |
| No of units via 300 dozen trucks for cluster 5 | U15 | 264 | T15 | 5.95 |
| Objective function | 27315.879 | | | |
| Constrains | | | | |
| Cluster 1 | U1+U6+U11 | 2104 | 2104 | |
| Cluster 2 | U2+U7+U12 | 1291 | 1291 | |
| Cluster 3 | U3+U8+U13 | 1318 | 1318 | |
| Cluster 4 | U4+U9+U14 | 1240 | 1240 | |
| Cluster 5 | U5+U10+U15 | 1795 | 1795 | |
| Total 900 dozens trucks capacity | U1+U2+U3+U4+U5 | 2998 | 5400 | |
| Total 550 dozens trucks capacity | U6+U7+U8+U9+U10 | 3850 | 3850 | |
| Total 300 dozens trucks capacity | U11+U12+U13+U14+U15 | 900 | 900 | |
| Non negative constrains | U1:U15 | | 0 | |

***Source: Author***

Linear programming model is entered to the MS Solver and Figure 4.15 is showing solver parameters.

Table 4.5 is showing linear programming MS Excel work sheet and it is representing unit cost and quantity of each lorry type. Linear programming model is given optimal solution but trucks are limited and there are only 6 trucks which can be carried 900 dozens, and only 7 trucks which can be carried 550 dozens and only 3 trucks which can be carried 300 dozens. Total 16 redistribution trucks are run in milk run. So according to transport cost and route demand, trucks should be manually allocated. Table 4.6 is showing manual truck allocation method. To find truck utilization, equation is mentioned bellow.

$$\text{Truck Utilization} = \frac{(\text{Total Carring Capacity})}{(\text{Total Allocation Capacity})} \times 100\%$$

**Table 4.6. Manual truck allocation with cost**

| Cluster | Lorry Capacity | Carrying Capacity | Transport cost per dozen | Allocation | Utilization |
|---|---|---|---|---|---|
| 1 | 900 | 777 | 2.04 | 1 | 91% |
| | 550 | 959 | 1.65 | 2 | |
| | 300 | 369 | 4.29 | 1 | |
| | Total | 2104 | Allocation Capacity | 2300 | |
| 2 | 900 | 583 | 1.88 | 1 | 89% |
| | 550 | 649 | 1.69 | 1 | |
| | 300 | 59 | 18.62 | 0 | |
| | Total | 1291 | Allocation Capacity | 1450 | |
| 3 | 900 | 492 | 4.28 | 1 | 91% |
| | 550 | 708 | 1.69 | 1 | |
| | 300 | 118 | 17.84 | 0 | |
| | Total | 1318 | Allocation Capacity | 1450 | |
| 4 | 900 | 468 | 5.88 | 1 | 86% |
| | 550 | 681 | 4.04 | 1 | |
| | 300 | 91 | 30.33 | 0 | |
| | Total | 1240 | Allocation Capacity | 1450 | |
| 5 | 900 | 678 | 2.31 | 1 | 90% |
| | 550 | 854 | 1.84 | 2 | |
| | 300 | 264 | 5.95 | 0 | |
| | Total | 1795 | Allocation Capacity | 2000 | |

***Author: Source***

According to the Table 4.6 - manual adjustment, 4 trucks allocated to Cluster 1, in order to 2 trucks allocated to Cluster 2, Cluster 3 and Cluster 4. 3 trucks allocated to cluster 5. In this proposed system, Total redistribution operation is running 13 redistribution trucks.

Variance = Existing Milk Run Total Kilometres – Proposed Milk Run Total Kilometres

**Table 4.7. Milk Run Outcomes of Two Models**

| Existing Milk Run | | | Proposed Milk Run | | Variance (Km) |
|---|---|---|---|---|---|
| **Distributor** | **Daily Km** | | **Cluster** | **Daily Km** | |
| Colombo 6 | 153 | | | 1152 | 26 (Saving) |
| Colombo 13 | 115 | | | 254 | |
| Boralasgamuwa | 312 | | | 3102 | |
| | | | 4 | 4 | |
| Total | 580 | | | 5114 | |
| | | | Total | 554 | |

***Author: Source***

Table 4.7 is showing outcomes of Existing milk run and proposed milk run, and difference of kilometres between existing model and the proposed are calculated using above equation. Existing milk run distance is 580km and proposed milk run distance is 554km. difference 26km. Cost of redistribution truck is paid based on Kilometres and rate per kilometre is 41.71 rupees. Existing milk run, and purposed milk run daily transportation cost is given bellow.

