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Message from the Chairman
Sri Lanka Society for Transport and Logistics
(SLSTL) and R4TLI – 2016 Conference Chair



The inauguration of the R4TLI - Research for Transport and Logistics Industry came from a growing understanding of the gulf that exists between the practice and research of transport and logistics in many developing countries including Sri Lanka. It is becoming increasingly apparent that Sri Lanka which seeks to exploit its geographic position to re-establish itself as a global logistics hub needs to reach the state of the art operational levels to compete with the already well established and rapidly advancing hubs both to the east and west of Colombo. Its poor choice of investment in logistics infrastructure, lack of cutting edge research or development does not auger well for its ambitions to become a logistics hub.

The R4TLI conference is a humble, yet significant beginning to harnessing the synergies of academia and industry in an effort to improve the performance of the transport and logistics industry in Sri Lanka and other developing countries. The conference which has attracted abstracts from senior academics as well as young researchers both from Sri Lanka and the region, is a validation of the potential for research and development.

Since the conference aims at high-end research, rigorous quality control has been carried out to ensure that all papers presented at the conference are of international standard. A panel of international reviewers from Japan, Hong Kong, Australia, Canada, Taiwan, Sri Lanka and Singapore have reviewed and recommended papers for presentation. While over 60 abstracts were received, only around 40 were accepted for inclusion in the proceedings. Only around 20 authors have been invited to submit full papers.

I am also encouraged by the assistance given by the Chartered Institute of Logistics and Transport Sri Lanka (CILTSL) and the membership of the Sri Lanka Society for Transport and Logistics (SLSTL). The unstinted financial support from the industry lead by the sole sponsors Walkers CML and the enthusiastic sponsorship received for the research awards from several leading establishments in the field of transportation and logistics has been overwhelming.

I also wish to place on record the assistance received from the Joint Organising Committee and the Scientific Committee of this conference which has greatly contributed to making this conference a success. Furthermore, the assistance received from the Secretariat of the CILTSL and the SLSTL is also duly acknowledged. The support extended by the Eastern Asia Society for Transport Studies (EASTS) and the personal attendance at the conference by its leadership is also greatly appreciated.

Thank you.

Amal S. Kumarage PhD
Chairman - Joint Organising Committee

Message from the Chairman
Chartered Institute of Logistics and Transport -
Sri Lanka



I am extremely happy and privileged to avail this opportunity to share a few congratulatory words with all those who are involved with the inaugural symposium on Research for Transport & Logistics Industry (R4TLI). This is an initiative spearheaded by the Chartered Institute of Logistics and Transport - Sri Lanka (CILTSL) and the Sri Lanka Society of Transport and Logistics to foster a culture of research and development within our industry in Sri Lanka.

This research symposium provides a forum for bringing academics, industry professionals, and students together to share their findings with the Logistics and Transport community. I am encouraged by the very high response received for the Call for Abstracts, which reflects the demand for such an opportunity by the research community into this very important and internationally relevant subject area, and the research potential and talents of the authors. It also demonstrates the possibility of this initial effort turning out to be a great success in bringing out items of immense interest to all stakeholders, both from Sri Lanka and overseas. I wish to acknowledge the dedication and commitment of the Scientific Committee and the Review Panel for making this an outstanding event. I also congratulate the authors who have put in so much effort in preparing their submissions and presentations. Moreover, I extend a warm thank you to each and every person and organisation that have been involved in this endeavour and their generous support in making this conference a success.

I trust that this symposium will be the first of many, and will serve a catalyst for further research on these aspects, enabling us to have more events of this nature in the coming years. I strongly believe that the outcome of such events will bring tangible benefits to the industry, both at home and abroad, and will pave the way for its furtherance into the future.

Have a successful and enjoyable R4TLI.

Capt. Lasitha Cumaratunga, Master Mariner, CMILT, MICS
Chairman - CILTSL

**Message from Professor Tetsuo Yai,
President of the Eastern Asia Society for Transportation
Studies (EASTS)**



Dear Distinguished Members of Sri Lanka Society for Transport & Logistics,

I am pleased to extend, on the behalf of Eastern Asia Society for Transportation Studies (EASTS), the warmest congratulations to the first international conference of SLSTL, Research for Transport & Logistics Industry (R4TLI).

EASTS was founded in November 1994 with 13 countries/regions in Eastern Asia. As of September 2015, the member domestic societies join from 19 countries/regions, including Sri Lanka. More countries/regions are expected to join as member domestic societies.

The primary objective of EASTS is to foster and support excellence in transportation research and practice. Under the objectives, EASTS is organizing biennial International Conferences. Since the 1st Conference held in Manila, Philippines in 1995, 11 conferences were held in EASTS area and provided great opportunities to enrich participants' professional knowledge. The 12th conference will be held in September 2017 in Binh Duong, Vietnam.

We believe SLSTL has contributed significantly in Sri Lanka and could be a more essential key player throughout the world. I believe SLSTL has significant potential and will thrive more with your continuous support and contribution.

Once again, congratulations to the first international conference.

Tetsuo Yai,
President of EASTS
Professor, Dr. of Eng., Tokyo Institute of Technology

Message from Professor Chan Wirasinghe

I am pleased to be associated with the inaugural international conference on “Research for Transport and Logistics Industry (R4TLI 2016)” to be held in Sri Lanka in June 2016, organized by the Sri Lanka Society of Transport and Logistics and the Chartered Institute of Transport and Logistics Sri Lanka. The submissions selected for the conference, from authors ranging from international experts to Sri Lankan students, are of high quality and cover a wide range of topics from theoretical to practical applications as well as logistics to passenger transportation. The Conference will in particular be a boon to the burgeoning logistics sector of Sri Lanka. I am very confident that the R4TLI 2016 will be an outstanding success. I congratulate Professor Amal Kumarage and others for organizing an international conference that will have an impact on academia and industry beyond the shores of Sri Lanka.



Sincerely,

S.C. (Chan) Wirasinghe
Co-Chair, Scientific Committee
Professor of Civil Engineering
Founding Dean (Emeritus) Schulich School of Engineering

Editorial Preface

Modern society faces a real challenge of producing and delivering transport and logistics services demanded through the production and consumption activities of the socio-economy. It is imperative that these services are generated and supplied efficiently in order to make such economic activities competitive and less costly while making the maximum possible contribution to the nation's GDP through the process of providing such services. Yet, at the same time, it is equally important that their derived necessity in the socio-economy be minimised, given the negative externalities with which their production and delivery are associated.

These twin challenges call for scientific endeavours in the transport and logistics sector to diagnose the issues it faces, to evolve innovative methods for the industry-wide adoption, to ensure continuous technological advancement, and to formulate and implement strategic plans and policies, in view of supporting it to emerge successful in the ever-intensifying competition of a business environment.

The inaugural Research Conference R4TLI-2016 was organised jointly by the *Sri Lanka Society for Transport and Logistics* and the *Chartered Institute of Logistics and Transport - Sri Lanka* as part of an effort to address this need, by encouraging the pursuit of research and dissemination of their findings. This publication is the culmination of that effort, and an accomplishment in itself.

As the Editorial Committee, we consider it a privilege to have had the opportunity to go through the rich collection of abstracts compiled herein, which proved to be a reward in itself. We are confident that this book provides ample proof of the potential *R4TLI 2016* has, to become an intellectually stimulating event.

We are grateful to the eminent reviewers from both Sri Lanka and abroad who tirelessly contributed through an intensive process of reviewing abstracts, and without whom it would not have been possible to compile this publication in its present quality and standing.

It is our hope that the *SLSTL* and *CILT-SL* will sustain the momentum that *R4TLI 2016* has gained in stimulating discourse on the significance, potential and challenges of the transportation and logistics industry, and in strengthening it, in years and conferences to come.

Chief Editor

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CONFERENCE ON RESEARCH FOR TRANSPORT AND LOGISTICS INDUSTRY 2016



Inaugural International Symposium

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TRANSPORT POLICY

User Rights in Passenger Transport

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1. Introduction

The agreements between users and providers of transport services are complex. In formal and regulated markets, agreements exist that are legally binding. However, in many informal markets common in developing countries, there are only broad consumer protection laws at best. This study reviews the different types of transport policies, consumer laws and contracts of carriage that determine transport user rights. First it identifies a hierarchy of general parameters of human rights through literature. Secondly, with the combined analysis of literature and primary data gathered through a questionnaire, it develops a framework of user rights in passenger transport. The study identifies the different service attributes that constitute satisfactory mobility and how the delivery of such expectations can be measured. These expectations have been classified under four headings, namely, the right to access, right of receiving the service offered, rights arising from unforeseen circumstances and the right to redress.

2. Literature Review

Discussion about human rights has gained much importance in the academic as well as political spheres. The Universal Declaration of Human Rights (UDHR), which is regarded as the primary document pertaining to human rights discusses a wide range of rights related to freedom such as those pertaining to equality, life, recognition, marriage, property, religion or belief, expression, assembly, governance, employments, leisure, education and culture. The traditional notion of human rights is further developed by later researchers by specifically bringing in the gender perspective, economic and social freedoms, political rights and participation in governance, moral obligations and legal institutionalisation. Thus, the general parameters of rights can be identified in a hierarchical pattern, until the level of ultimate liberation is reached.

The user rights in transport can be viewed as a subset within the large picture of human rights. Previous literature lacks any approach that discusses transport user rights as a whole. The current trend in literature has been limited to identifying the strengths and weaknesses of the existing legal framework regarding passenger

rights, or to evaluate the passenger needs within a specific sector. European Commission Transport Law can be considered as one of the most comprehensive passenger rights frameworks while Australia, Ireland and USA also provide legislation for the protection of transport user rights. Sri Lanka, like many other developing countries, has a strong legislative framework pertaining to rights in general, but the rights of transport users are not explicitly set out. Due to the complexity of the complaint and redressal processes many users refrain from seeking legal solutions. This lack of protection is also associated with poor governance issues and vulnerabilities of people.

3. Methodology

The crucial factors which affect customer satisfaction in public transport were identified as waiting time, service quality, cleanliness, comfort, reliability, driver kindness and vehicle quality. Availability of clear information is also a decisive factor for service quality. Another significant measure of transport improvement of a country is its accessibility by the disabled. Most developed countries have taken in to account passenger satisfaction and convenience when framing legislation regarding the passenger rights (Karsten, 2007; Government of Victoria, 2014; Irish Rail, 2008).

Based on information gathered from the previous studies and international models (dell'Olio et al., 2011; dell'Olio et al., 2010; Karsten, 2007), a questionnaire was developed in order to conduct a survey to validate these parameters. This questionnaire measured the attitudes and awareness of passengers about their rights, covering all modes of transport. The responses to questions were based on Likert scale from 0 to 5, 0 standing for the lowest and 5 for the highest ranking. The survey was conducted on an open participation basis. A total number of 180 responses from 17 countries were received. The data were analysed using excel software. The responses were analysed according to three criteria: developing versus developed countries; regular users versus non-regular users; and male versus female passengers.

4. Results and Discussion

While there were no significant differences in the responses depending on the gender, the other two categorisations showed substantial differences. Compared to developed countries, awareness as well as protection of rights is at a lower level in developing countries. Passengers in developing countries experience discrimination in accessing bus, rail and taxi services. They also face a number of difficulties in accessing the complaints and redressal procedures. Passengers from developing countries also face issues of safety and reliability in their encounters with fellow

passengers. It is evident in the data that regular users of bus and rail services are more aware about the availability of information on those services, user rights and redressal procedures. However, when it comes to delays and accidents, the refund and compensation procedures are quite difficult and unpromising for the passengers using bus, rail and taxi services in developing countries. The overall analysis highlights a significant difference in all aspects between users of bus, rail and taxi, and users of airlines and ships.

5. Conclusion

It is necessary to integrate passenger expectations into policy circles in order to ensure the rights of passengers are protected. It is important to ensure that passengers have adequate information about their rights and easy access to the rights-protection processes. The difference between developing and developed countries arises mainly due to the lack of awareness and of information.

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Keywords: *User rights, Transport, Service Attributes, User expectations*

Use of Stated Preference Survey to Determine Design Parameters of a Rideshare System: A Case Study from Sri Lanka

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Thillaiampalam Sivakumar

University of Moratuwa, Sri Lanka

1. Introduction

With nearly one million registrations at present, three-wheelers are the second-most popular vehicles on Sri Lankan roads, in terms of vehicle number. Promoting three-wheeler based taxi sharing could be one way of increasing high-occupancy vehicles on roads to cater to the existing trip purposes of road users while disincentivising the introduction of still-more three-wheelers to the existing fleet.

A short corridor of 1.4km length between the University of Moratuwa (UOM) and Katubadde junction in Sri Lanka was considered as the case location for this research as shown in Figure1. Available modes of travel for users in this corridor are bus, car and three-wheeler (TW). During morning and evening peak times, the share of road users from UOM is considerable. Students of UOM being a population of nearly 8,000 account for a larger share (90%) of all commuters. In the case of the corridor concerned, bus and TW are the most common modes of transport among students. The research objectives were to identify: (1) barriers in implementing ridesharing, (2) suitable approach to initiate taxi share and (3) realistic design parameters for ridesharing for decision makers.



Figure 1: Location of the study area (Source: <http://goo.gl/maps/QvPEd>)

2. Methodology and Analysis

A group of 50 students were considered as a convenient sample while the population of interest was the cohort of undergraduate students of UOM. Face-to-face interviews were conducted along with structured questionnaires to collect data such as socio demographic, trip-related information including mode of travel to UOM and data such as opinion on ridesharing using TW.

According to preliminary analysis, students expressed a higher level of satisfaction (8.6 out of 10 point Likert scale) arising from TW use while being neutral about buses (5.5 out of 10). In addition, the analysis indicated that 24% of respondents have tried self-initiated TW ridesharing. Both the above findings strengthened the case in favour of TW as a mode for ridesharing. However, 56% of respondents openly expressed that the main problem in ridesharing is negotiation. While respondents were reluctant to initiate pooling, interestingly, 94% of respondents expressed their willingness to take part in ridesharing when pooling was initiated by others. Jayasinghe and Sivakumar [1] identified it as a social and cultural issue in developing countries in general.

In order to overcome the problem of negotiation, the study proposed an infrastructure modification by dedicated halt (Share-Point) for gathering of TW users would be planned adjacent to existing bus stops to invite all users who are willing to make a rideshare while accommodating 56% of people who believe negotiation as the main problem towards ride sharing.

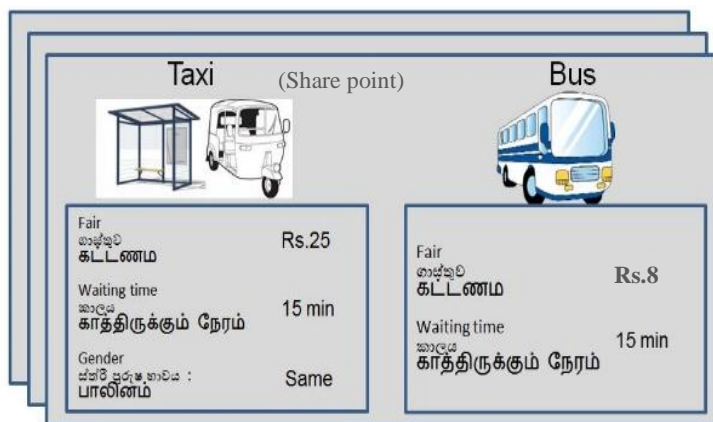


Figure 2: A sample card with SP survey question

A stated preference (SP) survey was designed to predict the future ridesharing market share based on this new share-point concept. Bus and TW were the only two modes considered as alternatives. Based on SP cards presented to respondents, the choice between two alternatives were recorded and analysed. In SP survey, bus fare

and average waiting time were fixed at LKR 8 and 15 minutes respectively while TW mode is attributed with different levels as follows: (i) fare in LKR [15, 25, 35, 45], (ii) Waiting time in minutes [5, 10, 15] and (iii) Gender [Same, Opposite]. The same 50 students were responded for SP survey with maximum of 24 cards (4×3×2) per respondent.

Based on responses collected, the probability of students waiting for ridesharing was identified as shown below in Table1.

Table1: Probability of TW being chosen over bus by a student

			TW fare per person/ (LKR)			
			15	25	35	45
Waiting time for TW/ (min)	5	Same Gender	0.98	0.62	0.48	0.26
		Opposite Gender	0.86	0.52	0.36	0.14
	10	Same Gender	0.90	0.54	0.38	0.20
		Opposite Gender	0.78	0.42	0.18	0.10
	15	Same Gender	0.76	0.34	0.34	0.08
		Opposite Gender	0.66	0.16	0.02	0.02

Though ridesharing was proven as win-win solution for riders and operators [1], ridesharing is still critical as the operators are motivated only by higher fares to make operators receptive to this system [2]. While the current fare per trip of the stretch is Rs. 70 and the maximum carrying capacity per TW is three riders as per regulation, ridesharing is possible with two or three riders. Therefore, realistic fare per rider to motivate operators would be LKR. 35 and LKR. 25 respectively, as shown in Table2.

Table 2: Willingness to share a TW against various design parameters

No of people to share	Most realistic fare per person/(Rs.)		Waiting time		
			5min	10min	15min
2 (minimum; for sharing)	35 (= 70/2)	Same Gender	0.48	0.38	0.34
		Opposite Gender	0.36	0.18	0.02
3 (maximum; as per TW capacity)	25 (\cong 70/3)	Same Gender	0.62	0.54	0.34
		Opposite Gender	0.52	0.42	0.16

3. Conclusion

This study identified volunteer reluctance to initiate a ridesharing negotiation as one of the major barriers among the people. Unlike in developing countries where various agents fill this gap through ridesharing clubs in Sri Lanka such clubs are not very common yet. Since TWs are generally waiting at informal stands closer to bus halts, this study proposed a share-point through a new infrastructure as a solution to overcome this barrier of negotiation. The proposal was tested using stated preference survey and ridesharing found to be feasible.

The SP survey also identified willingness to wait at share-point for TW along with various design parameters which could be used as initial estimators for decision makers. Willingness to go for rideshare from same gender was identified as being always higher than that of opposite gender which reflects local culture.

Gender category of same-gender and opposite gender can be further studied by considering all possibilities of gender mix (namely MMM, FFF, MM, FF, MMF, MFF, MF, where M and F stand for male and F respectively) for better clarity as gender would be a sensitive parameter in developing countries.

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Keywords: *Ridesharing, Stated Preference, Para-transit*

Developing a Fare Index for Para Transit: The Case of Urban Three-wheeler Taxi service in Sri Lanka

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1. Introduction

Para Transit is a popular informal public transportation service in Sri Lanka where three-wheeler plays the dominating role. There have been many studies carried out on para-transits known as informal public transport modes. In developing countries, most para-transit services are not regulated, and they function as a self-regulated manner. Many cities in developing countries have their own, often highly distinctive, forms of informal transportation.

Research has revealed several factors which contribute to the emergence of an informal public transport service. Initially, these modes have developed suddenly to fill gaps in conventional transport of urban areas [1]. The need to have integrated transportation connectivity is ever-increasing in transport systems in many parts of the world. The three-wheeler fleet in Sri Lanka comprises of around 1,000,000 vehicles accounting for around 17% of the active motor vehicle fleet [2]. These three-wheeler operations demonstrate a lack of regulatory control, and cartelised service provision featuring oligopolistic market behaviour. 74% of three-wheeler operators are registered at a particular three-wheel park having an informal unionised operation, while the rest park their vehicles at different locations and are not among the unionised three-wheelers [3]. Three-wheelers complement and most of the time substitute public transport services by transporting passengers along routes on which bus service is not available. Nevertheless, users have to pay much higher fares than the public bus fare. The existing fare systems are of three types and include fares decided through negotiation, fixed fares and meter based fares.

As a solution to fare charge conflicts, this paper presents fare index developed based on the vehicle operational cost. The paper is based on a survey of the operators who provide their services in Colombo Municipal Council area.

2. Scope and the objectives of the study

This paper aims at identifying methodology to calculate fare index for three-wheeler taxis, based on vehicle operating costs. To derive a fare index, there must be a logically determined basis of computing the operating cost of three-wheelers. The cost of three-wheeler operations are made in to costs on inputs such as value of fuel, tires and spares. Fare index will be presented as a distance-based function which includes the fare per kilometre. A cost index must be sensitive to the variations in the operating cost of the three-wheeler taxi service due to differences in the cost components, so that it can be used as regulatory indicator to revise fares whenever it is needed. The index is therefore a weighted average of all individual cost inputs. Consequently, a cost index is a composite index of all the components of costs under both operating types. This research sets out to derive the cost index as an iterative process.

3. Methodology

A questionnaire was developed based on the survey form developed by Kumarage, Bandara, & Munasinghe [3]. The structured questionnaire consists of 21 questions with sub questions to gather more profound data on owning the vehicle (license & registration costs, insurance costs), fuel cost, tire wear cost, vehicle repair and maintenance cost. The sample consists of randomly selected 30 three-wheeler drivers operating in Colombo city. Therefore, two types of three wheeler operator groups were used as the sample for this research. After finding values for the above cost categories, a cost index is developed with the fixed costs and variable costs. Since there should be only a single-fare structure implemented for all types of operators, it is necessary to arrive at a single index to calculate a weighted common operating cost. The result will be then presented using a formula as follows:

$$VOC = (O_c + D_c) + d(T_c + M_c + F_c)$$

Where;

- VOC - Vehicle Operational Cost per journey
- d - Distance travelled per journey
- D_c - Vehicle depreciation cost
- O_c - Costs of owning the vehicle
- T_c - Tire wear cost
- M_c - Vehicle repair and maintenance cost
- F_c - Fuel cost

Vehicle operational cost itself does not provide any information which is requested by the user. Therefore a distance based fare structure is needed to convey the

information more comprehensible manner. Following formula is adopted to construct the distance based fare structure,

$$F_i = f_0 + f_i (d_i - d_0)$$

where f_0 is the initial charge and d_0 is the distance covered by f_0 ; f_i is the charge rate for next km travelled [4]. Assuming that d_0 is equal to one kilometre, the above formula is modified as follows;

$$F = f_0 + f_i(d_i - 1)$$

For the calculation to get a value for f_0 which is the initial charge (minimum fare) for a three wheeler ride, all cost components are considered. However to calculate f_i which is the charge for next kilometre travelled, only the fuel cost, tire wear cost and maintenance cost are considered as they are the costs that will increased when distance increases.

Based on the vehicle operational cost estimates derived by analysing survey data, a distance based fare equation was estimated as below.

$$F = 30.68 \text{ LKR} + 7.49 \text{ LKR}(d_i - 1)$$

where; F = Minimum fare for a journey of d_i km

d_i = Total distance

4. Conclusion and Implications

Pricing and costing transport services is important for ensuring the profitability even though the three wheeler taxi sector is deregulated. If costs are too high, then demand will be less and even though transport capacity may exist, it will not benefit the passenger or the operator. On the other hand if costing is too low, the supplier may ultimately run out of the business even though the user will benefit. In this research fare index is presented which was derived with the value of vehicle operational cost in which fixed charged (Rs.31) is related to the all costs and variable charge based on distance is based on the operational costs. Further to this research, in order to improve the fare index presented, value of time (waiting time, traffic congestion) can be considered for future research. Further research also needs to consider user expectations and the demand.

