Factors influencing on optimizing the supply chain of shreddable waste for Cement Kiln Co Processing in Sri Lanka

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Research submitted in partial fulfilment of the requirements for the degree of

Master of Business Administration in Supply Chain Management

Department of Transport and Logistics Management

University of Moratuwa

Sri Lanka

February 2018

Declaration of Originality

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Statement of The Supervisor

The candidate has carried out research for the MBA in Supply Chain Management under my supervision.

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Abstract

INSEE Ecocycle is the waste management business unit of Siam City Cement Company (Lanka) Limited and they are serving over 300 number of customers and covers every sorts of industries in the country. Their focus is on industrial waste co processing using the cement kilns at Puttalam cement factory. This waste management business integrates comprehensive supply chain management concepts on customer management, large volumes of hazardous and non hazardous waste material transport, inventory management, material handling, Millions of rupees of financial transactions, all sorts of communication channels with customers, suppliers and internal stake holders and other sustainability drivers such as safety and compliance are always prioritized in this business. On the waste co processing operation model for Ecocycle Sri Lanka, always there is a supply demand mismatch due to acceptance limitations of the co processing facility.

General reverse logistics drivers are also different on this business model. When evaluating the nature of the Supply Chain managed by the INSEE Ecocycle, gaps are visible in almost every aspect of the characteristics in which need to drive for best supply chain management practices. Optimum Supply Chain characteristics of Inventory Optimization, Rapid fulfilment, Flexibility are not visible on the INSEE Ecocycle supply chain while very limited usage of big data by the organization.

Different scenarios are disrupting the smooth operation for INSEE Ecocycle and those are known by the management. However the optimization is always been a challenge. This research aims to identify the influential factors on optimizing the textile and polythene waste supply chain optimization via internal organization aspects using internal employees at 100% response rate. Factor analysis is used to identify the variables and the analysis results suggested five factors influential to waste supply chain optimization as distribution planning, immediate next day planning, behavior of accounts in charge, organization facts, and acceptance considerations. Beyond those factors, operational team is on dilemma situations on selecting the most suitable customer to be served out of several customers who are having opposite characteristics such as large volume vs small volumes or accurate planning vs poor planning. Also different opinions among the team members for the same situations such as planned maintenance or space unavailability situations are impacting adversely on for the optimization of the waste supply chain.

Key Words

Waste Management, Co Processing, Optimization,

Acknowledgements

I would like to pay special thankfulness, warmth and appreciation to the persons below who made my research successful and assisted me at every point to cherish my goal:

My Supervisor, Eng. Nishal Samarasekera, Senior Lecturer of Department of Transport and Logistics Management of University of Moratuwa for his vital support and assistance. His encouragement made it possible to achieve the goal.

I would also like to show my gratitude to Dr. Mahinda in the Department of Transport and Logistics Management of the University of Moratuwa Bandara, a Senior Lecturer in the Department of Transport and Logistics Management of the University of Moratuwa for sharing his pearls of wisdom with me during the course of this research

Professor Amal Perera, Head of the Department of Transport and Logistics Management , whose reminders and constant motivation encouraged me to meet the deadlines.

All the staff members, research facilitators and technicians of Transport and Logistics Management Department, whose services turned my research a success.

I thank my colleagues from INSEE Ecocycle Sri Lanka who provided insight and expertise that greatly assisted the research, although they may not agree with all the interpretations / conclusions of this research outcome.

Finally my mother and father, my wife and friends, without whom I was nothing; they not only assisted me to spend time for the research but also extended their support morally and emotionally.

List of Acronyms

SCCCL	Siam City Cement Company (Lanka) Limited
WWTP	Waste water treatment plan
ETP	Effluent Treatment Plant
PCB	Poly Chlorinated bi Phenyl
NPS	Net Promoter Score
KMO	Kaiser-Mayer-Olkin
AIC	Account In Charge
SC	Supply Chain
GAV	Gross Added Value
EBITDA	Earnings Before Interest Tax Depreciation and Amortization
CRM	Customer Relationships Management

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1 Introduction

1.1 Introduction to the supply chain and waste supply chain

Supply chains can be defined as an integrated network of facilities and transportation options for the supply, manufacture, storage, and distribution of materials and products. The supply chain process varies considerably in size, complexity, and scale from industry to industry. (Simchi-Levi, 2005; Shapiro, 2006; Chopra and Meindl, 2012). Standard elements of supply chains are involved of suppliers, manufacturers, and distributors.(Garcia and You, 2015) . In the physical dimension, these elements are translated in to processing facilities, factories, trucks, trains, sea-faring vessels, and warehouses. (Wassick,2009).

1.2 Introduction to Ecocycle business

INSEE Ecocycle (Previously known as Geocycle) is a business unit owned by the Siam City Cement Company (Lanka) Limited (previously known as Holcim (Lanka) Limited). INSEE Ecocycle Sri Lanka is operated as a separate business unit and under a separate organization structure which is ultimately responsible for the SCCCL objectives of EBITDA, Safety, Legal Compliance etc.

Sri Lanka is a third world, developing country which has a lower middle income. Economy of the country is mainly consisting of Agriculture and service sector. However, there are some industries operated in the country on apparel and footwear industry, food and agricultural processing, printing etc. Also, there are some more enterprises in the country who is importing frequently moving consumer goods, pharmaceutical products etc in to the country and selling to end consumers.

Apparel industry is the largest and established industry in the country and these industries generate waste such as chemical products, water treatment plant sludge in their production process as well as remains as excess fabric. These industrial wastes need to be treated and disposed in a safe and environmentally friendly manner.

As a developing country, there is only limited number of solutions available in the Sri Lanka for such wastes generated which has the nature of hazardous for the environment as well as human beings and for the branded wastes which needs secured disposal. Cement kiln waste co processing is a scientifically proven globally accepted technology for safe disposal of hazardous waste and as the one and only company owning a fully integrated cement manufacturing capability in Sri Lanka, INSEE Ecocycle Sri Lanka offers a sustainable, peace of mind solution by co processing for these waste generators using the best available technology in the country.

Ecocycle Business was started fifteen year ago in 2003 by introducing waste tires in to the cement kiln and present day, the business has expanded in to vast spectrum of complex waste streams as well as other waste management related services such as hazardous waste transport, Analytical testing, Environmental services, Consultation etc. At present, INSEE Ecocycle is equipped with over 30 number of professionals staff and state of the art equipment's, instruments, machineries for their waste management services. Their presence exists in the Puttalam Cement Factory where the waste co processing is taken place, at the Katunayaka Pre processing facility where the necessary waste preparations are made and at the Colombo office where customer services and sales and marketing activities are taken care of.

Ecocycle is serving over 300 number of customers (all are cooperate customers) and covers almost all of the industries in the country.

Figure 1-Industries Served by INSEE Ecocycle

Ecocycle is equipped with customized solutions for each customers who are having different business characteristics as well as different wastes with diverse characteristics. Key Accounts Management approach is the leading business model where the INSEE Ecocycle sales team is used to identify and serve their key accounts. On the other hand, Net Promoter Score is used as the customer satisfaction measuring tool which demonstrates the customers perception and recommendations on the INSEE Ecocycle Service.

Table 1-INSEE Ecocycle Sri Lanka Business Model canvas explains the Business model of Ecocycle Sri Lanka.

Table 1-INSEE Ecocycle Sri Lanka Business Model

Key Partners

Who are our Key Partners?
Central Environmental Authority and NWP Environmental Authority
Board of Investments
Sri Lanka Customs
Ministry of Environment
Low Land Reclamation cooperation

Who are our Key Suppliers?
SDG Construction and Heavy machinery
JMS Transport
Tasma man power service
AB Securitas
MelBn Steel, SR Steel, GreenLink, Orange bulbs
Viridis, Kalhari, Saddle international
Business consultants

Which Key Resources are we acquiring from partners?
Heavy machinery and vehicles
Third party Man power
Security Service
Facilities for steel, e waste, glass, Rubber, plastic recycling
Expert knowledge on other waste management technologies

Which Key Activities do partners perform?
Waste transport, handling, shredding, blending, drying, feeding, sorting, steel, glass, metal Recycling, Industrial land filling

Key Activities

What Key Activities do our Value Propositions require?
Waste sampling and Analysis
Brand protection
On time waste pickup and transport
Final disposal
legal and permit conditions fulfillment
B2B customer relationship
Provide sustainable solutions to diverse waste streams
Sustainability certifications

Key Resources

What Key Resources do our Value Propositions require?
Cement Kiln
Drying facility
Liquid mixing facility
Land filling facility
More storage facilities
Transfer stations at strategic locations
Mobile preprocessing equipment's
Skilled partners for offsite cleaning jobs

Value Proposition

What value do we deliver to the customer?
Final disposal to their wastes
Peace of mind solution
quick pick up waste at the customer location
Total waste solutions to the entire spectrum of waste

Which one of our customer's problems are we helping to solve?
Waste management
Sustainability measures improvements

What bundles of products and services are we offering to each Customer Segment?
Waste collection
Waste transport
Brand value destruction
Final disposal
Waste management Consultation
Sustainability consultation

Which customer needs are we satisfying?
Waste management solution for total waste streams
Peace of mind solution
Sustainable solution
Environmental friendly solution

Customer Relationships

What type of relationship does each of our Customer Segments expect us to establish and maintain with them?
B2B relationship
Real time communication and quick response
On time and continuous waste pickup
Total waste management
Low cost solution

Channels

Through which Channels do our Customer Segments want to be reached?
Direct sales
Industrial relationships

How are we reaching them now?
Same
How are our Channels integrated?
Through the Key accounts management and Market expansion concepts

Customer Segments

For whom are we creating value?
Hazardous waste generators
Apparel Manufacturers.
Branded waste generators
FMCG manufacturing and distributors
Printing and packaging industry
WWTP users

Who are our most important customers?
Board of Investments of Sri Lanka
Unilever Sri Lanka Limited
Ceylon Petroleum Cooperation
MAS group of companies
Hayleys group of companies
Pesticide *industry*
Brandix Group of Companies
Hidramani, Ocean Lanka, Textured Jersey

Cost Structure

What are the most important costs inherent in our business model?
Transport Cost
Preprocessing costs >> Shredding, labor, heavy machinery for mixing and blending
Employee Salary
Consultants fee
Which Key Resources are most expensive?
Employee service
Which Key Activities are most expensive?
Transport service

Revenue Streams

For what value are our customers really willing to pay?
Sustainable and environment friendly final waste disposal assurance at zero burden

For what do they pay?
environment friendly final waste disposal
waste Management service fee
revenue from waste redirecting services to recyclers

Figure 2 describes the organization structure of the INSEE Ecocycle Sri Lanka .

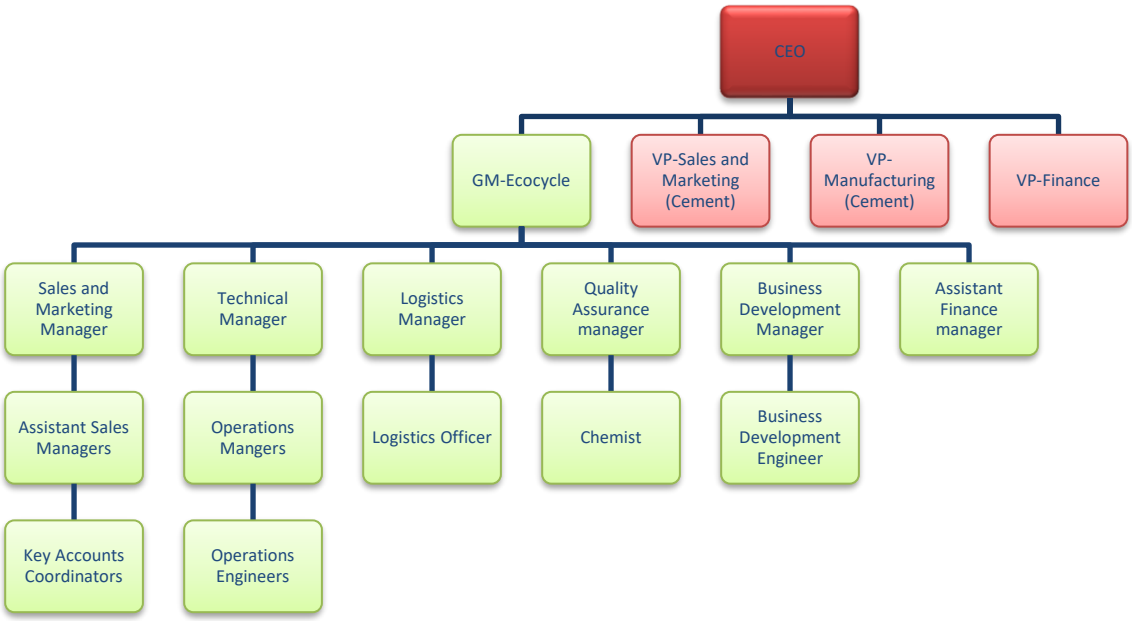


Figure 2-Organization Structure of SCCL and Ecocycle

1.2.1 Performance Indicators for INSEE Ecocycle Sri Lanka

Top line Key performance indicators of the Ecocycle business is described in Table 2. These indicators are representing all avenues of the span of the business on the financial achievement as well as the thermal benefit resulting to the mother company. For example, in order to achieve the Gross Added Value target, Ecocycle must bring sales as well as feed the waste stocks in to the cement kiln continuously as per the annual plan figures. Achieving the Sales target or bringing down the costs do not result the expected EBITDA (Gross Added Value on the reference of Ecocycle) of the business. Without feeding to the cement kiln (disposing waste), Ecocycle cannot achieve the Gross Added Value target since the calculations of the Gross Added Value is consisting of the benefit from waste disposal as well as the cost and the sales achievement all.

Table 2-Ecocycle Key Performance Indicates

Indicator	Description
Gross Added Value (in LKR)	Represents EBITDA comparative to other businesses
Thermal Substitution Rate (%)	Heat amount supplied by Ecocycle business unit as a percentage of total heat requirement for clinker manufacturing
Thermal Economic Equivalent (%)	Percentage of economic benefit derived from the alternative fuel usage on behalf of substituting traditional fuel

Sales (in LKR)	Sales achievement by providing waste management and peripheral service
Net Cash Benefit (in LKR)	Difference between total revenue and total cost
Substitution Cash Benefit (in LKR)	Calculated Benefit from the traditional fuel replacement

1.2.2 Waste Co processing

This refers to the use of waste materials in thermal manufacturing processes, such as cement, lime, or steel production and power stations or any other large combustion plants. Even though the EU calls this process co-incineration, co-processing means the substitution of primary fuel and raw material by waste. It is a recovery of energy and material from waste. (Ziegler *et al.*, 2006)

Cement Kiln Co-processing is further explained in as recovery of energy and materials from waste as a substitute for fossil energy and virgin raw materials.

Waste shall be co-processed only if there is no financially and ecologically better way of waste avoidance and recycling. The integration of co-processing into the waste hierarchy is shown below in Figure 3-Waste Management Hierarchy. The waste management hierarchy is defined as follows

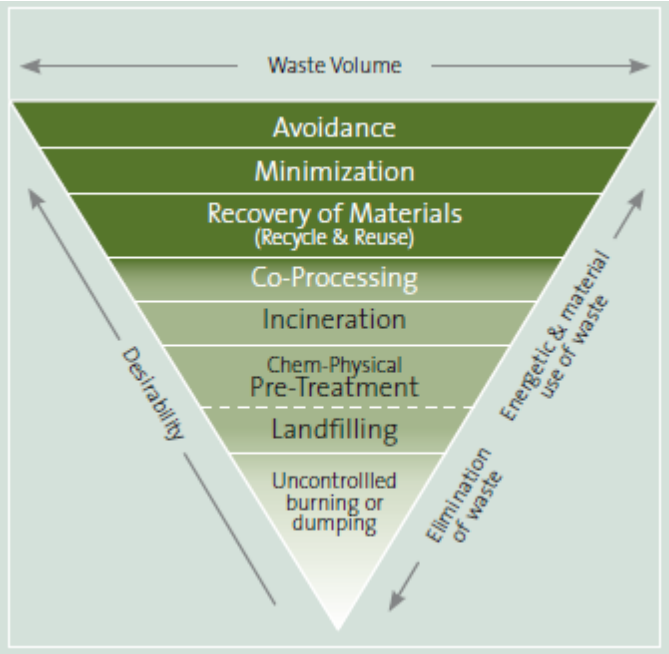


Figure 3-Waste Management Hierarchy

Ecocycle treat waste by co-processing it. This involves redirecting it to a proven industrial processes and making use of existing facilities to produce cement or power other energy-

intensive industries. Co-processing destroys waste, even hazardous types of it. It eliminates the risk of it being collected and resold or otherwise contaminating the environment.

Aside from reuse and recycling, co-processing is the most ecological way to treat waste. It leaves no residue while recovering useful energy and material. This benefits not just financially, but the entire environment. It lessens reliance on fossil fuels, preserves natural resources and reduces greenhouse gas emissions.

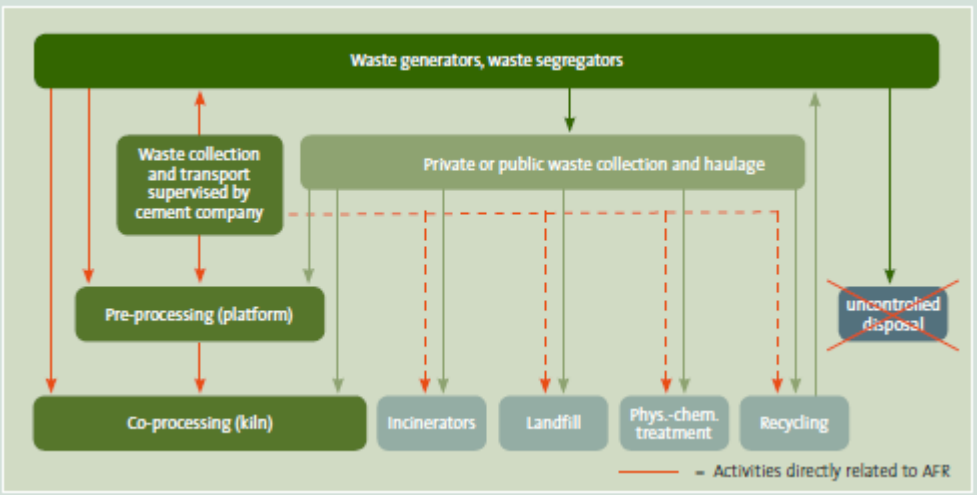


Figure 4-Waste treatment and co-processing

Clinker manufacturing is a process in which converts Limestone extracted from the earth is converted in to Clinker through the cement kiln using coal as the primary fuel. Cement manufacturing plant in Puttalam is in the process of waste co processing from year 2003.

Waste co processing is defined as using the cement manufacturing process to treat waste while simultaneously manufacturing cement in a single combined operation. In this process, waste is introduced in to the cement kiln and the waste material is decomposed in to primary stable chemical components due to the high temperature inside the cement kiln. This assures destruction of material under controlled conditions.

Figure 5-Waste Co Processing while Clinker Manufacturing

In global context, Waste Co processing in cement kilns is a scientifically proven and accepted final disposal method for hazardous waste.

Cement manufacturing plant in Puttalam is in the process of waste co processing from year 2003 and they are competent in co processing wide range of waste streams found in the country spanning from, ETP sludge to textile waste to complex chemicals such as PCB. As the one and only co processing facility in the country, they are receiving huge amount of wastes from almost all the industries in the country.

In this waste co processing business, Ecocycle receive waste all around the country from almost all of the industries in the country.

Table 3-Geographical distribution of industrial waste acceptance by INSEE Ecocycle

District	Quantity (MT)	District	Quantity (MT)
Colombo	10778.53	Gampaha	24080.65
Kaluthara	4717.61	Kurunagala	4475.58
Galle	2877.34	Puttalam	1335.22
Kandy	900.00	Ratnapura	256.40
Nuwaraeliya	230.30	Kegalle	200.00
Matale	3.82	Matara	200.00

1.2.3 Industrial waste supply chain model for Ecocycle Sri Lanka

1.2.3.1 Waste Generation

Major industries of the country includes Tea industry, Apparel and textile industry, Rubber Industry, Tobacco industry, Shipping industry etc.(*Major Industries In Sri Lanka*, 2015). Almost all of these industries generate some sort of waste in their production process. Other than these major industries, there are other industries which are generating significant amount of industrial waste such as expired pharmaceuticals, quality failed printing and packaging goods, waste water treatment facilities etc. Apart from these industries, local paddy industry and the timber industries also generating large volumes of waste products.

Waste volume managed by Ecocycle Sri Lanka is continuously increasing in par with the countries industrialization as well as the stringent environmental rules establishing by the government along with the sustainable development drives.

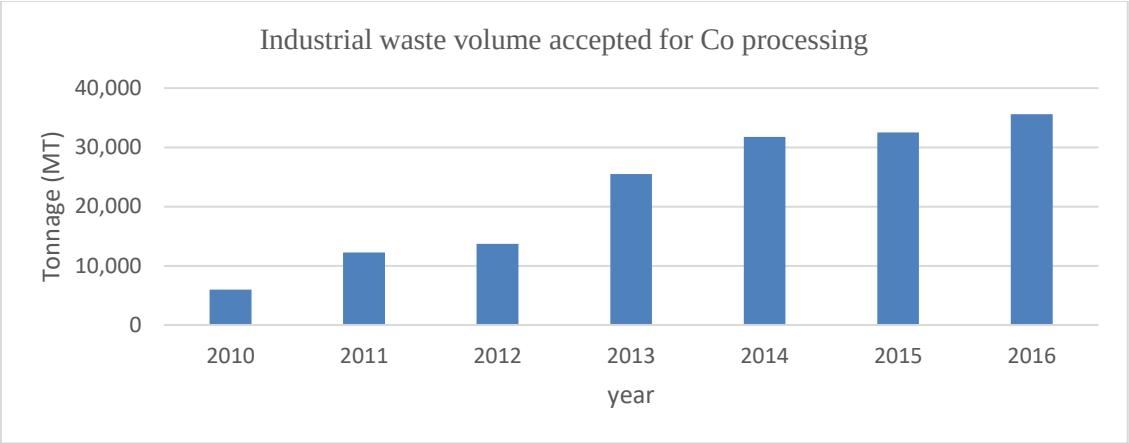


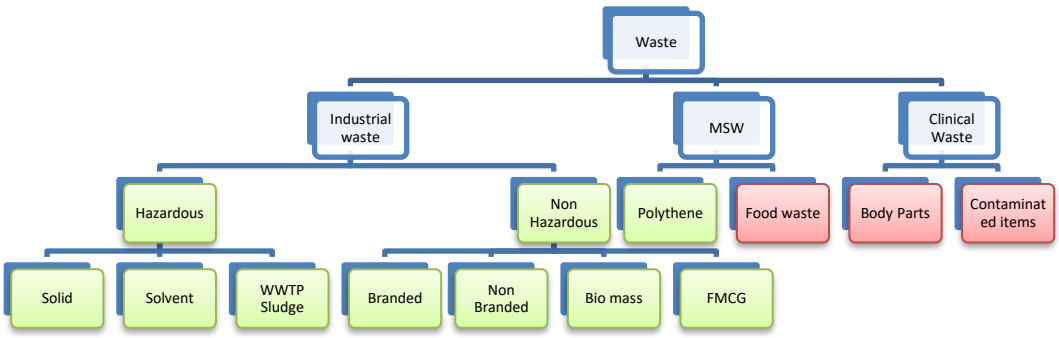
Figure 6-Industrial waste volume accepted for co processing

Managing this waste supply chain has its unique challenges compared to other conventional goods supply chain and even from the conventional reverse logistics concepts.

Out of these larger volumes, major portion is from the textile and polythene waste. This is well explained since the apparel industry is the country's widely spread and most matured industry at the moment.

This waste streams can be categorized in to different categories based on the objective of the categorization. For the waste co processing purpose, waste can be categorized in to industrial waste, Municipal solid waste, clinical waste etc.

Out of those industrial waste is mainly classified in to two types as hazardous waste and nonhazardous waste.



Out of these waste categories, majority of the waste received and handled by INSEE Ecocycle Sri Lanka is textile and polythene waste (approx. 1800 MT/month) and WWTP sludge (approx. 850 MT/month)

1.2.3.2 Waste transport

These industries are located in different parts of the country based on own individual specifications. For example, most of the consumer goods and other manufacturers are

concentrated in to Western province (Colombo and Gampaha districts) while apparel industries are almost scattered around the country due to man power availability in the rural communities rather than the urban community.

However, still there are significant number of apparel manufacturers operating inside major export processing zones managed by BOI Sri Lanka in Katunayake, Biyagama, Seethawake etc.

Since the waste co processing facility of INSEE Ecocycle Sri Lanka is located in Puttalam, and the waste generators are concentrated in western province, almost all the waste need to be transported more than 100 km in each consignment.

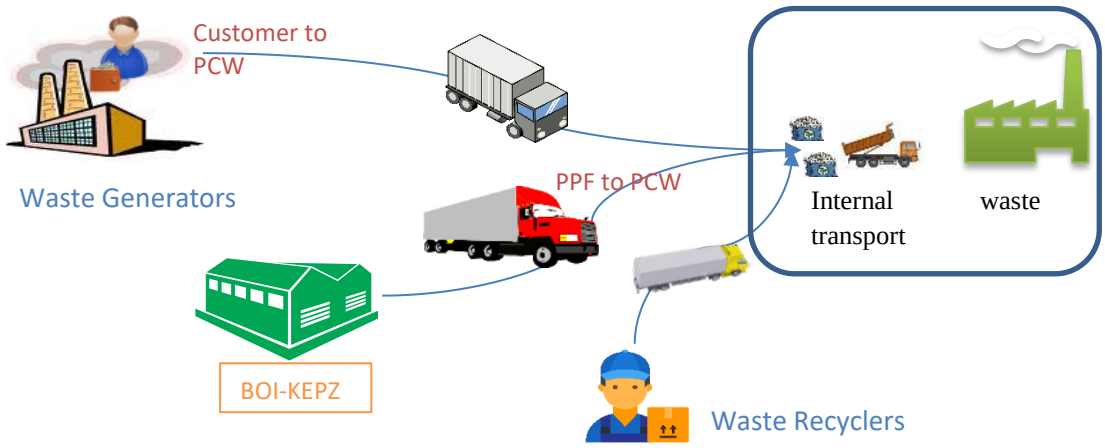


Figure 7-Ecocycle Sri Lanka Waste Flow

This waste transportation is performed by Ecocycle Logistics fleet as well as by the customers them self delivering goods to the plant gate.

INSEE Ecocycle Sri Lanka is practicing an internal web based platform for waste delivery planning and currently it is used by all the personal of the Ecocycle for their delivery planning. Sales Account In Charges are booking their future delivery requirements in the system and the sales managers are prioritizing the next day delivery based on the customers need, vehicle availability and the acceptance limitation at the co processing and the pre processing facilities.

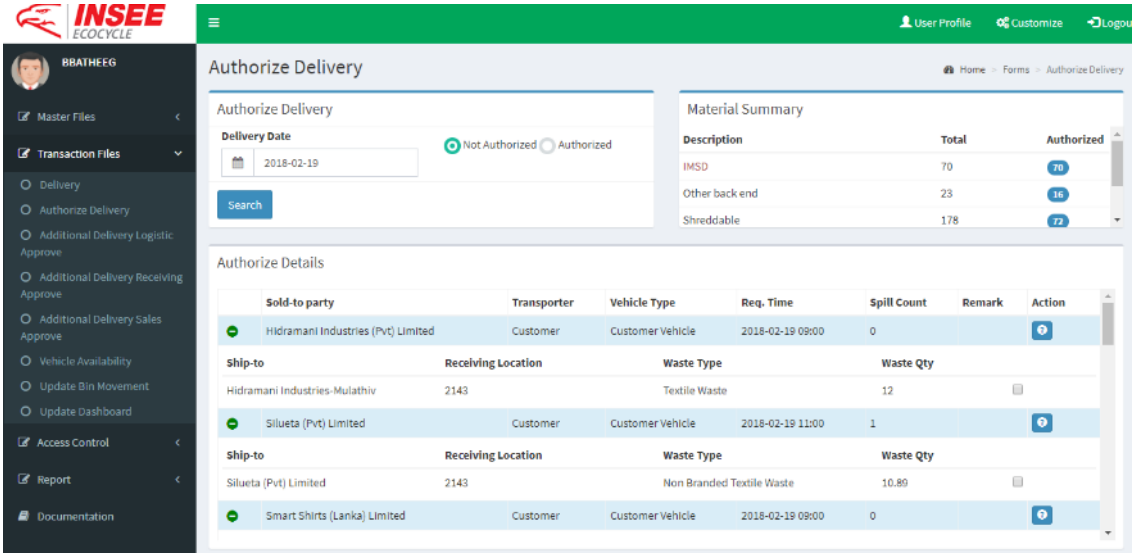


Figure 8-Ecocycle Delivery Management System

On the aspect of transport and logistics, the business model is still in the primary stages as both customers and Ecocycle is using dedicated fleets for their transportation needs with out any collaboration or synergetic practices.

1.2.3.3 Waste preprocessing, co processing and Customer relationship management

This waste management business incorporates comprehensive supply chain management concepts on customer management as they are managing with corporate customer base, large volume of material transport, inventory management, material handling, Millions of rupees of financial transactions, all sorts of communication channels with customers, suppliers and internal stake holders and other sustainability drives such as safety and compliance etc.

Waste acceptance for Co Processing undergoes a stringent prequalification process to overcome any adverse impact for the cement product and also for safe handling. All the wastes identified at the customer is undergone rigorous chemical analysis before accepting for co processing as well as finger print sample testing procedures are established to eliminated the risk on cement product quality and the risk for people who are handling waste.

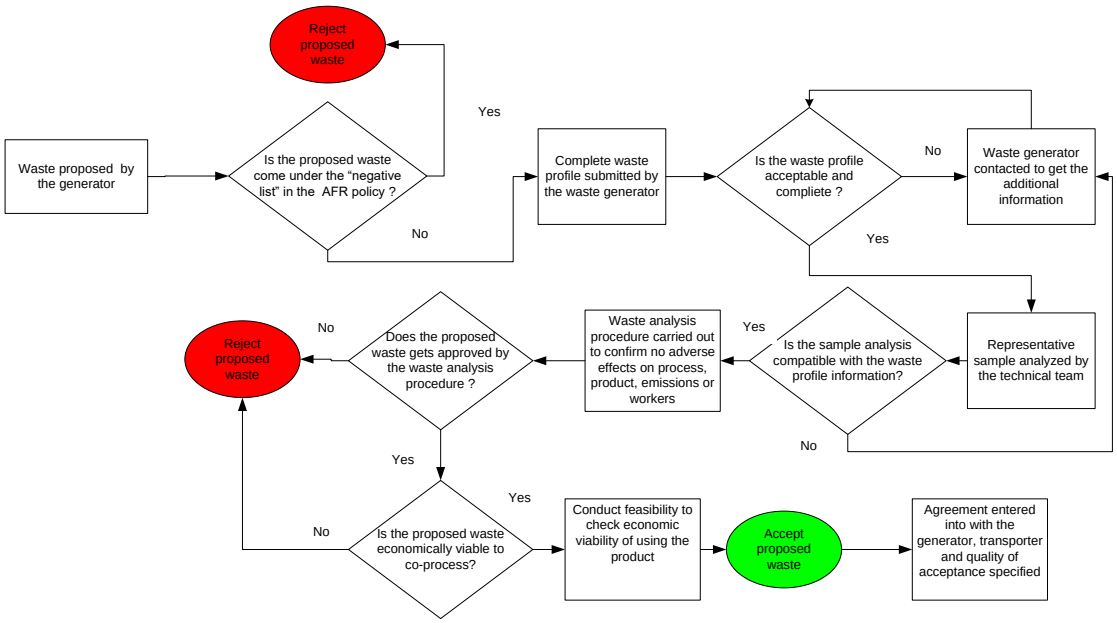


Figure 9-Waste Acceptance & Disposal Process

1.2.4 Supply chain management in Ecocycle Sri Lanka

On the waste co processing operation model for Ecocycle Sri Lanka, always there is a supply demand mismatch. Waste co processing capacity and waste generation is most times on either edge of the line. Sales team always demanding larger volumes acceptance for co processing while the co processing team demanding controlled volume flow.

INSEE Ecocycle Sri Lanka has experienced this mismatch due to various reasons and the waste supply chain is not at the best or having the optimum characteristics at the moment. Among other waste streams, textile and polythene streams has the least customer satisfaction due to issues related to waste acceptance limitations and the acceptance management.

These issues have triggered adverse impression among customers as well as the organization also has been impacted with financial losses on vehicle held up and demurrage costs. Difficulties on inventory management has also caused to high inventory management / handling costs and elevated risk levels.

Majority of the staff of Ecocycle Sri Lanka team consist with professional qualified staff and most of the staff is having post graduate qualifications also. Under these qualifications they are well aware of the bottlenecks of the process as well as the gaps in the operation. However, there is serious customer dissatisfaction on the waste acceptance. It is visible with the annual customer satisfaction survey outcomes also (NPS assessment).

Even though the team is well aware of the gaps in the supply chain, there is little improvements in the supply chain management over the recent past and the customer

dissatisfaction has further increased. So far the business unit has not reached the optimum supply chain due to the unknown or unexpressed factors influencing the optimization.

Standard logistics optimization models do not apply as it is on the waste supply chain management as there are significant other factors controlling the flow. For example, Ecocycle waste transport cannot distribute the goods from several locations in a single truck due to material compatibility or customers constraints and therefore Ecocycle have to allow less than truck load (LTL). On the other hand, Ecocycle can allow to load maximum volume in to a truck disregarding the maximum stack height or any temperature control or any other requirement since these are wasted goods.

Sales officers who are the contact point with the waste generators are highly demanding and influencing for higher waste volume acceptance based on the information from customers. And because of that, supply chain is heavily disrupted since logistics is unable to plan and control the waste flow as per the supply and demand. More importantly, the end-customers prefer more frequent deliveries to reduce their Inventory holding costs,(Dougherty, 2009). In this case it is waste storage in their premises which consist of inventory holding cost as well as other components such as brand risk, regulatory body influences etc.

On the other hand, there are unique facts experienced on the distribution for the Ecocycle operation on waste volume handling. As INSEE Ecocycle Sri Lanka is handling hazardous wastes, there are strict legal and occupational health and safety requirements to be fulfilled. Also, due to the complex nature of the cement manufacturing and the heavy machinery usage there are good maintenance practices obeyed at the Puttalam Cement plant. Under those conditions, there are unique characteristics limiting waste acceptance such as

- Preventive maintenance routines
- Audits (quality systems, brand security, safety systems)
- Top management or VIP visits

Apart from that there are some other scenarios such as due to high waste volume receival, storages are full and Ecocycle facing situations where they cannot accept or need to delay the acceptance.

1.3 Supply Chain optimization

1.3.1 Optimum Supply chain

The optimum supply has the following characteristics. (Markim, 2015)

- Proactive Use of Big Data
- Inventory Optimization
- Flexibility
- Rapid Fulfillment
- Customization
- Sustainability
- Compliance and Visibility

A great supply chain brings predictable, on-time performance, at the lowest cost. Eric Allais, President and CEO, PathGuide Technologies, Inc. But the waste supply chain currently managed by Ecocycle has very limited predictability especially for textile and polythene waste and the cost is high for held ups and double handlings.

In general, supply chain optimization covers detail assessment of the existing supply chain with big data and thereafter complex mathematical modelling and calculations to achieve the optimum design. This includes number of distribution locations, route planning, safe stock levels etc.

Supply chain optimization encompasses the entire process of combining resources in a supply chain with the intent of streamlining the process and leading to faster, more efficient and more profitable results. (Editorial Team at Exforsys, 2017)

Supply chain optimization uses models and planning to formulate solutions to internal problems and external problems. Internal supply chain problems can take the form of complex decisions that the supply chain planner has to make, while external problems stem from the supply chain itself. (Editorial Team at Exforsys, 2017)

Before moving in to complex mathematical optimization or in depth modeling, there are ample opportunities for INSEE Ecocycle Sri Lanka organization to improve the supply chain by improving the customer satisfaction. With the hand on experience of the operation, optimizing the Supply Chain is possible with minimal financial expenses and complex modelling or software packages when simple SC drivers are optimized which is not happened due to various factors.

1.3.2 Waste supply chain optimality for Ecocycle Sri Lanka

When evaluating the nature of the Supply Chain managed by the INSEE Ecocycle, gaps are visible in almost every aspect of the characteristics in which need to drive for best supply chain management practices.

There is very limited usage of big data for the decision making other than the standard SAP reports. Even those information is not critically analyzed at satisfactory level by the team. Inventory optimization has been the most critical issue of the SC as all the storages are full and hand to mouth operation has been practiced. Flexibility and customization is not properly managed since all the stake holders are dissatisfied on the operation such as the customer and the internal stake holders.

When considered about the chain drivers (i.e. Facilities, Inventory, Transportation, Information) all drivers are lagging. There are no intermediate facilities for efficient distribution, and inventory management is not up to the standard, Transport costs are high and information and communication need to be immediately improved

These gaps are very much visible with the annual customer satisfaction survey outcomes of NPS

1.4 Reverse logistics vs Supply Chain of co processing of Waste

In waste co processing facility, it is visible only the inbound stream unlike a recycling or assembly or disassembly plant. A disassembly plant would have inbound of defected or returned goods and an outbound flow of repaired or new goods. For the co processing facility, there will be no outbound movement since all the waste streams are totally destroyed at the facility.

1.5 Objective of the research

Due to various factors, the supply chain of the waste material is impacted. Those factors are known concerns by the AFR business management and the management is highly keen on optimizing the supply chain in order to provide better customer service. However the optimization is always been a challenge as different bottlenecks are advanced time to time.

Optimization can be achieved via careful analysis of the supply and demand (in this case waste receival and waste disposal rate). The management of the business unit well knows the technical reasons for the mismatch of this supply and demand. But still the business unit has not reached the optimum supply chain due to the unknown or unexpressed factors influencing the optimization.

Objective of conducting this research is mainly to smoothen the supply chain of the waste for the co processing plant after identifying the influencing factors on optimizing the waste supply chain.

1.6 Research challenges

1.6.1.1 Limited resources available on industrial waste final disposal supply chain.

Most papers and articles discuss about reverse logistics from supplier or distributor to the manufacturer. Throughout the literature survey, there are non-literature available directly related to this nature of a supply chain. All of the literature available is available on optimizing the conventional supply chain as well as discussing about the reverse supply chain management.

Specifically, this research is on the industrial waste supply chain and it has unique characteristics which cannot be directly considered as per the conventional Supply Chain. For example, There are no heavily influential factors such as regulatory bodies (eg. Customs, Environmental Authority, PHI) towards influencing the material flow. There was no literature available to study on how to analyzing such influences.

On the other hand, conventional supply chain optimization always emphasize to use full truck loads in order to reduce the cost and to deliver maximum tonnage always. However, in Waste Supply Chain Full Truck Load is not prioritized always.

2 Literature review

This research problem involves identifying the influencing factors on waste supply chain optimization of the final waste disposal solution. This is part of reverse logistics and most of the literature refers about the reverse logistics aspect of returning goods from seller or distributor to the manufacturer. But this research scope is extending in to further deeper of the chain and assess about the disposal of the waste generated by the manufacturer.

Markim A discusses about 7 Characteristics of A Best In Class Supply Chain in which used to identify how close waste supply chain to the best supply chain practices.

Thereafter the review is focused on what is supply chain optimization is. Internet presents simple but explanatory article on the supply chain optimization. That article describes on techniques used for standard optimization and how related issues are addressed.

2.1 Supply chain optimization

Supply chain optimization is the application of processes and tools to ensure the optimal operation of a manufacturing and distribution supply chain.(Editorial Team at Exforsys, 2017). This includes the optimal placement of inventory within the supply chain, minimizing operating costs (including manufacturing costs, transportation costs, and distribution costs). This often involves the application of mathematical modelling techniques using computer software. (Dougherty, 2009)

The classic supply chain approach has been to try to forecast future inventory demand as accurately as possible, by applying statistical trending and "best fit" techniques based on historic demand and predicted future events. The advantage of this approach is that it can be applied to data aggregated at a fairly high level. Unpredictability in demand is then managed by setting safety stock levels.(Dougherty, 2009)

There are certainly other important opportunities to consider in future supply chain design research. For example, the realm of so-called Big Data and the analytical strategies that the movement enables could signal a paradigm shift not only in the design and optimization of supply chains, but in a host of other fields (Garcia and You, 2015). Use of Big Data strategies should certainly be considered in supply chain design and optimization moving forward.(Garcia and You, 2015)

In the paper Garcia and You also discussing about supply chain design concerning enterprise wide optimization and through energy and sustainability.

2.1.1 Enterprise-wide optimization

Integrated, systems-wide optimization of operations and activities across the entirety of an enterprise is more crucial now than ever to a company's competitiveness. Globalization and modern communications technologies have provided a myriad of opportunities for improving supply chain performance. However, the same advancements also increase global competition, increasing pressure on both established and emerging industries and firms to design and operate their supply chains as efficiently and cost- effectively as possible (Garcia and You, 2015). Ideas emerging from the concept of enterprise wide optimization have provided a foundation for the large-scale optimization of supply, manufacturing, and distribution activities of a company to reduce costs and inventories(Garcia and You, 2015)

Literature review clarifies that there is large spectrum of industries who has benefited with enterprises wide optimization of supply chain. But there are limited literature on such optimization on industrial waste supply chain especially from the manufacturer to the final waste disposal solution provider.

2.1.2 Energy and sustainability

New energy and sustainability issues and initiatives have reframed supply chain design problems. Traditionally, optimization of supply chains focused on improving the economics and/or the performance of supply chains. However, industries are now subject to legislative and societal pressures to improve the energy, environmental, and social performance of their activities. (Garcia and You, 2015).

2.2 Managing Supply chain optimization

General supply chains spans over vast geographical spaces as well as along large time periods of years to shorter time periods of few hours. Thus there are multiple spatial and temporal scales that need to be coordinated in supply chains.(Garcia and You, 2015)

Coordination among the various spatial and temporal scales of a supply chain is integral to unearthing its optimal design and operations. Modeling this coordination poses its own challenge. Uncertainties arise at all scales of the supply chain and pose additional modeling challenges. Finally, solving large-scale, complex, multi-scale supply chain models poses a technical challenge that must be addressed. (Garcia and You, 2015).

Within the spatial scale of a supply chain, there can be multiple layers of networks of facilities. These layers might include an over- all distribution network, a manufacturing

process network, and even networks for each unit process within a manufacturing facility. creating a network of networks. Each layer could have its own network design and optimization problem. (Garcia and You, 2015).

2.2.1 Multi-scale uncertainty in supply chain design

Uncertainties exist at each temporal scale of the supply chain. These uncertainties can be grouped into two different categories of strategic and operational uncertainties as per the Figure 10. Strategic uncertainties involve events such as changes in government incentives and policies, unpredicted service disruptions, climate and weather effects, etc. Operational uncertainties are uncertainties that could change supply chain operations or execution strategies, such as price and cost volatility, process yield, supply delays, etc.(Garcia and You, 2015)

Understanding and preparing for uncertainty in multi-scale supply chains is crucial. Thus, the phenomenon of uncertainty at each scale will need to be addressed in multi-scale supply chain design. Supply chain design might include different types of uncertainties across temporal scales, but there is no universal tool that can address all types of uncertainties efficiently. Thus, there is a need to develop novel hybrid approaches combining the strengths of multiple techniques of optimization under uncertainty. .(Garcia and You, 2015).

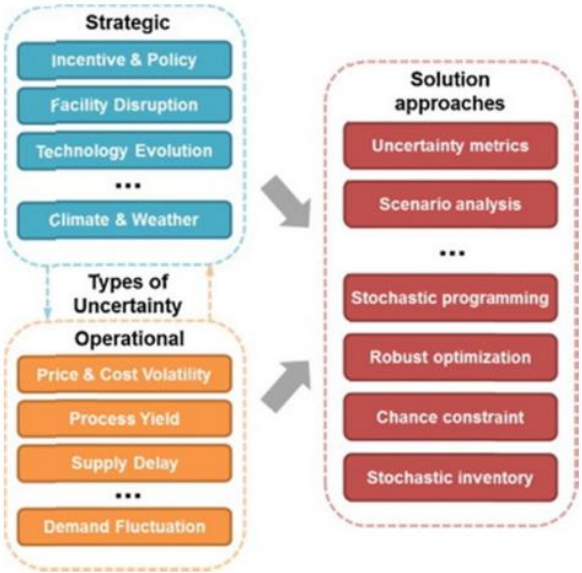


Figure 10-Supply Chain Uncertainty

2.3 Multi-scale optimization challenge:

Integrated supply chain design may lead to large-scale, simultaneous optimization across spatial scales of geographically distributed manufacturing and inventory facilities and over temporal scales spanning days to years. Temporal and spatial integration and optimization

could also require coordinated optimization of different types of models, e.g. simulation models could be used to capture a high level of detail with algebraic models used for higher-level decisions.(Garcia and You, 2015)

As per the article published by Dr. Donald Ratliff, there are ten Rules for Supply Chain & Logistics Optimization(Ratliff, 2013)

- Objectives - must be quantified and measurable
- Models - must faithfully represent required logistics processes
- Variability - must be explicitly considered

  Variability occurs in almost all supply chain and logistics processes (e.g., travel time varies from trip to trip, the number of items to be picked at a Distribution Centre differs from day to day, the time to load a truck varies from truck to truck). Many of the models associated with supply chain and logistics optimization either assume that there is no variability or assume that using average values are adequate. This often leads to errors in model results and poor supply chain and logistics decisions. Ignoring variability is generally a receipt for failure. Variability must either be explicitly considered in the models or the supply chain and logistics practitioners must have the expertise to explicitly consider variability in interpreting model results.

- Data - must be accurate, timely, and comprehensive

  Data is what drives supply chain and logistics optimization. If the data is not accurate and/or it is not received in time to include it in the optimization, the resulting solutions will obviously be suspect. For optimization that focuses on execution, the data must also be comprehensive. For example, having the weight of each shipment is not sufficient if some loads are limited by volume of the truck.

- Integration - must support fully automated data transfer

  Integration is important because of the large amount of data that must be considered by logistics optimization. For example optimizing deliveries from a warehouse to stores each day requires data regarding the orders, customers, trucks, drivers, and roads. Manually entering anything other than very minor amounts of data is both too time consuming and too error prone to support optimization.

- Delivery - must provide results in a form that facilitates execution, management and control

Solutions provided by supply chain and logistics optimization models are not successful unless people in the field can execute the optimized plan and management can be assured that the expected ROI is being achieved. The field requirements are for simple, unambiguous directions that are easily understood and executed. Management requires more aggregate information regarding the plans and their performance against key performance benchmarks over time and across facilities and assets. Web based interfaces are becoming the medium of choice for both management and execution.

- Algorithms - must intelligently exploit individual problem structure
- People - must have the domain and technology expertise required to support the models, data, and optimization engines

  Optimization technology is "rocket science" and it is unreasonable to expect it to function well over time without at least a few "rocket scientist" to insure that the data and models are correct and that the technology is working as designed. You cannot expect a complex set of data, models and software to be operated and supported without considerable effort from people with the appropriate technical and domain knowledge and experience.

- Process - must support optimization and have the ability to continuously improve

  Supply chain and logistics optimization requires a significant ongoing effort. There is invariably going to be change in logistics problems. This change requires systematic monitoring of data, models and algorithm performance not only to react to change but to initiate change when opportunities arise. Failure to put into place processes to support and continuously improve logistics optimization invariably results in optimization technology being either poorly utilized or becoming "shelf-ware."

- ROI - must be provable considering the total cost of technology, people and operations

  Supply chain and logistics optimization is not free. It requires significant expenditures for technology and people.

2.4 Reverse Logistics

First word comes in for any academia reading about waste and supply chain is on reverse logistics. This literature review has touched the concepts of reverse logistics accordingly even though the waste co processing supply chain extends far from conventional reverse logistics considerations.

A reverse supply chain represents the products collected from consumers and distribution centers back to manufacturers or recyclers. That may consist of end-of-lease products, product traded-ins, and products returned due to legislative requirements. The operational characteristics of reverse logistics are different from their manufacturing counterpart. Some of the unique characteristics of the reverse logistics problem are highlighted below. (Veerakamolmal and Gupta, 2001)

- Supply/Demand Balancing:

Perhaps the most difficult variable to forecast is the distribution of the returns of EOL or end-of- lease products over the planning horizon. Forecasters often face unexpected supply/demand patterns that will depend on their product's success in the market and competing products.

- Accumulation:

There will be accumulations of certain kinds of parts due to uneven market demands for certain components. For instance, there may be higher demands for certain models of memory chips and hard drives while other dismantled parts with no demand pile up on the operations floor

- Logistical Network:

In a reverse logistics supply chain environment there will be potentially three separate entities: the assembly plant, the disassembly plant and the recycling plant. Operations therefore have to be planned from a larger perspective that comprise those three entities. The inventory policies will alter in terms of the level and location of buffer stocks. From the supply of products, to collection, to dismantling, to reuse and/or recycling, the inventory of products and components must be properly maintained to balance the supply and demand of resources.

- Transportation:

Plant location decisions are influenced by the transportation cost of raw materials. However, when dealing with disassembly and recycling, the control for the flow of products is expected

to increase several folds. Manufacturers will have to consider this problem and plan the locations of new assembly, disassembly or recycling plants appropriately

2.5 Recommendations

After going through the literature, following recommendations were identified for the optimization.

Modeling this coordination poses its own challenge. Uncertainties arise at all scales of the supply chain and pose additional modeling challenges. Finally, solving large-scale, complex, multi-scale supply chain models poses a technical challenge that must be addressed. This need is further emphasized with the dawn of the Big Data movement, which will provide supply chain designers even more detailed data that can bridge the spatial and temporal scales of the supply chain. Different properties of each layer should not only be optimized for each layer, but also coordinated among the other layers, leading to a significant modeling challenge. (Garcia and You, 2015)

Appropriate methods to model these uncertainties through-out the supply chain should be considered. A variety of methods exist for handling uncertainty, such as stochastic programming (Kall and Wallace, 1994; Birge and Louveaux, 1997), robust optimization (Ben-Tal and Nemirovski, 2002; Ben-Tal et al., 2009; Bertsimas et al., 2011), and chance-constrained methods (Charnes and Cooper, 1959), among others. So far in supply chain design, different modeling strategies have been used for handling strategic (long-term) and operational (short-term) uncertainties. Stochas- tic programming could handle strategic uncertainty, as it has been shown to perform well for problems of longer term by model- ing uncertainty with probability distribution functions (Kall and Wallace, 1994; Birge and Louveaux, 1997; Yue and You, 2013; Grossmann, 2014). Often, two-staged programming models are employed (Liu and Sahinidis, 1996; You et al., 2009; Gebreslassie et al., 2012). I (Garcia and You, 2015).

Shorter-term supply chain operations and operational uncertainties might not be suitably handled by these stochastic programming methods due to the large number of scenarios. required to capture an appropriately detailed level of uncertainties in long-term supply chain design problems (Grossmann, 2012). Stochastic inventory approaches using chance constraints to optimize safety stock levels have been employed to address this issue (You and Grossmann, 2008b, 2011a,b; You et al., 2011a,b; Chen et al., 2013; Garcia-Herreros et al., 2014). This approach, however, is restricted to supply and demand uncertainties at the

operational level in the supply chain design problem. Scenario tree or scenario planning-based methods have also been used to optimize the design and planning of supply chains under product demand uncertainty (Cardoso et al., 2013; Georgiadis et al., 2011; Tsiakis et al., 2001; Zeballos et al., 2014). H

3 Research Methodology

3.1 Introduction

This research is focused on identifying factors to optimize the supply chain towards customer satisfaction. Survey is conducted focused on gaps in the customer service in the textile and polythene waste supply chain. Questionnaire is developed towards identifying the nature of the supply chain management at the customer front and the perceptions of the stake holders which are impacting the optimization. In this research, It is expected to identify the gravity of those identified factors and their nature in to the optimization of the SC.

This research is conducted mainly among the internal stake holders who are the main decision makers of the supply chain as well as, as an organization, factors from them are which can control to achieve the best Supply Chain.

3.2 Research Design and Data Collection

The questionnaire was designed based on the industry experience, literature on supply chain optimization, reverse logistics. The questionnaire consists of sets of questions including personal perception on the textile waste supply chain management as well as the practices done by the respondents.

All are closed ended questions on communication modes, frequencies and kinds of communications, how do they influence the stakeholders, how each respond to each different request, planning accuracies.

The following aspects of Supply chain management practices are incorporated in to the questionnaire.

- Customers engagement.
- Internal staff flexibility for customer service
- Magnitude of stake holders engagements in the operation

Questionnaire for the second set of questions consists of 5-point Likert scale questions which allow respondents to accurately specify their preference or views. All responses are scaled according to alignment towards complexing the Supply chain or align towards leaning the supply chain.

The study relies on the data collected from a survey among the internal employees as well as from the recently resigned employees within six months period. The believes of the employees on those aspects were assessed. There are no figures or facts on these aspects and the research was intended on individual understandings.

External customers were not invited to participate the survey as the research is focused on identifying the internal behavior first of all and approach the external customers thereafter.

An invitation letter to participate in the survey was directly sent to potential participants via email and data were gathered with their names from the 15th of November to 1st of December 2017 and complete the survey leaving the response rate of 100%. Higher response rates were achieved due to the close relationship with the peer colleagues of the staff as well as via frequent reminders.

3.2.1 Target Population and Sampling

Convenience sampling of all the officers in the Ecocycle operation is selected as the sample. The accessibility for the questions responses is assured with this population and had the benefit of easy communication and least time consumption for the feedbacks. 100% of the population of the waste co processing business internal stake holders are chosen as the population. They are distributed among all the functions of the operation who are very much aware of the business and the operation. The functions include

- Sales
- Quality Assurance
- Waste Co Processing
- Logistics
- Waste Pre Processing
- Safety and compliance
- Finance
- Business Development

Each of these functions interact with the supply chain management of the textile and polythene waste and they have substantial understanding on the supply chain.

Out of 30 respondents, there are 8 respondents who do not directly involve for the daily textile waste supply chain planning and operation. They belong to the support functions such as finance, business development or safety. How ever their understanding on the textile waste supply chain is significant as they involve extensively on overall textile waste supply chain on financial calculations, new business developments as well as on safety and compliance on handling, storage management etc. They actively engage cooperate level tasks such as strategy developments, pricing, financial analysis on KPI, inventory levels, new market expansion etc.

3.3 Questionnaire development

Research questions are developed based on the literature which emphasis the factors on supply chain optimization. However those general factors application in to the industrial waste final disposal is significantly different.

General reverse logistics drivers are also different on this business model as explained above and therefore the questionnaire is developed based on the principles of the supply chain and customizing in to the waste supply chain.

People fact which is one of 10 rules to optimization consideration is highly assessed in the questionnaire where the organization still do not have a fully integrated supply chain with the waste generators. Thus, the people fact has been considered as the pivotal fact on the optimization.

Questionnaire is developed in order to identify the influential factors on this disruption and the management of those factors by the sales front as well as the waste disposal team.

Also Supply chain and logistics optimization requires a significant ongoing effort. (Ratliff, 2013). The questionnaire addresses the efforts made by the stake holder to manage the Supply Chain on planning or negotiations for the agreed process. Organization can influence more on factors at own control and at minimal expenditure (information/communication improvements and therefore focused on managing the inventory and the information.

Out of four supply chain drivers (i.e. Facilities, Inventory, Transportation, Information), this survey excludes facilities fact as there is only one fixed location where currently Ecocycle Sri Lanka is managing, and organization has to optimize the supply chain with that limitation. (organization cannot invest on increasing the number of locations to serve higher flexibility or effectiveness in the near future)

This survey excluded factors related to transportation optimization for the research as the majority of the waste streams focused in this study (75% of tonnage of Textile and Polythene waste) is transported by the customer vehicles

Supply chain Optimizing on the sustainability aspects such as GHG emission etc. are excluded in this study on the basis that there are much easier and economical approaches for the optimization.

There are several questions developed to analyses the significance of the factors impacting the optimizing as well as another set of questions to identify how people see the operational behavior and how they react on the situation.

First set of questions are analyzed using the factor analysis to identify the most prominent factors influencing the supply chain. Second set of questions are used on identifying the current condition of the textile waste supply chain.

3.4 Methodology

To identify and analyze influential factors in Shredable waste supply chain management, this study applies factor analysis (related to principal component analysis (PCA), in evaluating the factors influential to Shredable waste SC Management. Factor analysis is applied to identify the underlying factors from a set of observed variables

These data analysis methods are chosen due to few main reasons. First, this method is well known for the relevance in analyzing survey data, especially those from a survey using Likert scale questions. Second, because of the exploratory nature of the study, EFA is necessary in order to identify the key underlying factors from a number of survey questions/variables covered in the survey.

Factor Analysis is capable of determining a number of unobserved influences underlying a domain of variables being investigated. It is able to quantify the extent of each variable associated with factors and is helpful in obtaining information about the nature of the variables from observing which factors contribute to the performance of which variable.

In this analysis, the varimax rotation method was used. It was selected as it helped to achieve a simple structure for data compared to other rotation methods. (Bandara and Nguyen, 2016)

4 Presentation of Data Analysis results

4.1.1 Characteristics of the respondents

The respondents' job position and departmental representation is given in Figure 11. About 77% of respondents were in middle management or above employees such as Engineers, Assistant Managers and the General manager while 40% are department heads.

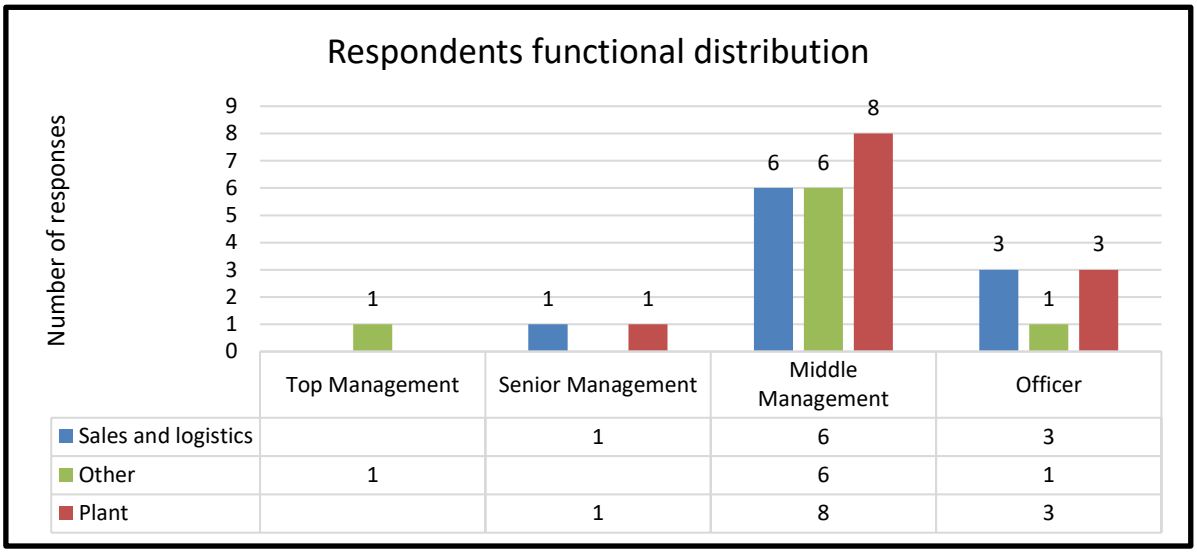


Figure 11-Respondents

Respondents Experience on Industrial waste management business is shown below in Figure 11.

The respondents' experience in waste management and the Ecocycle business is the most crucial matter of concern for the reliability and accuracy of the data collected. Below chart reveals that majority of the respondents had a substantial experience in the business.

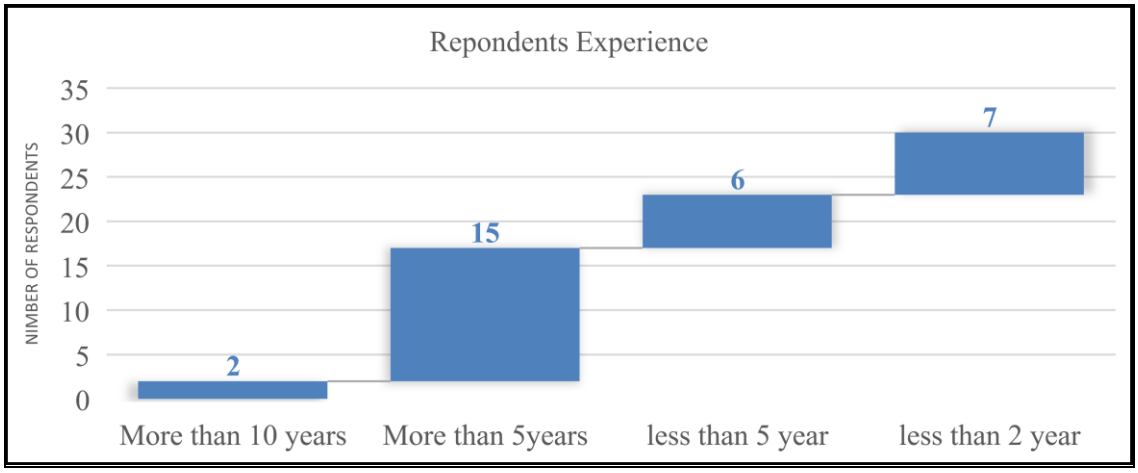


Figure 12-Respondents Experience

Over 50% of the employees are with more than 5 years experience and 75% of the employees have over two years' experience on the operation who can effectively evaluate the supply chain of the business.

In addition, the highest education level of the respondents is also shown below.

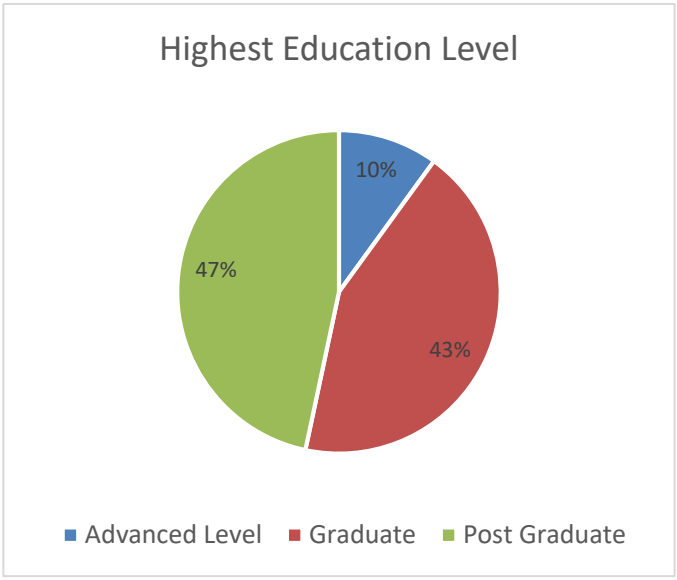


Figure 13-Respondents Education Level

90% of the employees are graduates and almost 50% of the employees are with post graduate qualifications. (completed or reading for the Masters). Thus the data used in the analysis are rather valid and reliable and representative of the views of the internal business model.

4.1.2 Current Characteristics of the Textile waste Supply Chain

First question was to identify the perception among the employees on the optimumness of the existing Supply Chain.

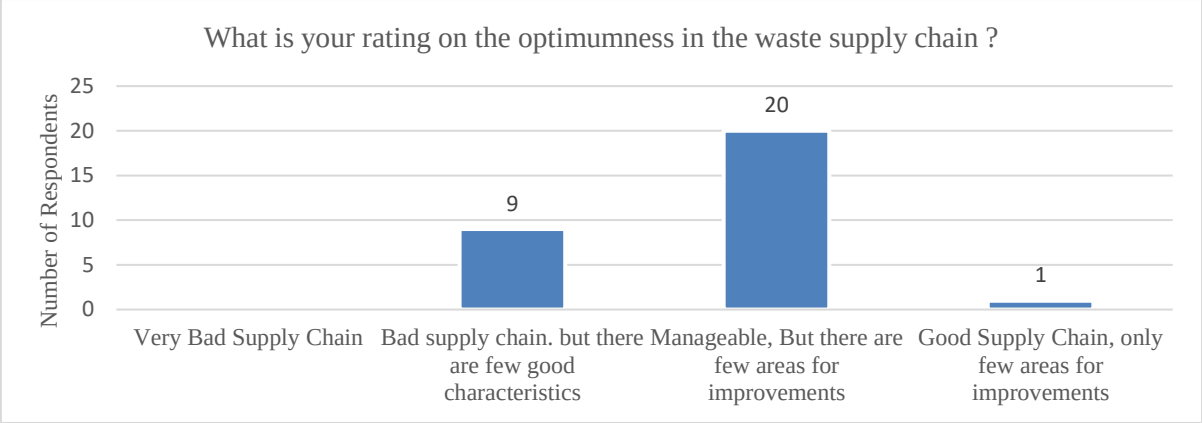


Figure 14-Supply Chain Optimality

Over 66% of the personal has responded as the SC is in manageable level. And non has responded the Supply Chain as a very bad Supply Chain. Thus we can conclude that the perception is that the current Supply Chain is in a manageable level for the majority of the personal, but need immediate actions to improve the quality of the Supply Chain.

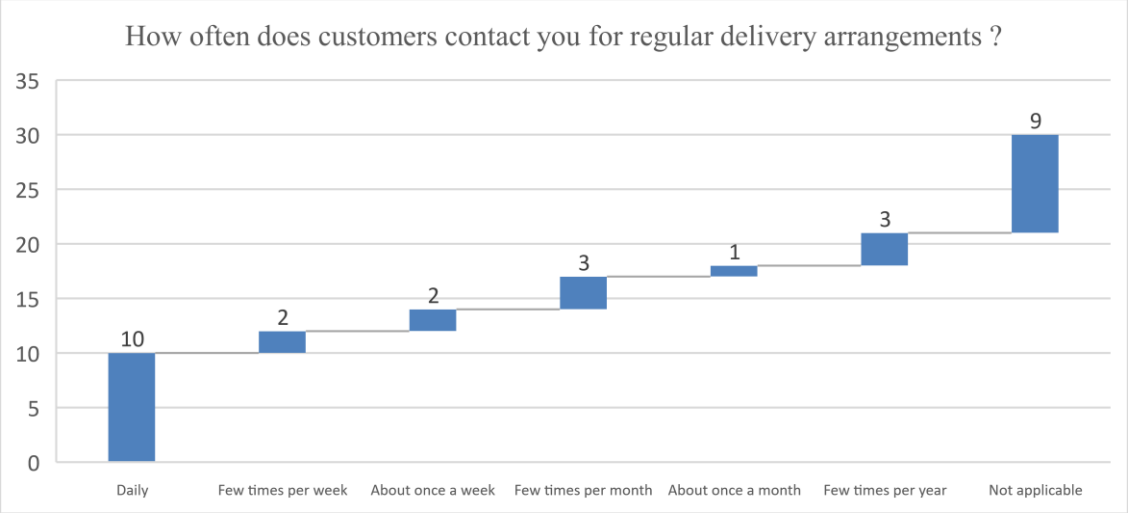


Figure 15-Delivery Arrangements

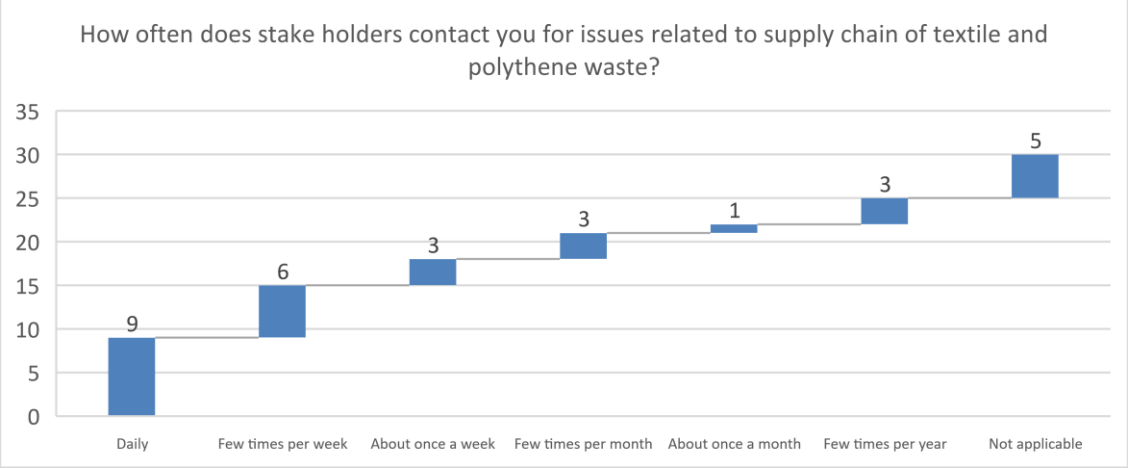
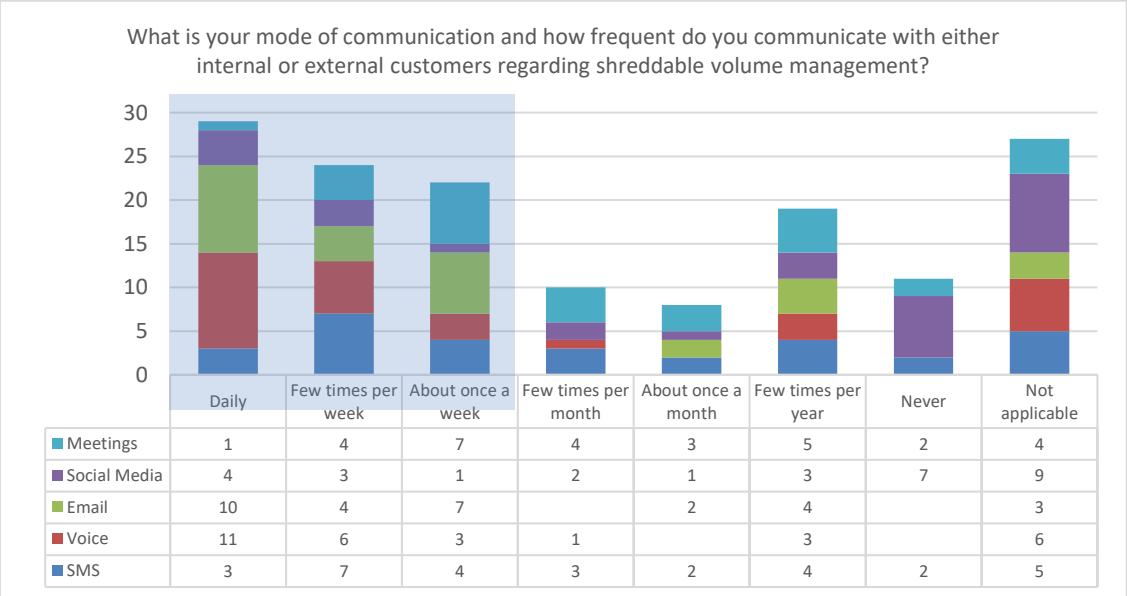


Figure 16-Delivery Issues

Above two graphs emphasize that the employees get frequent inquiries from their stake holders on delivery arrangements as well as issues. This kind of frequent contacts leads employees to be biased on the most frequently called or the most influential stake holder. We see around 50% of the employees get involved several times per week on the issues and the delivery arrangements.

This level of involvement for delivery arrangement can be expected at the business nature and the magnitude of the business. But this level of involvement on daily basis for delivery related issues may cause impedance for the other daily tasks since people need to pay special attention when an issue is raised. And raising issues daily indicates that there is a gap on the customer service level (both internal and external).

More details on modes of communications and the frequencies are described on Figure 17.



	Daily	Few times per week	About once a week	Few times per month	About once a month	Few times per year	Never	Not applicable
Meetings	1	4	7	4	3	5	2	4
Social Media	4	3	1	2	1	3	7	9
Email	10	4	7		2	4		3
Voice	11	6	3	1		3		6
SMS	3	7	4	3	2	4	2	5

Figure 17-Communications

This chart indicates that employs are involved on all sorts of communication modes available in the society. From face to face discussions or meetings to even social media and those channels are active on daily basis. For a two-way communication channel such as voice calls or for more formal and accountable communication channel as e mails, people has to always focus on customer centricity with external customers. In such situations, generally sales team tends to be more favorable for the customer service and may demand higher service levels from the plant technical team changing the plans. In parallel this increases the communications to the co processing team and causing them to amend the agreed plans

negatively impacting the plan accuracy (monthly as well as daily) and ultimately hindering the supply chain.

Figure 18 indicates that almost all the people applicable for planning matters do make a reasonably accurate plan at different time spans and even with that, we get higher number of issues and communications requirements.

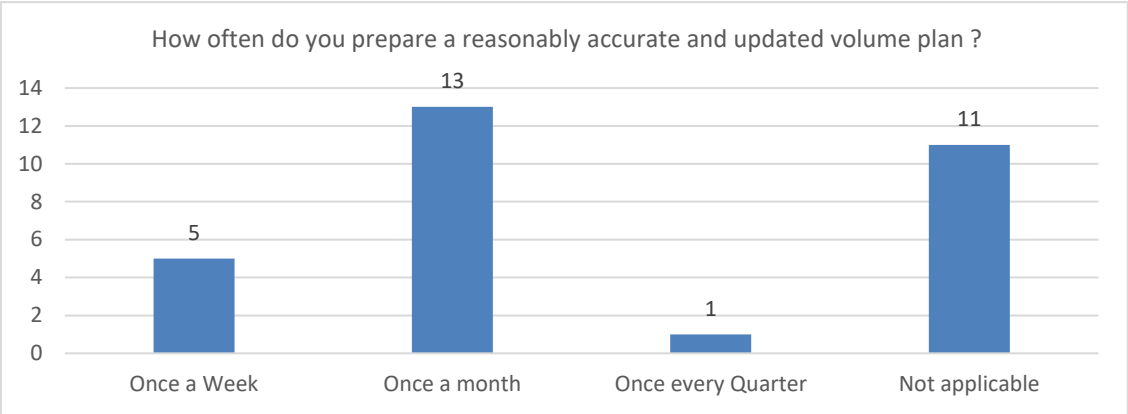


Figure 18-Plan Preparation

Figure 19-Employee Perception describes the perception of the employees on frequently raised concerns on daily waste acceptance volume changes (Increase or decrease from the plan)

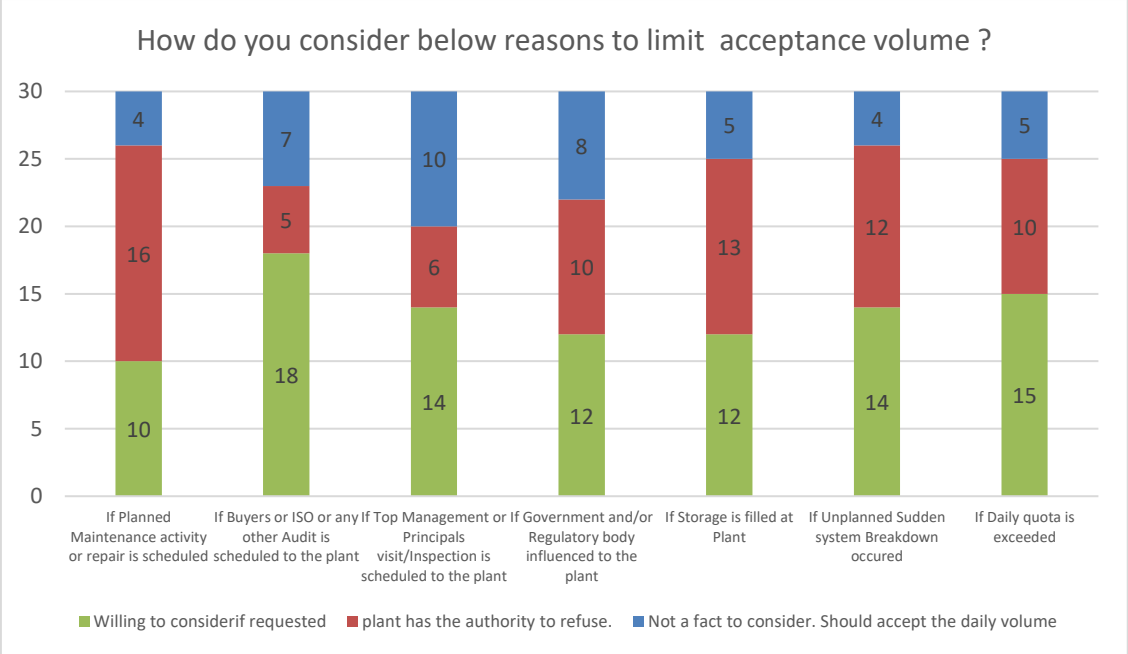


Figure 19-Employee Perception

Here it is visible that the majority of the employees has responded as willing to consider if requested. That implies the flexibility among the personal for the delivery plan changes on

these reasons. However all those changes from the plan causes fluctuations on the plan causing issues on the SC.

The fascinating fact is that always majority has selected the answer for providing flexibility / agility to the SC in which always serve the customers' aspect while alter the plan. Always clear minority has emphasized to go on with the plan which do not amend the plan.

4.1.3 Descriptive Analysis

Statistics on the research outcomes are shown below.

Question		Mean	Standard Deviation
I strongly influence for my quota when negotiating Shreddable volume during daily planning phase		4.433	1.308519
I prepare a monthly textile and polythene sales/volume plan mostly and negotiate with both of my internal and external customer base ?		2.300	0.737115
Up to what level of planning accuracy and forecasting can you communicate to your customers for the volume acceptance (external and internal) ?	Annual	4.500	1.176152
	For the next Three months	4.400	1.200000
	[For Next Month]	4.166	1.293144
	[For Next Week	3.800	1.536229
	[Next Day]	3.500	1.979057
I am planning the volume intake based on below considerations if any customer is with below nature	[Customer give us large volumes and because of that we need to treat him always]	3.566	1.116045
	[Customer gives small volumes only and because of that we need to treat him always]	2.700	0.971253
	Customer always give me a proper plan and we have to respect his planning	2.533	1.117537
	Customer sends the truck without informing me and I am unaware until truck reach plant]	2.033	0.87496
	[Customer is willing to bare all the waiting and demurrage costs, So I always facilitate him]	2.866	0.921352
State your understanding on below Statements for Shreddable supply chain optimization	[Unavailability of a centralized planning and controlling role for daily optimization is negatively impacting]	3.933	0.997775
	Individual personal demands has negatively impacted daily optimization]	3.933	0.85375
	[Involvement by functional leaderships is not at required level]	3.333	1.074968
	[Organization has not planned/installed adequate resources/assets for the market size]	3.400	1.171893
	[AIC/KAC do not have strong understanding on volume generation at Agreement level as well as day to day operation]	3.400	1.083205
	[Gaps in team work on organizational level]	3.700	0.822598

	[Communication gaps among stake holders]	3.900	0.830662
	Motivation facts to higher volumes such as incentives]	3.366	0.752034
	Customer is manipulating the volume generation]	3.133	0.884433

4.1.4 Factor Analysis

Factor analysis is used for the second set of questions to identify/Group the different factors and their significance on the supply chain optimization.

Following list of questions were used for the factor analysis using the SPSS tool.

1. Influ_Quota_Daily_Planning	2. I_Plan_Negotiate_IntExt	3. Plan_Accu_Annual
4. Plan_Accu_Nxt_3_Months	5. Plan_Accu_Nxt_Month	6. Plan_Accu_Nxt_Week
7. Plan_Accu_Nxt_Day	8. Consider_Cust_Large_Vol	9. Consider_Cust_Small_Vol
10. Consider_Cust_Planning	11. Consider_Cust_UnPlan_Reach	12. Consider_Cust_Bare_Demur
13. Unavail_Central_control_Role	14. Individual_Persoal_Demands	15. Involvemen_Functional_Leader
16. Org_Not_Install_Resources	17. AIC_NoUnder_CusGeneration	18. Gaps_TeamWork
19. Motivation_Incentive_HigherVol	20. Customer_Manipulate_Volume	21. Gaps_Communication

Responses are on the Likert scale model from 1 to 5. SPSS was used for assessing the KMO value, total variance and the rotated component matrix for the analysis.

4.1.4.1 Initial Model

4.1.4.1.1 KMO and Bartlett's Test

Table 4-KMO Test-Initial Model

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.612
Bartlett's Test of Sphericity	Approx. Chi-Square	587.308
	df	210
	Sig.	0

If the value of KMO is less than 0.50, the results of the factor analysis probably won't be very useful and since even the initial model gave a KMO value of 0.612 which is satisfactory to proceed.

4.1.4.1.2 Total Variance Explained

Table 5-Total variance-Initial Model

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.067	38.413	38.413	8.067	38.413	38.413	5.205	24.787	24.787
2	3.659	17.424	55.837	3.659	17.424	55.837	4.22	20.095	44.882
3	1.962	9.341	65.178	1.962	9.341	65.178	2.482	11.817	56.699
4	1.462	6.961	72.14	1.462	6.961	72.14	2.347	11.175	67.875
5	1.321	6.291	78.431	1.321	6.292	78.431	2.217	10.557	78.431
6	0.931	4.435	82.866						
7	0.722	3.438	86.304						
8	0.607	2.892	89.196						
9	0.534	2.542	91.738						
10	0.406	1.933	93.671						
11	0.346	1.648	95.319						
12	0.272	1.293	96.612						
13	0.209	0.995	97.607						
14	0.172	0.82	98.427						
15	0.125	0.597	99.025						
16	0.096	0.458	99.482						
17	0.043	0.207	99.689						
18	0.023	0.111	99.8						
19	0.021	0.101	99.901						
20	0.013	0.06	99.961						
21	0.008	0.039	100						

Five factors are derived with a total variance of 78.43%

4.1.4.1.3 Rotated Component Matrix Component

Table 6-Rotated Component Matrix-Initial Model

	1	*2*	*3*	*4*	*5*
Influ_Quota_Daily_Planning	0.739	0.385	-0.179	-0.128	0.332
I_Plan_Negotiate_IntExt	0.763				
Plan_Accu_Annual	0.747	0.386	0.345	-0.094	0.143
Plan_Accu_Nxt_3_Months	0.837				
Plan_Accu_Nxt_Month	0.873	0.293	0.228	0.022	0.078
Plan_Accu_Nxt_Week	0.899				

Plan_Accu_Nxt_Day	0.632	0.016	-0.532	0.236	-0.089
Consider_Cust_Large_Vol		0.772			
Consider_Cust_Small_Vol	0.08	0.905	0.073	0.073	-0.208
Consider_Cust_Plan		0.794			
Consider_Cust_UnPlan_Reach	0.413	0.706	-0.037	-0.06	0.194
Consider_Cust_Bare_Demur		0.741			
Unavail_Central_control_Role	0.06	0.411	0.521	0.095	0.577
Individual_Persoal_Demands				0.496	
Involvemen_Functional_Leader	0.021	0.152	0.002	0.352	0.764
Org_Not_Install_Resources					0.74
AIC_NoUnder_CusGeneration	-0.039	-0.066	0.221	0.855	-0.097
Gaps_TeamWork					0.179
Gaps_Communication	0.107	-0.123	0.741	0.265	0.026
Motivation_Incentive_HigherVol					0.459
Customer_Manipulate_Volume	0.055	0.096	0.362	0.655	0.281

However the initial model gave a low KMO value and a low variance. Thereafter two variables were dropped for the analysis based on their factor loading and final solution is achieved in the second iteration.

4.1.4.2 Final Outcome

4.1.4.2.1 KMO and Bartlett's Test

Table 7-KMO Test-Final Model

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.649
Bartlett's Test of Sphericity	Approx. Chi-Square	537.52
	df	171
	Sig.	0

In the final model, higher KMO value of .0649 is achieved.

4.1.4.2.2 Total Variance Explained

Table 8-Total Variance-Final Model

Component	Initial Eigenvalues	Extraction Sums of Squared Loadings	Rotation Sums of Squared Loadings

	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.953	41.86	41.86	7.953	41.86	41.86	4.628	24.36	24.36
2	2.893	15.226	57.086	2.893	15.225	57.086	4.414	23.234	47.594
3	1.953	10.28	67.366	1.953	10.28	67.366	2.404	12.655	60.248
4	1.319	6.94	74.305	1.319	6.94	74.305	2.075	10.92	71.168
5	1.278	6.727	81.032	1.278	6.727	81.032	1.874	9.864	81.032
6	0.812	4.274	85.306						
7	0.595	3.131	88.437						
8	0.501	2.639	91.076						
9	0.473	2.488	93.564						
10	0.329	1.73	95.294						
11	0.262	1.379	96.673						
12	0.213	1.121	97.795						
13	0.171	0.901	98.695						
14	0.108	0.571	99.266						
15	0.053	0.278	99.544						
16	0.036	0.189	99.733						
17	0.025	0.129	99.863						
18	0.018	0.094	99.956						
19	0.008	0.044	100						

4.1.4.2.3 Rotated Component Matrix Component

Below table reports the rotated, rescaled component matrix of these underlying factors.

Table 9-Rotated Component Matrix-Final Model

	Factors				
	1	2	3	4	5
Plan_Accu_Nxt_3_Months	0.896				
Plan_Accu_Nxt_Month	0.895				
Plan_Accu_Annual	0.848				
Plan_Accu_Nxt_Week	0.830				
I_Plan_Negotiate_IntExt	0.558				0.508
Influ_Quota_Daily_Planning	0.557				
Consider_Cust_Small_Vol		0.894			
Consider_Cust_Plan		0.822			
Consider_Cust_Large_Vol		0.789			
Consider_Cust_Bare_Demur		0.773			
Consider_Cust_UnPlan_Reach		0.71			

Involvemen_Functional_Leader		0.801	
Org_Not_Install_Resources		0.735	
Unavail_Central_control_Role		0.635	
AIC_NoUnder_CusGeneration			0.891
Motivation_Incentive_HigherVol		0.516	0.614
Gaps_TeamWork	0.528		0.59
Individual_Persoal_Demands			0.587

The result of Factor Analysis suggests that there are four factors influencing the optimizing of the Shredable waste supply chain for Ecocycle Sri Lanka.

These factors can be named as following groups considering the nature of Supply chain.

- Factor 1 >> Planning
- Factor 2>> Acceptance considerations
- Factor 3 >> Organizational facts
- Factor 4 >> AIC Behaviors

4.1.4.2.3.1 Factor 1-Planning

The behavior of the planning of shreddable volume has been grouped together. Here we can see that the forecasted volume planning as well as the behavior at the volume planning is also bounded in to this group. This is an obvious case since the most important fact is the next day plan as well as most of the issues on customer dissatisfaction is caused due to gaps in the immediate next day planning.

4.1.4.2.3.2 Factor 2- Acceptance considerations

This factor has been emerged from the group of parameters on consideration towards customer characteristics. This visualizes how does the organization consider and their approach on servicing different characteristics of different customers.

4.1.4.2.3.3 Factor 3 >> Organizational facts

This group of factors include the general organizational landscape. The leadership on managing the supply chain of the waste as well as the resource allocation and appointing responsible person is addressed in to this fact.

4.1.4.2.3.4 Factor 4 >> AIC Behaviors

This group consist of the individual behaviors of the sales Account In Charges (Sales officers). Their attitudes, behavior has been clubbed in to this fact.

Important point on this factor analysis is that this shows how the people in the organization see on the shreddable waste supply chain management. Their believes and understandings on the optimization are expressed in this survey.

5 Discussion

5.1 Factor analysis outcome

5.1.1 Planning Factor

Planning is the most important stage in any activity. For a project or an operational activity, the process beginning from the planning stage. Same is applicable for the supply chain also. In the factor analysis, it is identified that planning has been an influencing factor on optimizing the waste supply chain.

There is a significant impact on the volume planning for the weekly planning, monthly planning and annual planning for the supply chain. The accuracy of planning is the most significant since inaccurate planning always leading towards worst supply chain management.

From the descriptive analysis it is visible that the accurate annual volume planning shows and average of 4.5 with 1.18 standard deviation. This is the highest average and the least standard deviation for the accurate planning on different time intervals. This shows that the annual volume planning is more accurate compared to the quarterly or monthly or even the next day planning. When the time line is shrinking the planning, accuracy drops continuously while increasing the standard deviation.

Table 10-Planning Descriptive Statistics

	Question	Mean	Standard Deviation
Up to what level of planning accuracy and forecasting can you communicate to your customers for the volume acceptance (external and internal) ?	Annual	4.5	1.18
	For the next Three months	4.4	1.20
	[For Next Month]	4.2	1.29
	[For Next Week	3.8	1.54
	[Next Day]	3.5	1.98

In general, what happens is the planning is more accurate for the immediate time span while the accuracy deviates as the time span increases. But in this case the vice versa has happened. This perfectly describes the planning accuracy tragedy. The organization drives towards the

annual volume targets which drives through the organizations' top line Key Performance Indicators of Gross Added Values to the business, Sales value, Thermal Substitution etc. Overall performance of the business unit, management team as well as the individual performance is measured at the achievement of performance indicators in the annual basis. The key performance indicators for individuals are even set for annual target. In this scenario, what the operational team is making effort is on achieving the annual targets since the entire organization is also supporting towards those targets interdependently.

How ever when the time span shrinks, operational team of the Ecocycle has to manage the situation case by case. This causes the sales officers as well as the logistics and the co-processing team to manage the immediate concerns raising from external customers as well as through the internal stake holders.

This fact is more emphasized on the factor analysis. Planning related factors has been grouped as the factor one. Factor analysis reveals that the accurate planning has not been happening on all the intervals even for annual as well as immediate next day. Also this factor 1 has bounded two factors of negotiation and influences making by the stake holders.

Table 11-Planning factors

	Factors				
	1	**2**	**3**	**4**	**5**
Plan_Accu_Nxt_3_Months	0.896				
Plan_Accu_Nxt_Month	0.895				
Plan_Accu_Annual	0.848				
Plan_Accu_Nxt_Week	0.830				
I_Plan_Negotiate_IntExt	0.558				0.508
Influ_Quota_Daily_Planning	0.557				
Plan_Accu_Nxt_Day					0.858

Table 12-Planning Descriptive Statistics

Question	**Mean**	**Standard Deviation**
I strongly influence for my quota when negotiating Shreddable volume during daily planning phase	4.433	1.31
I prepare a monthly textile and polythene sales/volume plan mostly and negotiate with both of my internal and external customer base?	2.30	0.74

Influencing characteristic on the volume quota shows average of 4.33 and that indicates that almost all are influencing on having his own volume portion in the next day operation (Both sales and the Coprocessing). On contrast preparing a monthly sales or a volume plan shows a lesser average value highlighting that they seldom plan the operation. By always strongly

influencing a volume quota without planning definitely drives poor planning on the daily operation and resulting issue on supply chain planning and the customer dissatisfaction on both internal and the external.

Higher number of daily and several times per week customer interaction personal on regular delivery arrangements (Figure 15-Delivery Arrangements) and on issues related to delivery arrangements (Figure 16-Delivery Issues), shows operational team do not plan the next day plan with a reasonable accuracy.

This situation has occurred since comparatively less number of people is preparing a reasonable accurate weekly plan. (Refer Figure 18-Plan Preparation).

Factor two gives a clue on why the employees are shaking on accurate planning.

5.1.2 Acceptance Considerations Factor

This group of parameters are the considerations which are to concern on daily acceptance. These are certain characteristics which the customers are having based on their internal circumstances. And based on those characteristics and conditions, Ecocycle would have to prioritize the serving customer on the next day or the next week. Due to the imitations of daily acceptance volumes, Ecocycle sales team has to select the most suitable customer who needs the service mostly.

Different personal has different approaches on treating customers with such characteristics. Factor analysis indicates that out of those considerations, more impact is made from the customers who are having small volumes. Below table shows that majority of the personal believe that we should give priority to the customers with small volumes. More than 50% of the personal believes that priority need to be given to the customers with smaller volumes. There is a reasonable clear logic behind that consideration as by this approach; INSEE Ecocycle can serve more number of customers while issues will be remained only for few number of customers.

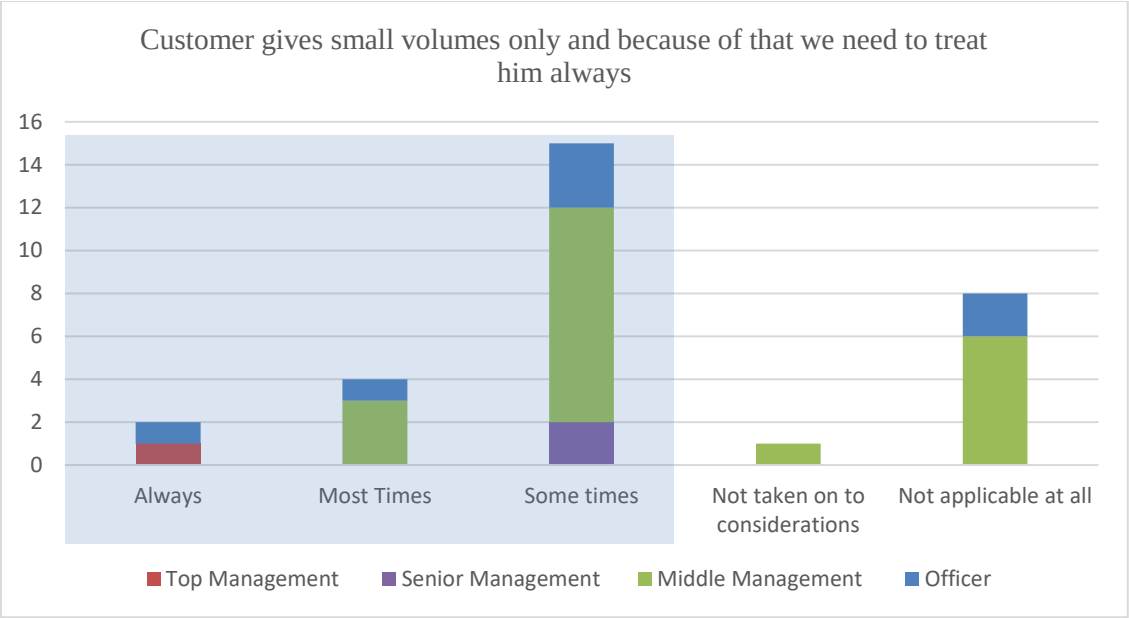


Figure 20-Considering customers with small volumes

But the people has responded on the same manner for large volume generators also. This is mainly because of they are the Key Accounts of the waste management business and they give more revenue to the business compared to small volume generators. On the other hand, they have more influencing power as the main customers of the business. More over due to the Key Accounts Management approach, INSEE Ecocycle is developing as well as has developed a close relationship with this customer group. The o, to the Sales account in charges.

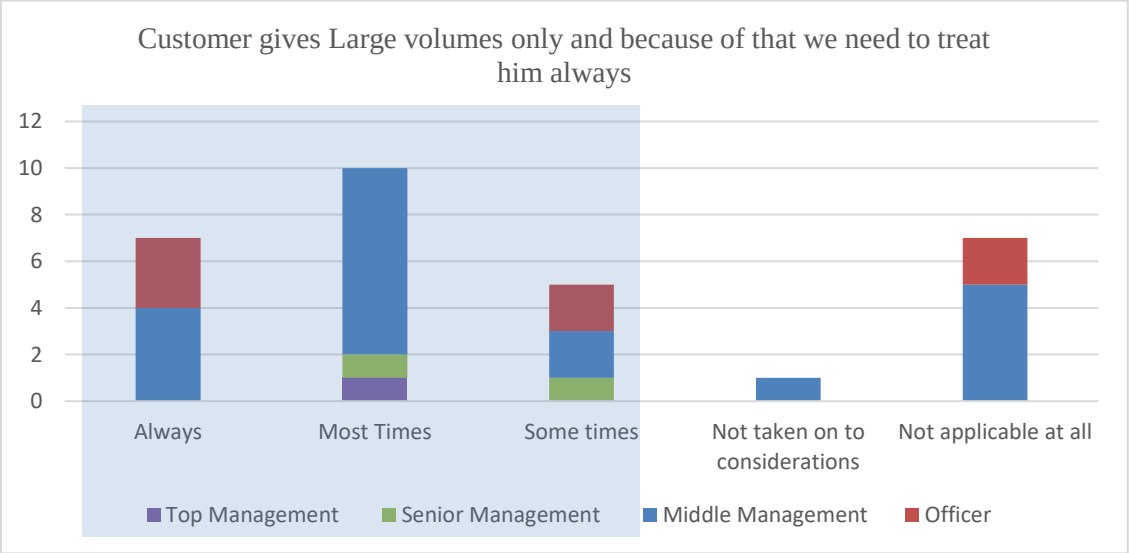


Figure 21-Considering customers with large volumes

As a result, the Account In Charges are facing much difficult situation on negotiating these customers. But when same kind of priority is to be assured to two exactly opposite set of

characterized customer segments, there is high potential to cause issue and confusion on to sales account in charges on prioritizing the customer.

Second factor on the factor analysis shows this status quo as those have been grouped in to a single factor and the considerations on the customers' volume generation is adversely influencing the optimization.

Table 13-Acceptance Considerations

	Factors						
	1	2	3	4	5	Mean	Std Dev
Consider_Cust_Small_Vol		0.894				2.70	.970
Consider_Cust_Plan		0.822				2.53	1.12
Consider_Cust_Large_Vol		0.789				3.57	1.12
Consider_Cust_Bare_Demur		0.773				2.86	.920
Consider_Cust_UnPlan_Reach		0.710				2.03	.870

There are three more parameters embedded in to this factor group. Customers planning characteristics as well as his acceptance of demurrage costs on unloading delays and customer sending trucks without informing.

Figure 22 and Figure 23 shows that there are certain personal who believe it is needed to have planning the volume intake if customer sends the truck without informing and if customer is willing to bare all the waiting and demurrage costs. This belief is causing consequences on the proper planning of the supply chain. When such sort of delivery is reached the plant, the plan of the waste acceptance is impacted and will jeopardize the pre plan. It will ultimately impact the immediate next day plan.

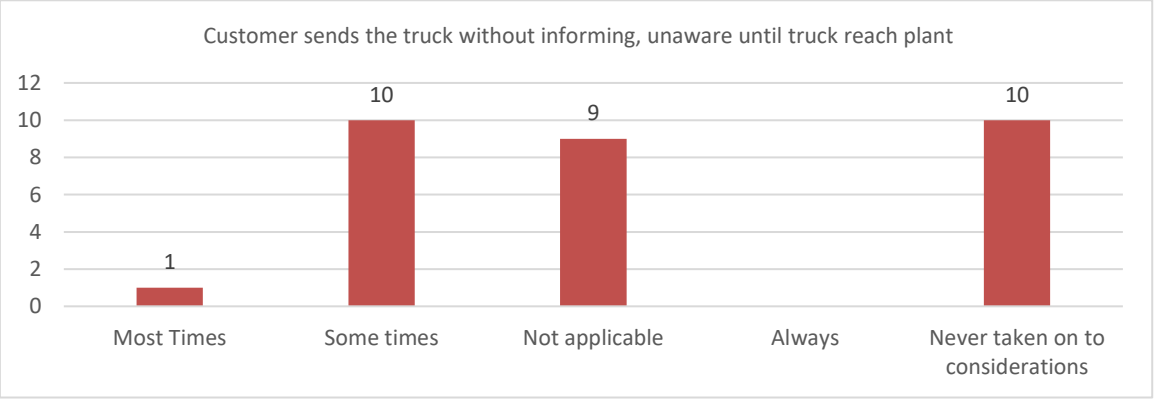


Figure 22-Facilitate when the customer send waste without informing

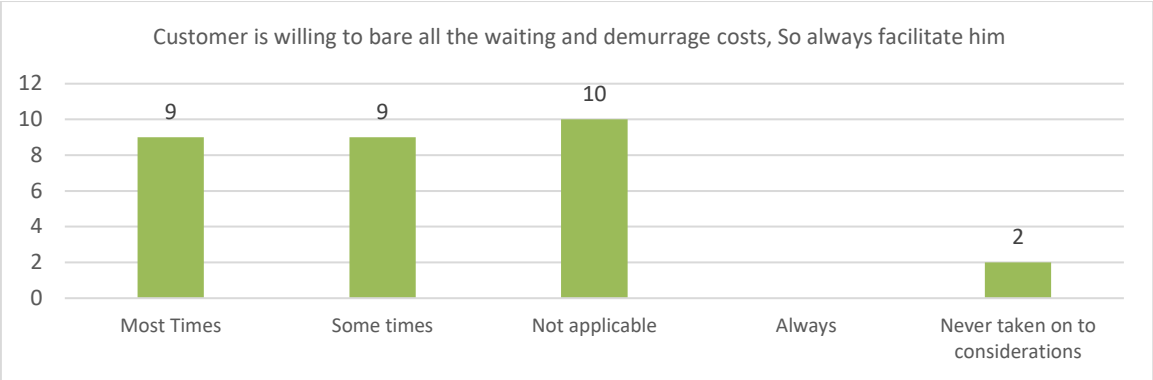


Figure 23-Facilitate when the customer willing to bare the demurrage cost

On the other hand when a customer is giving a proper plan, Ecocycle has to align with that plan. But it is visible in the Figure 24 that a minute number of people believing that it is not applicable on the proper planning of the customer.

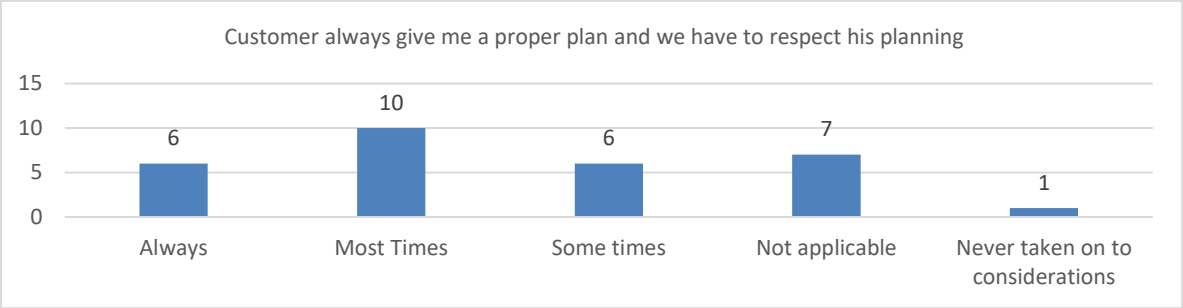


Figure 24-Customer Planning

Altogether this sort of different beliefs on the same characteristics are impacting the accuracy of the plan and the optimizing the supply chain.

5.1.3 Account In Charge Behaviors Factor

AIC's behaviors factor characteristics can be the visible impacting for the external stake holders due to above stated conditions. When the directions on prioritizing the customers on different characteristics, Account in Charge sales officers would come across different decisions as there are contradictory concerns. For example large volume vs small volume and pre non planning vs planning customers. This is visible to observers as account in charges do not understand the customer's volume generation or as gaps on team work.

Table 14-AIC behavior

	Factors				
	1	2	3	4	5
AIC_NoUnderstand_CusGeneration				0.891	
Motivation_Incentive_HigherVol			0.516	0.614	
Gaps_TeamWork	0.528			0.59	
Individual_Persoal_Demands				0.587	

Observers on the shreddable supply chain can visualize the issues in the supply chain in different modes. This survey is identifying the understandings and the beliefs of the respondents on different characteristics.

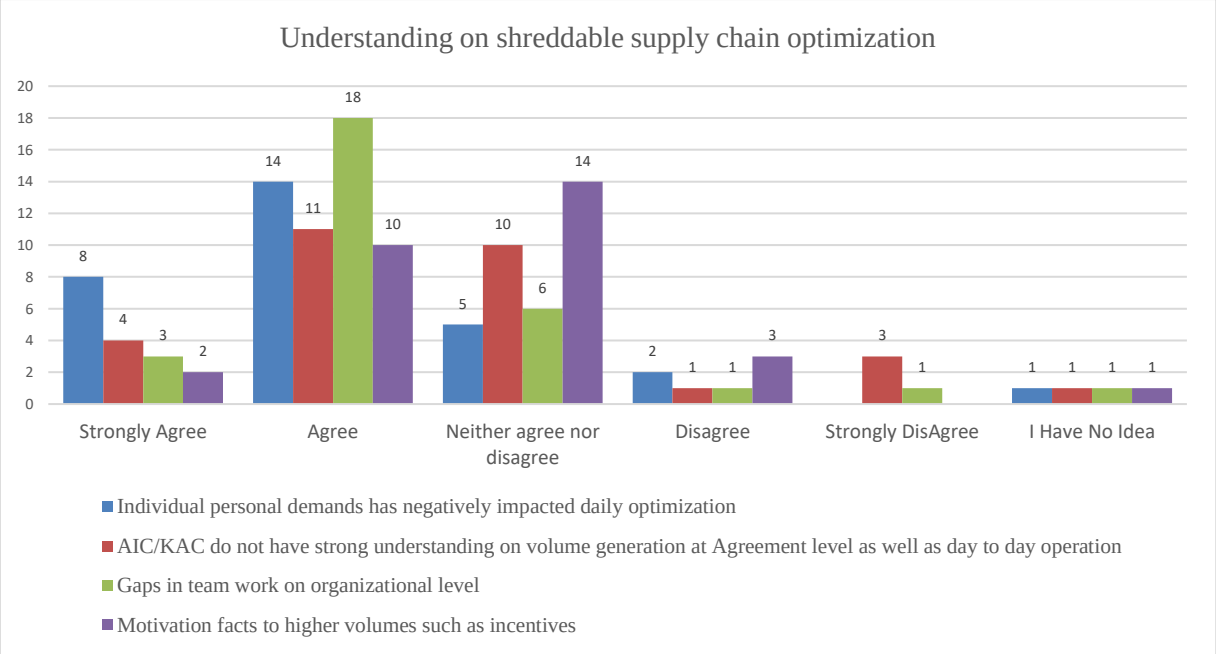


Figure 25-Understanding on Supply chain optimization

Characteristics embedded in to the factor four suggests that the respondents believe that

- Individual personal demands have negatively impacted daily optimization
- AIC/KAC do not have strong understanding on volume generation at Agreement level as well as day to day operation]
- Gaps in team work on organizational level
- Motivation facts to higher volumes such as incentives Since this kind of

For those questions, clear majority has agreed and strongly agreed on the above characteristics. We can conclude that the belief among majority is; there are issues among the behavior of the operations team.

Also we can see that certain factors are showing relationship to other factors also. Gaps in team work characteristic have been a component in the planning factor group also. That would be an obvious conclusion since when gaps on team work exists, the team cannot have agreed upon an optimized plan and will result gaps on planning. Understandings on functional boundaries of each other is well among these Account in charges since all are with ample experience of the business.

5.1.4 Organizational facts

This sort of individual behavioral issues are rising when there are gaps on management practices are existing. Factor four comprise of the group of concerns on those facts.

Table 15-Organizational facts

	Factors				
	1	2	3	4	5
Involvemen_Functional_Leader			0.801		
Org_Not_Install_Resources			0.735		
Unavail_Central_control_Role			0.635		

Grouping of those facts together indicates that there are certain improvements need to be made on the organizational behavior also.