**Table 4.8. Cost Difference between Existing Milk Run and Proposed Milk Run**

| | Daily Km | Cost Per Km(Rs) | Daily Cost (Rs) | Monthly Cost(Rs) |
|---|---|---|---|---|
| Existing Milk Run | 580 | 41.71 | 24191.8 | 628986.8 |
| Proposed Milk Run | 554 | 41.71 | 23107.34 | 600790.84 |
| Variance(Saving) | 26 | 41.71 | 1084.46 | 28195.96 |

***Source: Author***

According to the Table 4.8, cost of existing milk run is Rs 24191.80 and proposed milk run is Rs 23107.34. Variance is Rs 1084.46 per day.

### *Safety Stock Analysis*

As a safety stock, five days safety stock policy has been used. It is calculated as follows.

Safety Stock = 5 × 7748 dozens = 37 840 dozen

### *Central Warehouse Analysis*

First step of the research is to measure central warehouse capacity. Table 4.9 is given capacity plan and total rent cost of warehouse.

**Table 4.9. Capacity Plan and Rent of Central Warehouse**

| Capacity Plan and Rent of Central Warehouse | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Stock** | **Pallet** | | | | | **Capacity** | **Cost (Rs)** | |
| Dozens | Dozens | Position | Length | Width | Area(Ft2) | $Ft^2$ | 1 $Ft^2$ | Total |
| 37840 | 44 | 860 | 3.66’ | 3.33’ | 12.1878 | 10481.51 | 35 | 366852.8 |

***Source: Author***

According to the Table 4.9, Safety stock is 37840 dozen and each pallet can stack 44 dozen. So, central warehouse need 860 pallet positions. Area of the pallet is 12.1878 Ft2 and total needed capacity of the warehouse is 10481.51 Ft2. Cost of the 1 Ft2 is Rs 35 and Total cost of warehouse is Rs 366852.80.

Structure of the allocating trucks and employee involvement of the redistribution operation is, in order to 6 trucks, 5 trucks and 5 trucks are operated in Boralasgamuwa, Colombo 6 and Colombo 13 distributors. Each truck contained sales ref, driver and four porters.

Second step of the research is to determine no of employees and salaries of employees. Bellow table is giving outcomes of existing system and proposed system with employee analysis and salaries.

Table 4.10 is representing salaries of the existing system and proposed system. All the salaries are fixed, and allowances are given by the distributor and Lion Brewery is not liable to pay allowances (consignment agent relationship). Existing system, total cost of salaries and wages is Rs 2,959,400 and proposed system total cost of salaries and wages is Rs 2,398,200. When loading beers to the trucks, it is handled and monitored by assistant

**Table 4.10. Labour Cost Difference between Labours in Existing System and Proposed system**

| Description | Existing System | | | | | | | Proposed System | |
|---|---|---|---|---|---|---|---|---|---|
| | No of Employees | | | | | | | | |
| | Salary (Rs) | Boralasg amuwa | Col 06 | Col 13 | Total | Cost | | New Facility | Cost (Rs) |
| Area Manager | 47000 | 1 | 1 | 1 | 3 | 141000 | | 1 | 47000 |
| Accountant Assistant | 37000 | 1 | 1 | 1 | 3 | 111000 | | 1 | 37000 |
| Accountant | 21000 | 1 | 1 | 1 | 3 | 63000 | | 3 | 63000 |
| IT Officer | 28000 | 1 | 1 | 1 | 3 | 84000 | | 1 | 28000 |
| Logistics Officer | 37000 | 1 | 1 | 1 | 3 | 111000 | | 1 | 37000 |
| Assistant Logistics | 21000 | 2 | 2 | 2 | 6 | 126000 | | 5 | 105000 |
| Officer Clark | 15000 | 1 | 1 | 1 | 3 | 45000 | | 1 | 15000 |
| Sales Ref | 25000 | 6 | 5 | 5 | 16 | 400000 | | 13 | 32500 |
| Forklift | 30000 | 1 | 1 | 1 | 3 | 90000 | | 2 | 60000 |
| Driver Porters | 25600 | 24 | 20 | 20 | 64 | 1638400 | | 52 | 1331200 |
| Store Porters | 25000 | 1 | 1 | 1 | 3 | 75000 | | 1 | 25000 |
| Driver | 25000 | 1 | 1 | 1 | 3 | 75000 | | 13 | 325000 |
| Total | | | | | | 2959400 | | | 2398200 |

***Source: Author***

logistics officers. One Assistant logistics officer can handle 3 redistribution trucks and one forklift operator can handle 7 trucks (Fixed by the Company). Proposed system needed only 13 trucks and 5 assistant logistics officers, and 2 forklift drivers are enough to do operation.

Next step of the research is to determine new facility cost and compare with the cost of existing system.

According to the Table 4.11, it is showing monthly cost difference of two systems. All costs fixed by the Lion Brewery and electricity, water and even milk run total kilometres also fixed. If those costs exceed, distributor have to bare that cost. Fixed kilometres are given Table 4.7 and transport cost is given Table 4.8 existing system is operating 16 trucks (Boralasgamuwa – 6, Colombo 6 – 5, Colombo 13 – 5) but proposed system needs only 13 trucks. Total cost of existing system is Rs 6074747.8 and proposed system cost is 4750448.64. Proposed systems bring saving of Rs 1324299.16 per month and it is 21.8% savings of existing system.

## II. CONCLUSION AND RECOMMENDATION

With secondary data collected from SAP and Agent operation data base in Lion Brewery Ceylon PLC, the

**Table 4.11. Monthly Cost Difference between Existing System and Proposed System**

| Description | Cost | Existing System | | | | | | | Proposed System | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Distributor Name | | | | | | Total Cost | | |
| | | Bora | | Col 6 | | Col 13 | | | | |
| | | Qty | Cost | Qty | Cost | Qty | Cost | | Qty | Cost |
| Wareho use Rent | | | 100000 | | 420000 | | 265000 | 785000 | 366852.8 | |
| Lorry Lease | 75000 | 75000 | 6 | 450000 | 5 | 375000 | 5 | 375000 | 1200000 | 13 |
| Lorry Insurance | 3668 | 3668 | 6 | 22008 | 5 | 18340 | 5 | 18340 | 58688 | 13 |
| Insurance for Goods | 23000 | 23000 | 6 | 138000 | 5 | 115000 | 5 | 115000 | 368000 | 13 |
| License | 167 | 167 | 6 | 1002 | 5 | 835 | 5 | 835 | 2672 | 13 |
| Other Expenses | 3750 | 3750 | 6 | 22500 | 5 | 18750 | 5 | 18750 | 60000 | 13 |
| Transport cost | 41.71 | 41.71 | | | | | | | 628986 | |
| Salaries and wages | | | 2959400 | | 2398200 | | | | | |
| Electricity | 2000 | | 2000 | | 2000 | | 2000 | 6000 | | 6000 |
| Water | 2000 | | 2000 | | 2000 | | 2000 | 6000 | | 6000 |
| Total Cost | | 6074747 | | 4750448 | | | | | | |

***Source: Author***

researcher has planned a central warehouse strategy. location was found through demand. Colombo region has been divided in to 35 demand regions and a weight was allocated to each sub cluster according to demand. After finding locations of each clusters (latitude and longitude), Gravity model has been used to get location of new facility. It is situated in latitude 6.887700861 and longitude 79.90165817.

According to location, sub clusters divided in to five main clusters and Hamiltonian cycle has been used to get optimal path between sub clusters. Hamiltonian cycle problem has been solved using Lingo software. 900, 550 and 300 dozen capacity Trucks were used to redistribute goods and those are allocated each optimal path given by Hamiltonian cycle. Linear programming has been built and it is solved using MS Solver. Given solution was critical because some trucks unit cost had been increased and need more trucks than existing trucks. Therefore, manual adjustment has been introduced by considering transport unit cost. Trucks have allocated according to the units cost while satisfying daily demand. When considering daily transportation cost between existing model and proposed model, 26 kilometres have been saved profit is Rs 1084.46 per day. Existing model is running 16 redistribution trucks and proposed system can be covered, by using 13 trucks. 5 days demand has been taken as a safety stock and Cost of the central warehouse is Rs 366852.8 and it is saving Rs 418147.2. Salaries and Wages are given cost savings Rs 561200.

When comparing total cost of proposed model and existing model, proposed model is saving Rs 1324299.16 per month. Centralized distribution strategies give cost benefit rather than Decentralized Distribution Strategies.

For the future development of this research linear programming model must be developed without manual adjustment.

## III. ACKNOWLEDGEMENT

This dissertation represents the essence of the achievements during the four years of study in International Transportation Management and Logistics in CINEC Maritime campus, Malabe, affiliated with Dalian Maritime University, China.

This research gives knowledgeable and practical experience for the theoretical subjects that we have been studying during the academic period of time with connected to supply chain managements well as in outsourcing.

I wish to acknowledge the assistance Mr. Nuwan Jayarathna, and Ms Ganga Madhushani, the Supervisors, in the preparation of this dissertation writing. Their professional guidance, insightful suggestions and immense cooperation was immeasurably helpful.

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