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Keywords: *Para Transit, Informal Public Transport, Three wheeler, Vehicle operational cost, Fare Index*

TRANSPORT MODELLING

An Application of Agent-based Modelling to Explore the Complexity of Public Recreational Places: Case Study: Weras Ganga Public Park, Sri Lanka

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1. Introduction

In the contemporary planning practice, there available various methods to understand Safety in Mobility (SM) (Alemian et al., 2010). Yet the possibility to study different scenarios in order to select the best measures to enhance SM is minimum with regard to public spaces. For a space to become a place for everybody, the rhythm of time and the patterns of user behaviour which reflects the level of importance that place generates in the city life is very significant. Since this combination of people, space and time form complex relationships, particularly in public recreation spaces, there arises a crucial necessity to identify the true nature of complexity in order to facilitate safety of the users. In the modern scientific fields, the Agent-based Modelling (ABM) concept is vastly utilised to understand complex systems. The ABM enables the ability to create, analyse and experiment complex systems with models composed with agents that interact within an environment. (Tosto, 2012)

2. Research Background

A complex system comprised of numerous particles and their inter-relationships; hence every part and particle and each act of the elements within a system becomes highly important. At the same time, the 'entire structure' is much-more than the 'sum' of all those parts and inter-relationships. Most importantly, complex systems are continuously progressing and unfold over time (Batty, 2007).

The dynamic nature of public recreation spaces also have these characteristics, and hence can be considered as highly complex systems where safety is a higher level concern. Therefore, it is required to pay attention to the complex combination of individual behaviours in the physical setting of public recreation spaces to identify measures to ensure safety in mobility. However, this is an aspect which is being ignored in contemporary planning practice because the recreational spaces seem to

be considered as simply meant for recreation in most of the urban planning endeavours so far. This happens due to unavailability of a method to be utilised in a comprehensive manner to understand the complexity in public recreation spaces in present day practice.

In similar conditions where the ground situation is difficult to understand, computer simulation models play an important role enabling simulation capability (Ronchi E., 2014). Among most of those modelling concepts, application of Agent-based modelling (ABM) in spatial planning has been used to understand the urban spaces as complex systems for number of studies. Especially, in understanding the space–time dynamics related to behaviour of people in public streets and public buildings has drawn more attention since they are really difficult entities to understand by the usual methodologies. Still, the public recreation spaces are not considered as complex entities so far.

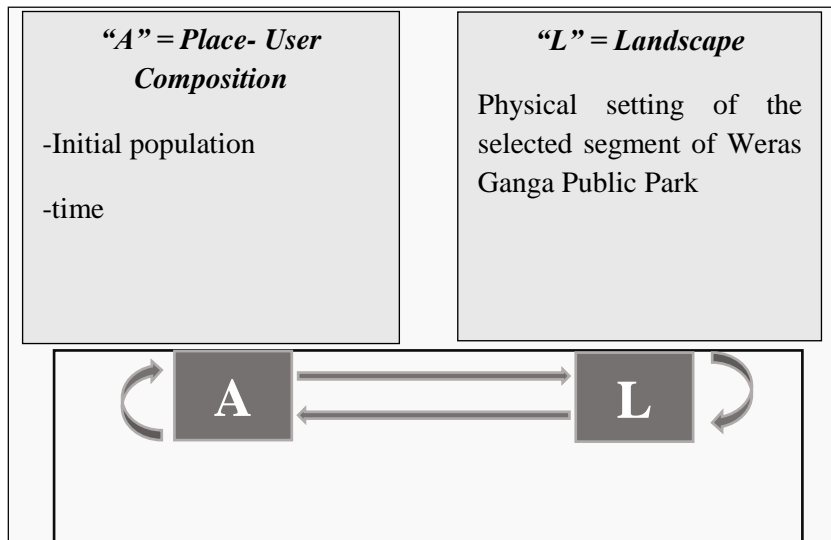
Hence this study explores the applicability of Agent-based Modelling (ABM) concept in observing complexity of public places. Focused on studying the significance of ABM to ensure safety in physical planning, the study reveals possibilities of using ABM as a tool to maintain safety in mobility. Accordingly, the paper demands attention for the importance of understanding simple rules of the interactions between place users and place landscape which act as the real generators of complexity in public recreational places.

3. Methodology

This research is designed with the main objective of framing out Agent-based Modelling as a suitable technique for Sri Lanka which can be utilised to understand the complexity of public recreational spaces and to reveal possibilities to develop the framework into a tool to ensure safety in mobility of public recreational spaces.

Weras Ganga Public Park was selected as the case study location and preliminary observations with place user composition audit, participatory observation, random in-depth focus group discussions, activity audit survey using a structured brief questionnaire, people centred maps and photographs were used for data collection.

The collected data were analysed to identify the characteristics of main components and parameters concerning Safety, relevant in developing an Agent Based Model framework representing the complex nature of the case study location using the ‘Simplest ABM structure (Batty, 2007). The model interface selected was ‘NET LOGO 5.2.1’, which enables the possibility to study the connection between the “micro-level behaviour of individuals and the macro-level patterns that emerge from their interaction.” (Wilensky U., 1999).



*Figure 1: The ABM structure of 'public recreation space as a complex system'
Source: Compiled by author using the concepts identified in literature review*

4. Summary of Findings

The stimulation results were used to understand whether there were collective patterns in complex individual behaviours towards the considered landscape. The identified conditions were elaborated using the concepts of complexity theory. Accordingly, this study framed out 'Behaviour pattern of place users' (**P**), as determined by the function of four parameters which raise concerns for Safety in Mobility.

$$\mathbf{P} = f(\mathbf{t}, \mathbf{a}, \mathbf{c}, \mathbf{f}) \dots\dots\dots (1)$$

1. The time which users prefer to visit the place (**t = time**),
2. Priority purpose of visiting the place and the preferred ways how users interact with each other (**a = active engagement**),
3. How people feel the elements of the place (**c = comfort and relaxation**)
4. The effects of imposed rules and controls (**f = freedom of action**)

The developed ABM framework enables the possibility to observe the case study location in the model interface and to simulate how the individual place – user agents' independent behaviour can be read into general patterns as explained in the Complexity Theory. The factors which disturb the ongoing interactions cause safety issues when the place become crowded with agents having different priority purposes who desire to actively engage with same landscape elements. Especially,

frequent accidents are happening when the imposed rules and controls are not followed by place users. Safety is in question where the active engagement of the agents' movements, path finding and speed becomes influenced by the changes of considered parameters.

5. Conclusion

Utilising an ABM framework as a tool to model the public recreation spaces as complex systems will open advantageous doorways in Physical Planning to understand the existing patterns of interactions between place users and place landscape. The study pinpoints the need to further develop the framework considering other important factors which increase the complexity of public recreation spaces. This is important since safety has become a higher level concern in the context. Hence this study reveals the possibility to capture the individual agents' behaviour patterns using ABM. With that, the Planner or Urban Designer will have the capability of identifying the most suitable changes in the landscape of a particular recreation space catering the needs of safety in mobility for the place users.

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Keywords: *Agent Based Modelling, Complexity, Safety of Mobility, Simple Rules*

An Assessment of Mobile Network Big Data-based Insights for Transport Planning in Sri Lanka

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1. Introduction

With increasing urbanisation and the accompanying trends in human mobility and traffic patterns, Sri Lanka is entering an era that demands greater flexibility and responsiveness from the local transport planning apparatus. The recent global data revolution has seen large transaction-generated datasets being leveraged to understand large-scale patterns in human behaviour. Transaction-generated mobile phone network data is one of the few forms of data with sufficient coverage of the population of Sri Lanka that provides an opportunity to apply similar techniques. The paper assesses the potential of this data for delivering insights that can enhance the traditional transport planning process in Sri Lanka through a series of analyses that quantifies and interprets human movement in urban regions.

2. Literature Survey

CDRs have been used in numerous analyses that can provide insights fitting in to different aspects of the existing transport planning process in Sri Lanka.

These include techniques for identifying home and work locations for subscribers which can be used to understand commuting behaviour [2] as well as more advanced techniques that derive estimations of more general mobility behaviour as Origin-Destination (OD) matrices [1]. Similar techniques have been adapted and evaluated in the Sri Lankan context as well [3], [4].

3. Data

The analyses were based on anonymised CDRs for thirteen contiguous months of activity (2012 - 2013) for nearly 10 million SIMs from Sri Lanka. This represents about 50% -60% of the mobile phone subscriber base of Sri Lanka. Sri Lanka had a

mobile penetration level above 90% at the time. The data provides greater spatial resolution in urban regions and lower resolution in rural regions as a result of the level of infrastructure operators have in place to serve regions based on demand. In addition, data from transportation surveys were used for validation.

4. Methods

4.1 Estimating Commuting Behaviour

Each CDR has location and time attributes. These attributes are leveraged to identify the most frequent locations that a subscriber was observed at during home (9pm – 5am) and work hours (10am – 3pm). For a given subscriber, commuting behaviour is defined as travel from the home location to the work location. Individual commuting trips are aggregated to derive high resolution commuting OD matrices.

4.2 Estimating Different Forms of Aggregate Travel Behaviour

The spatio-temporal information present in mobile network data can be used to extract different forms of travel, based on interpretation. Three such perspectives that define a trip (the basic unit of travel) differently were considered. The individual trips extracted based on these three approaches were aggregated initially at the mobile network base station level to estimate O-D matrices.

1. Stay-based approach: Locations where a subscriber has stayed for more than a minimum amount of time (10mins) are identified. These locations and the time period are considered as ‘stays’. A trip is recorded for each pair of consecutive stays.
2. Transient trip approach: Each pair of consecutive non-identical locations in a subscriber’s CDR for a day, is considered as the origin and destination of a trip. Trips identified in this manner are likely to be transient in that they may represent intermediate steps in actual trips. This approach is sensitive to noise in the data in the form of ‘false’ displacements observed due to expansion and shrinkage of base station coverage regions for load balancing purposes.
3. Regular travel approach: First sequences of two locations occurring more often than a threshold frequency (10%) during each day a person is observed in the data are identified. These pairs of locations are considered origins and destinations of frequent trips. The likelihood of making each of the frequent trips during different periods of each day of week is then estimated. Therefore, OD estimates that are derived from this approach are probabilistic.

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(1)

5. Results and Discussion

The OD estimates derived based on different approaches were compared with traditional survey-based forecast at the DSD level for the Western province

Table 1 - Summary of Linear Models for MNBD OD Matrices with Traditional Forecast

Method	Intercept	Estimated trips	R ²
Stay based	35,516***	76.41***	0.819
Transient trip	25,460**	2.66***	0.903
Regular travel	14,770'	1.16***	0.909

6. Conclusions

MNBD based techniques can provide insights with wide ranging applications in the traditional transport planning process in Sri Lanka.

Acknowledgement

This work was carried out with the aid of a grant from the International Development Research Centre, Canada and the Department for International Development UK

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Keywords: *Urban transport planning, Big Data, Call Detail Record*

TRANSPORT PLANNING

A Network Centrality Application: Examination of Structural Coherence of Colombo Road Network

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1. Introduction

Urban streets demonstrate a hierarchical structure in the sense that a majority is trivial, while a minority is vital [1]. Jiang claimed that “coherent urban streets demonstrate a scaling law and characterised by the 80/20 road hierarchy principle, i.e. 80% of streets are less central (below the average), while 20% of streets are more central (above the average); out of the 20%, there is 1% of streets that are extremely well central” [1]. Recent works on structural analysis of urban street networks in terms of topological centrality in European and USA cities done by Yang et al. [2], Hillier et al. [3], Huang et al. [4], Levinson [5], Wang et al. [6], Gao et al. [7], have also supported the above claim. Accordingly, network centrality is used as a strategic planning tool to identify the structural coherence of transport networks. Inspired by the previous works, this study examines the structural coherence of the road network of Colombo city from the perspective of topological centrality.

2. Method of Study

The study is principally built upon the database of ‘CoMTrans-2014, JICA’. The study used ‘Natural-street’ approach to convert street segments into meaningful streets. “Natural streets are naturally merged street segments with a good continuity according to the Gestalt principle” [1]. The threshold angle for the merging process was set as 45° [1], which implies that the deflection angle between two adjacent segments greater than 45° should not be merged to form a part of a natural-street. This operation applied to road network of the Colombo city and it led to 2,323 natural streets. Then, the natural-street network is converted in to a topological

graph, in which vertices representing individual streets, and edges if two streets are intersected. Utilising the topological graph, centralities of each street was calculated in term of 'Connectivity' (Cn), 'Global Closeness' (GC), and 'Betweenness' (Be). The study analysed statistical distribution of centrality values of streets and the relationship between hierarchies of natural street according to the network centrality values.

3. Results and Conclusions

Figures 1 and Figure 2 demonstrate the spatial pattern of street hierarchies and the cumulative probability distribution according to the network centrality values.

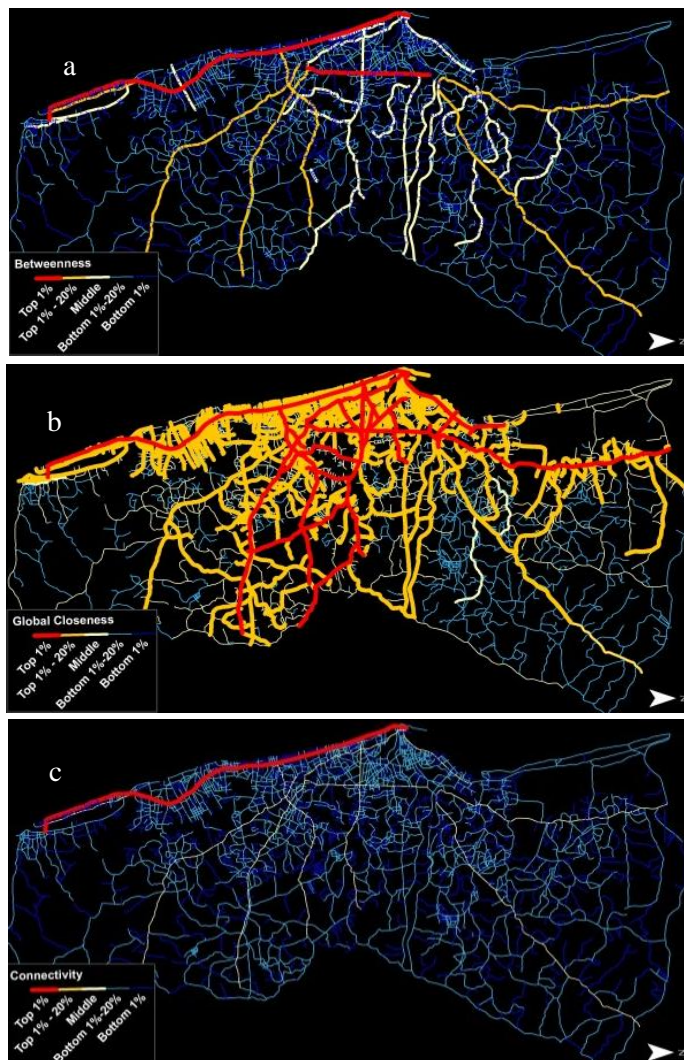


Figure 1: A Spatial Pattern of Street Hierarchies of Natural-Streets Based on A) Be, B) GC, And C) Cn

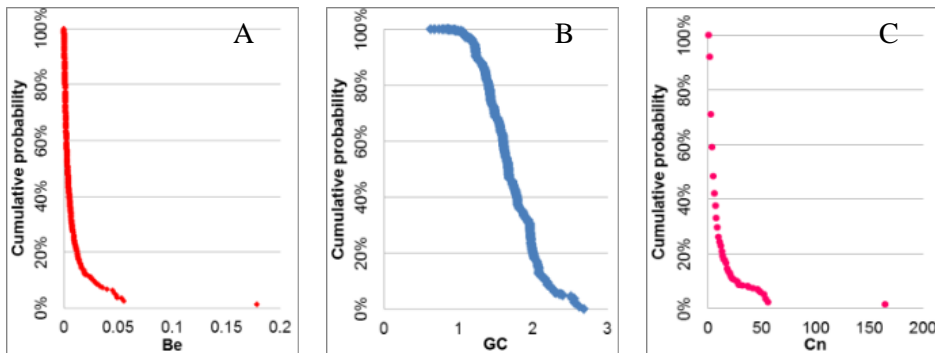


Figure 2: Cumulative Probability Distribution (Based On Street Length) of A) Be, B) GC and C) Cn

The distribution of Be and Cn values of Colombo road network are highly right-skewed whereas GC values are close to normal distribution. The average Be, GC and Cn are 0.09, 1.65 and 54 respectively; and the percentage of streets, whose Be, GC and Cn being less than the average are 93.2%, 47.3% and 96.5% respectively. This deviates from the 80/20 principle. Further, the study noted in terms of Be and Cn, percentage of top 20% streets is less than 20% of length of total street network, while percentage of top 20 streets in terms of GC is more than 20% (i.e. Be=4.9%; Cn=1.4%, GC=40.5% refer Table-1). It indicated that the centrality of Colombo's road network is far below the 80% rule in terms of Be and Cn values, while it exceeded the 80% rule in terms of GC values.

Table 1 - The Percentage Distribution (Street Length) of Natural Streets by Hierarchy of Centrality Values

Levels	Be	%	GC	%	Cn	%
Top 1%	>0.17	1.1	>2.20	8.4	>163	1.4
Top 20%	0.17-0.14	4.9	2.20-1.78	40.5	163-131	1.4
Bottom 20%	0.02-0.01	85.9	1.43-0.63	25.7	31-3	71.1
Bottom 1%	<0.01	32.1	<0.63	1.0	<3	29.9

Results of the study revealed that the topological centrality of the Colombo road network does not follow the scaling law and is far from 80/20 road hierarchy principle. It indicated that, the road network of Colombo city lacks structural coherence which causes inefficiency and capacity problems. "The urban web self-organises itself as a hierarchical and it reinforce the heterogeneity and diversity that

characterise living cities, therefore multiplicity rule that can be applied to urban planning and design” [1]. The study recommends for planners and traffic engineers to focus the ongoing and future redevelopment scenarios in Colombo city with strong concerns on the structural coherence of road network from the perspective of topological centrality

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Keywords: *Network centrality, Road hierarchy, Urban transport planning, Colombo*

Travel Characteristics of Low Income Households in Western Province, Sri Lanka

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1. Introduction

In recent years, transportation has become a critical element for every income group to accomplish tasks in their day-to-day activities, including accessing goods and services. Transport is of great importance, especially from the perspectives of town development and securing mobility. Travel characteristics of the low income group have been the theme of consideration in many developing countries, even though much still remains to be explored. This research mainly focuses on travel characteristics of the low income group in the Western Province of Sri Lanka. The total population of Western province was Rs 7.8 Million in 2013 and the low-income group (monthly income: less than Rs. 40,000) accounts for 70% (Fig 01) of the total population (CoMTrans Study, 2014). The role of public transport is hence of great importance in providing an affordable means of transport for people with lower incomes to access goods and services.

2. Objective

The primary object of this research is to examine the daily trips and travel pattern undertaken by the low income group of Western Province in Sri Lanka.

3. Methodology

The travel characteristic of the low income group is based on the detailed transportation survey of Household Visit Survey (HVS) in 2013, which was conducted as part of the Urban Transport System Development Project for Colombo Metropolitan Region and Suburbs (CoMTrans) from 2013 to 2014 (JICA and Ministry of Transport Sri Lanka), and analysis was undertaken to prepare a comprehensive long-term transportation plan. The HVS survey covers the entire Western Province, which includes three districts; namely, Colombo, Gampaha, and Kalutara having 2496 GN divisions in total. Originally, the target sampling ratio was about 3.0% of the population of the survey area and the sample size was approximately 35,850 households. In this paper, a household monthly income less than LKR 40,000 is defined as low income and a monthly income above LKR 40,000 is defined as non-low income.

4. Results and Discussion

According to the survey, there were about 3.9 million trips made by people with low-incomes and about 6.1 million trips made by non-low income people in 2013 in the Western Province of Sri Lanka. Table 1 provides the key household characteristics of the sample data.

Table 1: Key Households Characteristics

Description	
Average Household size	3.24
Average Age	38
Average Monthly Income	Rs. 23,053*
Average Monthly per Capita Income	Rs. 7115
Monthly Transport Cost	Rs. 4070

(Source- COMTrans Technical Report, 2014)

Table 2 provides the comparison of key travel characteristics of low income and non-low income groups, the analysis on which are summarised below.

4.1 Commuting Length and Time

Low-income people make shorter-distance trips than non-low income people (9.13 km vs 10.64 km). Similarly, trip duration of low income people is slightly lower than the non-low income group.

4.2 Trip Modes Distribution

The low income people mainly rely on the non-motorised modes such as walking and bicycle. The predominant motorised mode of the low income group is bus, while that of the non-low income group is car.

4.3 Trip Purpose

Subsistence activities of work and education by low-income people are higher than the non-low income people. On the other hand, low income group makes fewer non-home-based trips like recreation and shopping than the non-low income group. The reason may be the low salary and budgeting.

4.4 Gender

Nearly 60% of the trips are made by males, while only 40% are made by females. However, low income females make more trips than the non-low income group females. The reason may be that the female working population is greater in the low income group than in the other groups

Table 2: Comparison of Key Travel Characteristics of Low-Income and Non-Low Income

	Low Income	Non-Low-Income
Average Trip Duration	36.51 Min	42.54 Min
Average Trip Distance	9.13 Km	10.64 Km
Trip Modes Distribution		
Car	2.42%	24.36%
Motorcycle	13.97%	14.19%
Three-wheeler	14.07%	10.74%
Taxi	0.18%	0.37%
Bus	39.21%	35.69%
Railway	2.42%	3.10%
Non-Motorized	27.73%	11.56%
Trip Purpose		
Home to Work	12.63%	14.55%
Home to Education	12.76%	9.87%
Home to Other	16.10%	11.86%
Work to Home	12.62%	14.74%
School to Home	12.58%	9.73%
Other to Home	15.93%	11.41%
Non Home Based	17.38%	27.84%
Gender		
Male	59.61%	60.29%
Female	40.39%	39.71%

5. Conclusion

Low-income population accounts for 70% of the total population in the Western Province, Sri Lanka. The results have shown marked differences in income, car ownership levels, mode preferences, trip purpose, travel length and time and trip rates between low income group and non-low income groups.

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Keyword: *Households, Travel characteristics, Low income, Non-Low income*

PUBLIC TRANSPORT

Introduction of an Integrated Engineering Solutions to ease the Rapidly Increasing Traffic Condition in Main City Centres: A Case Study of Traffic Simulation at Main Network with Proposed Rajagiriya Flyover

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1. Introduction

Traffic congestion in Colombo, the capital city of Sri Lanka, has been a persistently aggravating issue since 1978, given the increased rate of private vehicle ownership resulting from the introduction of open economic policies. The city's travel demand is enormous: many junctions get congested with static traffic flow especially during peak hours. This has posed a huge financial and economic loss to the country. Industrial development and expansion of businesses seem to have contributed, to a great extent, to congestion, further supported by the growing affordability of private vehicle use due to reduced import taxes, increased per capita incomes, affordable fuel prices, lack of road pricing schemes etc.

Several other factors that would potentially further aggravate the present traffic congestion in the road links of urban and suburban centres can be identified. Among those figure inadequacy of road capacity to cater to increased traffic levels, delays at intersections owing to bottlenecks at intersection approaches, signal delays at main intersections, excessive weaving actions at un-signalised intersections, increased tendency for violation of traffic rules and absence of driver discipline.

Therefore, the mitigation of traffic congestion using integrated engineering solutions (IES), an inter-disciplinary approach combining conventional engineering with humanities, becomes very important in view of optimising the capacity of the already improved road networks in urban areas. These IESs are more appropriate over conventional traffic mitigation methods for their ability to provide proper information to road users in timely manner, and also for their lesser requirement of human involvement, properties and assets to cater for growing demand for capacity, land acquisition which is a deciding factor of great concern, especially in urban city centres.

2. Study Objectives

The main objectives of this study are;

1. To understand available traffic mitigation options inclusive of IESs.
2. To evaluate the level of present traffic congestion and main reasons for such traffic congestions along the Sri Jayawardenapura Road Corridor.
3. To introduce integrated traffic management solutions to overcome intersection delays and overall delay
4. To disclose the present economic loss due to “do nothing approach” and to appraise the possible gains to both users and the national economy through improved traffic conditions expected from integrated traffic management solutions

3. Methodology

The present research focused on the road network between Diyatha Uyana to Devi Balika intersection. Rajagiriya Junction was selected to study the possibility of undertaking traffic mitigation measures and the applicability and feasibility of introducing an integrated engineering solution. It examined the intersection traffic, link traffic, travel time along the associated road network, and attempted to use its results to predict future traffic flows. Installing a Flyover and implementing associated traffic management proposals, were appraised in view of understanding their investment economics and their ability to alleviate the existing traffic congestion and resultant costs along this road corridor.

4. Analysis and Results

Table 1 - Present Traffic at Associated Road Links

Road Name	Link	Flow Direction	Without Flyover		
			Traffic (PCUs)	V/C Ratio	LOS
Sri Jayawardenapura Road	Approach to Node 1	Fr: Colombo	19,097	0.60	C
		To Colombo	26,144	0.83	D
	Node 1 - Node 2	1-2	24,223	0.76	D
		2-1	19,167	0.61	C
	Node 2 - Node 3	2-3	25,924	0.82	D
		3-2	34,055	1.08	E
	Node 3 - Node 4	3-4	27,503	0.87	D
		4-3	28,427	0.90	D
Old Kotte Road	Node 2 - Node 6	6-2	7,394	0.71	C
Kotte Road	Approach to Node 2		34,144	1.01	E
ButhGamawa Road	Node 5 - Node 6	5-6	12,367	0.99	D

Table 2 – Traffic Conflicts along the Road

Jn: No	Junction	Existing Conflicts		Conflicts With Flyover		% Reduction of Conflicts	
		Total	Direct	Total	Direct	Total	Direct
1	Nawala Road Jn	56,173	48,696	26,822	19,345	52%	60%
2	Welikada Plaza Jn	76,486	52,693	43,564	22,914	43%	57%
3	Fuel Station Jn	37,321	34,744	37,492	-	0%	100%
6	Buthgamuwa Road Jn	18,662	3,759	16,313	-	13%	100%

Present traffic levels and conflicts in the study area summarised in Table 1 and Table 2 above, and the morning and evening peak travel time presented in the Figure 2 and Figure 1 below, were used in the analysis.

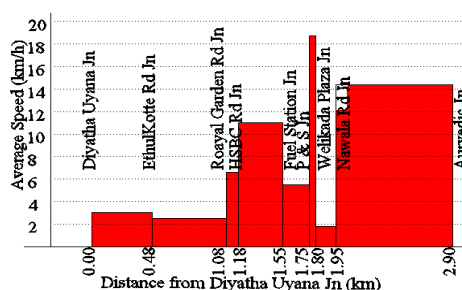


Figure 2 - Travel Speed during Morning Peak

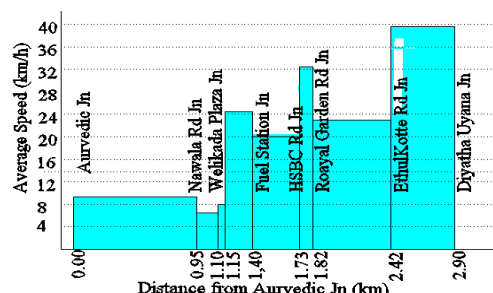


Figure 1: Travel Speed during Evening Peak

The expected economic benefits and outcomes, in terms of reduced travel time and other associated costs that are expected through the introduction of the proposed flyover are presented in Table 3.

Table 3 - Economic Benefits and Outcomes

Item No	Item Description	Amount (Rs.)
1	Savings in VOT in 12 hours	5,283,451
2	Savings in VOC in 12 hours	1,179,194
4	Savings in Extra Emission in 12 hours	18,777
5	Accident Cost (Not collected)	-
Total Savings in 12 hours Period		6,481,422
Annual Total (2016)		2,093,499,384
Estimated Total Savings due to the proposed improvements in next 20 years		41,869,987,681

As per the calculations, EIRR of the intervention would be 47.5 % while a B/C Ratio of 15 could be expected. Furthermore, a Net Profit Value (NPV) of Benefits was estimated to be Rs 17,737 Million and the investment could be recovered within 3 years.

5. Conclusion and Recommendations

The study outcome suggests that the proposed flyover, combined with the associated traffic management plans, could possibly be highly beneficial, both in terms of traffic and financial benefits that would be accrued to the users of the Colombo – Sri Jayewardenepura road corridor, and in terms of national economic benefits. The travel speeds would significantly improve from the present magnitudes in this corridor, resulting in very high economic gains. It was also revealed that the proposed flyover option would alleviate the major problem of conflicting traffic movements at main nodes along this corridor yielding significant traffic congestion alleviation benefits. Closure of the centre median and one-way traffic flow would complement the derived benefits from the proposed flyover option.

It is also observed that a flyover alone is unlikely to provide a proper and lasting solution to the existing traffic congestion problem in Rajagiriya junction. Several other ways and means are thus proposed, such as signal design as an integrated intersection, roundabout designs, alternative elevated highway in parallel to the road corridor, and long term solutions such as public transport improvements including BRT and railway options; implementation of which is likely to much longer time than would be desired.

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Key Words: *Improved Traffic Conditions, Integrated Traffic Management, Flyovers*

Bus Passenger Demand Analysis in Seven Major Corridors of Western Province

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1. Introduction

Buses have been a core mode of transport in Sri Lanka though their share is gradually falling. For instance, buses accounted for 65% of passengers crossing the Colombo Municipal Council (CMC) boundary in 1985, 57% in 1995, 55% in 2004 and 47% in 2013. The Sri Lanka Transport Board (SLTB) and private bus companies operate along roughly 680 and 400 inter-provincial bus routes in the Western Province, according to bus route information from the National Transport Commission (NTC). It is evident that most of the buses are operated in the seven major corridors in Western Province end in Pettah area where three bus terminals are located.

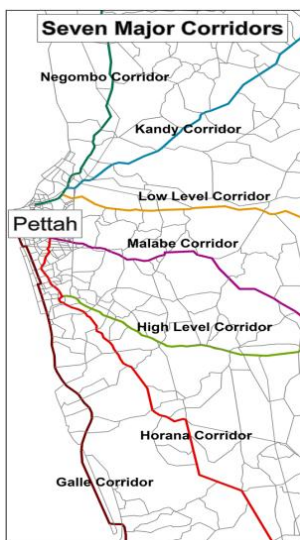


Figure 1 – Seven Major Corridors

Most of the inbound and outbound traffic of CMC use these seven major corridors of Galle, Negombo, Low Level, High Level, Horana, Malabe and Kandy (fig 1). Due to the traffic flow, these corridors are highly congested, especially during the peak hour. Another major impact on these corridors is that the average velocity of vehicles reduces significantly due to congestion and the lack of capacity of the roads. Especially, Horana and Low Level corridors as of recently experience high traffic flow but still have only 2 lanes capacity. These two corridors were developed recently due to the distribution of the traffic flow of the High Level corridor.

This research focuses on the bus passenger demand and supply of main seven corridors inside the Western Province and recommends catering to the demand during the peak hours. Moreover, this paper focuses on the oversupply during off peak hours and provides some alternatives to utilise the supplies. The analysis covers the

mode share on the corridors to evaluate the efficiency of bus operations and to propose rail based transportation to reduce the congestion on the road corridors.

2. The Objectives

The following are the main objectives of this research paper.

- To evaluate present bus passenger demand and supply during peak and off peak hours.
- To evaluate the impact of bus passenger demand and supply with other road transport modes along the seven corridors.
- To propose the possible solutions to cater the supply inadequacy during the peak hour and excess supply during the off peak hour for seven road corridors.

3. Methodology

Screen Line Survey (SLS) and Classified Vehicle Count (CVC) surveys were conducted to analyse the demand and supply of bus passengers along seven major corridors. Quantitative analysis was used to get the results. The main objective of the SLS is observing traffic volume at some of the previous survey locations. The CVC survey contains the number of vehicles by the hour, by mode and by direction. The survey locations were selected based on the major roads which cross the boundary of CMC, Kalutara-Colombo and Gampaha-Colombo. The bus demand was analysed from the SLS by using three separate buffer zones, namely

1. Colombo Municipal Council (CMC)
2. CMC+5km
3. CMC+10km

The SLS was conducted on one weekday either for 16 hours (6:00 AM to 10:00 PM) or 24 hours (6:00AM to 6:00AM of the following day) depending on the location. All surveys were conducted in 2013 and road settings are same as the 2013 road network.

4. Data Analysis and Results

Table 1 shows the peak hour bus passenger loading rate for Low Level is very high compare to other corridors except Horana. Off peak hour supply and demand and loading rate are at the optimum level at all the boundaries. The Horana corridor has supply deficiency along three buffer zones and much higher deficiency in the CMC+5km zone. This may due to the trip attraction and generation from CMC+5km is much higher than the other zones.

Table 1: Peak Hour and Off Peak Hour Bus Passenger Loading Rate (%)

Corridors	CMC		CMC+5 km		CMC+10 km	
	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak
Galle	95	75	81	83	98	76
Horana	120	80	140	86	121	83
Malabe	94	62	107	74	119	55
High Level	98	72	106	76	109	70
Low Level	120	85	102	71	107	89
Kandy	93	68	96	68	113	95
Negombo	105	68	105	83	110	85

Moreover, the capacity of the Horana corridor is much lower since it has only two lanes. Supply, demand and loading rate during off-peak period are at the optimum level at all boundaries of the Horana corridor.

According to the data analysis, it is evident that public transportation development is needed to reduce the traffic congestions along the corridors. The analysis also disclosed that poor performance of the public bus transport has become a major reason for the traffic congestion during the peak hours.

With the aim of mitigating these issues, new modes of public transport such as BRT and railway electrifications with traffic control and management should be focused on. Malabe Road, Horana Road and Low Level Road corridors need more attention than other road corridors. These corridors have now reached their maximum capacities and need development to avoid traffic congestions and bottle necks during the peak hour. Due to the higher share of the private vehicles the roads are congested and the road space to operate the buses is inadequate during the peak hour.

The analysis also shows the excess supply at off peak hour. In Malabe Road, Galle Road, Kandy Road, Negombo Road and High Level Road have the oversupply of buses during the off peak and it is to be well managed through the adequate scheduling and timing for these routes. The best solutions are re-routing and reduce the frequency of the buses during the off peak hour. Re-routing is one of the best solutions to serve congested areas and rural areas by shifting the bus fleet from over supplied area during the off peak hour. Private buses are owned by several individual organisations and managing the private bus fleet is also a difficult task as per the present experience of this industry. However, SLTB (Sri Lanka Transport Board) can focus on the re-routing of their buses during the off peak hour.

5. Conclusion

According to the results, it is evident that traffic congestion reduction along the corridors requires development of public transportation if the present situation continues, suburbs around the CMC boundary, where traffic demands on existing roads have almost reached or even exceeded capacity, and causing significant traffic congestion at each point. Malabe, Horana and Low Level corridors, already facing problems from traffic congestion, need strategies to alleviate traffic issues and bottlenecks during peak hours.

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Key Words: *Demand, Supply, Peak, off peak, corridor*

Effects on Passengers due to Long Dwelling Time at Bus Halt: A Case Study from Sri Lanka

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1. Introduction

Dwell time was measured as the time a public transit vehicle spends at its scheduled bus stop for passenger boarding without moving, which is one of the main determinants of service quality of public transportation [1]. Long dwell time causes many problems for passengers, public transport operators and environment. A bus route (Route No 255), between Mount Lavinia and Kottawa which is one of the bus routes with the highest demand in Moratuwa with a frequency of 300 buses per day was selected as the case. Katubedda junction being a major transfer point between two roads was selected as a case to study dwell time. The objectives of this research were to identify: (a) the present practice of dwell time, (b) passenger perceptions about longer dwell time and (c) the rationale of users' mode choice.

2. Research Methodology

Both quantitative and qualitative data for research were gathered through an array of surveys such as: (i) structured interviews with bus passengers to collect socio-demographic data of passengers along with their opinion on dwelling time, (ii) opinion survey with bus drivers towards dwelling time and (iii) inventory data like bus capacity, frequency and waiting time to identify average load factor. The targeted population was bus users who touch Katubedda junction during their trip. Due to limited financial and time budget, the survey was conducted only during peak times as a sample with randomly selected passengers on randomly selected buses and 30 responses were collected at the bus halt.

3. Data Analysis

Using some of the data collected, the value of time of passenger in Sri Lankan LKR ($V_t=1.94$ Rs/min), average dwell time per bus at bus halt in minutes ($T_d = 8$ min), average load factor of the bus upon arrival at bus halt ($L_f = 43$ passengers) and frequency, no of bus trips per day ($F=304$), it was found that the total value of money wasted ($V_t T_d L_f F$) at this bus halt alone per day is about 200,000 LKR.

Based on survey data, 82% of bus users were dissatisfied with longer dwell time whereas 18% of the people who arrive later than the bus favoured the longer dwell time. This study further identified that among 18% of respondents, majority were students of University of Moratuwa whose travel distance is small: approximately 1.4km from the halt.

A decision-making model is developed as given in Box-1 comparing bus mode against an alternative mode which attempt to compare the willingness to wait for a bus based on travel distance and monthly income.

Box-1: Condition for Users to Wait for Bus against Alternative Mode

Passengers' perceived cost of Alternative Travel		>	Total Cost of Bus Travel	
Direct cost for alternative mode (M_a)	-	Willingness to pay for extra comfort with M_a	>	Time value of money wasted at bus halt + Direct cost for Bus mode (M_b)
dF_a	-	dEF_b	>	TV + dF_b
dF_a	-	dEF_b	>	$\frac{TI \times 10,000}{(25 \times 8 \times 60)} + dF_b$

Where;

F_a	: Fare of alternative mode, Three Wheel	(LKR/km)	= 45
F_b	: Fare of bus	(LKR/km)	= 8
E	: Willingness to pay for the alternative modes in multiple of bus fare		= 2.2
d	: Travel distance	(km)	
T	: Time of waiting at bus halt	(min)	
I	: Average monthly income of passengers	(10,000LKR)	
V	: Value of time	(LKR/min)	

Using the present scenarios from bus and three-wheel modes of transport and users' preference expressed, the above model was converted into graphical representation as given in Figure1. Area below distance-curve represents the willingness to wait for bus as against the upper area favours moving to alternative mode. For an

example, a passenger, who draws monthly salary of 100,000 LKR with trip length of 1km or 2km, would not wait more than 2min or 4.5min respectively.

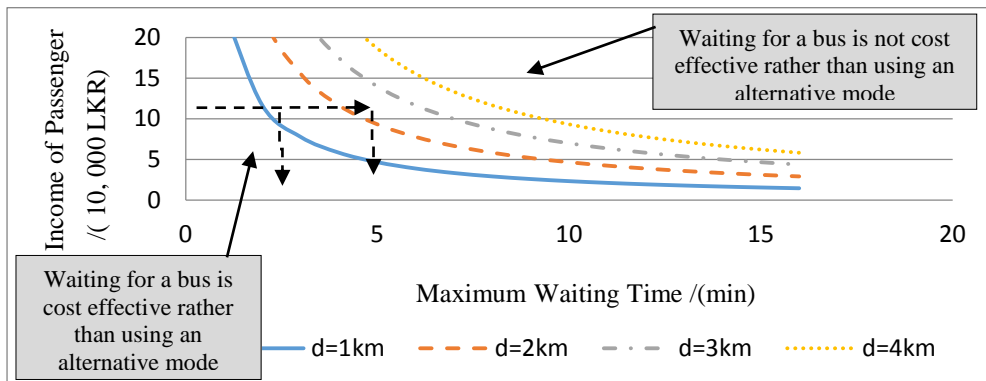


Figure1: Variation of Willingness to Wait for Bus with Monthly Income and Travel Distance

4. Conclusion

The study developed a relationship among passenger waiting time, monthly income and trip length, which would help operational planners to make the best dwell time by considering both determinants.

The study also has found that passenger willingness to wait for bus depends on their income level and their trip length. It is also noted that passengers having earnings below LKR 25,000 per month wait for bus regardless of trip length, which clearly indicates that they have become “captive riders”.

The study could be further extended to studying arrival time of people to bus halts as well as buses to include actual passenger waiting.

Reference:

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Keyword: Bus Passengers, Dwelling time, Sri Lanka

URBAN TRANSPORT

Studying the Public Transport User Preferences in a city and the People's Willingness to Shift to Metro: The Case of Jaipur

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1. Introduction

In modern times, urbanisation is the fastest growing phenomena globally which necessitates an efficient transport system. As a solution, the new concepts of public transport like BRTS and MRTS are being introduced. Metro Rail has gained immense popularity due to its high carrying capacity, cost effectiveness and most importantly providing security and comfort in daily travel. The introduction of such projects is associated with the risk of public acceptance and usability. Thus the new systems besides being innovative, effective and efficient, also need to be user-friendly and easily acceptable by the public.

2. Aim

The research aims on analysing the public transport user preferences and commuter satisfaction levels in the city and emphasizing on factors that affect people's preferences by giving recommendations for functioning of Metro to aid its better usability and acceptance. The case of Jaipur, capital of the Indian state of Rajasthan, has been taken up for study as a similar situation of introduction of Metro for addressing demand is observed.

3. Methodology and Data Collection Strategy

The stepwise methodology followed in carrying out the study is as follows

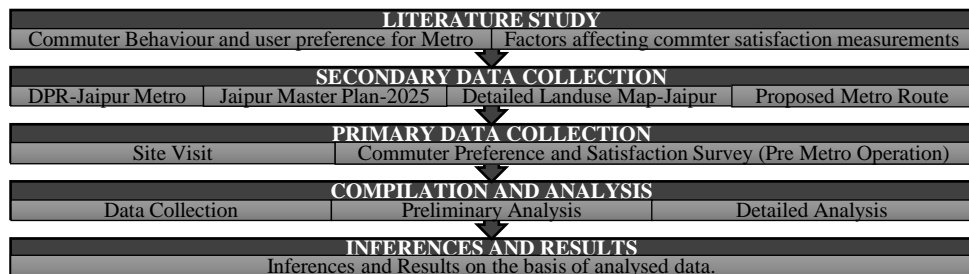


Figure 3 Methodology

A stage wise strategy was adopted for the Primary Data Collection including the three following stages,

- Questionnaire Design – Public Transport Commuter Preference Questionnaire, designed based on Literature Study.
- Survey Sampling – Total Number of Samples (280) calculated based on categories of income groups in the study area.
- Selection of Survey Locations – Locations selected (4) along the metro corridor, based on the land use and predominant activity. Samples divided equally among all four locations.

4. Analysis

The extensive study done on preferences of public transport users involved information collection at the household level about the mode choices and commuter satisfaction with the present public transport in the city (bus system). Collected data was analysed graphically by representing the relations between various parameters. Further, analysis of factors considered for commuter satisfaction measurement was carried out. Rigorous analysis has been done under the following heads:

Table 4 Primary Survey Analysis Parameters

PARAMETERS	SUB-PARAMETERS ANALYZED
Personal and Household Information	Income, Expenditure on Transport, Vehicle Ownership, Household Size
Mode Choice Information	Modal Split, Travel Cost & Travel Time Distribution, Waiting Time Distribution, Reasons for Preference for various modes, Mode Preferences for varying Trip Lengths – Travel Costs – Trip Purposes
Commuter Satisfaction Measurement Analysis	Scoring of Factors, Factor Importance Calculation, Composite Factor Score Calculation, Willingness to Shift to Metro

Source: Singh. A, 2015

4.1. Personal and Household Information

The method of analysis adopted for various sub-parameters under the head (listed in Table 1), has been shown below taking one sub-parameter (similarly done for all other sub-parameters),

Table 5 Monthly Household Expenditure on Transport

CATEGORIES (in Rs.)	BADI CHOPAR		MANSAROVAR		SINDHI CAMP		SHYAM NAGAR		OVERALL (4 Locations)	
	No. of Households	Percent age (%)	No. of Households	Percent age (%)	No. of Households	Percent age (%)	No. of Households	Percent age (%)	No. of Households	Percent age (%)
< or = 2,000	5	7	17	27	4	5	9	13	35	13
2,001-8,000	37	53	43	67	37	49	45	64	162	58
8,001-15,000	22	31	4	6	32	42	15	21	73	26
> 15,000	6	9	0	0	3	4	1	1	10	4
TOTAL	70	100	64	100	76	100	70	100	280	100
MEAN MONTHLY HOUSEHOLD EXPENDITURE	8085		4310		8130		5945		6820	

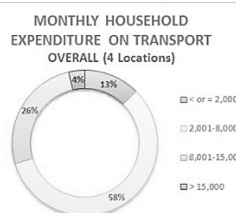


Figure 4 Categorical Distribution

4.2. Mode Choice Information

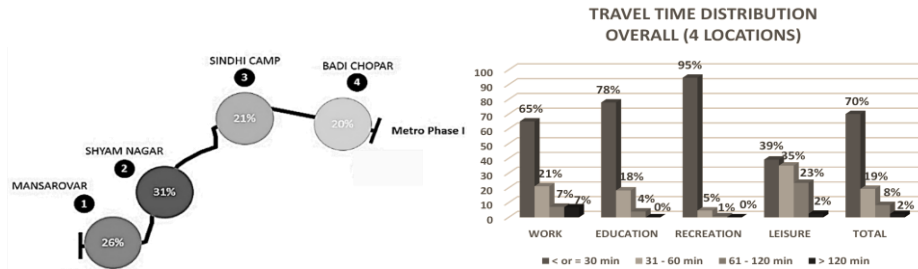


Figure 5: Public Transport Share Across locations **Figure 6: Travel Time in relation to Trip Purposes**

Various factors affecting the choice of mode of an individual (listed sub-parameters in Table 1) have been analysed, out of which the analysis of ‘Travel Time’ has been shown above in Figure 4. On a broader scale, the Public Transport Share in the study area (shown in Figure 3) was calculated based on Modal Split data obtained from Secondary Sources, which is observed to be low.

4.3. Commuter Satisfaction Score

Factors considered for measurement are, Transit Stop within walking distance, Schedule and Route Information Availability, Timely Operation and Punctuality, Seat Availability, Cost, Comfort and Convenience, Safety and Security, Aesthetics of Built Environment, and Overall Satisfaction. [Singh.A, 2015]

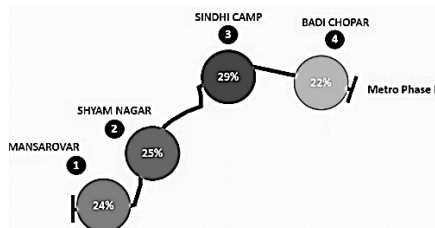


Figure 7 Commuter Preference Scores across locations

Table 6 - Parametric categorization of Scores

FACTOR	COMPOSITE FACTOR SCORE	%
FACTOR 1 - Transit Stop within walking distance (500m) of Trip Origin	1362	4
FACTOR 2 - Schedule and Route Information Availability	2987.5	8
FACTOR 3 - Timely Operation and Punctuality	4803	13
FACTOR 4 - Seat Availability	1617	4
FACTOR 5 - Cost	3952	11
FACTOR 6 - Comfort and Convenience	1429.5	4
FACTOR 7 - Safety and Security	13175	36
FACTOR 8 - Aesthetics of Built Environment	955	3
FACTOR 9 - Overall Satisfaction	5980	16
TOTAL SCORE OF ALL FACTORS	36261	100

5. Conclusion

The inferences drawn from the study show the usability pattern of public transport, as well as the flaws in the existing system and people’s requirements which need to be met by the metro to make people shift from private modes to public transport. The results show that people having higher incomes contribute least to the public transport share. People spend a considerably high share of their income on transport. The commuter satisfaction analysis indicates that factors like safety and

security, schedule information and route availability are assigned the highest importance. A majority of people, i.e. 91%, are willing to shift to metro, which shows that the metro is most likely to functionally succeed in the city.

6. Recommendations

Based on the significant inferences, certain specific recommendations for functioning of the metro are given which are as follows:

- *Reducing People's Monthly Expenditure on Transport* – Calculated Mean Daily per person per direction expenditure is Rs. 23.5. It is recommended to keep the metro fares considerably lower than Rs. 23.5 to attract commuters to opt for metro, increasing its footfall.
- *Variation in Metro Fares* – Calculation of Average length of public transport trips shows public transport is used majorly for higher trip lengths. Attracting commuters to opt metro for shorter distances is recommended by designing the revenue generation strategy to be based on distance and frequency of passengers within stations.
- *Ensuring Safety and Security* – To Children, Women, Elderly and Disabled by facilitating the metro and its stations with Feeder bus service for schools, CCTV Surveillance, Barrier-free environments etc.
- *Last Mile Connectivity* - Providing Feeder Service at each station covering all areas falling within a range of 500m from metro stations.
- *Improve Comfort and Convenience* – Providing adequate number of seats based on demand calculation. To attract HIGs, it is recommended to have a few luxury coaches with high comfort and higher fare which would also aid in better revenue generation.
- *Encouraging Metro* – Reduce waiting time of commuters with shorter headway, increasing reliability by timely and scheduled operation, aesthetically pleasing environment, Park and Ride facility at stations.
- *Towards Smart Metro* – Integrated Transit Systems, Integrated fare Collection System and Real Time Traffic Management.

Hence, these recommendations would aid in the better usability and acceptance of the Metro by city residents. The research can also be adopted as a pilot study to be taken up before proposing any other Metro System.

Keywords: *Public Transport, User Preferences, Commuter Satisfaction, Metro Rail.*

Reclaiming Urban Streets in Developing Nations through Ciclovía

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1. Introduction

Dancing groups of children, kids playing badminton, a mix group of adults and children performing activities like cycling, yoga, zumba, skates, hula-hoop, graffiti, pottery, etc. may sound like a view of a fair or playground to many of us, whereas few neighbourhoods in world witness this view on regular basis as part of Ciclovía. Ciclovía, in Spanish translates to “bike path”, refers to the permanent bike path or cycle way. However, now a days, it is referred worldwide as an event that temporarily closes streets for automobiles to provide safe space for walking, bicycling and social activities. Ciclovía was started 42 years ago as an initiative to reclaim streets by a group of cyclist in Bogota, the capital city of Colombia in 1974 and since then it has gained lot of popularity across various cities in world.

In India, to promote the use of non-motorised transport, to create awareness about empowering of pedestrians and to reclaim urban street space, the Ciclovía named as: “Cycle Day” and “Open Streets” in Bangalore; “Raahgiri Day” in Gurgaon, New Delhi, Bhopal, Navi Mumbai, Dwarka and Indore; “Equal Streets” in Mumbai; are conducted since October 2013 in Indian cities on a regular basis.

Streets are termed as public spaces which are to be equitably allocated to all street users. These events are organised on periodic Sundays and public holidays to convert public spaces into public places by engaging communities. However, this conversion of public space to public place in India is not a new concept and is happening since eons, largely as a part of Indian tradition in term of religious gathering for Ganesh Visarjan or Durga Puja or celebration of community festivals etc; but with the core aim of promoting walkability and cycling, it is definitely a new paradigm in urban transport.

2. Models of Ciclovía

"The Open Streets Guide" published by "Open Street Project" led by "The Street Plans Collaborative" examines the 67 case studies of Ciclovía event conducted in

North America and organise it into a typology of seven common model types. According to open street guide each open street initiative is unique but follows 10 common characteristics as mentioned (a) Population size, (b) Lead Organizing Entity (Public, Non-Profit, Private), (c) Year of Initiation, (d) Funding (Public, Non-Profit, Private), (e) Route Type (Loop, Arm & Loop, Neighbourhood Linear, Multi-Neighbourhood Linear, Regional Linear), (f) Route Setting, (g) Route Length, (h) Supporting activities, (i) Season, (j) Frequency.

However, seven common model types (Table-1) emerged on looking at few more specific lead characteristics: (i) Lead Organising Entity, (ii) Funding Structure, and (iii) Supporting Activities.

Table 7- Seven Common Model Type based on Lead Organising Entity and Funding Entity

S.no.	Model	Organized by	Funding	Year of initiation
1	Seattle Model	Public	Public	1965
2	Cleveland Model	Non-Profit	Private	2006
3	San Francisco Model	Partnership (Public-Non-Profit)	PPP	2008
4	Portland Model	Public	PPP	2008
5	Winnipeg Model	Non-Profit	PPP	2009
6	Savannah Model	Partnership (Public-Private)	Private	2010
7	Kentucky Model	Partnership (Public-Private)	PPP	2008

Source- Data derived from Open Street Guide & structured by author

3. Planning, Implementation and Evaluation of Ciclovía

Ciclovía event planning process reflects local conditions, politics, and constraints; however, the "Open Street Guide" has laid a set of actions occurring concurrently for planning of a Ciclovía event after study of 14 best implementation practices. Ciclovía event planning requires various tasks like bringing the idea to town, securing organisational and community support, planning the route, establishing a budget, scheduling the event, organising community outreaching strategies, coordinating traffic control, organising event activities, recruiting and managing volunteers and evaluating the events etc. Implementation of Ciclovía event requires good coordination among communities and various government sectors including transportation, law and order, sports and recreation and health. Proper implementation measures are to be taken care of to avoid events turning into fair or commercial activity, which may lead to enjoyment of public but not necessarily promote the use of non-motorised transportation.

Evaluation is an important process for any Ciclovía event to measure its success. Various municipalities across the world have formulated their respective methodologies which are dependent on different attributes to evaluate the benefits of Ciclovía events held in their neighbourhood. However, the "Implementation and Advocacy Manual" on Ciclovía have listed the important evaluation indicators which are common to evaluate most Ciclovía events.

4. Case study of Cycle day, Bangalore, India

Cycle Day initiated on 27 October 2013 which has been a monthly event for 11 months and then enhanced to weekly event anchored by DULT (Directorate of Urban Land Transport), Government of Karnataka, India, as a part of Bengaluru Coalition for Open Streets (BCOS), which is a non-profit collaborative comprising of various Government agencies like (BBMP, Bangalore Police etc.), community partners and individuals. More than 120 events have been organised till date in the period of 2 years and 7 months. Based on feedback survey of 552 samples, 14% of participators have bought cycle after attending the event and 26% started using cycles for shorter trips.

Based on visual observation survey and review of publications for case study, discussed below are few important factors that are to be kept necessarily in mind when implementing any Ciclovía event in developing nations:

4.1. Noise Due to Sound System: Supporting activities like public address system must be taken into consideration while allotting the space. Loudness of sound system should not distract the cyclists and residents in the neighbourhood;

4.2. Littering of Public Place: The waste disposals generated by campaigning or supporting activities should be taken care while planning for event. Waste collection methodology should be clear and efficient throughout and after the event;

4.3. Overcrowding of Space: Few activities may attract large public creating overcrowding of space making it difficult for pedestrians to walk and cyclist to cycle. Therefore, activities should be distributed in a way that avoids overcrowding of public place;

4.4. Promotion of Political and Commercial Campaign: Properly framed out Memorandum of Understanding between Public and Private or Non-profit organisations to keep event free from commercial and political campaigns, which can lead to deviation from the cause for which the event is being held and fosters other causes along with littering of space due to distribution of pamphlets or banners;

4.5. Cycle Rental: Ciclovía event aims at promoting ownership and usage of cycles by public but provision of cycles at events is a necessary feature to engage public in cycling activity at the event. This can be achieved by renting out cycle 'free on duration' basis or 'rental' basis depending on local conditions;

4.6. Ambulance for Causalities: Ambulances are necessary part of any Ciclovía event and should be available in sufficient number at the route to avoid any causality with a person during the event;

4.7. Awareness about the Event and its Objective: The measures to create awareness through street play, information provision etc. during the event are to be taken care of and before the event so that to avoid the unexpected inconvenience faced by public by barricading of vehicles on routes;

4.8. Activity Distribution: Activities are to be distributed evenly not only to avoid overcrowding but also to encourage public to walk and cycle in pursue of interest to visit all activity centres.

3. Conclusion

This paper discussed the type of Ciclovía, and major factors that are to be considered while planning for Ciclovía event, with the help of observations from a case study of Cycle Day, Bangalore city, India. These observations can be further developed as general toolkit for successful implementation of Ciclovía in cities of other developing nations.

Along with diversion of mindset of public from using vehicles to cycling and walking as mode of transport, Ciclovía provides for many other benefits that range from environmental benefits, community and social benefits to public health benefits. If conducted on regular basis, it may provide a platform to organise public health campaigns and educational campaign as parts of activities. It also aims at pulling off the implementation of Avoid-Shift-Improve (A-S-I) strategy as formulated by UNESCAP to develop eco-efficient infrastructure through conduct of well-planned events.

Keywords: *Ciclovía, Public Place, Urban Streets, Non-Motorized Transport, Cycle Day*

Strategic Interventions for Improving Transportation in Kandy City

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1. Introduction

Kandy is located in a mountainous terrain 116 km away from Colombo in the Central Province of Sri Lanka. It is recognised as the second-busiest city of the country with a population density of around 2,500 persons per sq.km. A sacred site for the global Buddhist community due to the situation of the Temple of Tooth, Kandy was declared a world heritage site by UNESCO in 1988. The Kandy Municipal Area (KMA) is about 12 sq. km and bounded by the Mahaweli River on three sides and by mountains to the South. The core area of KMA, its Central Business District (CBD), is around 3 sq.km, and serves as a regional centre for culture, commerce, tourism, administration and transport. This area attracts a large number of vehicles and passengers daily, resulting in average speeds of between 4 kmph to 15 kmph on busier roads. Such low speeds in the transportation network leads to lower economic productivity in the city, and to negative social and environmental externalities.

Based on the findings and recommendations in Kandy City Transport Study [1] and Kandy Transport Improvement Program [2], this paper summarises the transport issues identified and their consequences in the above context, and proposes mitigatory measures through a rational decision making methodology.

2. Methodology

Figure 1 graphically illustrates the methodology adopted for this study, which followed several sequential and simultaneous steps. Firstly, it involved data collection, analysis and interpretation to understand the issues in relation to transport infrastructure and land-use. As the second step, the same data were used to predict the current and future transport demand and required infrastructure to facilitate such anticipated demand. Thirdly, the design limitations due to geography, land use and heritage value were identified. Fourthly, a new transport demand

management plan was developed to address the issues identified, while also taking into consideration the design limitations. A physical infrastructure development plan was also prepared as a simultaneous fifth step to support the transport demand management plan. These two plans were thereafter merged to evolve an Integrated Development Plan covering the overall land-use, traffic management and physical infrastructure changes. Finally, the economic viability of the recommended solutions is tested for validity.

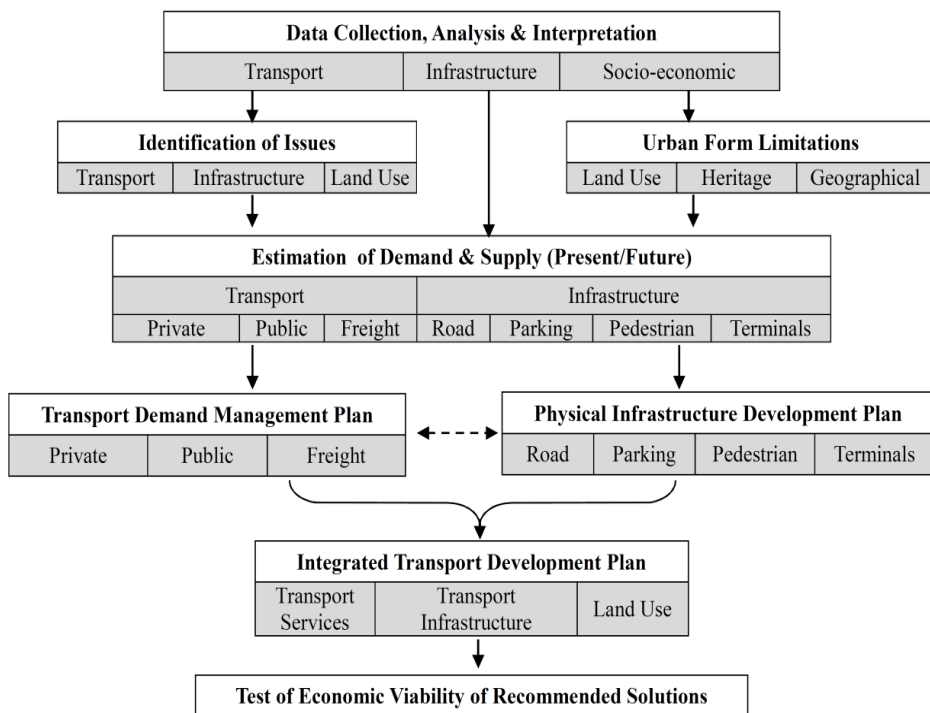


Figure 1: Methodology of the Study

3. Data Collection

Results of field surveys conducted in 2010 for the Kandy Urban Transport Study [1] were used to identify transport-related issues, their severities and limitations in proposing recommendations. These field surveys enabled the authors to establish travel demand and its characteristics for all types of transport including private vehicles, public buses, para-transits, goods transport, railway and pedestrians. In addition, several surveys were conducted to assess the physical capacity of transport infrastructure. The findings of these surveys were further strengthened and updated with the result of another set of surveys conducted in 2013 for Kandy Transport Improvement Program [2]. Key findings of the data analysis are summarised in section below.

4. Data Analysis

Traffic counts conducted at each of the entry points to the KMA and CBD areas indicate that there are a total of 318,000 passengers entering the KMA in 56,000 vehicles on a daily basis. Private vehicles make up 79% of the vehicle flow but carry only 32% of the passengers. On the other hand, route buses make up 9% of Average Daily Traffic (ADT), but carry 64% of passengers across the KMA cordon. This is equivalent to 5,100 buses and 214,000 passenger trips arriving at the 3 bus terminals located within the CBD. In addition to roadway traffic, rail also carries about 3,000 passengers to the city every day: just 1% of the total number arriving. Apart from the passengers coming from the outside, residents within the city make around 200,000 intra city trips. While overall traffic speeds within the KMA are observed at 17 to 26 kmph, while the speeds on busier roads with heavy bus flows are below this average, recording between 4 and 15 kmph.

Origin –Destination surveys conducted for private vehicles and freight vehicles revealed that about 16.3% of private vehicles, (i.e about 28,000 vehicles) and 37.6% of goods vehicles, (i.e about 5,000) engage in thoroughfare and have no business inside KMA. Similarly interviews conducted with bus passengers at these terminals indicate that 95% of their trips are home-based. Around 32% of them arrive to the CBD for work, 21% for schooling and the balance for shopping, business and recreational purposes. Further nearly 40% of bus passengers arrive for bus to bus transfers at Kandy terminals.

5. Identified Issues

The findings of data analysis and stakeholder consultations concluded that the main root causes for inefficient transport system in Kandy consist of limited road infrastructure, conflicting land use, poor orientation of bus routing, terminal and stops, inadequate by-pass roads for KMA and CBD, inappropriate traffic circulation and parking demand management measures, underutilisation of the railway network, and lack of management of para-transit modes such as school vans and three wheelers. Inefficiency of transport system has also led to increase in social and environmental issues such as air, water and noise pollution.

6. Conclusions and Recommendations

Kandy City should be a traffic restrained area given its cultural context as a Heritage City, its population density, as well as its geographical and environmental setting. In seeking a sustainable traffic management solution, these two studies have identified several strategic interventions. Among those interventions, reallocating land-use inside the city and setting up three satellite cities at Peradeniya/Gatambe, Katugastota and Tennekumbura are key long-term recommendations to eliminate

unnecessary vehicle movements inside the city. Furthermore, improving the capacity of by-pass roads, especially providing East-West by-pass tunnel, is proposed as a long term solution to take away significant portion of current through traffic. Re-routing bus services, integration of bus terminals and railway station, introduction of new railway commuter services are recommended as medium-term interventions to facilitate through-trips while reducing pedestrian movements in the city core. Capacity improvement of main city entry corridors and intersections, regulation of school transport services, promoting off-street parking while regulating on-street parking through a pricing policy and improving pedestrian facilities are identified as short-term solutions to increase network speed with immediate effect.

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Keywords: *Kandy Municipal Area, Central Business District, Land Use, Transport Demand* *Managemen*

RAILWAY TRANSPORT

Increasing Use of Railways for the Transport of Petroleum Products in Sri Lanka

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1. Introduction

Petroleum is among the most prominent industries in Sri Lanka. In order to fulfil the country's petroleum demand, the Ceylon Petroleum Corporation (CPC) has outsourced the storage and distribution function to Ceylon Petroleum Storage Terminals Limited (CPSTL). Currently CPSTL distributes petroleum products from two installation plants to eleven regional depots using both bowsters and rail wagons. When considering the distribution function from the Kolonnawa installation plant to the regional depots, bowster transportation dominates over rail. Even though rail transportation is more economical, efficient and environmentally friendly, only around 35-40% of the daily bulk petroleum volume is carried using rail while the rest is transported using the road network. The reason for lesser utilisation of railways for the distribution of petroleum products is investigated in this research and a new distribution model which maximises the utilisation of rail, while maximising savings for CPC and profits for Sri Lanka Railways (SLR) is also proposed.

2. Methodology

In this research, the linear programming methodology, adopted also by Gunaruwan and Sannasooriya (2013) in their research on macroeconomic impacts of the haulage of petroleum by rail [1], was used to determine the optimum benefits to CPSTL and SLR, and the corresponding volumes that should be transported to each regional depot using rail. Primary data were collected through unstructured interviews and through discussions with industry leaders in order to identify the constraints that limit better utilisation of railway for petroleum bulk distribution purposes. Secondary data were obtained from the ERP system of CPSTL and records from SLR.

The data related to the petroleum distribution operation during May, June and July of 2015 have been considered using the objective function,

$$\text{Max } B = \sum \quad (1)$$

Subject to:

$$\sum V_j \leq \alpha \cdot 50000 + \beta \cdot 45400 + \chi \cdot 26370 \quad (2)$$

$$\sum \leq \quad (3)$$

$$\sum \leq 156 \quad (4)$$

$$\leq V \quad (10 \text{ constraints for } 10 \text{ destinations}) \quad (5)$$

$$\leq N \quad (10 \text{ constraints for } 10 \text{ destinations}) \quad (6)$$

Where, B is the overall benefit to both CPSTL and SLR and V_j is the volume carried to j^{th} destination. D_j denotes the rail distance to j^{th} destination from Kolonnawa, P stands for SLR's profitability per kilo litre (kl) per km for j^{th} destination and S represents CPC's savings per kl for j^{th} destination if carried by rail. In the constraints V_t is the capacity of the Kolonnawa terminal, V_{dj} represents the capacity of the j^{th} depot, is the capacity of the wagon allocated to j^{th} destination and denotes the maximum number of wagons per engine that can be hauled to j^{th} destination. In the linear program j varies from 1 to 10, representing the ten regional depots. The coefficients α , β and χ stands for the number of 50,000, 45,400 and 26,370 litre oil wagons respectively.

2. Results

Through the primary data, lack of oil wagons was identified as the prominent reason for poor utilisation of trains. Further data proved that the existing distribution operation allows only 43% of the daily volume to be carried by rail.

Based on the linear program solution given in equations (1) to (6), the priority, when transporting petroleum using rail wagons and the resulting distribution model for existing resources, could be worked out, as presented in Table 1. The analysis assigns higher volumes of petroleum to destinations at further distances over flat terrain while lesser volumes are allocated to hill country destinations increasing overall rail allocation to 63.5%. The reason is that, to low country destinations, a single rail engine can haul up to approximately 15 oil wagons while to hill country destinations only a limited tonnage of between 4- 6 wagons can be hauled along the incline, reducing economies of scale. The revenue optimising liner programming assignment shows how railway's efficiency can be improved by around 50% with the same resources by reassigning its current fleet of 156 wagons and trains to more profitable destinations such as Anuradhapura, Batticaloa and Matara where 100% of

their requirements should be supplied, while only around 30% of the demand of Galle can be met by rail. This means that the remaining destinations, such as Vavuniya, Peradeniya, Badulla, Haputale and Kotagala cannot be served without additional wagons. The total petroleum transport demand can be met with a fleet of 372 wagons and a fleet of engines to haul them.

Table 1- Proposed distribution operation

Regional Depot	Rail Distance (km)	Volume (kl)	Cost per kl per km	Revenue per kl per km	Profit LKR/day	Road Distance (km)	Charge per l per km (LKR)		Saving (LKR)/day
							Rail	Road	
Anuradhapura	207	682	3.162	3.589	60,241	202	0.003589	0.01159	1,089,721
Batticaloa	351	212	3.162	3.589	31,761	321	0.003589	0.01159	521,658
Matara	154	395	3.162	3.589	25,964	154	0.003589	0.01159	486,701
Galle	127	114	3.162	3.589	6,180	127	0.003589	0.01159	115,838
Kurunegala	97	0	3.162	3.589	-	104	0.003589	0.01159	-
Vavuniya	256	0	3.162	3.589	-	255	0.003589	0.01159	-
Peradeniya	30	0	3.678	4.187	-	25.5	0.004187	0.01381	-
	86	0	3.162	3.589	-	112	0.003589	0.01159	-
Badulla	208	0	3.678	4.187	-	85	0.004187	0.01381	-
	86	0	3.162	3.589	-	150	0.003589	0.01159	-
Haputhale	164	0	3.678	4.187	-	43.3	0.004187	0.01381	-
	86	0	3.162	3.589	-	150	0.003589	0.01159	-
Kotagala	96	0	3.678	4.187	-	83.2	0.004187	0.01381	-
	86	0	3.162	3.589	-	55.1	0.003589	0.01159	-
Total profit for SLR					124,146	138.3	Total saving		2,213,918

Since the results of the model prove that destinations along a flat terrain with longer distances are favourable for rail transport, CPC should invest on building rail delivery facilities at Kankasanthurei. Even though Kankasanthurei already has a regional depot, it does not facilitate train deliveries. Both CPC and SLR can improve their gains by developing the regional depot at Kankasanthurei which is the furthest away from Kolonnawa. Privately owned depot at Vavuniya has a limited storage capacity of only 244 kl, and therefore, does not become an attractive regional centre unless the CPC expands its capacity.

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Keywords: *Rail and road transportation, petroleum distribution, linear programming*

ROAD SAFETY

Development of Relationships between Traffic Volume, Number of Accidents and Road Infrastructure Improvements

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1. Introduction

The national road network of Sri Lanka (Class A and Class B road network) serves 80% of the island's road traffic [1] and these national roads have been prime agents for road accidents [2]. The cluster of national roads inside the Western Province connecting a majority of socioeconomically active locations of the country, has the highest demand from both passenger and freight movements which has caused simultaneous increases in congestion and safety problems during the recent past [3]. Under the above circumstances, this research was conducted as an attempt to develop relationships between number of road accidents and road infrastructure improvements to predict the need of infrastructure improvements of the near future, in order to proactively direct the infrastructure providers.

The study was carried out on a 20 km road segment with a high traffic demand and a high frequency of accidents on the A4 road, inside the Colombo District of the Western Province as a case study targeting 25 hazardous locations that were identified and validated through maps plotted with historical data on road accidents from 2010 to 2014 [3]. The SICRS [3] had identified both the hot-spots (congested road sections) and the black-spots (accident prone road sections) separately on A4 road. It had recommended to the Road Development Authority (RDA) possible solutions to mitigate existing problems when improving the road by the end of the year 2014. The RDA having performed two consecutive widening and improvement projects on the studied length of the A4 road from 2010-2013 and 2013-2015, the objective of this study was to identify a relationship among traffic volumes, road accidents and the road infrastructure improvements.

2. Methodology and Analysis

For this research, traffic volumes (ADT) and number of accidents for the selected 25 hazardous locations from the year 2010 to 2014 were gathered as secondary data from the RDA and the Traffic Police Headquarters of Sri Lanka respectively. Using

an appropriately modified safety improvement checklist by La Cava and Cafiso [4] to audit safety on roads, the road infrastructure improvements on the studied road segment were audited from 2010 to 2014 using primary data gathered through interviews with relevant authorities. In order to quantify the road infrastructure improvements, the audit was converted in to infrastructure improvement index values for each location from 2010 to 2014 by allocating weights for each feature included in the checklist according to perceived importance as shown below in Table1.

Table 8 - Infrastructure Improvement Index

No.	Road Infrastructure Improvement	Weight
1	Segregation of transport modes (NMT mode lanes)	5
2	Adequate Lighting Conditions	5
3	Adequate turning circles by design (at junctions and bends)	10
4	Imposed speed limits/ Prohibitions on overtaking at critical areas	10
5	Increased skidding resistance of surfaces (Junction and bends)	10
6	Provided shoulders/ Pedestrian Walkways/ Drainage Systems	10
7	Well guided/placed lane markings and improved road signs	15
8	Islands/ Centre medians/ Guard rails	15
9	Adequate visibility by design (other legs of junctions, forth coming bends)	20
Total Infrastructure Improvement Index value		100

Traffic volumes, road accidents and the road infrastructure improvement index were analysed and developed various combinations of linear relationship. Based on correlation check, the traffic volume was removed and the following was found to be the most significant model, which deals with Fatal Accident (A) and infrastructure improvement index (I) at locations considered along the 20 km road segment. Correlation matrix of the final fit is given in Table 2.

Table 2 - Pearson Correlation Values (and P Values) of parameters

	$A_{(I,P)}$	$I_{(P)}$
$I_{(P)}$	-0.130 (0.196)	-
$I_{(F)}$	-0.320 (0.045)	0.921 (0.000)

$$I_{(F)} = 5.98 + 0.9841 I_{(P)} + 5.18 A_{(f, P)}$$

(R-sq 85.79%, R-sq (adj) 85.49%)

$A_{(f, P)}$ – Number of fatal accidents during the present year

$I_{(P)}$ – Infrastructure improvement index value from the present year

$I_{(F)}$ – Infrastructure improvement index value for future year

3. Conclusion

The linear model that was developed in this study can be used to predict the consequential infrastructure improvement index value for a forthcoming year. It can be concluded that this study reveals a numerical relationship that can be used to proactively determine the need for providing safer roads for the users by relevant authorities (in Sri Lanka, the RDA) to target the infrastructure maintenance and/or improvement to a level greater than or equal to the level predicted by the model based on present fatal accidents and present infrastructure existence. This study could be improved by further fine tuning the weightage assigned for infrastructure improvement, and incorporating more accurate historical data on traffic volume and speed as other additional inputs.

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Development of a GIS-Based Traffic Accident and Road Database Management System

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1. Introduction

This research was to develop a Traffic Accident Analysis System (TAAS) to aid in the identification of accident black spots and develop a statistical model to predict traffic accident severity. TAAS was developed as a set of python tools and deployed as a toolbox in ArcGIS® 10.X. There were all together more than 252,251 traffic accidents (from 2008-2014) reported in Sri Lanka. TAAS consists of data for 20,041 traffic accidents reported in the Southern province of Sri Lanka over eight years (2008-2014). All relevant attributes of traffic accidents in the possession of the traffic police were included in TAAS. (Traffic Police Statistics in Sri Lanka 2014).

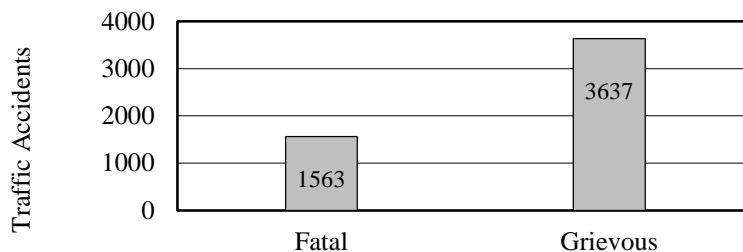


Figure 1: Fatal and Grievous Accidents from 2008-2014 in Southern Province

According to the World Health Organization (WHO) [1], more than 1.3 million people die each year in traffic accidents and more than 50 million are injured worldwide (WHO 2012).

Sri Lanka traffic police analyse traffic accidents through a software called MAAP. The collected data are not properly used for analysis because it cannot be done in a user-friendly manner. As a solution to this weakness, a GIS-based accident analysis system [2] which links a great volume of accidents was developed. As for the second objective of this study a logistic regression model was developed to predict the traffic accident severity. 2,802 serious and fatal traffic accidents were used in the model. Out of eight independent variables used, three were found significantly

associated with traffic accident severity: 'Time', 'Road Surface Condition' and 'Days of Week'.

2. Methodology

2.1. Traffic Accident Data Collection

Data for traffic accidents which occurred during eight years were obtained under several fields such as the location, severity, road surface information, driver's age, etc.

2.2. Graphical User Interface (GUI) with Python

This was used to display the entire system in a desktop. Initiation of creating the GUI was done using Python 2.7 and there were altogether three tools developed.

2.3. Logistic Regression Analysis

Logistic regression analysis was performed considering a traffic accident data set of 2,802 under rural conditions which relate to fatal or grievous traffic accidents. This analysis was done using SPSS Statistics 17.0 software.

3. Results and Discussion

3.1. Traffic Accident Analysis System (TAAS)

TAAS can be identified as the main outcome, through which final results can be obtained at the end of each execution. This provides convenience to the user when data are entered to each field of the interface under 11 fields. There were altogether eleven fields for the user of TAAS to input data.

3.2. Logistic Regression Model

In order to identify the possible contributory factors related to accident severity among eight variables, a logistic regression model analysis was performed. Accident severity, the dependent variable in this analysis, is a dichotomous variable with two categories of Fatal and Grievous accidents.

As Table 1 indicates, three variables among the independent variables were found significantly associated with accident severity, namely, "Time", "Road Surface Condition" and "Days of Week" (below 5% significance level). 'Lunch Peak Time' and 'Evening Peak Time' were identified under "Time variable", 'Slippery' and 'Flooded with Water' were identified under "Road Surface Condition", while 'Monday and Friday' were found under the "Days of Week" variables, to be most significant factors affecting traffic accident severity [3].

Equation 1 shows the model results for predicting traffic accident severity in Southern Province of Sri Lanka. Binary logistic model indicated by the Equation 1 achieved an overall classification accuracy of 70.1% as indicated in Table 2.

Table 1 - Coefficient Values for Model Variables

Variable	Coefficient (B)
Time	
1- Morning Peak Time	-.220
2- Lunch Peak Time	-.470
3- Evening peak Time	-.249
4- Daytime Without Peak	-.261
Workday or Non-Working	
1- Working day	.329
Day of week	
1- Monday and Friday	-.218
2- Tuesday, Wednesday and Thursday	.088
Road Surface Condition	
1- Slippery surface (mud, oil, garbage, leaves)	1.080
2- Wet	.135
3- Flooded with water	1.047
Light Condition	
1- Daylight	-.325
2- Night, no street lighting	-.270
3- Dusk, dawn	-.276
4- Night, improper street lighting	.081
Gender	
1- Male	-.059
Age Category	
1- Less than or equal to 20	.010
2- 21 to 35	.025
3- 36 to 50	.117

Accident severity = Coefficient for Time + Coefficient for Days of Week + Coefficient for Road Surface Condition + Coefficient for Light Condition + Coefficient for Gender + Coefficient for Age + Coefficient for Workday or Holiday - 0.383..... (1)

Table 2 - Classification Table for the Model

Observed		Predicted	
		Severity	
		0	1
Severity	0 - Grievous	1949	13
	1 - Fatal	824	16
Overall Percentage			
			70.1

4. Conclusions

The TAAS user interface created gives the user more than 150 different combinations of analytical methods under eleven different data categories where accidents appear in a digital map and can be displayed graphically. So TAAS can be further developed to better standard level more than MAAP since it involves more statistical information regarding the traffic accidents in Sri Lanka.

Results of the logistic regression model suggest that lunch and evening peak time, Monday and Friday, and also slippery and flood conditions, are significant causal factors contributing to traffic accident severity. These causal factors are found significant at or below 5% level implying that the conclusions could be accepted with 95% level of confidence [4].

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Keywords: *Traffic Accidents Analysis, GIS analysis, Python tool box*

Risk Factors of Motorcycle Crashes in Sri Lanka

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1. Introduction

The use of motorcycles has become a passion or even a way of life in many South Asian countries including Sri Lanka, for commuting to work or transporting goods, as they are easy to use and to cover short distances. In these countries, ownership and use of motorcycles and other two-wheelers are generally relatively high. Compared to drivers of other vehicles, motorcyclists are vulnerable road users as they often share the traffic space with fast-moving vehicles, they are less visible, and also they lack protection in the case of a crash.

All Sri Lankan regulations for motor vehicles are applicable to motorcycles. The owners are required to register their vehicles and also obtain driving licences to operate motorcycles. They also are required to obtain annual revenue licenses. Motorcycles are popular among middle income and low income people in Sri Lanka and mainly used to commute to work and also used to transport goods, as well as for recreational purposes. The most common vehicles on Sri Lankan roads are motorcycles and the number of motorcycles is more than three times the number of the second most popular vehicle, namely the three-wheeler. The percentage of increase of registered motorcycles in Sri Lanka from year 2003 to 2012, was 152% [1]. As the number of motorcycles increase, so does the probability of their being involved in motor vehicle crashes.

Despite their popularity, little research has been conducted to study the impact of motorcycles on road safety in Sri Lanka. The present research investigates the risk factors of crashes involving motorcycles and contributory causes using data from Sri Lanka.

2. Data and Methodology

Data were obtained from police crash records which contain details of police-reported crashes, at all severity levels. Data pertaining to crashes involving motorcycles in Sri Lanka which occurred between 2009 and 2013 were considered for this study. The number of motorcycle-involved crashes has increased during the last five years with the highest being observed in 2012. Data were used to investigate motorcycle crashes calculating their frequencies and percentages. Then a crash severity model was developed to investigate the severity of the motorcycle crashes. Crash severity, which is the dependent variable in this model, is

dichotomous, taking a value of zero for a crash with non-grievous injury and a value of one for a grievous injury or fatal injury. All other available variables were considered in the model development. These variables were checked for multicollinearity using Pearson's correlation matrix to confirm that they were significantly independent candidate variables [2]. Among these independent variables, a total of two correlated pairs achieved a significance level of $p \leq 0.5$, which was the cut-off criteria selected for the analysis. One variable from each pair was discarded, so that the variable providing the stronger model, i.e. the variable with the higher-magnitude of Pearson's statistic was retained.

To measure the association between crash severity and characteristics of crashes involving motorcycles, Odds-Ratios (ORs) and 95% Confidence Intervals (CIs) were estimated using severity models. An odds ratio greater than 1.000 indicates that the concerned characteristic would lead to a higher crash risk, and vice versa.

3. Results and Discussion

The total number of motorcycle crashes during the five-year period was 209,381 including 21,996 fatal crashes and 63,228 grievous injury crashes. Age of the motorcycle driver was one of the factors useful for understanding the characteristics of crashes involving motorcycles. While there were some younger and older drivers, 65.6 percent of motorcycle drivers involved in crashes were between 20 and 40 years old. Only 58.8 percent of motorcycle crashes involve riders holding valid licenses. Safety helmet usage in crashes involving motorcycle riders was 62.5 percent. More frequent crash conditions for motorcycle crashes were those occurring while driving on rural roadways, driving during week days, and driving newer motorcycles. Dry road surfaces, clear weather conditions predominantly characterised motorcycle-crashes, which may simply be owing to majority of motorcycles being driven under these conditions.

The variable 'male', which has the highest magnitude of odds ratio among all the variables, showed that motorcycle-involved crashes were likely to be more severe when the driver was male, as compared to female drivers. The odds ratio of alcohol-impaired drivers was higher than 1.000, which indicated alcohol had increased crash risk. Similarly, motor cyclists holding a valid licence were less likely to be involved in a more severe crash than those having no valid licence. When investigating odds of driver-related variables, usage of safety helmets appeared significantly lowering the risk. The odds ratios of environmental-related variables showed that the motorcycle crash severity increased when light condition was 'dark'. Motorcycle crash severity on urban roads was lower compared to rural roads. Also, at intersections and dry road surface conditions independently showed low crash severity risks. Two vehicle crashes had lower odds of causing more severe crashes

as compared to single or multiple vehicle crashes. This analysis provided a good measure to identify factors contributing to increasing severities of crashes involving motorcycles.

Many factors combine to produce circumstances that may lead to a traffic crash; there is rarely a single cause of such an event. The contributory causes could be mainly divided into three categories; driver-related cause, roadway-related causes, and vehicle-related causes. Aggressive/negligent driving and speeding were the most frequent driver contributory factors in the motorcycle crashes. It was interesting to note that when the contributory cause was one of those, the helmet usage was comparatively low. There were occasions when the driver had to react to unexpected events. Hence, road conditions, as well as surrounding conditions, needed to be considered as important factors when riding motorcycles. Defective road surface, or defective road sign, emerged as main roadway contributory causes. Safety helmet use was lower when defective road sign was the contributory cause. Crashes due to failure in the breaks were more frequent when considering vehicle-related causes.

3. Conclusions

The results of this study could be used for the targeting of future intervention programs aimed at reducing motorcycle crashes and reducing their severities. Incorporating these findings into existing training and education programs for both motorcyclists and drivers may improve their awareness of problems and help reduce the frequency of crash occurrence.

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Keywords: *Crash-data analysis, Motorcycles, Road safety*

ROAD TRANSPORT OPERATIONS

Factors Influencing a Shift towards Carpooling in Western Province, Sri Lanka

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1. Introduction

The current fast-paced development of the modern world has caused a massive need for mobility. With a 7.3% increase in Sri Lanka's GDP in 2013 (Economic and Social Statistics of Sri Lanka 2014, Central Bank of Sri Lanka), the number of vehicles bought also increased by approximately 12% that year. According to statistics published by the Daily Mirror newspaper which cites the National Transport Commission and Central Bank, the total amount of cars which enter Colombo every day is 170,000. Out of the total 500,000 vehicles that enter Colombo daily, 87% are private vehicles and 6% are public vehicles. These public vehicles, carry 52% of the total passengers who enter Colombo. Only 44% of the passengers who enter the Colombo City are carried in private vehicles. 31% of the vehicles are cars and the average occupancy of these vehicles is around 1.8 people. This has led to a large number of low-occupancy vehicles in the Western Province of Sri Lanka. The objective of this research is to identify the factors that could possibly influence people to shift towards carpooling in the Western Province of Sri Lanka.

2. Literature Review

Carpooling can be defined as a set of people riding in one vehicle owned by them when travelling together regularly from one place to the other where they take only one of their own vehicles to the ride. Dewanand Ahmad define it as the sharing of rides in a private vehicle among two or more individuals. It involves the use of one person's private or company vehicle to carry one or more fellow passengers. They state that, in New Delhi, the amount spent on petrol could be reduced by 30% if carpooling was carried out. A Swiss survey (Ciari, F. and Zurich, 2012) carried out on carpooling identified safety to be a concern but practical aspects such as being able to go back home as a passenger if pools are arranged on a one-way basis appeared a more important concern: this research makes a similar observation.

3. Methodology

Primary data were gathered from a random sample in the Western Province of Sri Lanka. Data gathering was carried out by administering a survey questionnaire (emails, online documents and interviews) containing respondents' details, journey details and the preferences towards carpooling. Part A contained questions on age, education, income and household details. Part B questioned on distance to work, mode of travelling, time taken to travel to work and Part C consisted of the respondent's concerns on the safety, security, environment and social concerns and also the expectations with respect to reliability, comfort and incentives. 649 questionnaires were collected. Descriptive analysis was carried out to identify respondents' views on carpooling.

4. Results and Discussion

59% of the respondents had a positive opinion on carpooling. 49% were willing to embrace carpooling. This shows that people are positively inclined towards carpooling yet are not willing to embrace it, since sometimes it does not result in the outcomes expected from the carpooling service providers. These service providers are not commercial service providers but drivers who travel for work daily. Respondents are concerned about the driving style of the driver and whether the riders smoke or not. The ethnicity and appearance of riders are rather unimportant concerns and gender is a neutral factor when the collective results are considered (male and female). When only the female population is concerned, gender is a very important concern for them. Respondents are well aware that carpooling will reduce congestion levels, reduce pollution, save time and increase parking space. The main barrier the respondents have when considering to join carpooling is the safety risk. These safety risks could be harassments, thefts and invasion of privacy. Another barrier is the risk of not being picked up. Reliability of the service is a very important concern for the respondents.

Out of the proposed incentives, rather than expecting separate lanes in highways and getting other incentives, respondents are expecting more practical incentives such as ride-back assurance, reserved parking spaces and possible fuel incentives. When joining carpooling, important factors for consideration are the proper availability of space, reliability of the service, picking up from the residence and dropping off at the residence. When respondents were provided with the statement *"If proper passenger preferences are provided, people will shift towards carpooling rather than using their own vehicles for routine activities"*, 51% of the respondents *"strongly agreed"* with it while 41% *"agreed"* with it. Only 1% disagreed.

Factor analysis was carried out in order to explain correlations among multiple outcomes. The important purpose of this was to describe the covariance

relationships among variables, which was unobservable. Initially, Cronbach's alpha test was performed. Cronbach's alpha, α , which is the most common measure of scale reliability turned out to be 0.844. Hence, it can be said that the internal consistency of the questionnaire is within required levels. KMO test statistic was 0.62. Therefore, it can be concluded that sample size was adequate for a satisfactory factor analysis. Using factor analysis, 36 of the variables questioned in the questionnaire were divided into 12 communalities: Utility, Service, Altruism, Convenience, Egoism, Skepticism, Attitude, Risk, Cost, Environmentalism, Community and Reliability. Reliability analysis was carried out for each of the above factors and the factors which yielded reliability value above 0.7 were identified. The two factors which had reliability value above 0.7 were Utility and Service. These were used to test the hypotheses using Kruskal Wallis test where the following hypotheses tested:

H_0 : Reliable factor is independent of the i^{th} variable
and

H_1 : Reliable factor is dependent of the i^{th} variable

where reliable factor was Utility or Service and the i^{th} variable was age, gender, education, sector of employment, monthly income, number of members in the household, distance to work from the residence, time taken to travel for work, method of transport, mode of transport or occupancy of the vehicle. When considering the Utility factor, all the i^{th} variables (11 variables) were significant. When Service factor is considered, except for gender all the other i^{th} (10 variables) were significant.

5. Conclusions

The study enables the conclusion that, when promoting carpooling and giving incentives to passengers, more consideration should be given to age groups above 35 years in which we could possibly find a high usage of private vehicles. Carpooling should be promoted among people who obtain higher salaries (above 50,000) since they are likely to be the main user of private vehicles to travel for work. Low salary earners mostly use public transportation. The proper route planning should be done in a way that it covers passengers travelling small distances to work (0-10KMs) as well as those travelling over 40 km. It is observed that people are partial to travelling by carpooling services rather than using their own vehicles or public transport to go to work. Also people are partial to joining carpooling to travel longer distances (above 50KM). Based on the opinion on carpooling and willingness to join carpooling, the government does not need to impose any harsh or stringent strategies to make people embrace it while giving a few of the proposed incentives. Initially the policy makers should concentrate on

creating a policy framework where they initially promote the benefits of carpooling and give the required incentives step by step as mentioned. Also government should support the private sector in creating a system which connects drivers who are willing to carpool and passengers who are willing to join.

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Keywords: *Single Occupancy Vehicles, High Occupancy Vehicles, Carpooling*

An Analysis of Methodologies for Solving Green Vehicle Routing Problem: A Systematic Review of Literature

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1. Introduction

The Vehicle Routing Problem (VRP) can be described as the problem of finding optimal routes for delivery to or pick-up from one or more depots to many customers who are geographically dispersed. This problem has been at the core of many operations research problems. Later the focus has shifted to sustainable business practices with a novel category of VRP, known as the Green VRP. In this category, the objectives are different from the original VRP: it focuses on minimising the impact on the environment as opposed to merely minimising costs and the distance travelled.

2. Methodology

Energy Minimising VRP (EMVRP) has been developed to minimise the energy consumption of a fleet while serving all customers. It has been identified that energy consumption has a direct impact on carbon dioxide emissions.

Heuristics, often referred to as ‘rules of thumb’, has the meaning of discovering techniques for problem solving. The algorithmic community has gone one step beyond, and developed a class of Heuristics named ‘Metaheuristics’ which is heavily used in combinatorial optimisation. Normally these problems are found to be np-hard, which cannot be optimally solved in polynomial time. VRP is among the most known np-hard problems, thus, Metaheuristics is widely used in finding near optimal solutions. The most widely used exact methods are Linear Programming and variations of branch and bound methods. Problem formulations of Green VRP have been extensively reviewed in literature, but not the solving methods. Refer to Table 1 for a detailed analysis of the heuristics being used to solve Green VRPs and Pollution Routing Problem (PRP).

Table 1- Heuristics-Based Solving Methods Used for Solving Green VRP Variants

Research Study	Solving Method
A Green Vehicle Routing Problem	Modified Clarke and Wright Savings algorithm (MCWS) and Density Based Clustering Algorithm (DBCA)
A Variable Neighbourhood Search Branching for the Electric Vehicle Routing Problem with Time Windows	Developed a variable neighbourhood search branching algorithm to solve formulated electric vehicle routing problem with time windows
Green logistics at Eroski: A case study	Used Mole and Jameson (1976) method to solve CVRP and Nearest neighbour insertion algorithm (Bodin et al. 1983) to solve VRPB
Solving the Capacitated VRP with Environmental Criteria Based on Real Estimations in Road Transportation: A Case Study	Developed Mole and Jameson algorithms based Algorithms with Environmental Criteria (AWEC)
A block recombination approach to solve green vehicle routing problem	Used a block recombination approach to solve formulated problem

3. Conclusions

Table 2- Metaheuristics-Based Solving Methods Used to Solve Green VRP Variants

Research Study	GVRP Category	Solving Method
Development of a fuel consumption optimisation model for the capacitated VRP	Green VRP	Developed a string-model based simulated annealing algorithm with a hybrid exchange rule.
Using simulated annealing to minimise fuel consumption for the time-dependent VRP	Green VRP	Developed a simulated annealing algorithm to solve the formulated TDVRP
The electric vehicle-routing problem with time windows and recharging stations	Green VRP	Hybridization of Variable Neighbourhood Search and Tabu Search
A Memory Structure Adapted Simulated Annealing algorithm	Green VRP	Developed a Memory Structure Adapted Simulated Annealing (MSA-SA) algorithm to solve Green VRP with time windows
An Adaptive Large Neighbourhood search heuristic	PRP	Used Adaptive Large Neighbourhood Search (ALNS) algorithm and at the second stage used a Speed Optimisation Algorithm (SOA) on the resulting VRPTW solution to find the optimal speed on every arc
The bi-objective Pollution-Routing Problem	PRP	Used Adaptive Large Neighbourhood search algorithm and a speed optimisation procedure to solve the formulated bi-objective PRP

Metaheuristics are a more generalised cluster of Heuristics; its potential of use in efficiently solving Green VRP is demonstrated through this study.

Table 2 reviews the studies which use Metaheuristics-based solutions and we find that these solutions can be used effectively for solving larger and more complex instances of Green VRP. Metaheuristics perform better than other approaches mainly because of their ability to explore feasible solutions in a wider random search space.

The scrutiny identifies several knowledge gaps where new methodologies can be developed to solve Green VRP formulations, and develops propositions for future research. With the development of novel data mining and machine learning techniques, focus also needs to be directed to combining current methods to produce solutions for larger problem instances in a timely manner.

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Keywords: *Green VRP, Exact methods, Heuristics, Metaheuristics*

Application of GPS Vehicle Tracking Technology in Sri Lankan Supply Chains

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1. Introduction

Supply chains at present can make use of a multitude of applications of GPS (Global Positioning System) vehicle tracking technology to enhance performance, particularly in fleet operations. These extend across a wide range of applications from basic features such as geo-fencing and the monitoring of vehicle position, speed and distance, to more advanced features such as operations planning, vehicle and personnel scheduling, vehicle maintenance, and real time demand planning [1, 2, 3]. Although these applications are becoming progressively more widespread, mere utilisation does not guarantee the significant benefits it can generate.

2. Literature Review

Complexity of operations motivates adaptation of sophisticated technologies [4, 5]. Cost savings, service level improvements, enhanced control, safety and security also motivate the use of new technologies. However, such motivations are hindered by factors internal to the company as well as those external to it: the former including factors such as company being small, lack of expertise in technology, insufficient financial support, fear of change, organisation culture, inability to quantify benefits, difficulty in integrating with legacy systems, estimated long time durations for implementation, perception of risk of rapid obsolescence of technologies, difficulty in integrating with previously adopted systems, lack of management support, and inability to model the complex reality of transport processes; and the latter including external factors such as influence from other companies along the supply chain, hardware instability, and ineffective software [5, 1].

3. Methodology

The specific objectives of the present study are to identify the motives of adopting GPS vehicle tracking technology, to analyse the extent of its application, to identify barriers for enhanced utilisation of the technology in Sri Lanka, and to propose necessary adjustments that may be required to achieve the purpose.

The population for the study is defined as business entities that are using GPS vehicle tracking technology at present. The sample was confined to 34 respondents representing different product supply chains, entity types (manufacturing/ third party logistics [3PL]), and fleet sizes, due to time and other resource constraints. Primary data were collected through a questionnaire; tested for reliability using Cronbach's alpha, the coefficient for reliability; and analysed using descriptive statistics.

4. Data Analysis and Conclusions

According to the findings of the study, irrespective of whether a company is specialising in logistics operations, its fleet size, or the product transported, the detection of fraud is the primary motivation for adopting GPS vehicle tracking technology in Sri Lanka. It is followed by the motivation to improve safety. Although not applicable to the majority, improvements of operational responsiveness and specific customer requests to implement such a system have also become motivational factors to adopt GPS vehicle tracking technology. Surprisingly, the reduction of operating costs is rarely an objective of Sri Lankan companies adopting GPS vehicle tracking systems.

The objective of fraud detection is also the key objective to adopt GPS for large companies (operating fleet above 30) in Sri Lanka. In contrast, small companies (with a fleet of less than 10) are not much motivated to use GPS, unless their customers have specifically requested its use. For companies transporting apparel, vehicles or machinery; safety is the key motivation in adopting GPS vehicle tracking followed by operational responsiveness, which may be due to specific characteristics of the product such as high value and time sensitivity.

As opposed to the motives for adopting GPS technology, a majority of the companies has claimed to achieve improved responsiveness; followed by detecting fraud and improved safety after utilising the technology. Further, reduction of operating cost is achieved by only a minority, implying both lack of understanding of possible long term cost savings and the poor utilisation of advanced features available with the technology.

According to the mean value analysis, a majority of present GPS vehicle tracking users make use of its basic features for daily operations. These features include distance travelled per journey, vehicle position, direction and speed, vehicle tracking reports, alert on speed violation and route geo-fencing. Application of features such as engine on/off status, door open/closed status, and seat belt status remains low. In contrast, application of advanced GPS vehicle tracking features is low among present users. Out of the thirteen features tested, only operational

planning and KPI monitoring (such as on time arrival/departure) were used by a majority (58.8%). Features such as vehicle and personnel scheduling, truck turn-around time (TTT) monitoring, fuel usage/efficiency monitoring, cargo conditions monitoring, security camera, two way voice communication, and integration with other business applications, are rarely used.

Among the major barriers for enhanced GPS vehicle tracking technology utilisation are lack of mechanisms in place to track and monitor performance and verify progress, and lack of knowledge on possible applications and benefits of the technology. Lack of system features is also a barrier as per the view of some present users. Although GPS signal blockage can happen typically because of overhead obstructions such as tunnels, bridges, and trees [1, 2] interrupting the operations management, it was not highlighted by the users. Lack of knowledge is significant in companies operating small fleets (less than 10 vehicles), while lack of performance measurement is significant in companies operating large fleets (greater than 30 vehicles). Due to the lack of knowledge prevailing among companies operating small fleets, the cost of investment will not be justifiable given the benefits gained, leading to a lack of motivation to use GPS, unless the customer specifically requests it. Thus, such companies can start off with strategies such as consolidated purchase of hardware at a discounted price through mutual association to reduce investment costs.

The analysis proved that a majority of the users in Sri Lanka has experienced improvements after adopting GPS vehicle tracking, although the application is limited to basic features. On one hand, this may also hinder exploitation of the technology to its optimum potential due to premature satisfaction. But the analysis also revealed the high possibility of improving supply chain performance in Sri Lanka through enhanced utilisation of the technology. Implementation of an appropriate mechanism to track and monitor performance and to identify improvements is the best solution to encourage the application of GPS vehicle tracking technology, followed by negotiation of service level agreements with GPS vehicle tracking technology service providers. Investing in an OCC (Operations Control Centre) with proper infrastructure is also suitable for companies with fleets larger than 30 vehicles.

5. Conclusions

The research findings stress upon the prevailing lack of knowledge and understanding of the subject among present users, and demonstrate the capacity available for them to improve supply chain performance by optimum adoption of the technology. Findings suggest that present and future GPS vehicle tracking users must continuously explore the possible applications of the technology innovatively

to obtain a competitive edge. Operational staff, in particular, must be well educated on the subject, which would enable them to think and experiment with creative applications/features using the technology. Also it is a critical need to establish a mechanism to monitor performance, especially in large companies. Conducting training programmes or hiring multi-skilled professionals in the field are proposed to obtain expertise. Most importantly, users and service providers could mutually benefit by developing collaborative relationships creating an environment for sharing knowledge and expertise.

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Keywords: *GPS vehicle tracking technology, Sri Lankan supply chains, performance, motives, applications, barriers*

FREIGHT TRANSPORT

A Study on Environmental Sustainability Policies in the Road Freight Transportation Industry in Sri Lanka

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1. Introduction

This research outlines the study of environmental sustainability policies in the road freight transportation industry in Sri Lanka. The aim of this research is to explore how far the road freight industry in Sri Lanka has implemented green transport solutions and investigate the relationship between the size of the business and variables such as the motives and barriers to implement environmental sustainability policies in the road freight transport industry in Sri Lanka.

2. Background of the Research

Environmental issues are becoming increasingly important and they are given more consideration in the overall strategy of organisations. As concerns for the environment rise, companies must realise the importance of the external costs associated with road freight transportation, mainly due to climate change, air pollution, noise, vibration and accidents. Therefore, more companies have concern for monitoring and tracking fuel consumption, purchasing more fuel-efficient vehicles, "green" procurement practices, experimenting with alternative fuels, reducing noise, reducing vehicle mileage operated, promoting freight consolidation initiatives within companies, limiting the speeds at which company vehicles are operated, qualifying fleet operators based upon their equipment and performance, sharing vehicles across multiple customers etc.

Within the supply chain, transportation is the largest source of environmental impact [1] and on an aggregate level, freight emissions account for roughly 8 per cent of worldwide energy-related carbon dioxide (CO₂) emissions [2]. As a result, policies that focus on the protection of the environment is continually being developed [3].

3. Significance of the Research

Many policy developments had been introduced worldwide which are concerned with reducing the negative impacts to the environment from freight transport operations. Identifying and quantifying the environmental sustainability policies implementation on the freight transport operation in Sri Lankan context is vital since it will depict the actual situation at present. Study of environmental sustainability policies is a very broad topic. Therefore, this research focuses on the study of environmental sustainability policies in the field of road freight transportation and not on the whole supply chain operations.

4. Data Collection

Data for this research were collected by a structured survey questionnaire forwarded to a convenient sample of large and medium scale logistics organisations in the business of road freight transport operations in Sri Lanka. Prior to preparation of the questionnaire, a comprehensive literature survey was carried out. Then the questionnaire was developed with the objective of targeting managerial personnel of the transportation sector of organisations. The questionnaire received responses from 37 individuals from the road freight transport industry in Sri Lanka.

5. Analysis & Results

As per the responses, all respondents had an environmental policy in their organisations. The identified barriers for implementation of such environmental policies are cost and business complexity. About 70 percent of respondents answered business complexity as the biggest barrier to implement environmental initiatives. Identified motives were: customer interest, competitive strategy, opportunity of growth, cost savings and sustainability of the environment.

Identified environmental sustainability policies were categorised as sub factors under four major categories: (i) Vehicles, (ii) Equipment and Operations, (iii) Facility, and (iv) Employees and Management. Most commonly used factors with respect to above four categories were (a) monitoring and tracking information on energy, (b) waste recycling and disposal, (c) conducting training programs for drivers ("eco-driving") and (d) usage of digital documents (using less paper).

As regards the measure of mean values of four categories, it appears that most of these values cluster around point two (medium level) on the specified scale. And one of the categories ("employee") scored a mean value around point three (high level) on the scale. None of the mean scores lie on the low side of the scale (point one), indicating that most of the respondents are using environmental sustainability practices at medium level or above. In calculating the overall mean values, all

variables have been taken into account for all respondents, and the mean value was then calculated for each category. To investigate the relationship between the size of the business (large and medium) and variables (barriers and motives), chi-square test was performed. The results revealed some significant relationships between those variables. It is indicated that when respondents answered for barriers and motives to the implementation of environmental sustainability policies, they were influenced by size of the organisation.

6. Limitations and Recommendations

Mainly large and medium-sized logistics organisations were included in the sample. However, smaller businesses might have different perceptions regarding the concern of environmental sustainability policies in road freight transport operations. Although the majority of respondents were managers, employees below manager level might have different perceptions regarding the implementation of environmentally sustainable policies, which are not captured in this research. For a future research it would be interesting to see if and how implementation of sustainable practices would change the strategy of a business.

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Keywords: *Environmental Sustainability Policies, Freight Transport*

The Development and Implementation of an Extended Transport Management System (ETMS)

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1. Introduction

Transport management plays an important role in the present day Sri Lankan context, particularly when the Government has made significant advancements in terms of investment in physical infrastructure in the domain of transport and logistics. Efficient management of transport and logistics systems by the relevant service providers, however, becomes an important lynch-pin for the nation to effectively realise the objectives of such large scale investment effort, namely becoming a regional transport and logistics hub. It is within this context that costly transportation, which has hit the bottom line of organizations engaged in manufacturing and logistics, has attracted attention of corporates, which look for way of minimising such costs through adoption of ICT and outsourcing to third-party service providers. This interest is mirrored by the increasing trend towards outsourcing of warehousing and distribution functions by manufacturers, importers and exporters in Sri Lanka to 3PL service providers. This, in turn, has led to an increased number of 3PL service providers focusing on transportation products and attracting an increased spectrum of customers.

The Third-Party Logistics Study Report (2015) refers to this trend also observable globally. According to this report, transportation management (execution), electronic data interchange (EDI), transportation management (planning), customer order management, visibility (order, shipment, inventory, etc.), warehouse/DC management, web portals for booking, and order tracking figure vital success factors in the global 3PL industry in providing cost-effective and advanced customised solutions. The report also states that there exists a persisting IT gap in this regard at global level, bridging which would be a strategic niche for gaining competitive edge.

This IT gap in the Sri Lankan setting is very significant, particularly in the context of the country's transport and logistics hub dream. Even though local 3PL industry comprises of many Fleet Management Systems (FMS) to track and trace vehicles on the move through web browsers, such systems have not been able to fill the gap between the transport requesters and 3PL service providers. Figure 1 below depicts this persisting IT gap.

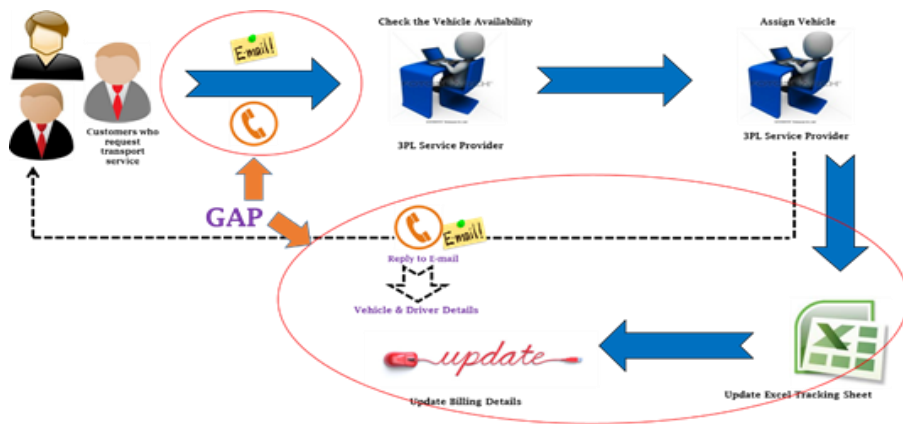


Figure 1: Previous Process of Transport Management in Third Party Logistics Industry

On the other hand, the Sri Lankan service providers face difficulties in implementing global IT trends and solutions, in view of bridging this service gap, mainly due to cost constraints. Even though, a few large firms have spent millions of dollars and purchased commercially available software products, developed for warehousing and transport management, such as SAP or Oracle Business Suit, and some have even extended such systems to 3PL service provision, the problem appears remaining largely unresolved. It is in this context that several 3PL service providers have taken initiatives to develop ICT solutions of their own for their business processes, the effort launched by Advantis 3PL plus being one such local initiatives.

This paper presents the inventive effort in view of development and implementation of an Extended Transport Management System (ETMS) undertaken in 2015 by Advantis 3PL Plus, one of the leading third party logistics service providers in Sri Lanka. It also discusses the outcomes of the research project, its benefits as well as lessons learnt for future research.

2. Materials and Methods

It was decided to develop an ETMS and implement it collaboratively with a local GPS Tracking service provider, considering the fact that reaching out for globally available products are costly and not perfectly fitting to the ground requirements of the company. A project team formed by the management of the organisation was led by a business systems analyst and it included a logistics analyst, business development experts and operational representatives. The project followed all steps

in the Software Development Life Cycle (SDLC) including detailed requirement gathering and analysis, documentation, development testing and user training. “Software-as-a-Service (SaaS)-Cloud Hosting Model” was chosen for the purpose of minimizing capital expenditure on the initiative where the software company would be paid as and when the ETMS is used.

3. Results of the Research: The Innovative Solution

By 2015, the research team completed the development of a web based (SaaS) Extended Transport Management System (ETMS) which enables transport requesters to highlight their requirements including pick-up points, delivery points, vehicle types and request time. Main functional characteristics of the newly developed ETMS are depicted in the Figure 2.

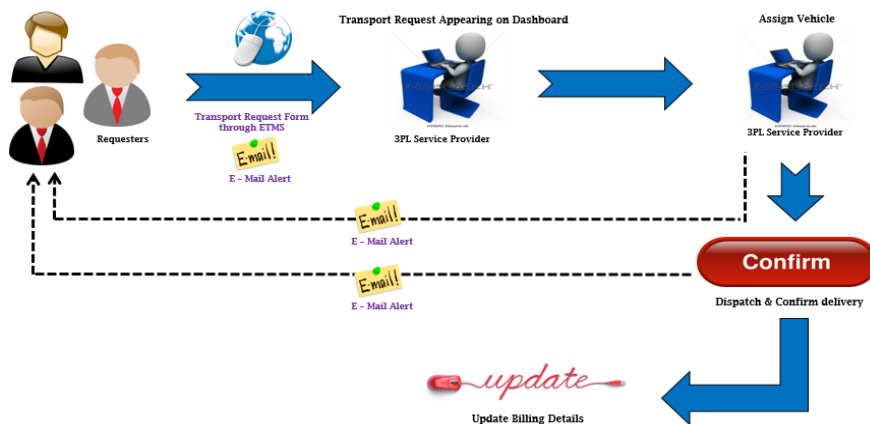


Figure 2: Process of Extended Transport Management in Third Party Logistics Industry

The system provided a dashboard of transport requests made to the transport coordinators of the 3PL service provider which would notify the details of the specific vehicles in the fleet assigned for a particular job to the client who originally made the request. The client in turn could view the vehicle allocations through the integrated Geographic Positioning System (GPS). Email alerts are sent by ETMS to defined parties specifying the status of the delivery through geo-fencing, and the system dashboard also is updated accordingly.

4. Analysis

The system was implemented in September, 2015, and the post-implementation performance was tracked for a period of 9 months. It was observed that almost all objectives set at the project initiation, including automation of communication and report-generation, elimination of manual communication used in transport

coordination within the supply chain, have been achieved. Further, the new system has enabled increased information visibility for all parties involved in the process in terms of traceability of information and accountability of cargo. A customer survey conducted revealed that they are highly satisfied with regard to the system functionality and to the extended level of information visibility. Moreover, the system now captures the cost details of each delivery and automatically producing the monthly billing report, which enhances cost efficacy and minimises payment defaults. It was also observed that this system-driven process has minimised human errors, enhancing the effectiveness and punctuality of operations and the accuracy of data and information.

5. Conclusion

The research enabled development and implementation of an ETMS, which proved that Information and Communication Technology (ICT) could play a significant role in creating and innovating more efficient and customer-friendly solutions for the 3PL industry. It has also established that the ICT industry in Sri Lanka has matured to an extent that it could develop research based inventions and innovation for the betterment of transport and logistics operations in the country, possibly helping the realisation of the nation's objective of becoming a transport and logistics hub. ETMS, however, needs continuous upgrading in phase with the evolving and ever more demanding customer requirements. Such dynamics could be suggested as seed for future research and development in this domain.

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Keywords: *3PL, Transport Management, Software as a Service (SaaS), ICT*

AIR TRANSPORT

Evaluating the Potential of Mattala Rajapaksa International Airport (MRIA) to have a Competitive Edge as the Second International Airport of Sri Lanka

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1. Introduction

The second international airport in Sri Lanka, Mattala Rajapakse International Airport (MRIA), was constructed in Hambantota District, located in the Southern region of the country. The airport was declared open on 18th March 2013. The airport has the capacity to handle 1 million passengers and 45,000 tonnes of cargo per annum. However, the airport was not able to utilise its facilities since the commencement of operations. The situation did not improve, but rather deteriorated with the stoppage of the operation of the national carriers to the airport. Therefore, though the airport is equipped with the necessary facilities for an international airport and operating for almost two years, the airport was unable to achieve its targeted objectives.

This research aims at identifying the reasons for this gap and the solutions to improve it. The key purpose of this study is to identify “why the airport (MRIA) was unable to meet its target as indicated in the master plan”. Identifying the requirement for another international airport in Sri Lanka, reasons for the underutilisation of the airport, benefits of the airport and viable options are the objectives undertaken to achieve the purpose of the study.

2. Research Methodology

A methodological approach including both qualitative and quantitative studies was used to achieve the objectives. In the initial stage, industry experts having more than 25 years of experience were interviewed to obtain the background information relating to the study area, and the information was later used as the basis for the survey. A sample of 40 responses was collected for the survey; and secondary data was used to confirm the findings of the survey. Descriptive methods were used to

analyse the data and finally a SWOT analysis was performed to develop strategies for the airport to have a competitive edge.

3. Research Findings

All sectors in the aviation industry, including the airline operation, regulatory body, airport operation, academic and training schools, are represented in the sample of 40 that was subject to survey. Moreover, 25% of the sample had more than 25 years of experience in the aviation industry, which further validates the survey findings.

According to the study, 75% of the sample stated that unavailability of another airport in Sri Lanka, to use in emergency situations, was the prominent issue faced when having only the Bandaranaike International Airport (BIA); whereas 57.5% of the sample also stated lack of an airport to divert in bad weather conditions at BIA as the issue. But according to historical data of aircraft diversions at BIA from 1996-2006, there were only 14 instances where an aircraft was diverted due to bad weather. Hence, aircraft diversions at BIA due to bad weather conditions seem to be a rare occurrence.

77.5% of the respondents stated the requirement of another international airport was to use as an alternative airport to BIA. However, 75% of the industry experts questioned do not agree with the location of the second international airport due to lack of infrastructure facilities, industrial activities, accommodation facilities and lack of demand in the region. Out of these respondents, 52.2% suggested either Kandy or Dambulla in Central province as the most suitable location for the second international airport. Reasons were accessibility, proximity to tourist attractions, good road network with other regions in the country, large catchment area and contrast weather condition compared to BIA.

When considering the benefits from MRIA since its opening, 82.5% of the sample considered that there is a benefit. 70% of the respondents indicated the availability of another international airport to use as an alternative airport as the benefit. Carrying of less fuel by the aircraft arriving at BIA and increase in aircraft flying over Colombo FIR (Flight Information Region) were considered as benefits obtained from the airport by the respondents. This is supported by the findings of secondary data analysis based on the number of overflying aircraft and alternate fuel carried by aircraft before and after the opening of MRIA. Certain assumptions were undertaken in arriving at these calculations due to the unavailability of data. Remarkably, the majority of the sample does not feel that there has been an economic or social development in the region due to the airport. MRIA did not have the required level of air services to help the development of Hambantota area,

which was a necessary requirement for an airport to assist the development of a region as per the studies conducted by Robertson [1].

Yet the potential for realising these benefits did not optimise the utilisation of the airport. According to the analysis, lack of demand in the region was identified as the highest-contributing factor for the under-utilisation of the airport. Only 9 districts out of the 22 districts in the country are close to MRJA compared to BJA; hence the airport does not have a large catchment area. This also confirms the finding where industry experts do not agree with Hambantota as the location for the international airport. It is evident that the location of the airport has played a critical role for the current status of the airport. Lack of airport marketing activities carried out by the authority was also identified as a cause for the underutilisation of the airport.

According to 62.5% of the industry experts surveyed, the best course of action to overcome the current status of the airport is to develop the region in terms of infrastructure, accommodation facilities and utility facilities. Implementing a proper marketing plan was voted by 55.5% of respondents as the second most important factor. Converting the airport to Maintenance, Repair and Overhaul (MRO) hub were also suggested by a majority as viable strategic options that could be exploited.

4. Conclusion

Considering the findings of the interviews, questionnaire survey and secondary data, a SWOT analysis was carried out for the airport in order to develop strategies for the airport to have a competitive edge. With the results of the SWOT analysis, strategies were established to develop an MRO facility in the airport and to promote low cost carriers to operate from the airport.

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Keywords: *Second International Airport, Alternative Airport, Competitive Edge*

LOGISTICS

Emerging Opportunities in Sri Lanka's Third Party Logistics Space

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1. Introduction

Supply chains are the backbone of international trade and commerce. Logistics powers the supply chain. In 2014 Sri Lanka's logistics cost to GDP was 10.6% whereas in US it was 8.3%. By managing logistics professionally, efficiencies can be derived to drive economic growth. A country's logistics-friendliness is an indication as to how connected the country is to achieve competitiveness. World Bank's Logistics Performance Indicator ranking (LPI) for 2014, Sri Lanka is ranked 89th out of 160. With a score of 2.7 out of 5, Sri Lanka is classified as a partial performer. An in-depth analysis of LPI attributes provides insights into gaps as well as opportunities in the current logistics industry (Table 1).

Table 1 - Sri Lanka's LPI Ranking and Score

Parameter	Ranking (out of 160)	Score (out of 5.0)
Customs	84	2.56
Infrastructure	126	2.23
International shipments	115	2.56
Logistics quality & competence	66	2.91
Timeliness	85	2.76
Track & Trace	85	3.12

Source: Arvis, J.F. et al

2. Purpose and Aim

The scope of this study was to understand the following with respect to Sri Lanka's third party logistic space:

- Understand what customers (users) outsource and the service offering of third party logistics service providers
- Understand the opportunities and challenges of outsourcing as identified by both customers and third party logistic providers

3. Methodology

Fifteen third party logistic providers and ten users were directly interviewed on an individual basis and also the first-hand experience of the author as a user was

integrated into the assessment. The selected third party logistic providers were all partial and full scope third party logistics providers in Sri Lanka.

4. Results and Analysis

Table 2 presents the summary of study with respondents and the number of opportunities and challenges that were identified.

Table 2 – Summary of Results

Category	Respondents	Opportunities	Challenges
Third party logistics provider			
a. Partial scope provider	10	4	6
b. Full scope provider	5	7	8
Users			
a. Short term contracting	2	-	2
b. Limited scope users	6	5	6
c. Full scope users	2	3	5

4.1. Third Party Logistics

Research revealed that Sri Lankan companies are realising the benefits of outsourcing their logistics operations in full or part to create efficiencies in their businesses. Globally, integrated logistics is emerging as the new norm of the industry, wherein a single service provider provides end-to-end logistics services not only within the country, but also through international networks. This enhances the efficiency and productivity of logistics as a function as a whole and directly contributes to savings all around. However, in Sri Lanka, most organisations are still not ready to outsource their operations to one lead logistics provider due to perceived risks arising from fear of collaboration.

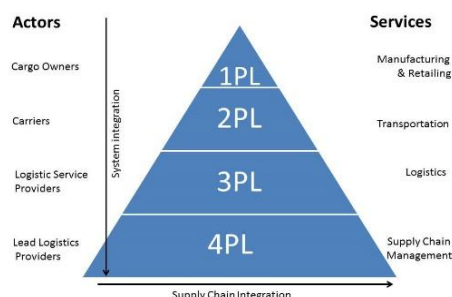


Figure 1 - Logistics Industry Hierarchy

The logistics industry hierarchy moves from first party logistics provider (1PL) to fourth party logistics (4PL) provider based on the scope of activity. Foundation level activities are done at 1PL and 2PL levels. At 4PL level, system and supply chain integration is at the highest level as shown in Figure1 above.

The third party logistics market in Sri Lanka is fragmented with few major local players dominating the scene. Based on the scope of activity and the warehouse footprint, the top five players in the market are Global Park, Hayleys Advantis 3PL plus, JK logistics, EFL and DHL.

4.2. Challenges

The survey revealed the following challenges as summarised in Table 3

Table 3 - Challenges faced by users and 3PL providers

Cost focus
Low margins
Lack of professionalism
Skill gaps
Fear of collaboration
Lack clear industry standards and legislation
High attrition rate
Unorganised transport sector
Suboptimal cold chain logistics
Readiness to adopt technology and innovation

4.3. Opportunities

Few of the leading players provide full scope 3PL services and have the capability to manage all industry verticals. Emerging opportunities identified by the respondents are stated in Table 4.

Table - 4 Emerging Opportunities

Integrated supply chain service offerings
R&D and Technology as a differentiator
Collaborative transport
Multi user facilities
Green logistics
Micro logistics
E-logistics
Omni Channel evolution

5. Conclusion

The 3PL market in Sri Lanka is yet to achieve maturity. There are few major players who have developed specialised service offerings over the years and have achieved market leadership. The market is highly fragmented and the majority is still providing limited scope 3PL services to customers. A lack of understanding of the potential benefits of 3PL operations exists among users in general.

It can be stated that the emerging opportunities as identified from stakeholder analysis indicates that what the local industry perceives is in no way different to the global standards. However, readiness to integrate the full scope of logistic activities under a 4PL is yet to evolve in the country.

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Keywords: *Supply chain, Logistics, Logistics performance indicator, Third party logistics*

MARITIME TRANSPORT

Use of the Baltic Dry Index as a Leading Economic Indicator to Predict Asian Share Market Performance

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1. Introduction

The London-based Baltic Exchange measures changes in the cost of transporting raw materials such as metals, grains and fossil fuels by sea, through the Baltic Dry Index (BDI). Dry bulks represent initial or intermediary steps of the production cycle. Shipping of dry bulks therefore happens even before the production cycle begins. This allows the use of BDI as a practical leading economic indicator. This research attempts to prove that the BDI has predictive ability for a range of major Asian stock market returns.

The following formula is used to calculate the BDI,

$$BDI = \frac{CT+PT+ST+HT}{4} * 0.110345333 \quad (1)$$

T = Time charter average (TCavg)

The value 0.113473601 is the multiplier introduced to standardise the calculation and was first applied when the BDI replaced its predecessor BFI (Baltic Freight Index). Time charter average (TCavg) on routes measured covering Handysize (HT), Supramax (ST), Panamax (PT), and Capesize (CT) ships. These dry bulk carriers carry a range of commodities including coal, iron ore and grain in the 23 routes tracked by the BDI.

2. Research Methodology

To prove that BDI is a leading economic indicator in Asian context it should be established that Asian share market prices have a correlation with BDI. The ideal relationship would be share prices being a function of BDI. Linear regression was used to determine correlation between various share market indexes and the BDI. Correlation coefficient for the BDI return was analysed using the method detailed in

the research design to derive the relationship between the BDI and stock market returns.

2.1 Research Design

This research analysed data related to the Baltic Dry Index with the main Asian Stock Exchanges of India, Japan, China, Hong Kong, Thailand, Malaysia, South Korea, Sri Lanka and Singapore. MSCI World, Dow Jones and S&P 500 were used to observe any deviations from the observations of Asia. MSCI AC Asia ex Japan index which captures the gist of Asian share markets were used for gain an overall view. Data were fed into IBM SPSS Statistical Application in order to observe the outcomes using simple linear equation model.

$$b1r \quad b2r \quad (2)$$

The lag period of one month was predicted through the extensive researches done on the delayed diffusion of information across the markets. Here $r_{s,t}$ was taken as the end-of-the-month logarithmic return of a countries' Share Index, s , at time t . The independent variable was the end-of-the-month logarithmic return of the Baltic Dry Index, included in the regression at time $t-i$ months. Moreover, b was considered as the constant and $\varepsilon_{s,t}$ as the error term.

2.2 Testing for Non- Stationarity and Autocorrelation

Durbin Watson test was performed to exclude the concerns relating to autocorrelation in the considered dataset. The constructed time series on BDI raw data and selected indices appeared to portray significant levels of autocorrelations depicted by having Durbin-Watson values closer to zero. To eliminate the autocorrelation, logarithmic returns of the BDI and share index returns were used.

2.3 Improving the data set

To improve non-stationarity, the data set was converted into one with log changes. Log changes are an accepted method in predictive regressions conducted in financial and economic research and has been used by Alizadeh and Muradoglu [1], Oomen [2] and Bakshiet el [3].

The t month logarithmic return (r_t^{BDI}) was calculated as below,

$$r_t^{BDI} = \ln (BDI_t) - \ln (BDI_{t-i}) \quad (3)$$

3. Findings and Conclusion

This research was limited to five years with 60 monthly observations. Considered period from 2009 to 2014 was after the global recession and it can be considered as a unique phase in economic cycle where the global economy was recovering.

Table 1: Regression Output of the Improved Dataset

Index	R	R Sq	Durbin-Watson	F	Sig
CSE	0.185	0.034	1.692	2.055	0.157
STI	0.241	0.058	2.265	3.585	0.063
TWII	0.248	0.062	2.207	3.803	0.056
FTSE BUR	0.017	0	2.290	0.017	0.896
Hang Seng	0.136	0.019	2.425	1.098	0.299
KOSPI	0.274	0.075	2.233	4.718	0.034
SPBSESSX	0.030	0.001	2.201	0.052	0.821
SS COMP	0.118	0.014	2.033	0.816	0.370
NIKKEI 225	0.036	0.001	1.944	0.075	0.786
MSCI Asia	0.146	0.021	2.108	1.255	0.267
SP 500	0.015	0	2.206	0.013	0.908
DOW	0.024	0.001	2.248	0.034	0.854

According to the results of the regression analysis summarised in Table 1, no significant correlation is found between the BDI and share market indices considered, as the highest reported correlation value (R square) was a mere 0.075 in Korea. The research confirms the delayed diffusion of information and the optimality of lesser time periods to derive the predicative quality of BDI.

BDI returns distribution showed a significantly skewed nature. Prevailing overcapacity in the shipping industry was suggested as the reason behind this behaviour. The results indicate that the slope coefficients in predictive regressions of stock market returns on the BDI growth rate are overwhelmingly negative and statistically non-significant for a number of markets, in an in-sample analysis. Second, the R^2 statistic is very low for all indexes than reported in the extant literature. All these findings lead to lower the economic significance and predictability of BDI as a viable economic indicator in predicting Asian share market returns.

Finally, it should be noted that BDI's viability as an economic indicator is subjected to the time period considered. Empirical evidence supporting the conjecture that a higher BDI return will one month later result in a higher stock market return appeared only in researches for the period 2001-2007.

Therefore, it can be recommended to investors and interested sectors that BDI predictability is highly subjective to the time period considered and long time periods tend to provide false signals on the returns of share market.

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Keywords: *Baltic Dry Index, global stock markets, global real economic activity, predictive regressions*

The Benefits of Container Exchange between Carriers: A Case Study

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1. Introduction

The paper proposes that the container exchange mechanism is an effective solution to the container inventory imbalance problem. Drewry Shipping Consultants state that about 20% of total container flows at sea around the world are empty, and the costs of repositioning are about USD 400 per container [3]. There is a tremendous pressure on reducing logistics cost and carbon footprint. The fundamental reason for Container Inventory Imbalance (CII) is the external trade imbalance of countries. A major challenge revolves around repositioning of empty reusable containers [6]. It is noted that the exchange mechanism works well with respect to the shipping space (slots) that has proved immense benefits to carriers as well as to the industry in general. However, the carriers believe that there is no opportunity for container exchange as the intrinsic trade imbalance is commonly applicable to all carriers. The industry has not made any attempt to evaluate the benefits of container exchange due to this myopic view.

2. Container Exchange

Many service agreements between carriers already have provisions to exchange containers in addition to slot exchange between consortium partners. However, the fact remains that there is no exchange of containers taking place in reality. This is mainly due to the lack of initiatives by shipping agents and it is quite a paradox as carriers regularly spend considerable amount of money on container re-positioning. Shipping companies spend in average USD 110 billion per year in management of their container fleets (purchase, maintenance and repairs) of which USD 16 billion is for the repositioning of empties [5]. If few leading lines take the initiative and exchange containers wherever possible, the rest may follow suit [4].

3. Analysis

Given the dispersed international nature of shipping business it is rather difficult to evaluate this phenomenon on a truly global scale. Therefore, the study was

conducted in Sri Lanka which was considered achievable and realistic. It is justifiable because Sri Lanka attracts 16 out of the ‘top twenty’ global carriers. They carry 72% of world container capacity [1], thus suggesting that data provides a reasonable representation. Industry statistics reveal that 289,474 TEUs of empty containers were evacuated from port of Colombo during 2014[2]. It actually reflects 50.3 % of 515,875 TEUs of total domestic exports (both laden and empty) which shows the seriousness of the issue. Paradoxically, carriers have imported 48,629 TEUs of MTYs in 2014 to already overflowing Colombo Port. Table 01 provides the 40’ container inventory (of carriers with excess containers and those who are short of containers) in Sri Lanka for the first three months in 2014. These data challenges the carriers’ myopic view. Similarly, opportunities for exchange are evident in other months also.

Table 01- Status of 40’GP Container Inventory -2014

Month	Status of container inventory			
	prior to exchange		after the exchange	
JAN	Excess	557	Excess	211
	Shortage	346	Shortage	0
FEB	Excess	286	Excess	0
	Shortage	369	Shortage	83
MAR	Excess	477	Excess	0
	Shortage	672	Shortage	195

Source: Industry data based on individual carriers’ unpublished data in Sri Lanka

As the results show a positive outcome, the same exercise was repeated for all container types. Table 02 summarises the outcome of two scenarios namely, the imbalance of containers under ‘work alone’ and ‘collaboration’ for the year 2014.

Table 02- Analysis of Container Inventory (selected types/sizes) in Sri Lanka -2014

Container Type& Size	Imbalance when Work alone	Imbalance when Exchange
20’GP	158221	156285
40’GP	10486	794
40’HC	44586	27842
45’HC	2155	101
20’&40’RF	5975	4791
Total	221423	189813

Source- Industry data based on individual carriers’ unpublished data in Sri Lanka

In order to make the result more realistic the estimation of exchanging rate was examined though interviews with ten leading carriers. The estimation was done for the month of March 2016 and only the 40’ GP containers were considered. Each carrier was proposed the possible combination to share containers. Except for one

pair, all other combinations were found workable. Table 03 illustrates the agreed combinations between carriers. The carriers are listed anonymous due to marketing reasons.

Table 03 - Exchange of containers between 10 carriers

Pair of carriers	A	B	C	D	E	F	G	H	I	J	No of containers agreed to share
A--> D				32							32
B--> F						8					8
G--> H								28			28
I--> J										Not agreed	
CI level	32	44	21	-36	63	-8	34	-28	45	-11	

4. Conclusions

It is clear from these analyses that the imbalance could have been reduced by 31,610 containers in 2014 if carriers opted to exchange containers. The estimated saving is approximately USD 12.6 Million. Sri Lanka has exported 269,931 TEUs in 2014. If carriers used this money to assist exports from Sri Lanka freight rates could have been reduced by USD 47 per TEU. In addition, it would help reduce environmental pollution which is the most critical factor in today's business world for sustainability. This study clarifies the actual position using real container data and response from industry professionals proves that opportunities exist for container exchange between carriers. Accordingly, the CII could be reduced by 14% at least which reflects a reasonable saving to carriers.

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Keywords: *Container, Exchange, Sri Lanka, Carriers, Imbalance*

Skill Requirement for the Realisation of Maritime Hub Status in Sri Lanka

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1. Introduction

The global maritime sector has been growing rapidly in order to meet the increasing demands of world trade. This rapid development in world trade has led to interdependency among countries, and to an increased competition among different of the logistics chains. In this context, Sri Lankan ports play a major role in connecting the sub-continental region in view of supporting the local transshipment business, and the Sri Lankan government is looking to transform the country into a strategically important economic centre by developing the island into a maritime hub.

Skilled and knowledgeable personnel are among the key factors of achieving greater productivity, and thereby the attractiveness, of any logistics supply operation, making human resource development a vital requirement for the country to realise hub status. Planning for human resources, in today's context of the rapid advancement of technology and the emergence of concepts like globalisation, is not only concerned with hard skills but also with soft skills such as creativity, flexibility, risk attaining, innovativeness, and problem solving. Competitive knowledge and skills are needed for the labour force to become effective.

The present study aimed at identifying the perceived skill requirements of Sri Lankan enterprises involved in the ports and shipping industry, and at evaluating the existing labour force characteristics against the real demands stimulated by the desire to achieve maritime hub status.

2. Literature Review

As explained by Smith (1980), competent employees are organisational level factors that have the potential to contribute to the economic benefit of a firm, while the knowledge, skills and attitudes are recognised as competencies required for the effective performance of their duties (Pinto and Walker, 1978; Hayes, 1980).

Studies on logistics professionals have revealed that there could be several such important skills, ranging from technological skills to organisational and interpersonal skills, that are required for companies to be effective (Murphy and Poist 1991).

3. Methodology

Data and information on internationally-demanded managerial skills the maritime labour force is expected to possess were gathered by surveying secondary sources and literature. Information pertaining to the current maritime work force and the human resource requirements of enterprises were gathered through semi-structured interviews conducted by administering a questionnaire. Moreover, information also was collected through a survey among pioneers engaged in the maritime sector in Sri Lanka. The sample was selected with the help of maritime directory of Sri Lanka 2012-2013. This study, being a qualitative research, non-probabilistic sampling method was adopted, while data gathered were tabulated and analysed using Excel.

4. Findings and Discussion

Agents being the entities linking the logistics chain, the first phase of this research attempted to identify the preferable recruitment criteria adopted by the agents operating in the maritime sector. The findings revealed that 70% of the respondents do not consider gender as an important criterion in recruiting employees. But, 65% of the companies give preference to the age category of 24- 27 years. According to the respondents, this age group is believed to be physically strong, more efficient, more educated on average than the other age groups. 95% of the companies preferred single persons over married candidates at the point of recruitment. The second phase of the research focused on identifying the duties of agents in the Sri Lankan maritime sector in view of perceiving the skills that are considered necessary to carry out the duties involved. According to the findings, a majority demands employees with a reasonable educational background and professional qualifications. A significant share (55%) of the employers reported that they preferred to recruit graduates. The respondents assigned high priority for team work, listening skills, being polite to customers and management skills. Self-confidence, problem solving skills and relationship building also were highly preferred by the shipping agents. 80% of respondents indicated these skills as required in order to realise maritime hub status. 70% of respondents reported flexibility also as an essential quality in this sector as not always does the shipping business run smoothly. These attributes are thus likely to be sought from applicants for executive jobs. Managers of almost all companies considered computer and internet skills as important; those being necessities in the modern online work

environment, particularly to monitor the day to day operation of organisations. English literacy is considered important with 75% of respondents assigning high priority to it. At managerial level, senior managers gave priority to skill types such as intuition and forecasting, delegation of work, computer and internet skills, creative thinking, analytical thinking and accuracy of work.

5. Conclusion and Recommendations

This research found that the skills required by shipping lines for different agency functions would differ, and could be categorised under skills and attitudes affecting performance. It emphasised that the agents are instrumental in adding value to the logistic services within the region and, to enable which, their human resource, imperative to provide a quality service to their customers, is a key factor. This research, based on perceptions of shipping lines, also finds that the skill requirements of the Sri Lankan maritime industry are not sufficiently met. Computer literacy, language skills, and more importantly team work and listening skill have to be improved among employees in the maritime sector. These attributes would assist the country to realise its aim of becoming a regional maritime hub. Study outcomes also suggest that recruiting people with professional qualifications or a degree at executive level would help. The government should improve the maritime industry's skill development activities as well, particularly when more and more job opportunities in the Sri Lankan shipping industry await qualified and competent candidates. Skill development programmes have to be expanded and upgraded. Sustainable systems that continuously assess the requirement of skills in line with new challenges in the industry have to be put in place. A better institutional setting which provides maritime education of quality and international standing is essential. Not only English literacy but also computer literacy should be developed in students. The students ought to be trained to acquire evolving attributes demanded by the global industry. This study also recommends to develop a comprehensive work force database for the maritime industry, which may prove beneficial in realising the maritime hub vision. These findings mean that candidates when entering the Sri Lankan maritime industry should possess positive attitudes, required educational qualifications and the essential components of industrial experience.

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Keywords: *skills, hub, soft skills, employment, hard skills, logistics*

SUPPLY CHAIN PERFORMANCE

Evaluation of Fresh Vegetable Supply Chain Structure and its Performance

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1. Introduction

The term “Supply Chain Management” (SCM) first appeared in the literature in the early 1980s. Since then SCM concepts have captured significant attention from academics and practitioners in the field [1]. In the current competitive business environment, SCM has become an important for all industries due to the increased focus on overall revenue growth and performance [2]. Supply chains are complex in nature as many partners such as producers, processors, marketers and distributors are generally involved. Increasing the number of partners along the supply chain would increase its length as well as its complexity, which ultimately reduce the efficiency. Traditionally SCM principles were mainly implemented in manufacturing sector due to the complexity of both in-bound and out-bound logistical operations. Meanwhile, Salin showed that the application of SCM practices in agricultural sector was also vital mainly due to increased awareness of issues of food quality, food safety and ethical concepts [3]. Due this fact, many food supply chains have also gone through significant structural changes over the last three decades.

A Traditional Fresh Vegetable Supply Chain (FVSC) involves in moving vegetables from farmers to consumers through many middlemen, which result in inefficiencies and quality issues along the supply chain. As a result, large-scale retailers such as supermarkets have taken initiations to purchase directly from the farmers to minimise the inefficiencies and costs as well as to maintain the quality of vegetables.

Therefore, this research focuses on how supply chain structure affects their performance. Further, the relationship between supply chain length (number of intermediaries) and its performance level is analysed.

2. Research Objective

Vegetable industry in Sri Lanka also has gone through similar structural changes over the last few decades, as many emerging retailers such as supermarkets have

implemented the direct purchasing models. Even though the direct purchasing model has been implemented widely, still there is a lack of research to determine whether this model actually helps to improve the logistics performance, especially in developing countries such as Sri Lanka. Therefore, this study aims at filling this research gap. The main objective of this research is to identify the effect of supply chain structure on the performance of both traditional and modern direct FVSCs. Accordingly, the hypotheses were developed to find the relationship between supply chain length with variables such as lead time, quality, wastage and cost for both supply chains.

3. Research Methodology

Data were collected from the main stakeholders involved in both supply chains: traditional and supermarket supply chains. For traditional supply chains, the farmers, vegetable collectors and distributors and wholesale distributors were selected randomly. The sample size was 100, representing each category equally. With respect the supermarket supply chain, in addition to the above mentioned stakeholders, the professionals who are working at supermarkets, wholesalers and collecting agents were also interviewed. From the supermarket chain, 10 were professionals and 10 were farmers (Angunakolapelassa and Embilipitiya areas) who supply vegetables for supermarkets. Five wholesalers and five collecting agents were also interviewed.

A questionnaire was developed using the existing literature review. Data were gathered using two channels: data from supermarkets were gathered from purchasing professionals in the company using an online data collection approach, while face-to-face data collection approach was used to collect the data from the farmers and the other stakeholders in the FVSC. This included wholesale distributors at Colombo Wholesale Market, Manning market, Embilipitiya Economic Centre, transport service providers as well as farmers around Embilipitiya and Angunakolapelassa areas.

4. Data Analysis

Analysis was carried out to identify the relationship between supply chain length and performance indicators which are mostly affected according to previous published research, such as total supply chain cost, lead time, transport, wastage and quality level of both traditional chain and super market chain structure. Supply chain length is measured according to the number of intermediaries involved along the chain. When there are 0-1 intermediaries, the chain is considered “short”, 2-3 as “medium” and more than 4 intermediaries would classify the chain as “long”. The relationship was analysed using Chi-Square test while the Spearman correlation test

was used to measure the correlation between supply chain length and each performance factor.

Table 1- Output from Chi-Square Analysis

Alternate Hypothesis	Pearson chi- sq value	Likelihood Ratio	D.F	Asymp Sig value (P value)	Critical value for chi- sq	Spearman correlation	Decision on Alternate Hypothesis
Traditional SC (SC Length Increase)							
1 – Cost Increase	9.334	9.229	1	0.020	3.841	0.306	Accepted
2 – Lead Time Increase	11.771	11.692	2	0.003	5.991	0.230	Accepted
3 – Wastage on transit Increase	4.340	4.331	1	0.037	3.841	0.208	Accepted
4 – Wastage at Warehouse Increase	4.027	4.236	2	0.134	5.991	-0.195	Rejected
5– Quality Reduce	8.070	8.368	2	0.018	5.991	0.276	Accepted
Super Market SC (SC Length Reduce)							
6 – Cost Reduce	11.808	13.301	1	0.010	3.841	0.627	Accepted
7- Lead Time Reduce	19.260	22.343	2	0.000	5.991	0.798	Accepted
8– Wastage Reduce	10.208	10.664	1	0.001	3.841	0.522	Accepted
9 – Quality Increase	5.926	6.035	1	0.015	3.841	0.444	Accepted

This study shows that when the partners along the supply chain is increasing the supply chain length is also increasing, resulting an increase of the total supply chain cost, lead time and wastages, while the quality reduced. Interestingly, this study shows that wastages at warehouses for traditional supply chains are rejected. This study shows due to the less number of intermediaries involved, direct purchasing supply chain structures are comparatively more efficient and effective than traditional FVSC in terms of post-harvest losses, quality of vegetable, price of vegetables and degree of transparency. It was observed that the direct model provides a win-win solution for both stakeholders: farmers and super markets.

5. Discussion and Conclusion

According to the results of this research, the traditional supply chain shows inferior performance compared to the supermarket chain, apparently due to its longer supply chain structure. Increasing the supply chain negatively affects not only the individual performance but also the overall performance of the entire supply chain. Furthermore, the analysis shows that longer the supply chain, more would be

wastage and costs. This highlights the need for more collaborative supply chain partnerships between primary producers (farmers) and retailers. Research further shows that reducing the supply chain length not only reduces wastage during transport and storage but also stimulates better collaboration among supply chain partners as they can understand each other's requirements and operations efficiently and effectively. Reducing supply chain length also helps reduce the lead time from farmer to retailer. This study indicates that it is essential to develop logistics infrastructure and network operations to reduce this lead time while creating an environment where quality is not compromised over price.

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Keywords: *Logistics performance, supply chain length, food supply chain, supply chain structure*

Assessing the Impact of Global Outsourcing and Global Offshoring over the Upstream Supply Chains of Apparel Industry: A Sri Lankan Context

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1. Introduction

The increasing trend of globalisation of upstream supply chains in the apparel industry has taken in different strategic forms. Main objectives of this research are to investigate the different factors influencing each decision of outsourcing and offshoring in apparel industry in SL, different impacts on Supply Chain Performance Indicators caused by the outsourcing and offshoring decisions, and positive or negative relationships between each influencing factor for outsourcing and offshoring and the supply chain performance measurements so that the initial viability of the decision for outsourcing and offshoring could be assessed based on the current performance of the Supply Chain visible through KPIs.

2. Literature Review

The influencing factors for the strategies of offshoring and outsourcing were drafted based on Dunning's eclectic paradigm or "OLI model" [1], which summarises the impact of Globalisation of multinational corporations. Lüthje in a qualitative research titled "Global operations and their interaction with supply chain performance" [2] describes the influencing factors for Globalisation as location-specific advantages (influencing Outsourcing), the ownership-specific advantages (influencing Offshoring) and internalisation specific advantages (influencing Offshoring) having nine, thirteen and five sub factors, accordingly. SCOR model is used in the questionnaire carrying thirty seven measurements according to the model defined by Gunasekaran [3] which used measures and metrics in five main areas, namely Plan, Source, Make, Deliver and Return as performance measurements.

3. Methodology and Data Analysis

The various accounts (DBA, Nike, Triumph, Women Secret, and Victoria's Secret etc.) of three organisations, which consist of more than 34 different accounts, were taken as research population. The questionnaire was based on both OLI model and SCOR Model on five-point scale Likert Questionnaire.

The data analysis sequence mentioned below was adopted for both data sets gathered on Global Offshoring and Global Outsourcing. When the standard deviation values for each category in each survey response were lower than 0.5, the responses that were identified as following a specific pattern were removed from the final data set. Cronbach's α was calculated to assess the reliability of each scale (the scale of the performance measurement section as a whole, each sub-section separately on plan-source-production-delivery-customer satisfaction and service levels, and Ownership specific, Internalisation specific and Location specific sections). If the value of Cronbach's α indicated higher than 0.7, it was assumed that the scale was reliable [4].

Factor analysis method was used to identify the variables with common characteristics/ correlation and to reduce the total number of variables to a lesser number of underlying variables. It was assumed that, if the KMO measure was greater than 0.5, the sample would be adequate. The factor extraction was implemented using Principal Component Analysis based on the Eigen value greater than 1. Varimax rotation was used to construct the rotated component matrix. Spearman's Correlation was used to identify the relationships between variables under influencing factors for Globalisation, variables under performance measurement in both Offshoring and Outsourcing based on the factor scores.

4. Research Findings and Conclusion

According to the below mentioned findings of this research, the motivating factors for any globalisation strategy would not always positively contribute towards supply chain performance.

Hence these research findings could provide an alerting framework for top management in any decision whether to outsource or offshore since they would know which area that would be affected in advance and that if the specific area to be affected was not doing well currently then the globalisation strategy would not be suitable for the company.

The figure below shows what areas in supply chain that will be affected and in what manner, if any globalisation strategy is undertaken in search of the mentioned tempting factors.

Offshoring				Outsourcing	
Independent Factors Influencing Offshoring / Outsourcing	Ownership 1: Value adding & Demand Management in various geographical locations	Ownership 2: Tangible & Intangible Asset Advantages	Internalization 1: Reduction in Market Risk	Independent Factors influencing Outsourcing	Location 1: Demographic Characteristics of the Country and Trade & Transport
	1.7 Intangible Asset Advantages: Organization & Marketing Systems	1.5 Intangible Asset Advantages: Trade Names	1.24 Increased Market Control		1.14 Transport Cost
	1.9 Formal/ Informal Institutional Assets governing value adding processes	1.3 Intangible Asset Advantages: Product Innovations	1.23 Reduced Risk of Product Imitation		1.17 Trade Barriers: Tariffs, Import Quotas
	1.8 Ability to manage several geographically separated activities	1.1 Property Rights over Raw Materials			1.18 Cultural Differences
	1.4 Intangible Asset Advantages: Production Management				1.19 Language Barriers
Dependent Factors affecting Performance				Dependent Factors affecting Performance	1.20 Corruption in Systems
					1.22 Economic Development of the Country
	Plan 2 : Cash flow time with high information carrying costs	- .430 ⁺	.691 ⁺		
	2.2 Employee Satisfaction Factor due to Duplication of work				Plan (i) : Employee satisfaction with increased complexities resulting high information carrying cost & Total cash flow time
	2.5 Total cash flow time				-0.520
2.9 Information Carrying Cost				3.2 Employee Satisfaction Factor due to Duplication of work	
Source 1 : Supplier Reliability with quality, time and cost	Nil	.425 ⁺	Nil	3.3 Increased Complexities of Processes	
2.13 Supplier lead time against industry norm				3.4 Accuracy of forecasting techniques	
2.14 Supplier pricing against the market				3.5 Total cash flow time	
2.19 Purchase order cycle time				3.9 Information Carrying Cost	
2.16 Achievement of defect free deliveries				Make (i) : Cost, Time and Capacity dealing with the Production Schedule and Inventory Levels	.446 ⁺
Deliver 1 : Cost & Time savings in Distribution	Nil	.493 ⁺	Nil	3.20 Manufacturing cost	
2.25 Delivery lead time				3.21 Capacity utilization	
2.26 Number of faultless deliveries/ Delivery Reliability				3.22 Effectiveness of master production schedule	
2.28 Information richness in carrying out				3.23 Production/ process cycle time	
2.27 Increased Cost of Documentation & Customs Screening				3.24 Inventory levels: Incoming stock +Work in Progress+ Finished goods + Scrap /waste/ write off+ Inventory in transit	
2.30 Total distribution cost				Deliver (i) : Cost, Quality & Time in Distribution	.405 ⁺
2.29 Response to number of urgent deliveries				3.25 Delivery lead time	
Return 1 : Customer satisfaction in	Nil	.545 ⁺	Nil	3.26 Number of faultless deliveries/ Delivery Reliability	
2.32 Customer query time				3.29 Response to number of urgent deliveries	
2.35 Measurement of customer satisfaction				3.30 Total distribution cost	
2.34 Customers' ability to seek assistance				Deliver (ii) : Government Regulations and Documentation needed for the Logistics	-.407 ⁺
2.37 Return process of goods with Quality				3.27 Increased Cost of Documentation & Customs	
2.33 Level of customer perceived value of product				3.28 Information richness in carrying out delivery	

Figure 1: Research Findings on Globalisation Strategies used for Upstream Supply Chains in Apparel Industry in Sri Lanka

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Keywords: *Globalisation, Offshoring, Outsourcing, Non-parametric, PCA, Cronbach*

Managing Supply Chain Transformation Projects in the Manufacturing Sector: Case-based Learning from Sri Lanka

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1. Introduction

This empirical research investigates three supply chain transformation projects at three Sri Lankan subsidiaries of Multi-National Corporations (MNCs). The research builds on extant literature in both Supply Chain Management as well as Project Management to identify how the principles of both these increasingly important fields of management could be used in cohesion to achieve corporate objectives. Hence, this research seeks to clarify how applications from project management aid production supply chain transformations. In addition, this research builds on the existing knowledge base of the newly shaping study area known as “Supply Chain Project Management” by being a pioneering empirical study in the field, not only in Sri Lanka, but globally as well.

2. Background

The focal supply chains of the research were three MNCs representing the cement, dairy and FMCG manufacturing industry. All three of the focal firms were market leaders in their respective industries at the time of the study (2012). This was purposely designed to be so in order to capture the best-practices in supply chain transformation projects from industry leading companies with the assumption that market leaders in each industry were enjoying this status due to their innovative supply chains which were the best in their respective industry; going along the notion that modern day business competition is between supply chains as opposed to products. Furthermore, it was assumed that MNCs would be better poised to utilise supply chain and project management principles best-practices than Sri Lankan companies, due to their international exposure.

3. Methodology

The research methodology was a combination of semi-structured interviews along with a systematic review of extant literature in both academic and corporate spheres. The triangulation method was used to verify the research outcomes.

The subjects for the study were intra-organisational, managerial level stakeholders of the three identified supply chain transformation projects. The data were collected from 21 participants through semi-structured interviews based on mixed methods. The collected data pool comprised of both quantitative and qualitative data. The quantitative data were statistically analysed and the qualitative data were used to fill in the contextual gaps and explain the quantitative outcomes of the research.

The semi-structured interviews consisted of several Likert scales with ranges from 1 to 5, with the latter being the most significant in the element under question being true. The interviews and data collection were structured based on work conducted by James B. Ayers in his book titled *Supply Chain Project Management* (2009, CRC Press) as well as empirical evidence gathered from industrial know-how and inputs from industry practitioners. Ayers' descriptions on causes for supply chain transformation projects to hinder projects as well as factors driving the implementation of such projects were widely tested among the participants.

4. Analysis

Figure 1 portrays how “improving processes” are the most prolific driver of supply chain transformation projects while assessing the rest of the key drivers motivating such projects.

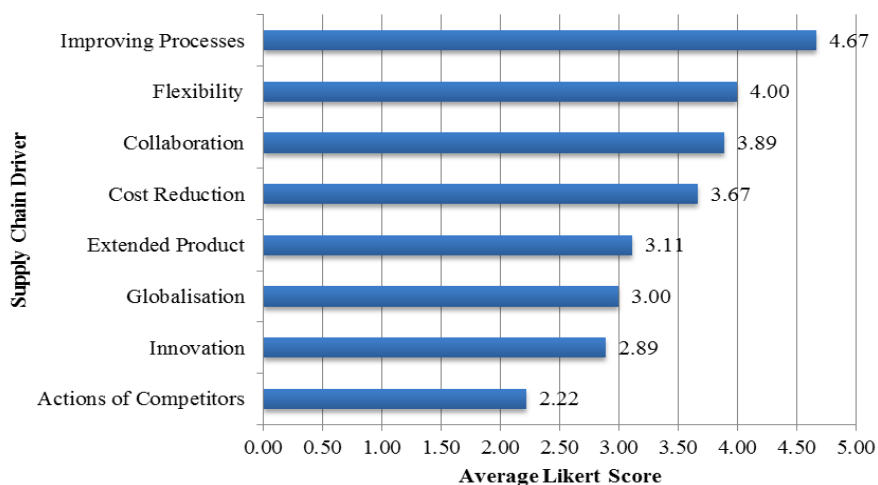


Figure 1: Key Drivers for Supply Chain Transformations

Going beyond that, the research uncovers key reasons that can derail a supply chain transformation projects, in the eyes of the respondents [Figure 2]. The research identifies that “organizational roadblocks” generated within the organization as well as inadequate technical capacity as well as rigidity of supply chains amounted most to the hindrance of the focal supply chain transformation projects.

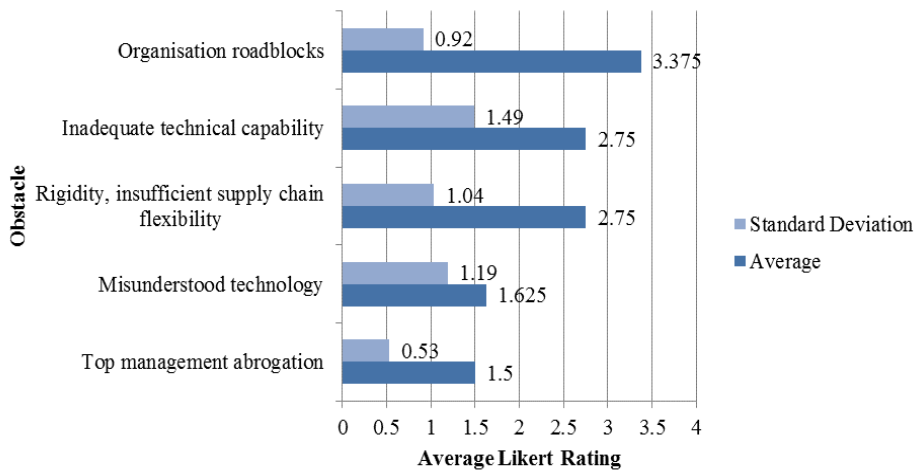


Figure 2: Key Obstacles for Supply Chain Transformations

5. Conclusions

By triangulating the data gathered for this research, a 7-step model [Figure 3] is proposed by the authors of this research to be followed by organisations when managing supply chain transformation projects.

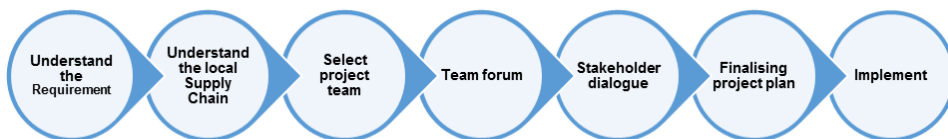


Figure 38: The 7 Step Model for managing supply chain transformations.

In conclusion, the research identifies and underscores the importance of “Change Management” in balancing aspirations of project stakeholders in planning and implementing supply chain transformation projects for their success.

Keywords: *Supply chain, project management, manufacturing supply chains, supply chain transformations, supply chain management*

PROCUREMENT MANAGEMENT

A Decision Support Model to Select Suppliers in Apparel Industry in Sri Lanka

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1. Introduction

Within the competitive supplier base environment, firms are more conscious about selecting the right supplier at the right time by considering a wide range of qualitative and quantitative criteria [1]. Supplier selection is an essential part of the procurement process and it is common for any industry. In the current situation of the trade, selecting the right supplier is far more than analysing the price lists and how to cope up with dynamic situations like unpredictable market where there are changes in customer demand with the changing taste, consciousness of quality, price and the delivery time [2].

This research work devises a mathematical algorithm for selecting suppliers and develops the decision support model for apparel industry in Sri Lanka with the incorporation of Pareto analysis and Analytic Hierarchy Process (AHP). The main focus of this research is to address the research problem “How to select supplier in a dynamic situation (order changing)” while achieving two research objectives, to identify the prominent criteria for selecting a supplier for apparel industry in Sri Lanka and to model the supplier selection process in a dynamic situation.

2. Methodology

The summary of the research methodology is as shown in figure 1. Both primary data and secondary data were used. Top 15 most-used supplier selection criteria were identified by using 30 literature reviews. Sixty-five companies registered under Export Development Board and having valid email addresses were chosen to constitute the population. Sample of 30 responses were selected based on those having a supplier pool. Afterwards, five procurement professionals were interviewed for the pair wise comparison. In order to stimulate the decision support model, one company was incorporated.

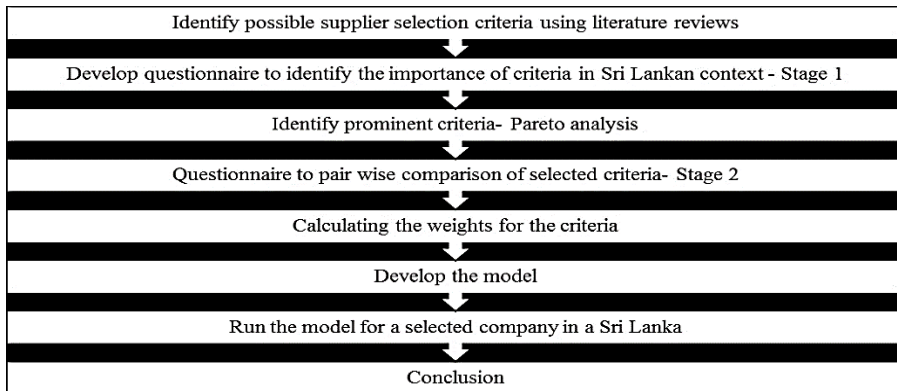


Figure 9: Research Methodology

3. Data Analysis

The research problem was solved according to five stages. At the first stage, descriptive analysis was conducted. In order to ensure the significance of the research, whether the supplier selection process is crucial was analysed. All the respondents have answered that supplier selection process is crucial for their company. So it is 100% sure that there should be a proper and organized way for this process. 73.3% of 30 valid respondents have said that they have separate department for procurement. Even though the other 26.6% do not have separate departments, there are special responsible professionals such as merchandisers and supply chain advisors to handle the process. From the 26.6% of respondents, 37.5% handle procurement process in merchandising department, 25% supply chain and rest has not particular department for take responsibility for the procurement process.

It is well known fact that procurement cost accounts for about 60% of average total cost. It is identified that the procurement cost percentage of apparel industry in Sri Lanka in almost all the companies in the population exceeded the 40% limit with the 93.3% agreement. 66.7% respondents have said that the average procurement cost as a share of total cost lies between 40%-60%. It is important to highly consider about this as a logistician. Even though firms have separate departments for procurement process, there is high procurement cost due to complexity. No reduction of procurement cost was observe in those companies having separate departments for procurement, where the procurement cost was found ranging between 40% - 80%.

Before developing the supplier selection model, it is important to identify the current scenario of the apparel industry in Sri Lanka. 43.3% of respondents have not answered this question. 23.3% of the respondents have said that they select

suppliers based on past experience. It is proven that demand uncertainty is a dynamic situation which makes the supplier selection process costly and time consuming. 45.5% of the respondents have agreed with that. By considering all the demographic factors, it is proven that there is an opportunity for the research “Developing Decision Support Model for Supplier selection of Apparel industry in Sri Lanka at the dynamic situation of order changing”.

At the second stage, using the rankings that respondents has given to the top most used fifteen criteria and the Pareto analysis, the prominent criteria, quality, per unit cost, delivery lead time and supplier service level were identified. Then using pair wise comparison for the prominent criteria were conducted at the third stage. The respective relative weightages for quality, per-unit cost, delivery lead time and supplier service level were calculated. The respective weights for prominent criteria are 0.2510, 0.3298, 0.2285 and 0.1908. The consistency of responses in pair wise comparison is 16.11%. Even though consistency ratio value is more than 10%, it is acceptable up to 20%, because of the procurement professionals’ non-familiarity with pair wise comparison. It is identified that there is high probability of selecting a supplier when the quality and service level increase, and there is a lesser probability of that selecting supplier when cost and lead time decreases. The maximum quantity that a supplier can supply and the lead time were identified as constraints. Considering all these factors, at the fourth stage, an algorithm was developed to calculate the supplier score.

Constraints:

Supplier maximum quantity \geq Required Raw material Quantity

Supplier's delivery lead time \leq Required lead time for raw material

Equation 1 Proposed supplier selection algorithm

$$\frac{(0.2510 * C1 \quad (0.1908 * C4)}{(0.3298 * C2 \quad (0.2285 * C3)}$$

Where, Y_i = relevant supplier score

$C1_i$ = Supplier's quality

$C2_i$ = Supplier's per unit cost

$C3_i$ = Supplier's delivery lead time

$C4_i$ = Supplier's service level

The highest scored supplier is the most suitable supplier according to the scenario. At the fifth stage, the model was stimulated using real time information gathered by a company in apparel industry in Sri Lanka. As the final tangible outcome, a mini

software program was developed with the incorporation of the developed model. The intention of the mini software was to reduce the time, calculation errors and the human hours taken for the supplier selection process.

4. Conclusion

Lack of previous literature in the Sri Lankan context and the context of the apparel industry is the main limitation of this study. In order to overcome this limitation, research design was developed to suit the Sri Lankan context. The proposed model with decision support system framework helps procurement professionals in the apparel industry in Sri Lanka to make sound decisions when selecting suppliers in dynamic situations of order changing. Future research can be conducted for another industry in Sri Lanka and considering more criteria.

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Keywords: *Supplier selection, decision support model, Pareto, Analytic Hierarchy Process*

E-Procurement Awareness and Adoption: A Sri Lankan Perspective

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1. Introduction

At present in many Sri Lankan manufacturing and service organizations, there is plenty of manual work conducted in procurement from raising purchase request to finalising payments. