OPTIMIZATION OF WATER TANK DISTRIBUTION: CASE STUDY OF WATER TANK DISTRIBUTION NETWORK AT A REPUTED COMPANY

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MBA in Supply Chain Management

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Dissertation submitted in partial fulfillment of the requirements for the MBA in Supply Chain Management

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Student Declaration

The work described in this research was carried out by me under the supervision of Dr. T. Sivakumar and a report on this has not been submitted in whole or in part to any university or any other institution for another Degree or Diploma.

……..

GHCS Amarasooriya

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Abstract

The study was developed based on the actual case study related to the details of Arpico Plc. The major purpose of studying this case was the company incurs huge cost on transport operation and logistics activities. The company has its own factories locate at three different locations including RPC Horana, Dambulla Factory, and Plashtishel Ltd at Pallekale. Further the company consist with one re distribution warehouse locate at Mattegoda. Horana, Pallekale and Dambulla factory has manufacture differently diversified product range at their premises and also they have different capacity of water tanks in the stores and mainly they have their own inventories in the same premises.

And also it was identified that the total company linkage has a distribution network error on their existing process. Therefore it was collected the data related to Distribution network including starting point and destination point with vehicle capacity, quantity demanded, date, distance, whether item has send by couple with some other good, and type of water tank for three months including November, December 2018 and January 2019.

Then to analyze situation of the company as the 1st step it was drew a map of existing situation and then identified few issues such as distance of distribution network, cost incur on the distribution network, and etc.

Then to find the solution, again drew a map by clustering the regions based on the center vise and shortest route vise. Then identified the distance based on the shortest path rules. Finally it calculated the total cost of existing project with all the centers, total cost of existing project without delivering to the centers and cost of newly planned project without delivering to the centers. Then, it was compered and identified that it could minimize cost of each cluster and then could minimize the total cost of distribution network.

Acknowledgement

I would like to express my deepest appreciation to University of Moratuwa for the opportunity granted and to Dr. T. Sivakumar for the great efforts of supervising and leading me, to accomplish this fine work.

Furthermore I would like to express my gratitude towards Mr. Manoj Sameera (the Logistics and Finance executive of Arpico Plc), Mr. Lalith Wijesinghe (Director Operation) and Mr. Sanjeewa Thushara (Chief Finance officer) of Arpico Plc for giving me the permission and opportunity to study the water tank distribution network of Arpico Plc.

As well as, I would be interested to thanks for viva panel member and second markers of the research; Prof. Amal Kumarage, and Eng. Nishal Samarasekera to giving me guidance and advices to complete this research.

Then I would like to thanks all the staff of Arpico Plc, Friends of MBA and staff members of Transport and Logistics Management faculty at University of Moratuwa and all others who gave me support, courage and all facilities to complete this fine work.

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Chapter I

1. Introduction

1.1.Background

Product distribution has huge impact on operating efficiency of the companies. Companies sell their products using different distribution channels from the manufacturer to their end customers via retailers, wholesalers, direct dealers, agents, distributors or mainly most of the companies sell their products directly to the customers currently by the use of the online markets or online spaces. Currently large scale organizations tend to manufacture enormous diversification of goods and they are targeting different marketplaces to sell their products. Distribution of those goods from the focal point to end customer involve massive cost if the company have complex distribution network.

The mangers in the current globalized and technological advance world tend to increase the efficiency of product distribution and also in the same way customers expecting extraordinary responsiveness from the product manufacturers. Company to company distribution network will differ and most of the companies consider identifying cost effective network as a competitive advantage.

The factors such as road network, number of customers, number of intermediaries, vehicles, mode of transportation, capacity transported, fuel, maintenance and other vehicle related expenses would influence to the efficiency of product distribution network. And also the growth in strategies, techniques and management philosophies improves the load carried at once, speed of delivery, quality of the service, operation costs, the usage of facilities, and energy saving.

In distribution network of any company, the transportation takes a vast fragment and transportation takes a fundamental part in operation of logistics. In generally transportation takes one-third of the total logistics costs and transportation systems impact the performance of logistics arrangement. Transporting is required in the whole production process, from manufacturing to delivery to the final consumers and returns. The good coordination and mapping between each component including the intermediary, customer, transport service provider and manufacturer would bring the maximum benefit.

The purpose of this study is to identify and map the best solution for the water tank distribution network of Richard Pieris Plc.

1.1.1. The Richard Pieris and Co. PLC

The Richard Pieris and Co. PLC is a Mother Company which nourishes local and foreign employees by providing diversified products and service categories to the local and global community for more than 80 years. Richard Pieris & Company PLC (ARPICO) established in 1940s and it is one of Sri Lanka's largest corporations with interests in manufacturing, engineering, construction, automotive, lighting and electronics, retail and plantation industries. The group enjoys its market leadership by assisting to the Sri Lankan economy by minimizing unemployment rates, stimulates the local economy, takes Sri Lanka image to the world, with a wide range of high quality products, manufactured locally and distributed globally. The company categorized its business into below sections.

1. Retail Sector- With its retail arm of 'Arpico Supercentre' the Arpico group is the largest retailer of general household products in Sri Lanka and group manages the renowned Arpico chain of Supercentres, Superstores, and an island wide network of Showrooms facilities. The group initiated the concept of "Hypermarkets" in Sri Lanka.
2. Plantation Sector- this group is a one of major player in the plantation sector and the group owns Maskeliya Plantations PLC, Namunukula Plantations PLC and Kegalle Plantations PLC and sector employs more than 25000 employees.
3. Tire Sector - Richard Piries Company is the pioneer and the market leader in the tire Retread industry of Sri Lanka and achieved more than 60% of market share. Moreover the company becomes the largest Retreader in the South Asia. The company is associated with Bandag Corporation-USA and Birla Group India.
4. Rubber Sector - manufacture of moulded, extruded and foam rubber both for the international and domestic markets, majorly export to the North America, Europe and the Middle East countries. And the company manufactures their products based on the standards of ISO 2002.

5. Financial services and other - the Arpico group started to provide financial service to domestic market since 2013 and company cater to the diversified market segments such as leasing, hire purchase, micro finance, factoring, motor loans, deposit mobilization and corporate solutions. As other services the company provides service such as logistics, health care, fund management, interiors, stock broking to the domestic market.
6. Plastics and Furniture Sector - The sector is symbolized by Arpitech (Pvt) Ltd, Plastishells Ltd, RPC Polymers (Pvt) Ltd, and the Re-Distribution operation. Plastic sector manufactures and trades an assortment of products, extending from furniture, household items, and water solutions for day to day consumer durables.

Each category provides different types of goods and services to the domestic market as well as international market. As an example the Richard Pieris and Co. PLC is the market leader for "Rigiform" brand more than 50 years for the Styrofoam product category and most of Sri Lankan households use the name "Rigiform" to all types of Styrofoam products by showing the vigor of the Arpico branding and product positioning. In this study major purpose is to optimization of water tank distribution of Arpico Group.

As most of other products which Arpico group provide, Arpico water tanks are the inventers in the local moulded water tanks business in Sri Lanka. The Company has accomplished a leading position in the domestic moulded water tank market, with the market share of 44% Arpico branded water tanks. The Company manufactures and markets a wide range of bins, water tanks, Septic Tanks, Garbage Bin, Green Gas Unit, Compost Bin, Traffic Accessories and containers. Products are manufactured at the factories located in Horana, Pallakalle, and Dambulla which give easy access to island wide distribution.

Product diversification consider in this study as below.

1. The Plastishells Tanks

The Plastishells Tank Redefined to include an inner screw lid, this tank ensures the prevention of any insects and germs getting inside the tank. Identifying this need, Arpico has also strengthened the neck area of the tank, in order to give the necessary stability, making this tank more durable. By using only FDA certified material, the tank also focuses on the health platform; securing the health and hygiene of all our customers.

THE PLASTISHELLS TANK

The Triple Layer Tank - This unique tank is a feature-driven product. The three specific layers have its own functions to provide the best quality water storage. Arpico is the only tank manufacturer that markets a triple layer tank with the below mentioned value additions.

Outer Layer - The outer layer protects the tank from UV rays of the sun.

Middle Layer - The middle layer reduces water heating.

Inner Layer- The inner layer is blue in colour, enabling the user to see the water clarity at all times.

AQUA TOUGH

Aqua Tough water tank from Arpico is technologically advanced and made to international standards using 100% food graded raw material. The uniqueness of this tank is its height and the ribs. If the tank is Higher, it course for greater water pressure.

Smaller in Diameter - Less Space - Aqua Tough tanks require less space, therefore helps you save on the cost of slab construction and installation.

Greater in Height - Maximum Water Pressure - Because of the unique height of the Aqua Tough tank, you are guaranteed maximum water pressure.

Inner Layer - The six outer ridges give more strength, stability & endurance to the Aqua Tough tank

Water Tank specification

Table 1. 1 Water tank specification (http://www.rpcpolymers.com)

Tank Size (L)	L (Feet)	Height (Ft)	Diameter (Ft)	M (Inches)
250 Liters	2' 8.6"	3' 4"	2' 1"	15"
500 Liters	2' 10.4"	3' 7.7"	2' 9.5"	18.9"
750 Liters	3' 10.7"	4' 6.5"	2' 11"	18.9"
1000 Liters	3' 10.7"	4' 9.7"	3' 6.6"	18.9"
2000 Liters	4' 7.1"	5' 4.9"	4' 5.6"	18.9"
5000 Liters	5' 4"	6' 4.6"	6' 6.7"	18.9"
10000 Liters	7' 8.9"	9' 0.2"	7' 10"	18.9"
500 Liters Aqua	3' 7.3"	4' 2.0"	2' 6.7"	18.9"
1000 Liters Aqua	4' 3.2"	5' 2.0"	3' 4.2"	18.9"
2000 Liters Aqua	5' 8.9"	6' 6.4"	3' 10.9"	18.9"

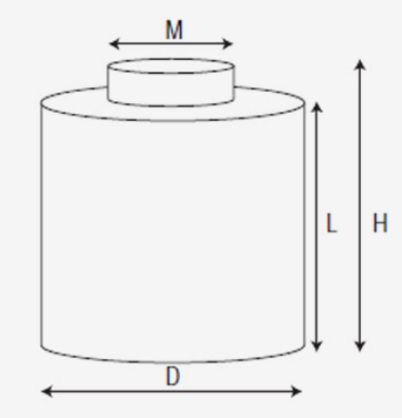


Figure 1. 1 Dimensions of water tank (http://www.rpcpolymers.com)

2. Hybrid Tanks

Arpico Hybrid's function oriented features include a state of the art monocoque diagonal design for maximum strength. A screw lid seals the tank, preventing insects and dirt from contaminating the water. The Hybrid's wide opening and strong base ease the cleaning process whilst its strengthened shoulder lugs enable easy lifting and anchoring of the tank. Aerodynamically

designed, the tank can withstand strong winds and maintains a moderate water temperature through fluctuating weather patterns.

Incorporating the premium, multi-layer technology used in Arpico's Triple Layer Tank, the Hybrid offers a threefold commitment to quality water storage. Each layer serves a function beginning with the innermost white layer which determines the freshness and purity of the water, providing a clear visual backdrop. The insulating properties of the middle layer keep the water cool by minimizing the absorption of heat, and play the key role of preventing algae formation. The outer Layer protects the water from harmful ultraviolet rays of the sun.

Water tank capacity based dimensions as below.

Table 1. 2 Water tank capacity based dimension (http://www.rpcpolymers.com/)

CAPACITY	DIAMETER	HEIGHT WITHOUT LID	HEIGHT WITH LID
500 L	860 mm	1085 mm	1160 mm
1000 L	1090 mm	1320 mm	1392 mm
2000 L	1375 mm	1590 mm	1665 mm
Overflow 32 mm	Outlet 50 mm	Washout 32 mm	Inlet 32 mm

1.1.2. Introduction to the Re-Distribution Warehouse

Richard Pieris Re-Distribution Warehouse (ARD Warehouse) is a centralized hardware item distributor which locates in strategic geographical location within the Colombo district. The Re-Distribution Warehouse distributes different products categories island-wide through a complex network of distributors and direct dealers. This distribution channel catering to over five thousand Hardware & Furniture outlets island-wide by becoming the largest in the country. Further, the warehouse is concentrating on continued diversification into new areas of business and new technology areas. The division also distributes Arpico branded water pumps, and PVC Vinyl Carpets, Electrical items including iron, blenders, rice cookers and fans, plus Rubber items such as garden hoses which are currently the market leader.

This division has also expanded its transport fleet (no of containers) and warehousing operations to accommodate to the emergent market with the objective of being a dominant player in the Hardware sector.

ARD Warehouse distributes their products to 28 Distributors similar to regional warehouse and

more than three hundred direct dealers. The regional warehouse has their own Arpico representatives (Sales force) and they brings the orders from the market and deliver/sell the product to the market. Therefore when ARD distributes the Hardware items to the regional warehouses the prices will be lesser than when they provide the same products to direct dealers. The direct dealers are selling the Arpico hardware items by themselves while keeping profit margin, therefore ARD Warehouse vend the product at higher price for them.

1.2. Background analysis of the case

Arpico Water tanks manufactured at three different plantations in Sri Lanka including Horana BOI zone, Dambulla and Pallekale. Hybrid 300*l*, 500 *l*, 1000 *l*, 2000 *l*, 5250 *l*, 10,500 *l* water tanks manufactured at Horana factory at BOI zone and Dambulla factory manufacture only Hybrid 500 *l* and 1000 *l* water tanks. Further full range of Aqua Tough water tanks manufactured at Pallekale water tank plantation including the size of 500 *l*, 2000 *l*, 1000 *l* and 5000 *l* water tanks.

According to the ARD warehouse details from the total transportation cost the water tanks gets higher value to transport due to the passivity of distribution network. Also when investigate the transport process, it appear many factors such as not having proper network, coordination errors such as lack of communication, management interference, not using enough technology such as GPS, RFID, GPRS and etc, and mainly they have low featured information system to connect all four destinations, which could affect to the distribution network of the company.

And also mainly the product diversification and lack of inter transportation also affect to the company distribution network. Specially the according to the information received by the company the four factories as distribution centers they are not maintain stocks properly, which means for some products they are not maintaining the Economic Order Quantities, stock management systems and etc.

1.2.1. Information flow of current transportation process (order process)

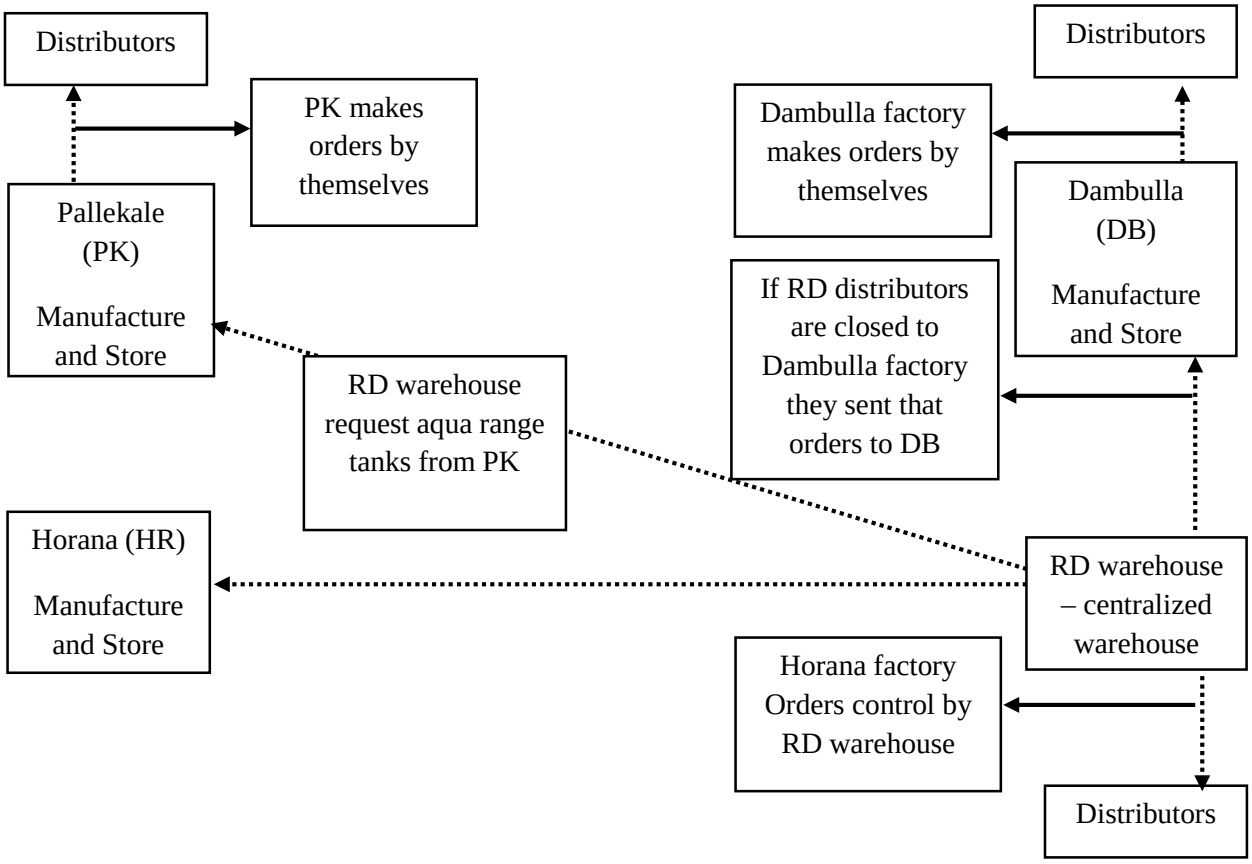


Figure 1. 2 Information flow of current transportation process (order process)

According to the case study the RD warehouse (centralized warehouse) collect all orders from each distributor and send the Lorries to Horana factory in most of the cases to load the lorry. Especially if RD warehouse does not have enough capacity in the stores and 5250 *l*, and 10,500 *l* water tanks stock available only in the Horana Factory therefore they sent the lorry to Horana Factory and deliver to the distributors.

Dambulla factory makes the orders by themselves and if distributors of RD warehouse are locate closer to Dambulla factory then RD warehouse deliver the water tanks via Dambulla factory.

Since all the Aqua Tough water tank range manufactured only at the Pallekale warehouse, sent stocks to RD warehouse and Pallekale factory makes orders from their distributors.

But in there information management system has two separate options such as order processing and order demand. Therefore in the current process if one distributor could make the order from

the system, it shows to all the centers and person, who available with the product which closer to the center. But in that system does not include the details of distribution network of water tank.

1.2.2. Vehicle allocation and production details of water tank distribution

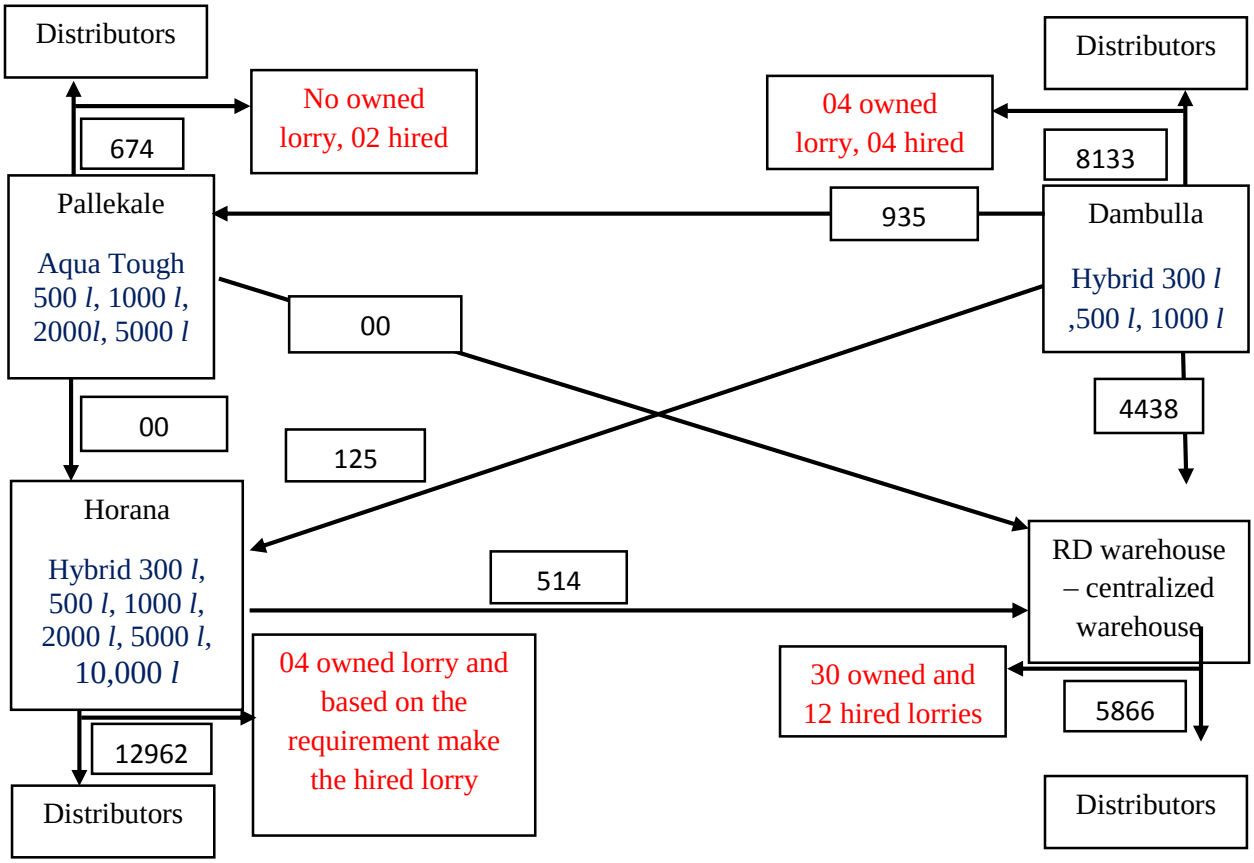


Figure 1. 3 Vehicle allocation and production details of water tank distribution

To analyze the problem of water tank distribution in this study has been considered three months including November 2018, December 2018 and January 2019. Within these three months Pallekale has sent 4438 water tanks to RD warehouse and warehouse has sent 5866 water tanks to their distributors. The deficit between Pallekale and RD warehouse water tank amount consider as opening inventory of RD warehouse. 12962 water tanks sent via Horana factory and 514 tanks have sent to RD warehouse from Horana factory.

Dambulla factory has sent 4438 water tanks to RD warehouse and 8133 water tanks to distributors, 935 water tanks to Pallekale and 125 tanks has been sent to Horana factory as stock.

Within these three months Pallekale factory has no water tanks sent to RD warehouse or Horana factory. But to their distributors they have sent 674 tanks.

Further in this case study it was identified about the vehicle details on water rank transportation and Lorry type and expected running capacity.

Vehicle details on water tanks transportation.

Table 1. 3 Vehicle details on water tanks transportation

Warehouse	**Owned**	**Hired**	**Type of owned lorry use for operation**
Re Distribution warehouse	30	12	Icher 24ft-4, Icher 33ft-2, Izuzu ftr 24ft – 2, Mitzubishi 24ft – 1, Tata 24ft -2, Leyland 24ft - 23
Pallekale Factory	-	02	-
Dambulla Factory	04	04	Icher 24ft-1,Leyland 24ft- 3
Horana Factory	04	Based on the requirement	Izuzu ftr 24ft -1, Leyland 24ft - 3

Lorry type and expected running capacity

Table 1. 4 Lorry type and expected running capacity

Type of lorry	**Expected running capacity**
Leyland 22ft	Per 1 *l* 4.5 km
Icher 22ft – 4 cylinder	Per 1 *l* 5 km
Icher 32 ft – 6 cylinder	Per 1 *l* 3.5 km
Izuzu ftr 22ft	Per 1 *l* 5 km
Mitzubishi 22ft	Per 1 *l* 5 km
Tata 22ft	Per 1 *l* 5 km

1.3. Problem statement

How to optimize the water tank distribution of Richard Peris Plc.?

1.4. Research problem

The real problem is that the company not utilizes the property including vehicles, technology and factory/warehouses effectively and not gets the maximum benefit of the transport network. As an example during the peak time it is unable to allocate vehicles from RD warehouse. Therefore it generate problems such as increasing cost of transportation, delay the process due to communication errors, safety of transportation, increasing truck km and etc. As recognized in the prior discussions had with management of RD warehouse the major problem is that they don't have properly synchronized transport system. As an example if stocks not available in Dambulla factory, even the distributor not closer to RD Warehouse, RD warehouse has to send the water tanks to particular distributors.

In same times if RD does not have enough stocks available with them they sent the trucks to Horana factory and from that point they sent the water tanks to distributors. That include additional 32 km to truck km since trucks comes to RD warehouse first and collect the waybill which address "To Horana" then load the water tanks from Horana factory to deliver to the relevant distributors. To get the maximum benefit of the transport network the company has to look the problem from a modern angel.

1.5. Scope and limitation of the study

The major objective of this study is to identify the transport network of water tank distribution at Richard Peris Plc and optimize the water tank distribution. To this analysis planning to consider three water manufacturing plantations with their own stores locates at Horana BOI zone, Pallekale and Dambulla, plus one centralized warehouse locate at Polgasovita, Mattegoda. In addition to that 28 distributors are considering for this study to analyze the distribution network of water tanks. And also all three companies manufacture wide range of diversified product categories such as water tanks, Septic Tanks, Garbage Bin, Green Gas Unit, Compost Bin, and Traffic Accessories etc. But only water tanks has considerable portion of sales. Therefore in this study consider only about different ranges of water tanks.

Further as constraints of this study would be some products will sent to the distributors by coupling with water tanks and also in some times when distributing to one the vehicle could serve to another

if distributor locations are closer or if the distributor locate in the same route. As mentioned, those details, challenging to collect since they don't have proper information reporting system.
To reduce the costs of project necessary to analyze the shortest path by using excel. First of all it wants to identify the shortest routes and then identify the distribution centers which could deliver together at once if demand generated within pre-defined time period. This analysis couldn't continue since the company policy of providing goods after making demand was only 3 days (gap between making demand and delivery). Therefore the other distributors cannot wait until other distributors make demand/orders.

No of vehicles want to use and the capacity need to load for particular vehicle need to analyze as a future research. In this research that area not planning to study that area due to time constrain. In this study it was gathered following details related to vehicle capacity.

1.6. Significance of the study

The transportation and logistics is a most significant activity in developing and developed countries because it is the only way to flow the finished, semi-finished and raw material over the supply chain. Anyway if manufacturer needs to get the supplies it will create need for transportation and logistics and in other way round if customer create demand for the finished product it will again create demand for the T&L. Further in the supply chain they have inward logistics, outward logistics as well as vitally reverse logistics which transport the damaged, return, empty cartoons, and for the recycle purpose items.

According to Sri Lankan Scenario 12% of GDP contribute from logistics and transportation sector. And further it is 20% from the total service sector (2015-2016). The Logistics Cost is 23% of Sri Lanka's Gross Domestic Product while 10 % which is the global benchmark. According to the research data 2012 of CSCMP (Council of Supply Chain Management Professionals) 62.8% of total logistics cost was spent on transportation activities of USA. The logistics cost is 8.5% of the GDP and for transportation contribute 5.4% of the US GDP. In Europe the total logistics cost is average 12% from the GDP and China it is approximately 21% of the GDP.

By looking at the early figures in Sri Lanka, they spent 21% from GDP for logistics and transportation activities while they contributed 12% to the GDP. The reasons for this gap are lack

of infrastructure and insufficient maintenance and not using available resources in order to get the optimum benefit. Same as all manufacturing companies spent more than 30% of total earnings.

According to Jean-Paul Rodrigue (2017) Transport systems required to reduce the costs of movements and to increase their capacity. All users including individuals, corporations, institutions, governments, have to negotiate for the transfer of goods, people, information and capital because supplies, locations, tariffs, salaries, distribution systems, marketing techniques as well as fuel costs are changing constantly. There are also costs involved in gathering information, negotiating, and enforcing contracts and transactions, which are often referred as the cost of doing business. Trade also involves transactions costs that all agents attempt to reduce since transaction costs account for a growing share of the resources consumed by the economy.

"The connectivity of a network defined as the degree of completeness of the links between nodes."(Robinson and Bamford, 1978) Transport geography/ transport modeling is very important to visually identify the relationship of each node, identify the links of distribution channels and to identify the cost effective route and to recognize which product should sent from which center and etc. Transport geography/ transport modeling could increase the efficiency of transportation by reducing time taken to transport, empty backhauls, minimizing energy usage, optimizing infrastructure usage, and etc.

1.7. Research gap

As Richard Peris Company have not done any research to minimize the transport cost of their process, or increase the efficiency of their distribution network, this is to highlight the most affecting factors for the increasing efficiency and optimizing of water tank distribution of this company.

1.8. Research variable

Variables of this study identified base on the case study analysis. The independent variable of this stud is efficiency of water tank distribution. Efficiency would increase or decrease due to distribution network or transport system which they use. Therefore the dependent variable would be distribution network of water tanks production.

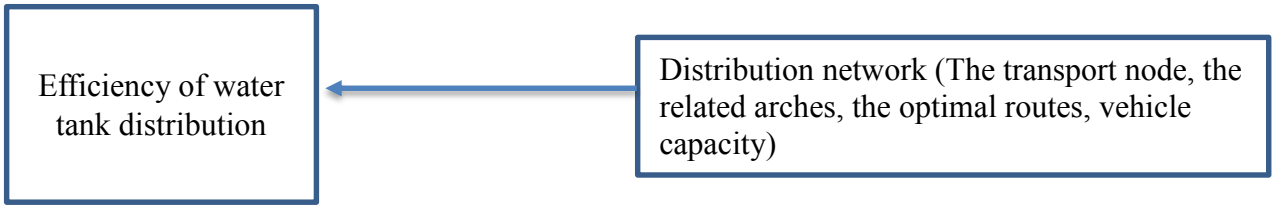


Figure 1. 4 Research variable

$Y = f(x_i)$

1.9. Research objectives

The main purpose of this study to achieve below mentioned objectives. The methods of achieving each objective explain in the chapter 3 – Methodology.

1. To identify the existing distribution network including details of quantity demanded, vehicle movement, vehicle capacity, distance, and etc.
2. To graphically represent a network by determining both starting and destination nodes. (Mapping)
3. To develop transport models which reduce the cost of transport network and select most appropriate model for the organization

1.10. Summary

In this chapter basically provide introductory idea on the company, product diversification, and back ground analysis as well as the case study. Further to add this chapter includes the research question, research problem, research gap, variables and objectives of the research. And also this chapter consists of the scope and limitation of the research and significance of the study as well.

Chapter 02

2. Literature Review

The logistics is one of main factor which affects to the company's financial status and the profit earnings of the company. Therefore study about the transportation cost and efficiency of distribution network of the company will be affect to the finance potion of the company and to increase the market share of the company by increasing the competitive advantage.

In this study, literature review is planning to carried out by focusing few main factors including what is logistics, how logistics impact on a company, factors affecting to the cost of transport of a company, link between supply chain management and logistics, transportation, distribution networks of products and etc.

According to Nowak, 2014 and Caban, 2001 "the logistics, in an organization is one of many factors engendering costs which may significantly contribute to the financial position of enterprises". "The definition of cost as the starting point of the considerations can be found in the Accounting Act, based on the general definition of costs and losses. Costs constitute a probable reduction in economic benefits in the reporting periods of a reliably determined value in the form of a reduction in the value of assets or an increase in the value of liabilities, which will lead to a reduction in equity in a different way than a withdrawal of funds by owners." (Journal of Laws, 2013). (Data Source: Identification and Measurement of Logistics Cost Parameters in the Company, Marcin Stępień , Sylwia Łęgowik-Świącik , Wioletta Skibińska , Izabela Turek, 2016)

Stankand Goldsby, 2000 states that Successful managers today need to take a broad view of transportation management's role and responsibilities in an integrated supply chain.

Hua et al in 2014 states that "The logistics distribution involves preparing goods in the distribution center or logistics node for most reasonable delivery according to the requirements of customers". And also as said by Johnson et al in 2010 " the warehouses are a considerable component of logistic operations and an important contributor to speed and cost in supply chains. In addition to that benchmarks for individual warehouse functions such as order picking, little is known about the overall technical efficiency of warehouses."

On the word of Fuller et al on 1993, "Logistics should be tailored correctly to the needs of the company and its customers. If done then it could become the next governing element of strategy as an inventive way of creating value for customers.". (Data Source: *A Study on Transport Cost Optimization in Retail Distribution, Shilpa Parkhi, Jagadeesh D, R. Arun Kumar, 2015*)

(Thomas J. Goldsby, 2014) presented that the logistics is define as "that parts of supply chain management that plans, implements and controls the efficient, effective and forward and reverse flow and storage of goods, services and related information from the point of origin to the point of consumption in order to meet customers' requirements,"

Dubey et al The Supply Chain Management defined in their journal in 2013 "the management of upstream and downstream associations with vendors and customers to provide better customer value at least cost to the supply chain". To coordinate upstream and downstream of the supply chain it is really crucial the transportation factor and according to the Dubey et al to have a proper coordination and to provide better customer value at least cost to the customer transportation is one of critical factor.

According to Chen, et al 2004 "The supply chain management is not only limited to Logistics activities and planning and control of materials and information flow, internally within the company or externally between companies". Chen, et al, 2004 further states that "supply chain management also covenants with the strategic decisions such as inter organizational issues, alternative organizational form to vertical integration. And also it mentioned that it is the management of relationship between customers and suppliers." This point is important by reason of providing better service by the particular company management must focus on the supply chain of the company including the supplier relationship management and customer.

And also Stankand Goldsby,2000; Mason and Lalwani,2004 states that as seen in this light, it is clear that whilst effective transport operations can enable the delivery of customer value and hence integration of transport operations in to the overall supply chain is critical to improving supply chain performance.

(Thomas J. Goldsby, 2014) States that by looking at the economy it could call as total supply chain, why the production and consumption repetitively occur by exchanging the finish good, raw material, finance, and information via transportation and logistics (warehouse and other services).

Luo, 2007 presented that the "delays in grading, sorting, transporting and disposition only work for to reduce the value remaining in the product". According to Tracey 2004 transportation is often ignored as a competitive advantage. And also the transportation performance is influenced by the terms such as, satisfactory delivery service, acceptable overall performance, and product quality and delivery schedules.

According to Sri Lankan Scenario 12% of GDP contribute from logistics and transportation sector. And further it is 20% from the total service sector (2015-2016). The Logistics Cost is 23% of Sri Lanka's Gross Domestic Product while 10 % which is the global benchmark. As mentioned in the research data 2012 of CSCMP (Council of Supply Chain Management Professionals) 62.8% of total logistics cost was spent on transportation activities of USA. The logistics cost is 8.5% of the GDP and for transportation contribute 5.4% of the US GDP. In Europe the total logistics cost is average 12% from the GDP and China it is approximately 21% of the GDP.

By looking at the early figures in Sri Lanka, they spent 21% from GDP for logistics and transportation activities while they contributed 12% to the GDP. The reasons for this gap are lack of infrastructure and insufficient maintenance and not using available resources in order to get the optimum benefit. Shilpa Parkhi, 2014 in the article states that India spends 15 to 20% of its GDP on transport and logistics compared to an average 8 to 10% in other developing countries.

Logistics is a major part of the supply chain and same as to the cost potion. In a company bear huge cost for logistics activities from their supply chain cost. the people who are in the industry used to split logistics cost into transportation, warehousing, inventory carrying, customer service and order processing, administration, and other costs according to the article depending on the activity and nature of the company the logistics cost vary 5%-9%. The article has taken an example of logistics costs of The Establish, Inc. in 2010 (Logistics_costs, 2010). (*Renata Kudryavtseva, Simulation-based analysis of performance of AS/RS*)

Average percentage of Logistics costs in % of Sales	
Transportation	4,08 %
Warehousing	1,75 %
Inventory carrying	1,79 %
Customer service and order processing	0,43 %
Administration	0,23 %
Total logistics costs	8,28 %

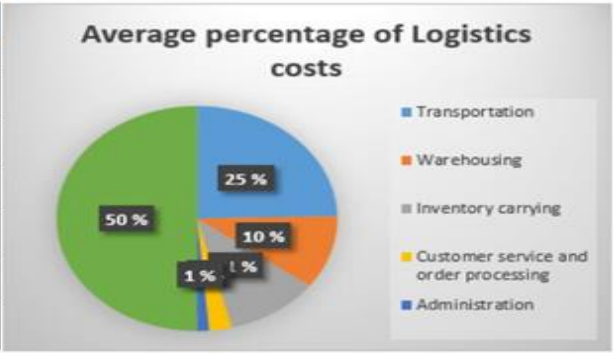


Figure 2. 1Average percentage of logistics costs in % of sales

The annual state of logistics 2015 CSCMP; insight that the if it is consumer product providing company, transportation cost may generally exceed 60% of total distribution cost of the company and many cost headings associated with transportation factor such as fuel and insurance which are driven by the international forces. Also mainly affect the demographic factor to find the sufficient amount of drivers and retain them in the company (demand and supply of drivers and helpers). All these factors influence operating costs of a truck fleet higher.

Figure 2. 2Factors of logistics cost of an organization

According to the CSCMP, they are suggesting that two factors will be mainly affected to lower the transport cost and higher the service. First one is about Eliminate the Need for Shipments and Order Optimization - An end-to-end solution that helps create and ship fewer, more efficient loads. Under first point article suggested that; Eliminating wasted moves is a significant opportunity to reduce total supply chain costs.

"Transportation/Warehouse Optimization has two systems that support the elimination of shipments by planning:

1. AutoSPO (Automatic Ship Point Optimization) – determines the best place to ship any order from based on cost, margin, fill rates and available capacity.

2. AutoScheduler – a scheduling genius that takes into account all factors to plan minute-by minute deployment of inventory and activities to support on-time shipping in a capacity constrained world (finite capacity distribution scheduling and DRP)"

under the order optimization (fewer ships, more efficient loads) factor they have done a study of over 1 million trucks moving on U.S. highways in June 2008, and it indicates that 84% wasted more than 5% of their weight capacity due to different reasons. One of the reason is most of the trucks are not shipped in full. By consideration of this factor one of US major consumer good providing company came up with a concept of "Super Truck" - More Product, Fewer Loads, to increase shipment size (optimize the capacity)

Also the US companies use AutoO2 (Automatic Order Optimization) software to minimizes supply chain transportation costs by optimization orders to maximize the loads on all trucks in a way that cannot be achieved manually, with TMS (Transportation Management Systems) or with non-optimizing systems. Procter & Gamble states that replacing their load builder with AutoO2 has reduced their transportation costs by 7%. (*Annual state of logistics 2015 CSCMP*)

Frazelle 2002 indicates that the warehouse can categorized into few dissimilar types based on its main functions in Supply chain such as local warehouses, work-in-progress warehouses, finished good warehouses, raw material warehouses, fulfillment warehouses, value added service warehouses and distribution centers/warehouses and etc. (Figure 2.3: *Types of warehouses*) Warehouse as a term is not equivalent to distribution center (DC). And further the article states that Distribution warehouses and distribution centers main purpose is to accrue and consolidate products from various points of manufacture within a single firm, or from several firms, for combined shipments to common customers.

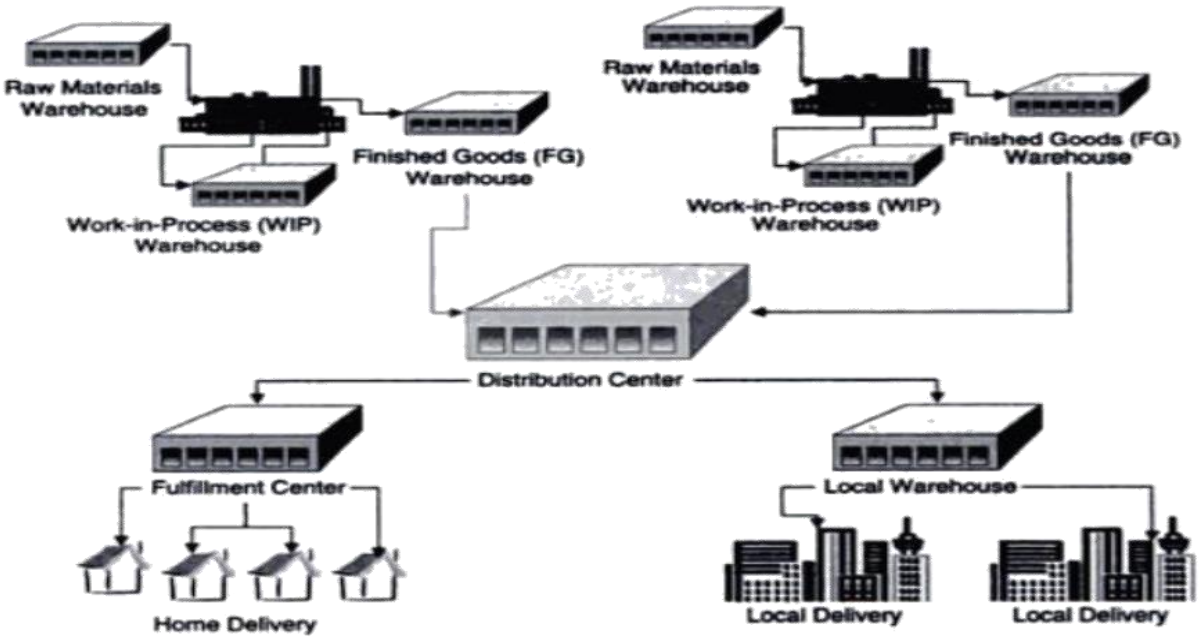


Figure 2. 3Types of warehouses

Frazelle ,2002 in their thesis focus on the distribution center -type of warehouse. DCs gather and consolidate products from different manufacturing points and combine these to shipments for the final customers. The location of a DC is usually central in relation with the production location or the customers. Products are moved in to the DC on larger units (full trucks, pallets) and out as a smaller units (pallets, parcel boxes, cartons).

According to Lambert et al. 2006, the main differences between a "normal" warehouse and a distribution center are: Warehouses hold all products, when DCs hold minimum inventories of high demand products. On the other hand warehouses perform minimum of value- added services, when DCs perform a lot of value-added activities. DCs collect data in real-time, but in warehouses data is collected on batches.

Bartholdi et al. 2011 states that two of the basic distribution models are point-to-point distribution and hub-and- spoke distribution. These have certain benefits and negative attributes which are discussed in the following section. Distribution models are presented in the figure 4. With *m* vendors and *n* stores (point-to-point) the transportation consists of m times n direct shipments, each usually small and likely to have higher, less-than- truckload rates. Hub-and-spoke distribution model gets its name from the bicycle wheel of one center hub and spokes connected to the hub.

With using a hub there are only $m + n$ shipments through a distribution center or cross-docking. Each shipment is larger and has lower, full-truckload rates.

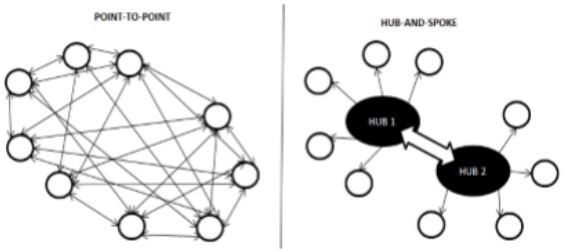


Figure 4. Basic distribution models. (Bartholdi et al. 2011, p. 7)

Figure 2. 4Basic Distribution Models - Bartholdi et al. 2011

Weiskott 1999 indicates that a hub acts as a distribution center to hold large inventories for a region it is responsible for. This hub is connected to nodes, which serve the local factories/customers. The main driver behind this model is to be able to serve customer with short lead times and be able to respond to varying customer needs when there are clear business regions. Hub-and-spoke –model is efficient especially, when the goods are not transported by air freight but by using road transportation.

The literature review was carried out to understand and evaluate the importance of transportation to the warehouse and to understand the relationship between logistics and warehouse cost of warehouse. Further expected to understand the existing distribution network of aforesaid company, and identify the best distribution network matches to the said case study.

As said by (Stîngă, 2017) the analysis of transport systems cannot be realized without a detailed analysis of transport networks. Nowadays, in land development, multiple networks interfere, which impose an analysis of their fundamental role within underserved territories, regarding different ways of territorial organization and synchronization, but especially regarding the transport techniques. Transport networks shall be seen not only in terms of flows existing along them. Through the rational use of the area, these ensure connections/relationships between technical capacities and the services that are delivered within the territory.

Further (Stîngă, 2017) mentioned that a general analysis of a transport network shows that it ensures the freight transport between the shipping point and the destination point, through links

(graphically represented under the form of some arches) which connect the network nodes (beneficiaries and terminals – ensuring additional sorting, storage, consolidation or transshipment activities). The networks' modeling is realized by connecting sources with their related transshipment nodes through an increasing number of links.

Ellanti, Gorshe, Raman and Grover, 2005 mention in the book that the analysis of networks shall consider both their division depending on the geographical position and on the functions realized by them, but also taking into consideration three fundamental criteria: control, transport and management.

In this way, one can easily assert that networks represent basic principles of the society, allowing the study and the optimization of some essential issues for modern society, as are those regarding: external costs, urban expansion, diseases dispersal or development of some regions. Thus, the main elements composing a transport network are:

- The transport node: represented by any location which, in terms of its location, allows the access to a transport network;
- The related arches: transport infrastructure ensuring the connection between two nodes;
- The optimal routes which can exist between two nodes;
- The flow of goods/ passengers existing on the levels of nodes or arches.

As Raicu and Roșca (2006) highlight in the research paper, the standard definition of a transport network (R) presents if as an undirected graph (a set of nodes and links, at which the crossing direction of the links has no importance) G[R], whose representation is made through its sets of nodes and links:

$R= (V, A)$

Where:

- $V= \{ v_0 , v_1 ,\ldots, v_n \}$ which represents the set of nodes: considering the transport terminal (v_0) and the recipients ($v_1 ,\ldots, v_n$);
- $A=\{(v_i, v_j)/ i\neq j; v_i, v_j \in V\}$ which represents the set of links of the graph.

Ducruet and Lugo (2013) point out in their paper that the analysis of the transport network features shall be realized on global level (by the description of the network as a whole) and on local level (by the analysis of one or more nodes individually).

The table below presents the methods used both on global level and on local level for the description of complex transport networks.

Table 1. Methods used to describe complex transport networks.

Method adopted at global level	**Definition**	**Formula**
Average shortest path length	Average number of stops between two nodes of the transport network	$l_G = \frac{1}{n(n-1)\sum_{i,j} d(\vartheta_i, \vartheta_j)}$
Method adopted at local level	**Definition**	**Formula**
Degree centrality	Number of adjacent nodes	$k_i = C_D(i) = \sum_j^N x_{ij}$
Shimbel Index	Sum of the length of all shortest paths connecting all other nodes in the graph	$A_i = \sum_{j=1}^N d_{ij}$
Eccentricity of a node	Number of links needed to reach the most distant node in the graph	$e(x) = \max_{y \in X} d(x, y)$

Figure 2. 5Methods used to describe complex transport networks

And also further in their study states that on global level, the structure of transport networks is influenced by physical constraints imposed by the infrastructure, but also by the transport means. In this case, the literature presents more methods which aim the definition of the network characteristics such as: the graphs method, the minimum distance method (determine the route which ensures the connection of all nodes with minimum costs, method which measures the network efficiency), geomorphometry (it analyses the fluvial transport networks) etc.

On local level, it is pointed the determination of the relative position of a node or the identification of a group of nodes within the network. Therefore, it can be followed the determination of the eccentricity of a node, of the position towards the center of a node, the modality index Shimbel etc. Over the years several models have been developed in order to increase the general performance of the intermodal transport chain. The designed, analyzed and presented models aimed at optimization, simulation and establishing a transport system network.

According to Narus and Anderson, 1996 there is a need for freight transport to be used in more flexible and responsive ways, to respond effectively to customer demand. As said by Morashand Clinton, 1997; Duclos et al., 2003 while at the same time minimizing the impact of transport on costs and on the environment.

On the word of Beier, 1989; Bask, 2001 there appears to have been a failure to properly integrate transport into supply chains to date. The aim is to develop a supply chain uncertainty model that explicitly incorporates transport operations. The foundation stone of this model is the concept of the logistics triad – the set of relationships between the supplier of the goods, the customer for the goods and the logistics provider (or carrier) (Figure 1). Our model has its roots in previous research on the logistics triad where it has been argued that this represents the minimum set of dimensions for supply chain analysis.

"Figure 1. Logistics triad"

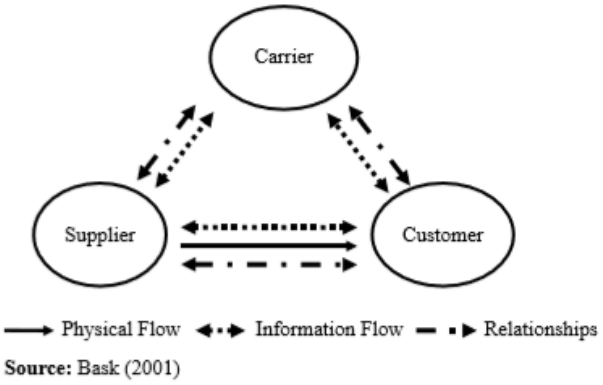


Figure 2. 6 Logistics triad

As consider by Baumol and Vinod, 1970 transport uncertainty in terms of variations in a number of factors including transit times, schedules (for example, to take into account delivery windows), volume and transport mode. A traditional approach to investigating the logistics impact of uncertainty is the use of "Inventory theoretic" models following Baumol and Vinod (1970).

Typically, these models identify the total costs of transport and inventory, and how these vary according to choice of transport mode or transport carrier. Most relevant here is that the issue of uncertainty is addressed through the cost of increased safety stock held to prevent stock-outs due to variability in transit times. Such methods are still used, as for example by Swan and Tyworth (2001) in their study of the impact of unreliability in American rail freight services.

A large body of research employing a wide range of methodologies continues to highlight the inventory impacts of transport-related uncertainty. Closs et al. (2003), for example, investigated rail wagon delays specifically in the chemical sector, and concluded that even quite small changes in rail transit times and, more relevantly here, transit time variability could significantly reduce safety stock levels for the shippers concerned.

Saldanha et al. (2006) suggested that the issue of variability over-rode that of absolute speed, and hence carriers may be better off adding slack time into their published schedules in order to achieve better reliability.

In this chapter mainly discussed on logistics definition, transport definitions and definition of supply chain and supply chain management. And also it identified the difference between distribution center to warehouse as well as it explained about the different types of warehouse based on their function in the context. Then this chapter enclosed with basic distribution models including point-to-point distribution and hub-and- spoke distribution. Further this chapter includes the analysis of transport network, importance of analyzing transport network and methods used to describe the complex transport network and etc.

2.1. Literature survey on Major variables affects to transport cost of transportation process

There are few factors identified under different surveys conducted before (literature survey).

Retail Distribution Network

As said by Hua et al. (2014) logistics distribution involves preparing and arranging the finished goods in the distribution center for stores same as ARD. Distribution network in retail

perspective comprises the transportation from distribution center with a multi-vehicle distribution to multiple stores. According to them this should fulfill the following conditions: (1) Each delivery path of each store, demand and delivery of the vehicle does not exceed the carrying capacity

(2) The length of each distribution route, delivery vehicles does not exceed the maximum travel distance delivery time

(3) Each delivery of goods cannot exceed the time required

A network design is considered if it performs well with respect to revenue, costs and delays (i.e. delivery time)

Transportation

Luo (2007) provided the insight that the value remaining in the product will reduce by delays in transporting, sorting, grading and disposition. From total logistics cost averagely 50% goes for transportation. Generally retailers have improved control over their distribution network i.e., distribution centre to retail stores. Road network and mode of transportation is used in distribution of retail supply chain. Distribution centers and transportation network are unusually expensive if that is not controlled effectively.

Further in his paper mainly discuss about reduction of transportation costs in the distribution network of the retail supply chain. As per their study transport goods between warehouses and retail stores are not inexpensive, it includes both the capital and running costs. India spends 15% to 20% of its GDP on transport and logistics compared to an average 8% to 10% in other developing countries.

According to Tracey (2004) the transportation is frequently unnoticed as a major cause of competitive advantage. Further he stated that transportation performance depends on the factors alike delivery schedules, satisfactory delivery service, product quality and acceptable overall performance.

Cost Involved in Transportation

As per Wu (2014), all the costs in the transportation, distribution accounted for a very high proportion. The core issue of the distribution system is path planning problem. Rational path arrangement can effectively improve transport efficiency and reduce service costs of the total transportation system.

According to Yang et al. (2014) a good routing for logistic distribution can cut down transport cost and improve efficiency. The efficiency of transportation system has great influence on improving whole efficiency of reducing transport cost and logistics system.

Zeng and Rossetti (2003) in their research classified the key logistics cost elements into six categories namely transportation, inventory holding, customs charges, risk and handling, administration, and packaging costs. Transportation cost has been a very common topic of research. Examples of these include the routing of transportation (Eilon et al, 1971), minimization of transportation cost (Bodin et al, 1983), etc. supposed that the transportation cost should relate to the travel distance between the warehouse and destination, and such cost should include the equipment cost, driver's wages and in-transit inventory cost.

Sahin et al. (2009) stated that one of the significant parameters in the determination of optimal transportation costs is the state of economy. The authors further stated that realistic technical, economical, and operational parameters are needed for determining transportation costs. Sahyouni et al. (2007) developed three generic facility location models for the integrated distribution and collection of products. The models quantified the value of integrated decision making in the design of logistics networks by focusing on facility and transportation costs throughout different stages of a product's life cycle. The trucks used in distribution network can either be owned by retailer or can be rented from 3rd Party Logistics provider. At ARD also they have their owned fleets as well as out sources fleets from 3rd party logistics service providers. Generally the fixed costs involved in transportation will be time related cost. And the Capital costs (vehicle cost), includes vehicle taxation, vehicle insurance, driver salary and overhead cost also fall under fixed costs category. The variable costs involved in transportation are running costs. Fuel cost, oil & lubricants cost, vehicle repair and maintenance, tires & tubes cost, trip allowance to crew, loading and unloading personnel cost, other operating cost if the

truck is owned by the retailer, retailer has to bear all the risks of breakdown, fitness certificate, accidents etc. As 3rd Party Logistics provider will be having large scale of operation, these risks can be avoided based on the credibility of the logistics provider. Depreciation of capital cost should be taken into account if the truck is owned by the retailer.

Transport Planning in Retail Distribution Centre

According to Shilpa Parkhi, 2014 Batch plan contains the details of sequence of store delivery and total number of crates in the respective truck. Batch plan for Distribution Centre is studied and route optimization is validated. This involves all the process in delivering the goods to the store from the DC. While dispatching the goods, three things are taken into consideration; they are Vehicle Plan, Route Plan and Loading Plan.

Shilpa states that Vehicle planning in retail is defined as the allocation of the available vehicle in the fleet to the stores so that truck utilization is optimum and cost incurred is low. The dispatcher must be careful to consider vehicle equipment and conditions, integrate special transport, plan maintenance actions, relay and assign open parking spaces and take into account personnel allocations. Therefore, dispatch systems should give an overview of which vehicle is currently deployed and with which crew.

Transport manager looks after vehicle planning and truck has to be deployed based on the tonnage or cubic utilization. Based on the load of stores, number of stores in a trip and also the compatibility of vehicle to the store, the vehicle to be allotted are decided. Compatibility of vehicle to the store means the road conditions, traffic conditions and parking space required for the vehicle.

Route plan is made to obtain optimum turnaround distance and time. Based on the distance between stores, load of each store and truck capacity a route plan is made. Route plan is made to comply with the city entry restrictions and on-time delivery to stores. Delivery sequence is formulated in route plan.

Load plan is the process of obtaining optimum truck utilization by clustering of stores based on the store load. It is done based on route plan. It also given the order in which vehicle has to be loaded so that first stores stock be at the entrance of the container. Last In First Out (LIFO)

technique is used to improve productivity. Load plan is done after vehicle plan and route plan is done.

2.2. Literature survey on appropriate cost function for the water tank transportation process

Cost Factors

According to Shilpa Parkhi, 2014 five factors affect to cost of transportation.

1. **Truck Volume Utilization:** Truck utilization is defined as the percentage of truck capacity that is filled with goods. The number of Head Units of particular dimension or weight that a particular truck can carry should be determined. Capacity of the truck can be considered based on the volume or tonnage depending on the type of goods handled. Based on the store load, batch plan is made.

Batch plan contains the details of sequence of store delivery and total number of crates in the respective truck. A truck will carry the load to single store or multiple store depending on the load of the stores. The main objective of the transport planner is to fully utilize the truck capacity.

Fleet utilization: Fleet utilization is the number of vehicles in service from the total given number of vehicles. Vehicle can be utilized if it is available for service. In usual cases an average of around 30% of the total vehicles will be off road due to breakdown, accidents and renewal of Fitness Certificate (FC). This is due to poor road conditions in India, lack of training and proper Maintenance of vehicles. Transport Planner in DC will have a track of all the vehicles current status. If the available vehicle is not enough to meet the demand of the customer i.e., stores, alternate plan should be made. Market vehicle should be obtained to meet the demand. On Time Delivery (OTD) and Customer Satisfaction should be the primary goal of the Transport Planner.

2. Route Optimization: The basis for route optimization is the use of models to describe the transport network that needs to be planned. When building a model, the scope of the overall network needs to be defined, ensuring that all the data is included. The model has a number of components such as products, vehicles, personnel etc. The product will be defined by its weight

and its volume, which are important factors. The product moves from one geographic location to another, i.e. origin and the destination.

A transportation network within the model can be divided into a number of sectors which is represented by a vehicle, which moves between an origin and a destination location. Each vehicle may have different attributes such as volume or weight capacity, loading times, cost per mile, and vehicle limitations, i.e. speed of the vehicle. The personnel assigned to the model have characteristics that are governed by the type of work they perform. In retail distribution the Vehicle Routing Problem with LIFO principle is followed which is very similar to Vehicle Routing Problem with Pickup and Delivery except an additional restriction i.e. the item being delivered must be the item most recently picked up.

Transport cost depends on the distance covered by the truck which carries the goods. Transportation models play an important role in reducing cost and improving service. Therefore, the goal is to find the most cost effective way to transport the goods. Considering 'm' warehouses which supplies goods to 'n' geographically dispersed retail centers, each with a given demand.

The objective is to determine the minimum possible transportation costs. Considering C*ij* as the unit cost of transportation between the i^{th} warehouse and the j^{th} retail center then the objective function becomes:

$Min \sum \mathbf{C}ij\boldsymbol{x}ij$

While targeting the above objective function, the challenge is also to satisfy various operational and logical constraints. Constraints such as supply at warehouse, demand at retail center, availability of trucks, availability of manpower, full truck load, road conditions, traffic conditions, green transportation etc. have to be taken in to consideration.

3. Turnaround Time (TAT): It is the total time taken by the truck from loading the truck in the distribution centre, delivering it to retail stores and returning back to the distribution centre for reloading. TAT includes loading time, document verification time, travelling time, idle time and retention time in stores. Retention time in stores can be further detailed as waiting time, document verification time, inspection time and unloading time. By reducing turnaround time,

the truck can be utilized more i.e., more delivery schedule. Also resource will be readily available to planning department for next schedule.

4. Backhauling: On each route, after all deliveries are made, returnable items are picked up and brought back to the depot. Shear (1997) stated that combining 'pallet rate' pricing from carriers and pallet tracking from store to-vendors allows for the most cost efficient hauling of returned items. For the re-use purposes, crates and empty cartons are hauled back to DC from stores. The crates used are foldable in nature. The foldable structure provides more space utilization and helps in backhauling purposes. Long-lasting crates replace traditional packing, provides great cost savings over disposable material. Robust construction ensures products are well protected. Extra lightweight crates are used for handling ease.

5. Information Technology: Information technology plays a major role in today's world as it brings the communication faster by reduction of significant amount of costs.

1) Enterprise Resource Planning

2) Building Transportation Network Model (Shilpa Parkhi, 2014)

Chapter 03

3. Methodology

Introduction

The major objective of this study is to understand the existing water tank distribution network of Richard Peris Plc and develop and test most suitable cost optimization network model for the case.

3.1. Data collection method

Primary data and secondary data will be used for this study and those data will be collected from the Arpico Re-distribution warehouse, from few selected distributors and other data collecting sources.

To understand the existing transportation process, nature of the vehicles used for the process and transportation network use the structural interview with selected few top level managers including, logistics and finance executives of the ARD.

Table 3. 1Research instruments

	Method planning to use
Existing transportation process	- Unstructured interview/ discussion
Existing transport network – geographical plan of the company	- Unstructured interview / Semi structured interview/discussion
Suitable network function for the water tank transportation process	- Excel and literature survey/Mapping software

1. Unstructured interview – planning to conduct the unstructured interview to get idea about existing transportation process, existing transport network – geographical plan of the company since the researcher having a clear plan about the problems but minimum control over how the respondent answer. (Margaret C. Harrell, 2009)

Population: population of the study is all the staff members of the Arpico Re-distribution center

Sampling units – in ARD sampling unit comprise with random sample of managerial and executive level. Planning to interview all related managers and executives involved with the transportation process at ARD.

Sample size: two managers and three executives who are involved with the transportation process at ARD.

Sampling procedure: The sampling procedure will be the judgment sample which means selects the population members who are good prospects for accurate information. And base for selecting the sample will be the designation.

2. Semi – structured interview – to collect the ideas about existing details of transport network for water tank transportation, and demand pattern and demand details of ARD expecting to conduct a semi structured interview. In this interview a guide is used, with questions and topics that must be covered during the interview. The interviewer has some discretion about the order in which questions are asked, but the questions are standardized, and probes may be provided to ensure that the researcher covers the correct material. This kind of interview collects detailed information in a style that is somewhat conversational. In semi-structured interviewing, a guide is used, with questions and topics that must be covered. (Margaret C. Harrell, 2009)

Population: In this part population is same as above. The all staff of the ARD

Sample Units – same as earlier one and sample unit comprise with the related managerial level executives will participate for this.

Sample size: two managers and three executives who are involved with the transportation process at ARD.

3.2. Method of Data Analysis

The data which collected from Questionnaire and face to face interviews, expected to analyze by SPSS and Excel software. Further below steps and tools will use to achieve the objectives of the research.

Step 01: Understand the existing transportation network including the fleets' types and the water tank carrying capacity

Step 02: Understand and analyze the past demand data and identify the demand pattern of past few months.

Step 03: Objective 01

1. To understand the importance of transportation factor to the organization and the similar organization. - Critical factor analysis and hypothesis testing

Step 04: Objective 02

2. To understand the various cost components affect to transportation cost of water tank transportation - Detail cost function analysis

Step 05: Objective 03

3. To identify the solutions for major components affect to transportation cost of water tank transportation - Optimization solution

The data collected via different sources will be presented by using charts, diagrams, and tables etc.

3.3. Methodology

To continue this study the mainly methodology has planned with using excel and planning to analyze the distribution network of the said organization after collecting all the data related to starting point, destination point, distance between each points starting and destined point, types of water tanks including product variations, quantity demanded by the different distributors

attached to the organization, and vehicle capacity details and whether item has sent by couple with some other product or not and etc.

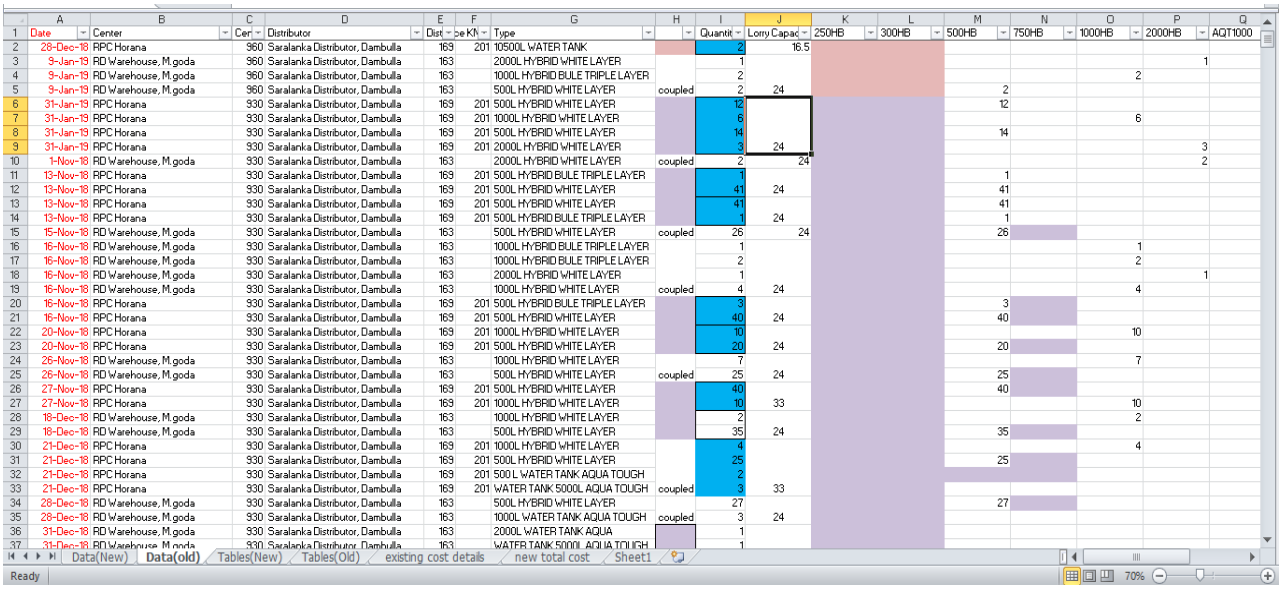
Then planning to make a 28*4 matrix by using excel and develop summery sheet based on the details collected earlier. Details summarized as total quantity distributed to each distributors, distance of distributors from each manufacturing centers, distance cart for all centers with adding 32 km to RPC Horana, distance chart for all centers without adding 32 km to RPC Horana, and item vise delivery among each distribution centers. Based on that summarized details it was planned to develop map of existing distribution network and then develop a map based on cluster based shortest path as a suggested solution. Then do a cost analysis to identify the lowest solution and recommend that solution as the best solution.

Chapter 04

4. Data Analysis

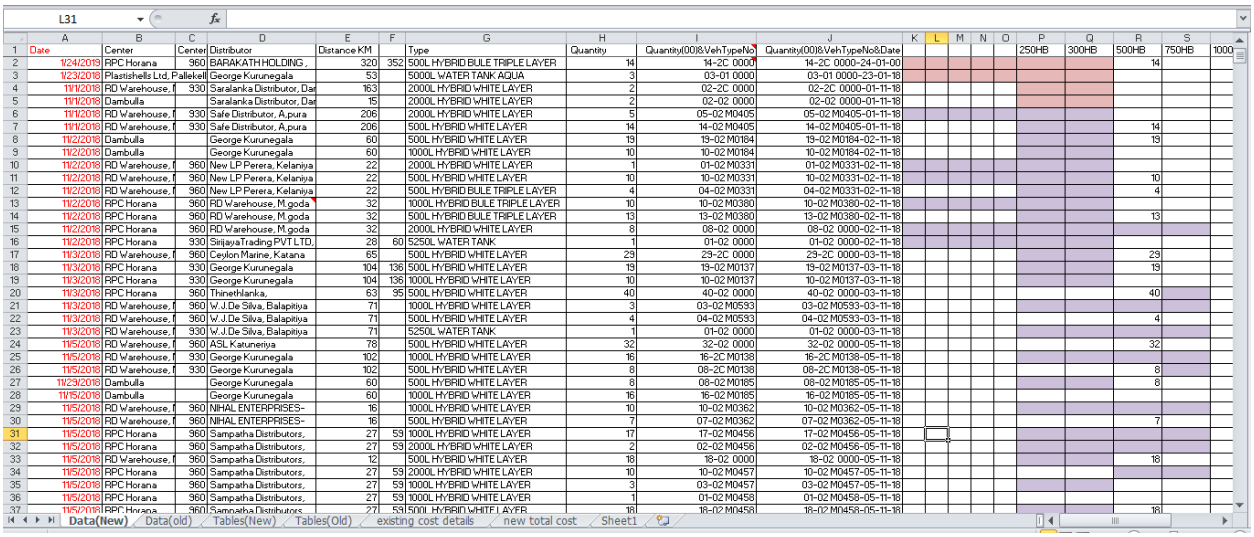
In this research mainly data analysis will be done by using excel. Basically to identify best solution for the transport network in this study mainly analyzed road usage plan including vehicle capacity, product diversification of the company, starting point and destination point of the network, quantity demanded by each distributors and factory itself, distance of each nodes and etc, for three months. (November 2018, December 2018 and January 2019 respectively).

In the early stages when collecting the data from the company it was only received the raw data and that data was filled in to the one format as below figure 4.1. It was really hard to collect the raw data from the company since the said company does not have proper system to monitor the transport and distribution data. And then the aforesaid data format was changed into convenience model which could easily analyse the data as researcher want (figure 4.2).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Date	Center	Cent	Distributor	Dist	pe KM	Type		Quantit	Lorry Capac	250HB	300HB	500HB	750HB	1000HB	2000HB	AQT1000
2	28-Dec-18	RPC Horana	960	Saralanka Distributor, Dambulla	163	201	10500L WATER TANK		2	16.5							
3	9-Jan-19	RD Warehouse, M.goda	960	Saralanka Distributor, Dambulla	163		2000L HYBRID WHITE LAYER		1							1	
4	9-Jan-19	RD Warehouse, M.goda	960	Saralanka Distributor, Dambulla	163		1000L HYBRID BULE TRIPLE LAYER		2						2		
5	9-Jan-19	RD Warehouse, M.goda	960	Saralanka Distributor, Dambulla	163		500L HYBRID WHITE LAYER	coupled	2	24			2				
6	31-Jan-19	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500L HYBRID WHITE LAYER		12				12				
7	31-Jan-19	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	1000L HYBRID WHITE LAYER		6						6		
8	31-Jan-19	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500L HYBRID WHITE LAYER		14				14				
9	31-Jan-19	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	2000L HYBRID WHITE LAYER		3	24						3	
10	1-Nov-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		2000L HYBRID WHITE LAYER	coupled	2	24						2	
11	13-Nov-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500L HYBRID BULE TRIPLE LAYER		1				1				
12	13-Nov-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500L HYBRID WHITE LAYER		41	24			41				
13	13-Nov-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500L HYBRID WHITE LAYER		41				41				
14	13-Nov-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500L HYBRID BULE TRIPLE LAYER		1	24			1				
15	15-Nov-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		500L HYBRID WHITE LAYER	coupled	26	24			26				
16	16-Nov-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		1000L HYBRID BULE TRIPLE LAYER		1						1		
17	16-Nov-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		1000L HYBRID BULE TRIPLE LAYER		2						2		
18	16-Nov-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		2000L HYBRID WHITE LAYER		1							1	
19	16-Nov-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		1000L HYBRID WHITE LAYER	coupled	4	24					4		
20	16-Nov-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500L HYBRID BULE TRIPLE LAYER		3				3				
21	16-Nov-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500L HYBRID WHITE LAYER		40	24			40				
22	20-Nov-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	1000L HYBRID WHITE LAYER		10						10		
23	20-Nov-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500L HYBRID WHITE LAYER		20	24			20				
24	26-Nov-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		1000L HYBRID WHITE LAYER		7						7		
25	26-Nov-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		500L HYBRID WHITE LAYER	coupled	25	24			25				
26	27-Nov-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500L HYBRID WHITE LAYER		40				40				
27	27-Nov-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	1000L HYBRID WHITE LAYER		10	33					10		
28	18-Dec-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		1000L HYBRID WHITE LAYER		2						2		
29	18-Dec-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		500L HYBRID WHITE LAYER		35	24			35				
30	21-Dec-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	1000L HYBRID WHITE LAYER		4						4		
31	21-Dec-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500L HYBRID WHITE LAYER		25				25				
32	21-Dec-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	500 L WATER TANK AQUA TOUGH		2								
33	21-Dec-18	RPC Horana	930	Saralanka Distributor, Dambulla	163	201	WATER TANK 5000L AQUA TOUGH	coupled	3	33							
34	28-Dec-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		500L HYBRID WHITE LAYER		27				27				
35	28-Dec-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		1000L WATER TANK AQUA TOUGH	coupled	3	24							
36	31-Dec-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		2000L WATER TANK AQUA		1								
37	31-Dec-18	RD Warehouse, M.goda	930	Saralanka Distributor, Dambulla	163		WATER TANK 5000L AQUA TOUGH		1								

Figure 4. 1 Raw data before filter



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Date	Center	Center	Distributor	Distance KM		Type	Quantity	Quantity(00)&VehTypeNo	Quantity(00)&VehTypeNo&Date						250HB	300HB	500HB	750HB	1000
2	1/24/2019	RPC Horana	960	BARAKATH HOLDING ,	320	352	500L HYBRID BULE TRIPLE LAYER	14	14-2C 0000	14-2C 0000-24-01-00								14		
3	1/23/2018	Plastishells Ltd, Pallekell		George Kurunegala	53		5000L WATER TANK AQUA	3	03-01 0000	03-01 0000-23-01-18										
4	11/1/2018	RD Warehouse, M	930	Saralanka Distributor, Dar	163		2000L HYBRID WHITE LAYER	2	02-2C 0000	02-2C 0000-01-11-18										
5	11/1/2018	Dambulla		Saralanka Distributor, Dar	15		2000L HYBRID WHITE LAYER	2	02-02 0000	02-02 0000-01-11-18										
6	11/1/2018	RD Warehouse, M	930	Safe Distributor, A.pura	206		2000L HYBRID WHITE LAYER	5	05-02 M0405	05-02 M0405-01-11-18										
7	11/1/2018	RD Warehouse, M	930	Safe Distributor, A.pura	206		500L HYBRID WHITE LAYER	14	14-02 M0405	14-02 M0405-01-11-18								14		
8	11/2/2018	Dambulla		George Kurunegala	60		500L HYBRID WHITE LAYER	19	19-02 M0184	19-02 M0184-02-11-18								19		
9	11/2/2018	Dambulla		George Kurunegala	60		1000L HYBRID WHITE LAYER	10	10-02 M0184	10-02 M0184-02-11-18										
10	11/2/2018	RD Warehouse, M	960	New LP Perera, Kelaniya	22		2000L HYBRID WHITE LAYER	1	01-02 M0331	01-02 M0331-02-11-18										
11	11/2/2018	RD Warehouse, M	960	New LP Perera, Kelaniya	22		500L HYBRID WHITE LAYER	10	10-02 M0331	10-02 M0331-02-11-18								10		
12	11/2/2018	RD Warehouse, M	960	New LP Perera, Kelaniya	22		500L HYBRID BULE TRIPLE LAYER	4	04-02 M0331	04-02 M0331-02-11-18								4		
13	11/2/2018	RPC Horana	960	RD Warehouse, M.goda	32		1000L HYBRID BULE TRIPLE LAYER	10	10-02 M0380	10-02 M0380-02-11-18										
14	11/2/2018	RPC Horana	960	RD Warehouse, M.goda	32		500L HYBRID BULE TRIPLE LAYER	13	13-02 M0380	13-02 M0380-02-11-18								13		
15	11/2/2018	RPC Horana	960	RD Warehouse, M.goda	32		2000L HYBRID WHITE LAYER	8	08-02 0000	08-02 0000-02-11-18										
16	11/2/2018	RPC Horana	930	SirijayaTrading PVT LTD,	28	60	5250L WATER TANK	1	01-02 0000	01-02 0000-02-11-18										
17	11/3/2018	RD Warehouse, M	960	Ceylon Marine, Katana	65		500L HYBRID WHITE LAYER	29	29-2C 0000	29-2C 0000-03-11-18								29		
18	11/3/2018	RPC Horana	930	George Kurunegala	104	136	500L HYBRID WHITE LAYER	19	19-02 M0137	19-02 M0137-03-11-18								19		
19	11/3/2018	RPC Horana	930	George Kurunegala	104	136	1000L HYBRID WHITE LAYER	10	10-02 M0137	10-02 M0137-03-11-18										
20	11/3/2018	RPC Horana	960	Thinethlanka,	63	95	500L HYBRID WHITE LAYER	40	40-02 0000	40-02 0000-03-11-18								40		
21	11/3/2018	RD Warehouse, M	960	W.J.De Silva, Balapitiya	71		1000L HYBRID WHITE LAYER	3	03-02 M0593	03-02 M0593-03-11-18										
22	11/3/2018	RD Warehouse, M	960	W.J.De Silva, Balapitiya	71		500L HYBRID WHITE LAYER	4	04-02 M0533	04-02 M0533-03-11-18								4		
23	11/3/2018	RD Warehouse, M	930	W.J.De Silva, Balapitiya	71		5250L WATER TANK	1	01-02 0000	01-02 0000-03-11-18										
24	11/5/2018	RD Warehouse, M	960	ASL Katuneriya	78		500L HYBRID WHITE LAYER	32	32-02 0000	32-02 0000-05-11-18								32		
25	11/5/2018	RD Warehouse, M	930	George Kurunegala	102		1000L HYBRID WHITE LAYER	16	16-2C M0138	16-2C M0138-05-11-18										
26	11/5/2018	RD Warehouse, M	930	George Kurunegala	102		500L HYBRID WHITE LAYER	8	08-2C M0138	08-2C M0138-05-11-18								8		
27	11/23/2018	Dambulla		George Kurunegala	60		500L HYBRID WHITE LAYER	8	08-02 M0185	08-02 M0185-05-11-18								8		
28	11/15/2018	Dambulla		George Kurunegala	60		1000L HYBRID WHITE LAYER	16	16-02 M0185	16-02 M0185-05-11-18										
29	11/5/2018	RD Warehouse, M	960	NIHAL ENTERPRISES-	16		1000L HYBRID WHITE LAYER	10	10-02 M0362	10-02 M0362-05-11-18										
30	11/5/2018	RD Warehouse, M	960	NIHAL ENTERPRISES-	16		500L HYBRID WHITE LAYER	7	07-02 M0362	07-02 M0362-05-11-18								7		
31	11/5/2018	RPC Horana	960	Sampatha Distributors,	27	59	1000L HYBRID WHITE LAYER	17	17-02 M0456	17-02 M0456-05-11-18										
32	11/5/2018	RPC Horana	960	Sampatha Distributors,	27	59	2000L HYBRID WHITE LAYER	2	02-02 M0456	02-02 M0456-05-11-18										
33	11/5/2018	RD Warehouse, M	960	Sampatha Distributors,	12		500L HYBRID WHITE LAYER	18	18-02 0000	18-02 0000-05-11-18								18		
34	11/5/2018	RPC Horana	960	Sampatha Distributors,	27	59	2000L HYBRID WHITE LAYER	10	10-02 M0457	10-02 M0457-05-11-18										
35	11/5/2018	RPC Horana	960	Sampatha Distributors,	27	59	1000L HYBRID WHITE LAYER	3	03-02 M0457	03-02 M0457-05-11-18										
36	11/5/2018	RPC Horana	960	Sampatha Distributors,	27	59	1000L HYBRID WHITE LAYER	1	01-02 M0458	01-02 M0458-05-11-18										
37	11/5/2018	RPC Horana	960	Sampatha Distributors,	27	59	500L HYBRID WHITE LAYER	18	18-02 M0458	18-02 M0458-05-11-18								18		

Data(New) | Data(old) | Tables(New) | Tables(Old) | existing cost details | new total cost | Sheet1

Figure 4. 2 Data before summarize

According to the data received by the respective company, it has categorized and summarized the details as below.