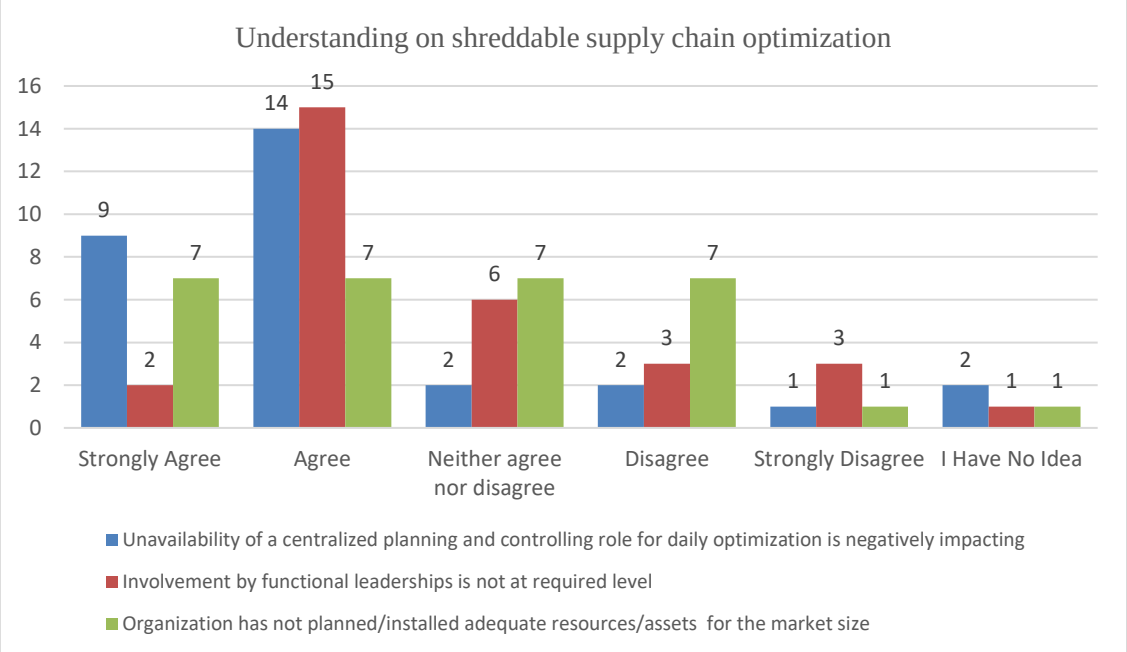


Figure 26-Understanding on Supply chain optimization

Majority has agreed that the unavailability of centralized roll and lack of involvement by functional leaders has negatively impacting for the supply chain optimization. Such

responses yields that the people believe that if the organization has put more attention on making a centralized role as well as more involvement by leadership would result better optimization.

This is going to be one of the underlying reasons for the of above discussed influencing factors for the optimization. If a centralized role is available for the planning, then that person would have the authority as well as responsibility to manage the customer requirements as well as the plant conditions. Then the sales account in charges will not need to come across negotiations on contradictions on selecting large volume vs small volume or planning vs unplanning customers among each.

When more involvement by the functional leaders on planning and especially on prioritizing is available, we can expect more rational supply chain management. Otherwise different sales account in charges would demand for individual achievements and may not be able to come to a single conclusion.

Both of central role and leadership goes jointly together as those two factors are interrelated to each other in the same aspect.

On the other hand the adequate resource availability do not shows a single majority as the responses are well distributed on agree over disagree. In general, supply chain management or optimization is always bounded to the limited resources availability. Task of management is to always optimize the deliverable with the available limited resources. Thus resource unavailability or inadequacy should not be considered as a impeding the optimization.

5.2 Organization Behavioral Impact

5.2.1 Impact on Experience in the supply chain optimization

Organizational structure of the Ecocycle business unit consists majority with middle management level staff and they are graduates (90% of the staff). Figure 11-Respondents, Figure 12-Respondents Experience and Figure 13-Respondents Education Level shows that with professional qualifications, medium level of industrial experience, and with a young staff compared to the cement organization, this team is driving the business. And this staff majority believes that the current supply chain is at a manageable level as per the Figure 14-Supply Chain Optimality. This conclusion may has derived under the understanding of the above discussed characteristics and/or factors. The staff is believing those factors / characteristics are in the operation model and themselves are operating under these circumstances.

The limited experience level and the young age would be influential to such conclusion. Young age and limited experience would be causing people to believe that optimization or improvement to condition always has to be achieved by providing favorable parameters. But not by optimizing the available resource. In the practical situation, optimum condition need to be achieved by managing the available resources and proper prioritizing by self.

5.2.2 Impact of planning in to the supply chain optimization

Figure 18-Plan Preparation shows that they prepare a reasonably accurate plan on weekly and monthly basis. However the factor analysis demonstrates that the planning has been a fact on the Supply chain optimization. Even though the team is preparing a plan, the effectiveness is challenging since planning itself has been a factor for the supply chain optimization. The accuracy drop as the time span shrinks is a good indicator show that the effectiveness of the planning is low. And the important fact on behalf on management and the time is that people spent more time frequently on inaccurate planning. But it is not suggested to omit or reduce the daily or weekly planning activity since the daily operation is highly contingent on the daily plan.

5.2.3 Reasoning for acceptance volume limitations

Figure 19-Employee Perception on different reasons shows how the people believe on managing different cases where the actual waste supply chain management is experiencing.

As per the figure we see that the majority of the people is believing to be flexible on accepting volume as per the situation. This sort of flexibility is always recommended for the customer satisfaction in the service industry. However being flexible always leads to changes in the plan and that is causing inaccurate planning. Some of those facts assessed on the survey are related to the safety and compliance (such as storage are filled incidents, Planned maintenance) of the operation as well as some are precautionary measures (such as VIP visits or ISO audits) taken for operation while limiting acceptance. Employees may get confused to select which end for this kind of practical situations as they must serve the customer to delight the customer while stick to the organization objectives on safety and compliances.

6 Summary of findings and recommendations

6.1 Summary of findings

Findings of the research on the Supply chain optimization can be summarized as below

- Majority of the Ecocycle staff believes the existing supply chain of shreddable waste is in manageable situation
- Customers are recurrently contacting for delivery arrangements and other related queries
- Annual, Monthly, weekly, daily planning is done for the waste acceptance, but the accuracy drops as the time span reduces
- Staff believes it is necessary to be flexible on waste acceptance despite different limitations in place
- There are certain areas for improvement on the management and the team work

6.2 Recommendations

Under these conditions of the there are certain decisions to be made by the management of the Ecocycle to improve the waste supply chain especially for the shreddable material. In general all the recommendations would be for the management of the supply chain and the processes rather than recommending for infra structure development or recruiting more people.

6.2.1 Policies development

There should be standard guidelines to prioritize the customers under the limited acceptance capacity. Even though the customers or the sales account in charges demanded, there is a maximum volume where Ecocycle is capable of accepting. Thus there it is recommended to develop policy and guide lines for prioritizing the daily or weekly waste acceptance. This policy should clearly resolve the ambiguities on prioritizing which were identified in the survey such as large volume vs small volume.

The responsibility of favoring on the small volume generators or the large volume generating customers as well as enforcing to accepting the planned volume irrespective of audits or visits are needed to be specified in the policy. Also there are several characteristics of the business to be considered on prioritizing as customer satisfaction is mandatory for the long run of the business. Because of that Waste volume accumulated at the generator and the Minimum volume needed to be cleared immediately are also important facts. However in the

prioritization always business needs to consider on the revenue gain by the particular waste stream and that also should be an area covered in the policy.

6.2.2 Organizational Structure changes

Establishing a centralized role for the waste acceptance planning and management is an urgent less capital incentive step. The Particular role should be empowered to decide the priorities on the daily basis and the above discussed deliver prioritizing policy would be his guide. Management of the Ecocycle team should select the most suitable personal for this role since this is the role who is deciding the organizations revenue as well as the customer satisfaction. The person should have some good negotiation skills to manage the internal stake holders as well as the external customers.

6.2.3 Tools development

6.2.3.1 Revenue Optimizer

It is recommended to develop models and ICT tools for revenue optimization while improving customer satisfaction over waste supply chain. A model can be developed for monthly, weekly, and distribution planning by considering different parameters for the highest revenue.

Equation 1-Revenue Optimization

$$\boldsymbol{Maximize}\ (\boldsymbol{Revenue}) = \sum Volume_{\ 1} \times Price_1 + Volume_{\ 2} \times Price_2 + .. + Volume_{\ n} \times Price_n$$

Equation 2-Volume Planning-Individual

Volume per customer = ***function of {*** *Material properties, min volume for satisfaction, vehicle availability, Total waste availability****}***

Equation 3- Volume Planning-Plant acceptance

Total Acceptance volume = ***function of {****Material properties, feeding capacity, space availability, maintenance plan, other(audits, visits etc.)****}***

By developing this kind of models, Ecocycle can calculate the optimum volume mix for the given time frame and then the above recommended centralized role is obliged to deliver the volume in the given time frame.

Another research is recommended to develop this model in order rate the impact of each characteristic under different circumstances.

Below images show an example of excel tool developed for the optimization.

Customer	Type	Material	Price	Plan	Total	Min	Availability
USL	Polythene	Polythene	4,500.00	9.999997	44,999.99	1.00	10
Dilmah	Non Branded	Foam Waste	4,500.00	1	4,500.00	1.00	300
Dilmah	Branded	PVC and Plast	7,500.00	4.999994	37,499.96	1.00	300
MAS	Yarn	Textile	5,500.00	3.999997	21,999.98	1.00	200
MAS	UnCut Yarn	Textile	10,500.00	35.99997	377,999.73	1.00	200

Figure 27-Optimized Volume

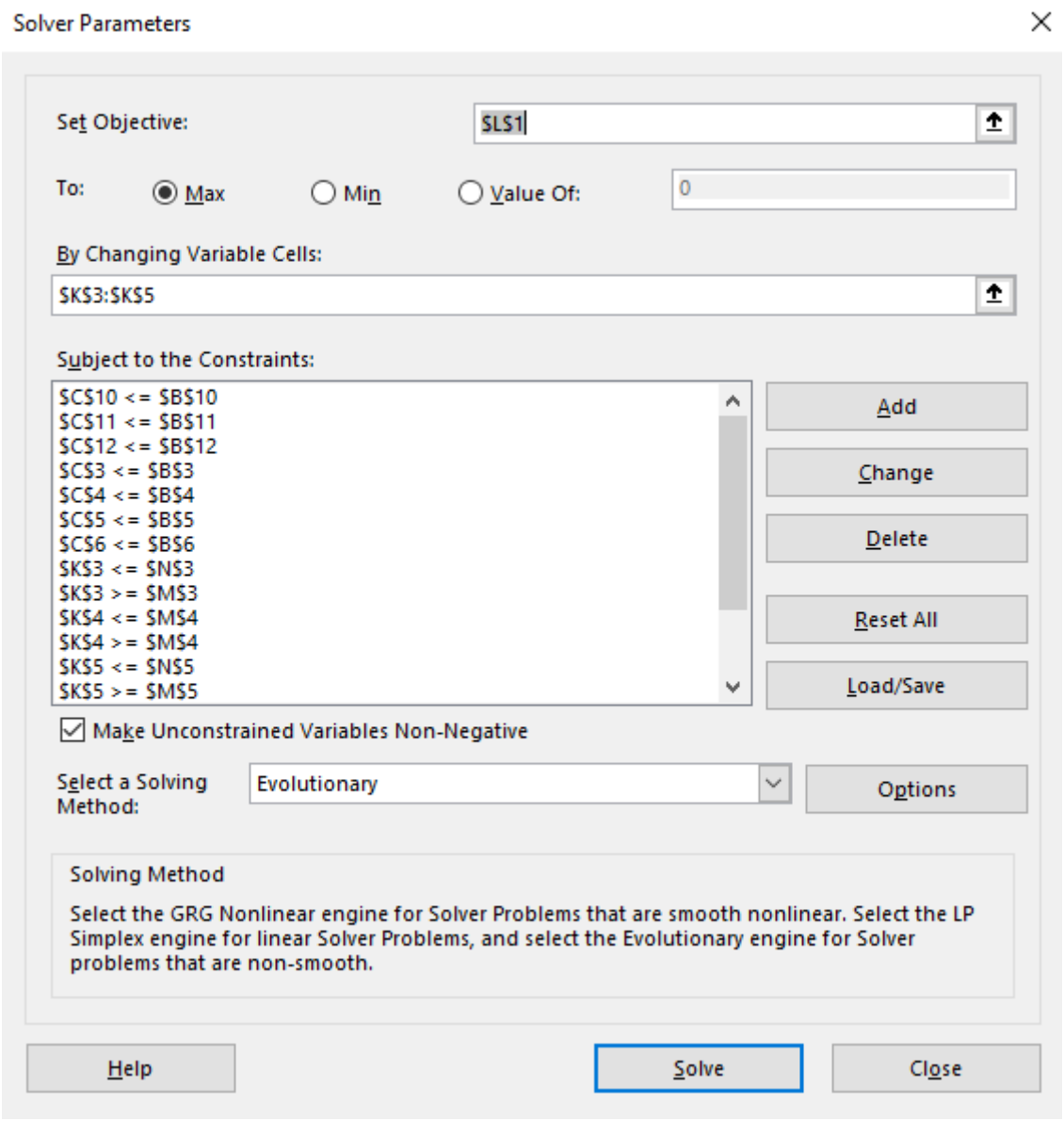


Figure 28-Excel Solver conditions

Usage of excel is limited for the operation due to the limitation of maximum number of constraints of 256 is not sufficient. Thus a more advanced optimizer tool is recommended.

6.2.3.2 Communication channel development by CRM

Ecocycle need and can minimize the number of communications from customers to the sales Account in charges for their daily delivery planning by extending their existing Delivey Management System such that the customers can make the bookings. Also the system need to be extended with SMS and email facilities where the customers are communicated on exact date of delivery accepting to the plant. On this way, Ecocycle can significantly drop the extensive communications received from the customers for the daily delivery planning.

6.2.4 People development

Knowledge, skills, Attitudes are the components of the people development on any arena. Especially on this Ecocycle waste supply chain management related people development, one of the main need is to develop the peoples skills on the team work and planning. This is a identified fact in the survey which would not need any extra expenses. Focus should be on building trust among each other team members and functions especially on communicating the actual possible volumes of the waste generation.

Reference

Bandara, Y. M. and Nguyen, H. (2016) 'Influential factors in port infrastructure tariff formulation , implementation and revision', *ELSEVIER*, 85, pp. 220–232.

Dougherty, M. (2009) 'Supply chain optimization'. Available at: http://www.dhl.com/content/dam/downloads/g0/logistics/case_studies/DHL_Optimisation_Casestudy_Jaguar.pdf.

Editorial Team at Exforsys (2017) *Supply Chain Optimization*.

Garcia, D. J. and You, F. (2015) 'Supply chain design and optimization : Challenges and opportunities', *Computers and Chemical Engineering*. Elsevier Ltd, 81, pp. 153–170. doi: 10.1016/j.compchemeng.2015.03.015.

Major Industries In Sri Lanka (2015) *UK Essays*. Available at: https://www.ukessays.com/essays/economics/major-industries-in-sri-lanka-meaning-of-industry-economics-essay.php (Accessed: 2 December 2017).

Markim, A. (2015) *7 Characteristics of A Best In Class Supply*.

Ratliff, H. D. (2013) *10 Rules for Supply Chain & Logistics Optimization*. Available at: http://www.supplychain247.com/article/10_rules_for_supply_chain_logistics_optimization
.

Veerakamolmal, P. and Gupta, S. M. (2001) 'Optimizing the supply chain in reverse logistics', *Proceedings of SPIE - The International Society for Optical Engineering*, 4193(617), pp. 157–166. doi: 10.1117/12.417259.

Ziegler, D. *et al.* (2006) 'Guidelines on Co-processing Waste Materials in Cement Production', *The GTZ-Holcim Public Private Partnership*, 20(9), pp. 1–135. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Guidelines+on+co-processing+Waste+Materials+in+Cement+Production#0.

Hazen BT, Boone CA, Ezell JD, Jones-Farmer LA. Data quality for data science, predictive analytics, and big data in supply chain management: an introduc- tion to the problem and suggestions for research applications. Int J Prod Econ 2014;154:72–80

V. D. R. Guide Jr., R. Srivastava and M. S. Spencer, "An Evaluation of Capacity Planning Techniques in a Remanufacturing Environment", International Journal of Production Research, vol. 35, no. 1, pp. 67-82, 1997