		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A.pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna		RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		1	2	3	4
RD Warehouse, M.goda	1	322	126	23	211	227	0	152	277	155	88	90	206	151	245	331	0	156	240	141	453	446	93	430	470	80	610	143	0		0	0	0	0
Dambulla	2	640	133	146	237	495	0	797	1257	384	366	0	220	155	250	0	125	178	1229	102	173	10	224	24	75	310	227	231	145		4438	0	935	125
Plastishells Ltd, Pallekelle	3	23	0	0	37	173	0	0	3	196	0	0	27	192	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0		0	0	0	0
RPC Horana	4	373	409	218	683	917	28	742	1246	527	201	80	836	187	607	300	65	42	1076	330	1361	59	213	499	427	218	1176	142	0		514	0	0	0

Figure 4. 3 Total quantity distributed to each distributors

Herein summarized graph declared all type of water tanks including Hybrid and Aqua tough and how it was demanded by each distributor from each centers. This is important to identify that the high demanded distributors and their locations and low and medium demanded distributors and their destined points. And also it is easy to identify that from where it was origin and how it is spread among each distributor.

As identified RD warehouse, Mattegoda has been delivered 5866 water tanks to each distributors and Dambulla, Pallekelle, RPC Horana has been delivered 8133, 674, 12962 water tanks respectively to each distributors. And also Dambulla has been sent 4438 water tanks to RD warehouse Mattegoda, 935 water tanks to Plastishells Ltd, Pallekelle, and 125 water tanks to RPC Horana. Then RPC Horana has been delivered 514 water tanks RD Warehouse, M.goda for selling purpose.

		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A.pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralegamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna		RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		1	2	3	4
RD Warehouse, M.goda	1	163	78	349	65	197	0	129	102	108	215	16	19	119	22	16	0	326	206	204	12	46	399	124	48	261	71	142	0		0	0	0	0
Dambulla	2	15	133	212	121	149	0	95	60	93	0	0	195	98	143	0	244	168	64	253	160	197	243	282	117	105	237	247	65		158	0	87	178
Plastishells Ltd, Pallekelle	3	78	0	0	115	122	0	0	53	42	0	0	153	36	0	0	0	0	0	226	0	0	0	0	0	0	0	0	0		0	0	0	0
RPC Horana	4	201	140	352	122	209	76	176	136	132	254	55	76	162	74	55	440	367	246	213	59	60	449	152	95	301	96	157	0		32	0	0	0

Figure 4. 4 Distance of distributors from each manufacturing centers

This summarized details states that truck Km to each distributor from each centers. With this chart it could recognize the locations and their distance to each center. As an example RD Warehouse, Mattegoda to Saralanka Distributor Dambulla it has 163 km and Dambulla factory to Saralanka Distributor Dambulla has 15 km, Plastishells ltd Pallekale and RPC Horana to Saralanka Distributor Dambulla has 78km, 201km respectively. This will impact to identify the shortest path of particular distribution network.

		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A.pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna		RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		1	2	3	4
RD Warehouse, M.goda	1	163	78	349	65	197	23	129	102	108	215	16	19	119	22	16	399	326	206	204	12	46	399	124	48	261	71	142	131		0	163	135	168
Dambulla	2	15	133	212	121	149	159	95	60	93	95	148	195	98	143	244	244	167	64	253	160	197	243	282	117	105	237	247	65		158	0	87	176
Plastishells Ltd, Pallekelle	3	78	123	206	115	122	153	89	53	42	64	124	153	36	119	124	322	180	141	226	139	174	322	245	91	182	204	235	18		135	78	0	153
RPC Horana	4	201	140	352	122	209	76	176	136	132	254	55	76	162	74	55	440	367	246	200	59	60	449	152	95	301	96	157	148		32	182	152	0

Figure 4. 5 Distance cart for all centers with adding 32 km to RPC Horana

In this study especially all the water tanks sent via Horana need to collect waybill from RD warehouse Mattegoda. In same times if RD does not have enough stocks available with them they sent the trucks to Horana factory and from that point they sent the water tanks to distributors. That include additional 32 km to truck km since trucks comes to RD warehouse first and collect the waybill which address "To Horana" then load the water tanks from Horana factory to deliver to the relevant distributors. Therefore summarized details mentioned additional 32 added to RPC Horana distance. All the pink colored cells have been marked as lowest distance pints.

		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A.pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna		RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		1	2	3	4
RD Warehouse, M.goda	1	163	78	349	65	197	23	129	102	108	215	16	19	119	22	16	399	326	206	204	12	46	399	124	48	261	71	142	131		0	163	135	168
Dambulla	2	15	133	212	121	149	159	95	60	93	95	148	195	98	143	244	244	167	64	253	160	197	243	282	117	105	237	247	65		158	0	87	176
Plastishells Ltd, Pallekelle	3	78	123	206	115	122	153	89	53	42	64	124	153	36	119	124	322	180	141	226	139	174	322	245	91	182	204	235	18		135	78	0	153
RPC Horana	4	169	108	320	90	177	44	144	104	100	222	23	44	130	42	23	408	335	214	168	27	28	417	120	63	269	64	125	116		32	182	152	0

Figure 4. 6 Distance chart for all centers without adding 32 km to RPC Horana

In this figure it could identify the distance chart for all centers without adding 32 km to RPC Horana. This figure is important to identify the shortest path of particular distribution network. All the pink colored cells have been marked as lowest distance pints.

4. 1. Item vise delivery among each distribution centers

		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralegamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
RD Warehouse, M.goda	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0
Dambulla	2	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
Plastishells Ltd, Pallekelle	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
RPC Horana	4	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

	RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
	1	2	3	4
RD Warehouse, M.goda	0	0	0	0
Dambulla	0	0	0	0
Plastishells Ltd, Pallekelle	0	0	0	0
RPC Horana	0	0	0	0

Figure 4. 7 Item - 250Hybrid water tanks

		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralegamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
RD Warehouse, M.goda	1	2	12	10	0	0	0	3	0	7	44	5	0	35	0	7	0	0	19	0	42	21	0	5	101	0	33	0	0
Dambulla	2	3	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0
Plastishells Ltd, Pallekelle	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
RPC Horana	4	3	11	0	10	0	0	3	25	0	0	0	0	0	25	4	30	0	10	0	15	0	60	0	0	0	0	0	0

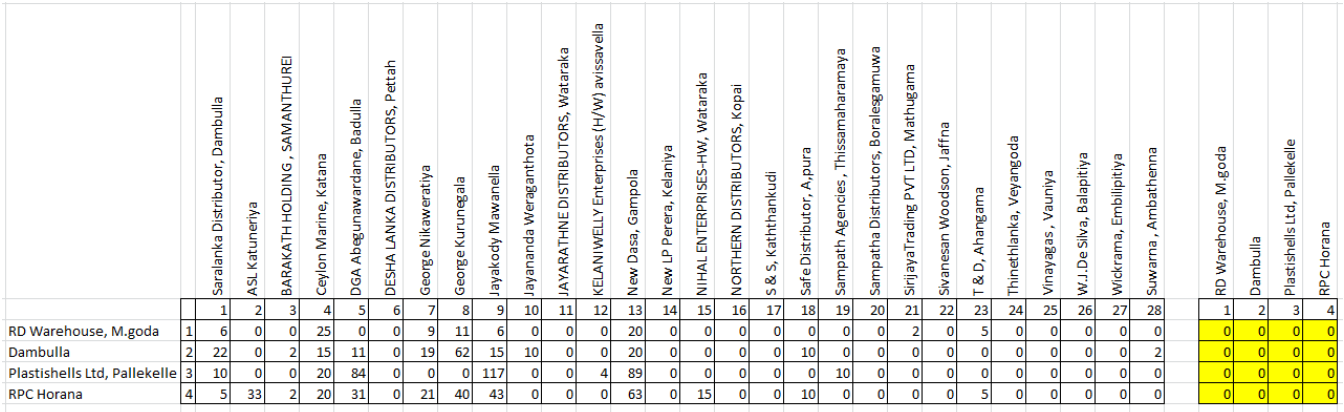
	RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
	1	2	3	4
RD Warehouse, M.goda	0	0	0	0
Dambulla	0	0	0	0
Plastishells Ltd, Pallekelle	0	0	0	0
RPC Horana	83	0	0	0

Figure 4. 8 Item - 300Hybrid water tanks

		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralegamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
RD Warehouse, M.goda	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
Dambulla	2	489	126	88	197	265	0	595	901	183	252	0	166	107	211	0	105	160	943	88	146	0	134	0	74	205	170	184	89
Plastishells Ltd, Pallekelle	3	253	72	0	150	189	0	64	174	74	32	38	122	45	127	217	0	134	115	89	222	311	56	243	256	37	438	74	0
RPC Horana	4	294	295	145	570	532	0	487	989	279	120	75	513	56	290	135	26	36	839	101	583	45	85	280	363	149	862	42	0

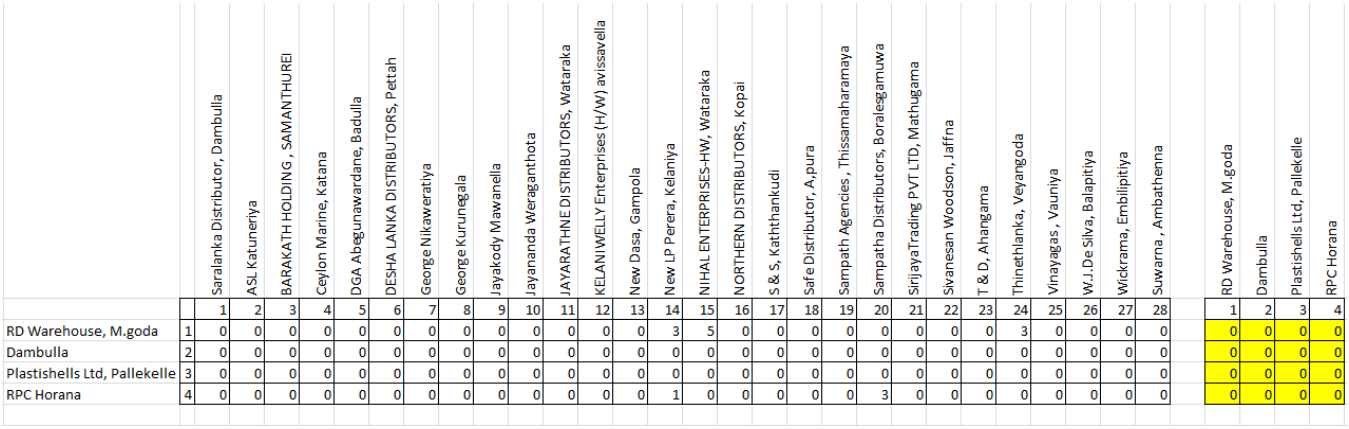
	RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
	1	2	3	4
RD Warehouse, M.goda	0	0	0	0
Dambulla	4284	0	674	106
Plastishells Ltd, Pallekelle	0	0	0	0
RPC Horana	109	0	0	0

Figure 4. 9 Item - 500Hybrid water tanks



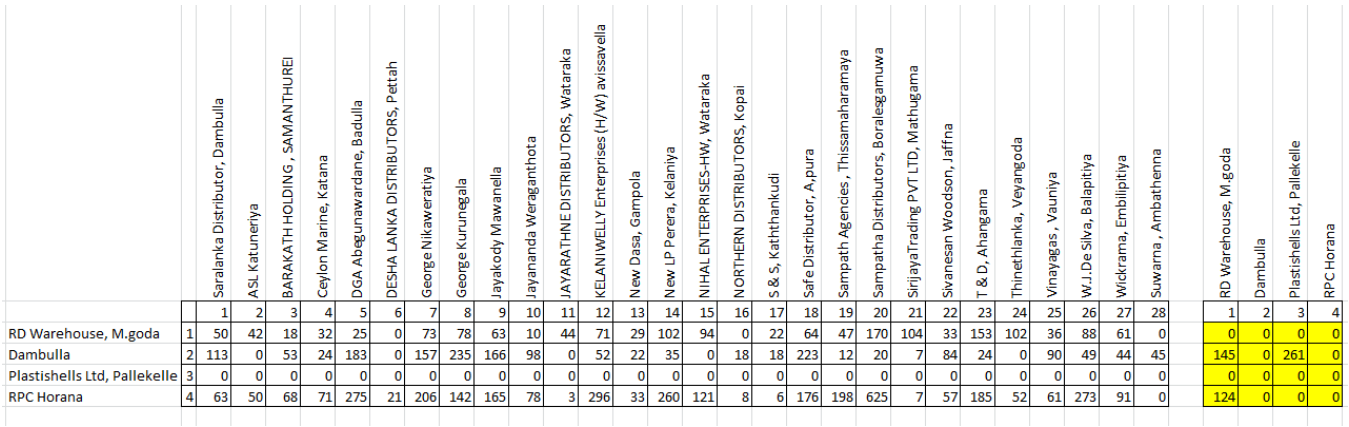
		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna	RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4
RD Warehouse, M.goda	1	6	0	0	25	0	0	9	11	6	0	0	0	20	0	0	0	0	0	0	0	2	0	5	0	0	0	0	0	0	0	0	0
Dambulla	2	22	0	2	15	11	0	19	62	15	10	0	0	20	0	0	0	0	10	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Plastishells Ltd, Pallekelle	3	10	0	0	20	84	0	0	0	117	0	0	4	89	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0
RPC Horana	4	5	33	2	20	31	0	21	40	43	0	0	0	63	0	15	0	0	10	0	0	0	0	5	0	0	0	0	0	0	0	0	0

Figure 4. 10 Item – 500 Aqua Tough water tanks



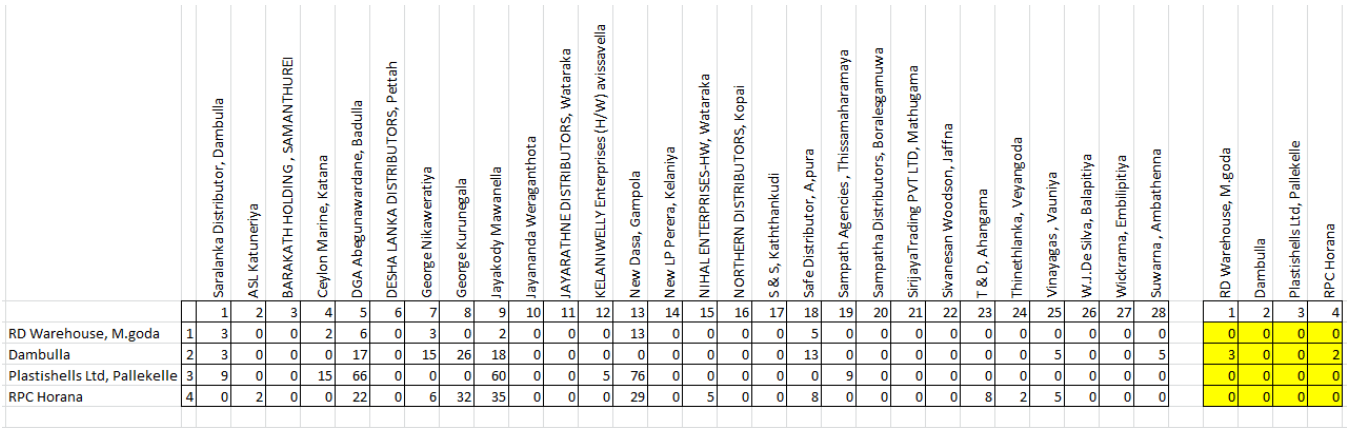
		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna	RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4
RD Warehouse, M.goda	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Dambulla	2	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
Plastishells Ltd, Pallekelle	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
RPC Horana	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4. 11 Item – 750 Hybrid water tanks



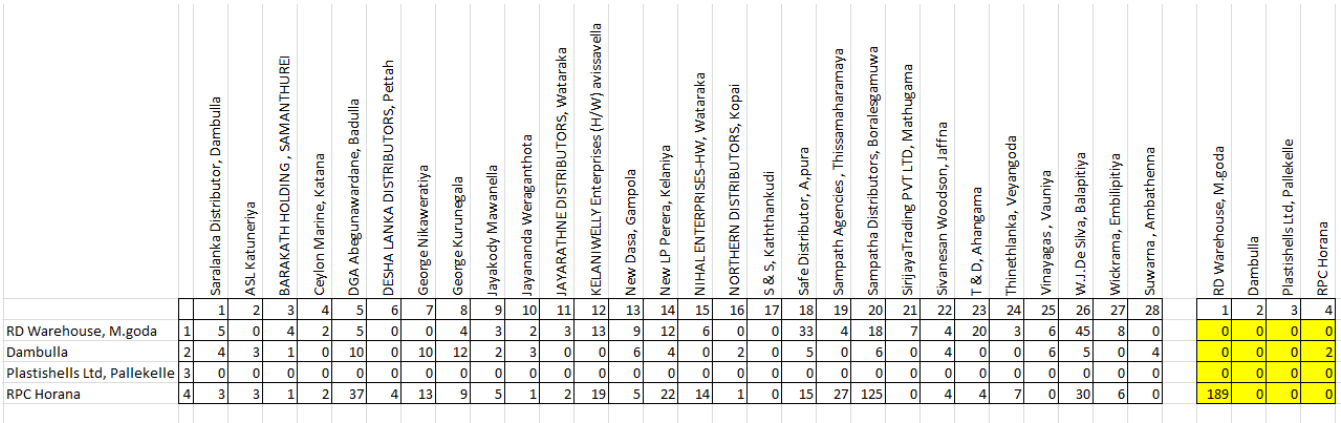
		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna	RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4
RD Warehouse, M.goda	1	50	42	18	32	25	0	73	78	63	10	44	71	29	102	94	0	22	64	47	170	104	33	153	102	36	88	61	0	0	0	0	0
Dambulla	2	113	0	53	24	183	0	157	235	166	98	0	52	22	35	0	18	18	223	12	20	7	84	24	0	90	49	44	45	145	0	261	0
Plastishells Ltd, Pallekelle	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
RPC Horana	4	63	50	68	71	275	21	206	142	165	78	3	296	33	260	121	8	6	176	198	625	7	57	185	52	61	273	91	0	124	0	0	0

Figure 4. 12 Item – 1000 Hybrid water tanks



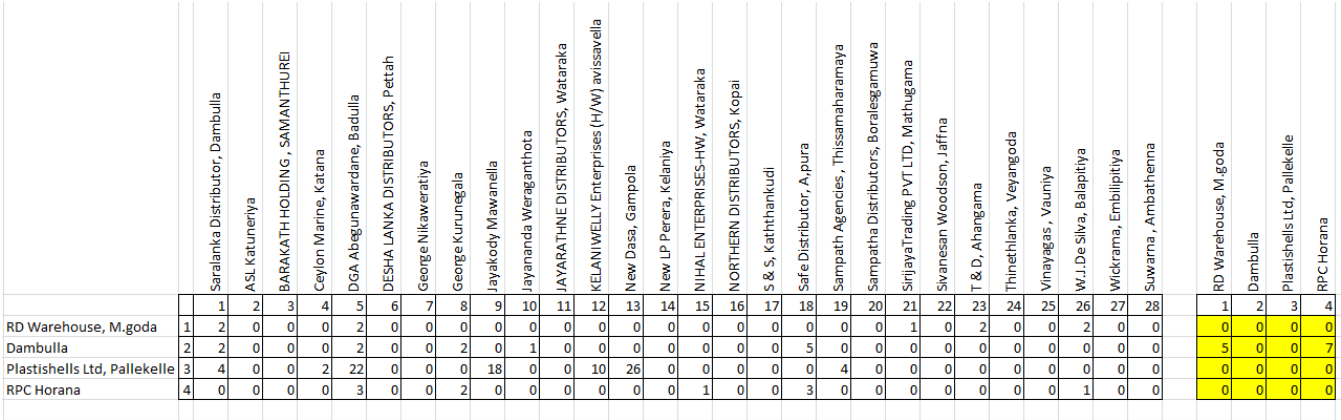
		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna		RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		1	2	3	4
RD Warehouse, M.goda	1	3	0	0	2	6	0	3	0	2	0	0	0	13	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0		0	0	0	0
Dambulla	2	3	0	0	0	17	0	15	26	18	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	5	0	0	5		3	0	0	2
Plastishells Ltd, Pallekelle	3	9	0	0	15	66	0	0	0	60	0	0	5	76	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0		0	0	0	0
RPC Horana	4	0	2	0	0	22	0	6	32	35	0	0	0	29	0	5	0	0	8	0	0	0	0	8	2	5	0	0	0		0	0	0	0

Figure 4. 13 Item – 1000 Aqua Tough water tanks



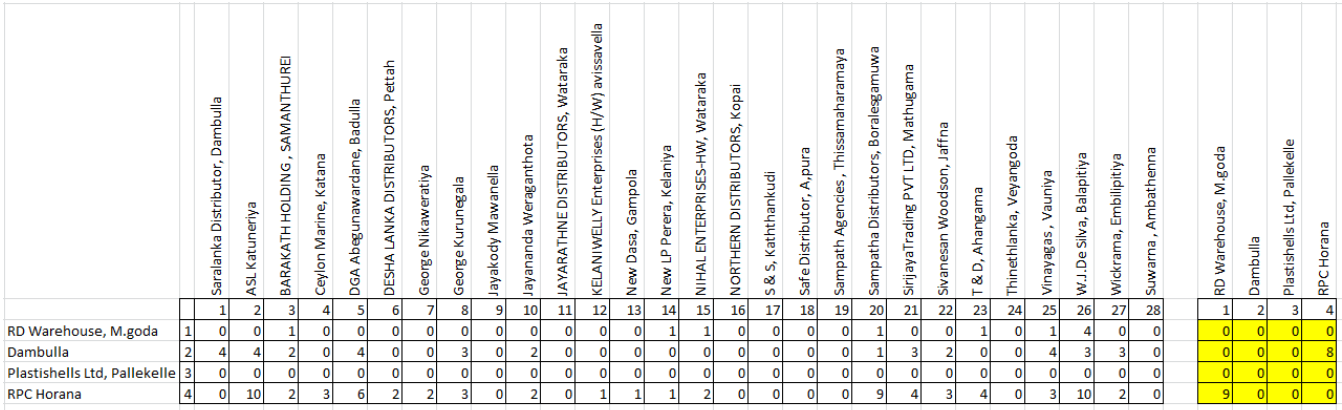
		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna		RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		1	2	3	4
RD Warehouse, M.goda	1	5	0	4	2	5	0	0	4	3	2	3	13	9	12	6	0	0	33	4	18	7	4	20	3	6	45	8	0		0	0	0	0
Dambulla	2	4	3	1	0	10	0	10	12	2	3	0	0	6	4	0	2	0	5	0	6	0	4	0	0	6	5	0	4		0	0	0	2
Plastishells Ltd, Pallekelle	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
RPC Horana	4	3	3	1	2	37	4	13	9	5	1	2	19	5	22	14	1	0	15	27	125	0	4	4	7	0	30	6	0		189	0	0	0

Figure 4. 14 Item – 2000 Hybrid water tanks



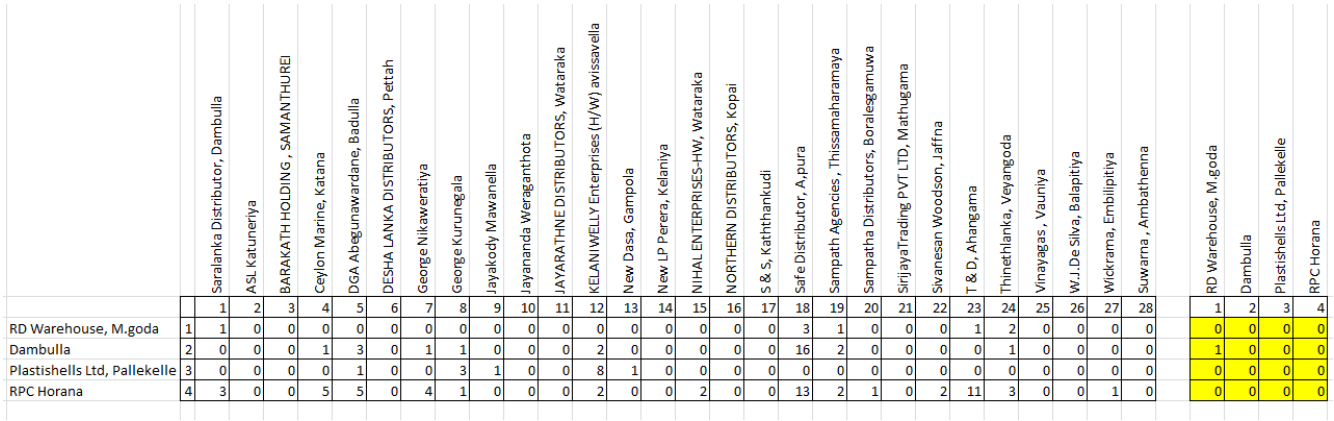
		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna		RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		1	2	3	4
RD Warehouse, M.goda	1	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	2	0	0		0	0	0	0
Dambulla	2	2	0	0	0	2	0	0	2	0	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0		5	0	0	7
Plastishells Ltd, Pallekelle	3	4	0	0	2	22	0	0	0	18	0	0	10	26	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0		0	0	0	0
RPC Horana	4	0	0	0	0	3	0	0	2	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	1	0	0		0	0	0	0

Figure 4. 15 Item – 2000 Aqua Tough water tanks



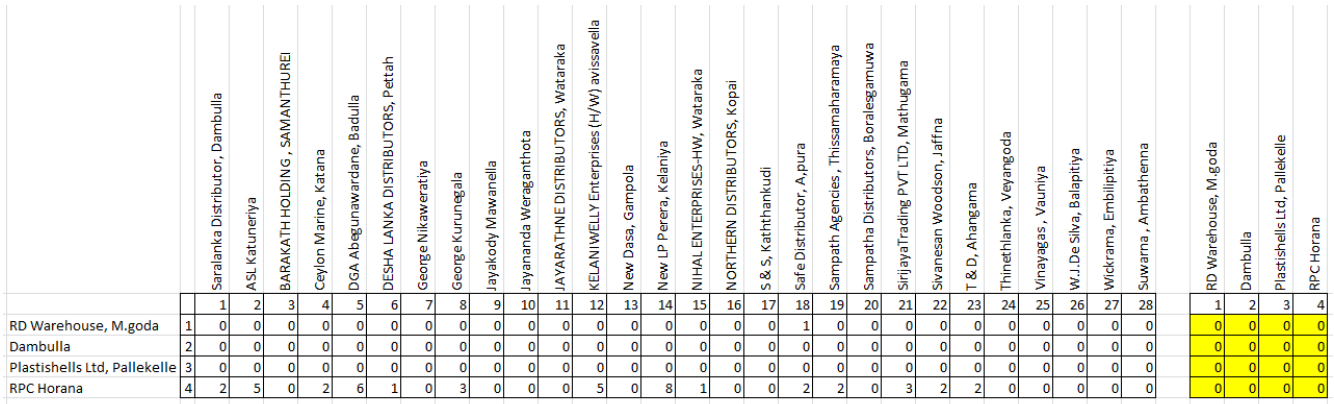
		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna		RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		1	2	3	4
RD Warehouse, M.goda	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	1	4	0	0		0	0	0	0
Dambulla	2	4	4	2	0	4	0	0	3	0	2	0	0	0	0	0	0	0	0	0	1	3	2	0	0	4	3	3	0		0	0	0	8
Plastishells Ltd, Pallekelle	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
RPC Horana	4	0	10	2	3	6	2	2	3	0	2	0	1	1	1	2	0	0	0	0	9	4	3	4	0	3	10	2	0		9	0	0	0

Figure 4. 16 Item – 5250 Hybrid water tanks



		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna		RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		1	2	3	4
RD Warehouse, M.goda	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	1	2	0	0	0	0		0	0	0	0
Dambulla	2	0	0	0	1	3	0	1	1	0	0	0	2	0	0	0	0	0	16	2	0	0	0	0	1	0	0	0	0		1	0	0	0
Plastishells Ltd, Pallekelle	3	0	0	0	0	1	0	0	3	1	0	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
RPC Horana	4	3	0	0	5	5	0	4	1	0	0	0	2	0	0	2	0	0	13	2	1	0	2	11	3	0	0	1	0		0	0	0	0

Figure 4. 17 Item – 5000 Aqua Tough water tanks



		Saralanka Distributor, Dambulla	ASL Katuneriya	BARAKATH HOLDING , SAMANTHUREI	Ceylon Marine, Katana	DGA Abegunawardane, Badulla	DESHA LANKA DISTRIBUTORS, Pettah	George Nikaweratiya	George Kurunegala	Jayakody Mawanella	Jayananda Weraganthota	JAYARATHNE DISTRIBUTORS, Wataraka	KELANIWELLY Enterprises (H/W) avissavella	New Dasa, Gampola	New LP Perera, Kelaniya	NIHAL ENTERPRISES-HW, Wataraka	NORTHERN DISTRIBUTORS, Kopai	S & S, Kaththankudi	Safe Distributor, A,pura	Sampath Agencies , Thissamaharamaya	Sampatha Distributors, Boralesgamuwa	SirijayaTrading PVT LTD, Mathugama	Sivanesan Woodson, Jaffna	T & D, Ahangama	Thinethlanka, Veyangoda	Vinayagas , Vauniya	W.J.De Silva, Balapitiya	Wickrama, Embilipitiya	Suwarna , Ambathenna		RD Warehouse, M.goda	Dambulla	Plastishells Ltd, Pallekelle	RPC Horana
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		1	2	3	4
RD Warehouse, M.goda	1	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
Dambulla	2	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
Plastishells Ltd, Pallekelle	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
RPC Horana	4	2	5	0	2	6	1	0	3	0	0	0	5	0	8	1	0	0	2	2	0	3	2	2	0	0	0	0	0		0	0	0	0

Figure 4. 18 Item – 10500 Hybrid water tanks

Based on the identified figures, it could ascertain the item vise variation of products which delivered to each distributor from each centers.

To minimize the cost of distribution network it was draw a map of existing process including the distance and total quantity delivered to each distributor details.

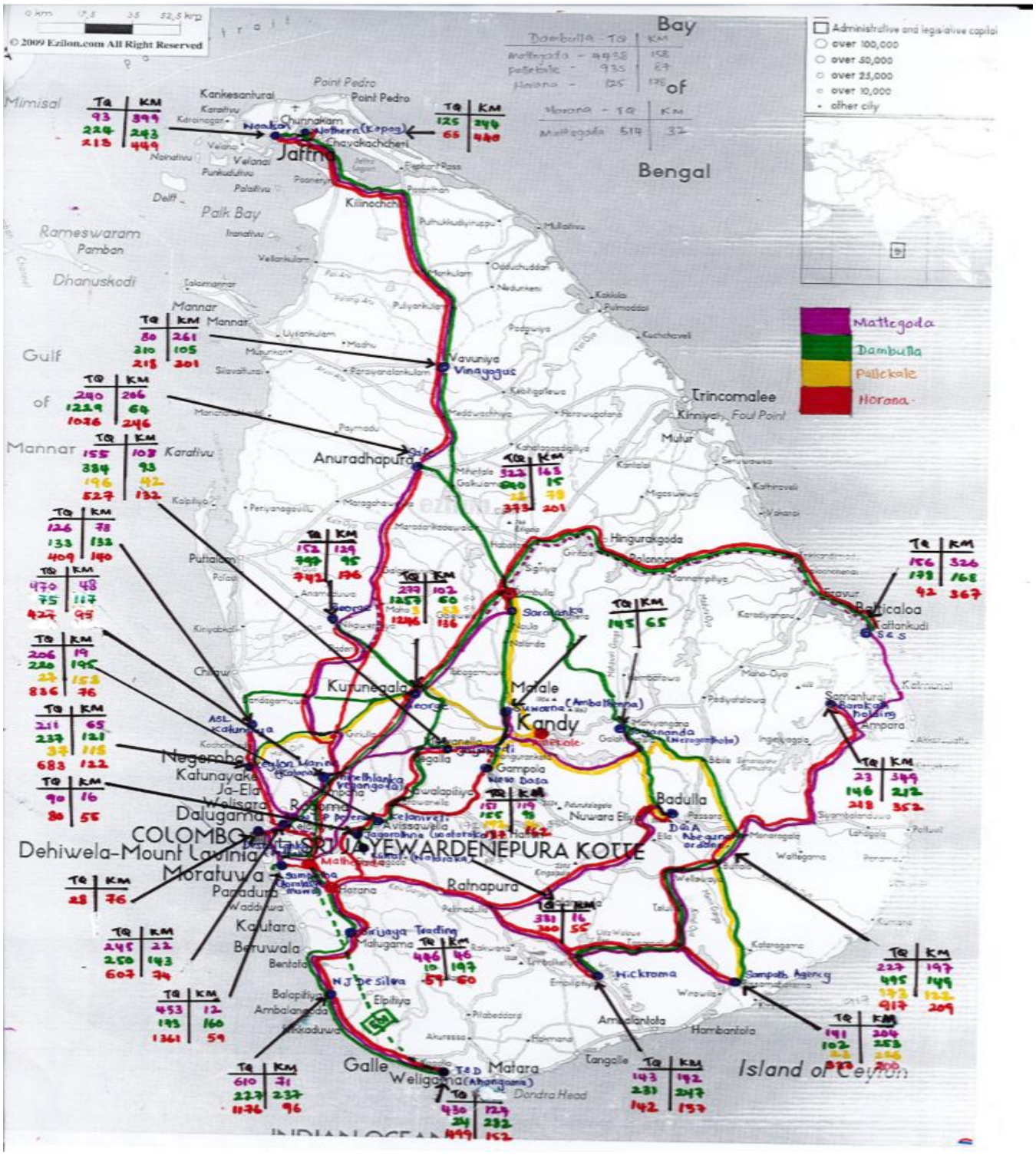


Figure 4. 19 Map of Existing network

Based on that map there was identified many figures as below.

1. All the manufacturing centers/ warehouses deliver water tanks to the distributors in every nook and corner of Sri Lanka without considering the distance. (When distributor makes a demand from system it has connected to all the centers.)

2. As shown in the figure different routes use to arrive to each distributor. And this routes decided based on different variables. The company does not utilize a pre-arranged shortest route plan.

3. Not paying attention on inventory of main four centers which the centers are not keeping enough stock at their premises and has a poor coordination on that.

4. Vehicle circulation among distributors does not properly planed. And this occurs also due to poor coordination and poor transport planning and designing.

5. Due to all above factors it increase the cost of total project highly. Each points increase the cost of total transportation and it impact to the final sales price of particular product.

Therefore to reduce the cost of project was analyze the shortest path by using excel. First of all it was identified the shortest routes and then identified the distribution centers which could deliver together at once if demand generated within pre-defined time period. This analysis couldn't continue since the company policy of providing goods after making demand was only 3 days (gap between making demand and delivery). Therefore the other distributors cannot wait until other distributors make demand/orders.

Then to minimize the distributing network of particular organization it was cluster the map into four sections based on the distance from centers.

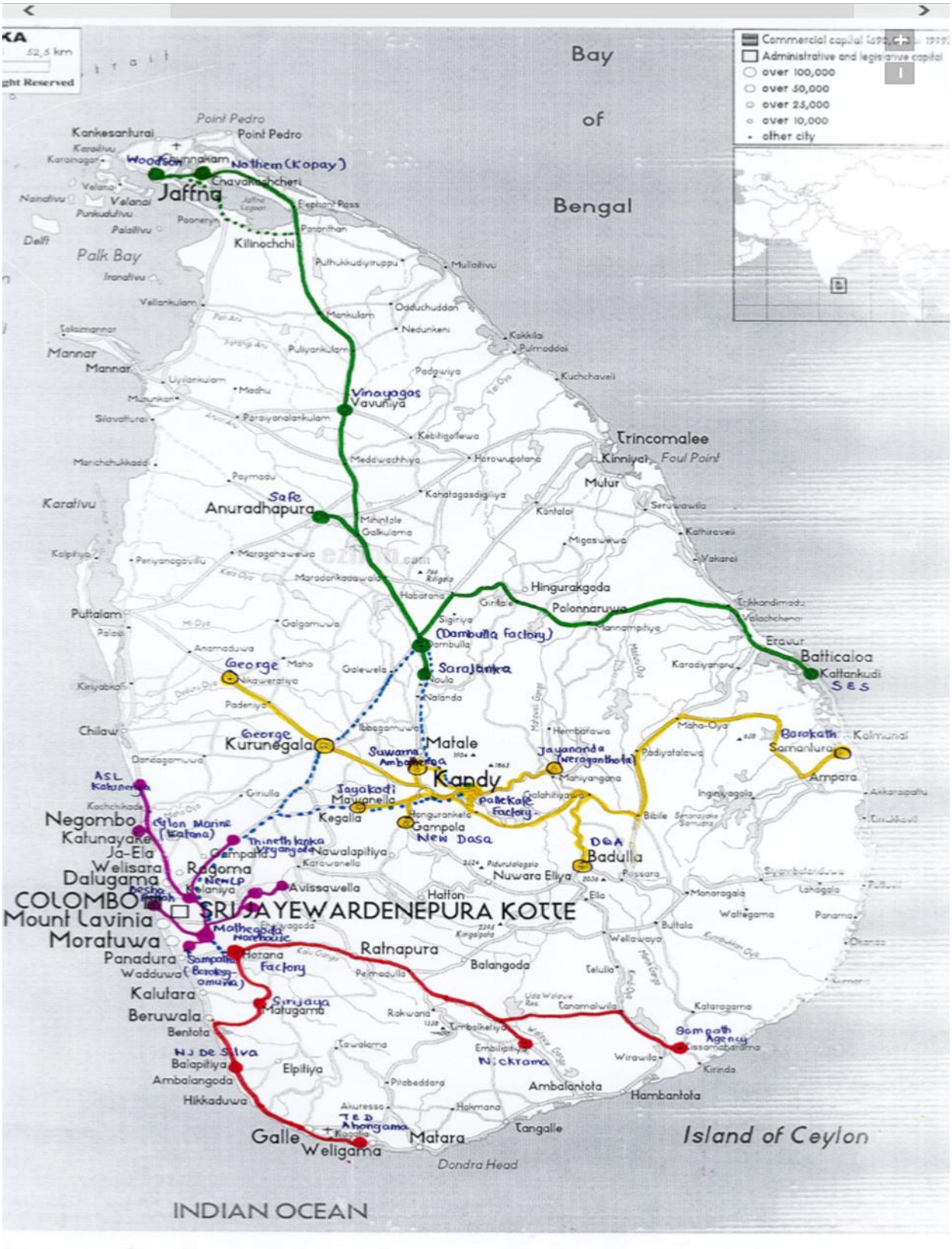


Figure 4. 20 After clustering shortest path map

Each cluster has distributors closed to their factory/warehouse. All four clusters and its distributor details had shown as below.

Table 4. 1Cluster based delivery plan

Cluster	Center	Distributor, location	Distance in (Km)
Cluster A	RD Warehouse, M.goda	Asl Katuneriya	78
		Ceylon Marine, Katana	65
		Desha Lanka Distributors, Pettah	23
		Jayarathne Distributors, Wataraka	16
		Kelaniwelly Enterprises (H/W) Avissavella	19
		New LP Perera, Kelaniya	22
		Nihal Enterprises-Hw, Wataraka,	16
		Sampatha Distributors, Boralesgamuva	12
		Thinethlanka, Veyangoda,	48
Cluster B	Dambulla	Saralanka Distributor, Dambulla	15
		Northern Distributors, Kopai	244
		S & S, Kaththankudi	167
		Safe Distributor, Anuradhapura,	64
		Sivanesan Woodson, Jaffna	243
		Vinayagas , Vavuniya	105
Cluster C	Plastishells Ltd, Pallekelle	Barakath Holding , Samanthurei,	206
		Dga Abegunawardane, Badulla	122
		George Nikaweratiya	89
		George Kurunegala	53
		Jayakody Mawanella	42
		Jayananda Weraganthota,	64
		New Dasa, Gampola	36
		Suwarna , Ambathenna	18
Cluster D	RPC Horana	Sampath Agencies , Thissamaharamaya	168
		Sirijayatrading Pvt Ltd, Mathugama	28
		T & D, Ahangama	120
		W.J.De Silva, Balapitiya	64
		Wickrama, Embilipitiya	125
Total distance of network			2272

As mentioned in *Figure 4.2: Distance of distributors from each manufacturing center* they have deliver water tanks within 12813 kms and it could reduce to 2272 kms if they use the shortest path of the network. To prove this statement it was calculated the total cost of project. To calculate the total cost it was identified the vehicle types including 16.5ft, 24 ft, 33ft and 40ft lorries. For each center use the company owned lorries and hired lorries to deliver the water tanks.

Table 4. 2 Vehicle details with the capacity

Warehouse	Owned	Hired	Type of owned lorry use for operation
RD Warehouse, M.goda	30	12	Icher 24ft-2, Icher 33ft-2, Izuzu ftr 24ft – 2, Mitzubishi 24ft – 1, Tata 24ft -2, Leyland 24ft - 21
Pallekale Factory	-	02	-
Dambulla Factory	04	04	Icher 24ft-1,Leyland 24ft- 3
Horana factory	04	Based on the requirement	Izuzu ftr 24ft -1, Leyland 24ft - 3

And further it was identified the per Km rate for each lorry. Per km rate includes diesel, driver salary, over time, batta, wastage, and etc. Then, per rate km of each vehicle capacity mention as below.

Table 4. 3 Vehicle capacity with per Km rate

Hired/ owned	Vehicle capacity	Per Km Rate (Rs.)
Hired	**16.5"**	44
Hired	**24"**	58
Owned	**24"**	48
Owned	**33"**	50
Hired	**40"**	110

The total cost calculates by using following formula;

Total Cost of the Project = No of vehicle * Distance* Per km rate

Further it was analyzed the total cost of existing project and it was calculated as 17805560 Rs. And to comparing purpose the project it was only taken the cost of centers to distributors. In here did not discuss about the transportation among each centers (four centers). Existing project's total cost calculated as 15,601,080Rs. And after clustering the project total cost has calculated as 4,406,050Rs. Both projects have 11,195,030 Rs different and that is the different of distance.

Chapter 05

5. Findings and Recommendation

It is really important to minimize the cost of transportation network of the aforementioned organization and there are some other factors including organization policies, management interference and top management decisions will affect to the changes of the distribution network. As well as the warehouse capacities, vehicle capacities and order quantity also will have major impact to the distribution network.

As identified in the study the total cost of project can be compared with the distance map of distributors to centers. As per the result of the analysis it could reduce the cost by 11,195,030 Rs by using the shortest path to deliver the water tanks. And with that result there are few suggestions can be make as below.

1. Use the shortest path as mentioned in the figure 4.20, and deliver the products since currently the particular centers make Delivery Island wide based on the distributor request. In this study mainly explain it could reduce the distance after clustering the network. Therefore it could get maximum benefit if the company could cluster the network and divide all the distributors to their centers based on the distance vise.

2. The currently the company spend extra cost since they are under go with some process and those processes affected to the distribution network of the organization. In the existing process they have to come from RPC Horana and collect the waybill from Mattegoda RD warehouse and then go back to Horana RPC and collect the shipment. Therefore it added additional average 32 Km and if they could issue the waybill from the Horana center it could minimize that 32*28 (average 896km).

3. Most of the time company vehicles move with full loaded water tanks and in most cases they are using 24 ft or 16.5 ft lorries to deliver the cargo. As the researcher by examining the given data it could identify that the company have one purpose as fulfill the customer order as soon as possible at any cost, therefore the warehouses and factories always try sent maximum full load to the distributors by using vehicle available or convenience with them. And then in the study it was identified that if the company can deliver the goods which locate along the given route in the same time by using high capacity vehicle such as 33ft or 40ft can be minimize the cost of total project.

4. It was really hard to collect the data for this study since the company does not have a proper information management system. The information management system is very important to this process to coordinate all the ends of the process. The company has its own system to deliver the orders, pick the orders and process the orders. But in that system does not collect and coordinate the data of transportation network. Therefore it is really important to have a company own transport information management system for the organization. If the company has proper system to collect the data, deliver the data among centers could minimize the cost involve with the network. And also the company does not get the advantage of high end technologies such as RFID, GPRS, and GPS etc. If the company tends to utilize those technologies for their transporting network it would minimize more cost than current process.

5. And also if the company could maintain the sufficient stocks at other three plantations including RPC Horana, Dambulla Factory and Pallekale Factory and warehouses it could optimize the distribution cost as shown in the map (figure4.20). In this study suggesting that since only Pallekale factory manufacture the Aqua Tough range they have deliver the stocks to all other three centers including Dambulla, RPC Horana and Mattegoda warehouse. And also since Dambulla manufacture only 300l, 500l and 1000l water tanks and RPC Horana manufacture all other water tanks RPC could share the stock to RD warehouse, and RPC Horana could send the stocks to Dambulla factory since they are not producing some items. Then it could minimize the cost of sending water tanks from unscheduled manner.

In this study above suggestions could apply on to the company with making slight effort and if the company policies and management agree with said recommendation it could simply optimize the cost of transportation network.

5.1. Future research

In this study it was identified that after clustering the map it could minimize the distance and along with that it could minimize the total cost taken for the particular project. But in the other hand it is difficult to analyze the how many distributors need to be served at a time since in this company has gap of 3 days for the delivery after receiving the order to the company system.

And the same time no of vehicles need to use and the capacity need to loaded for particular vehicle need to analyze as a future research. In this research that area not planning to study that area due to time constrain. In this study it was gathered following details related to vehicle capacity.

And as suggestion this vehicle can be loaded with shuffled water tanks and it could again reduce the cost of particular network.

Table 5. 1Loading capacity

Capacity	Full load at a time	Per Km rate
16.5ft	5000L 3	44
	10000L 2	
24ft	500L 44	48
	1000L 20	
	2000L 8	
33ft	500L 66	50
	1000L 30	
	2000 15	
40ft	500L 86	110
	1000L 44	
	2000 20	

In this study needed to calculate the warehouse capacities and container capacity, which could match with the quantity demanded by the said distributors (based on the clusters developed in the new map – figure 4.20) to continue the study further.

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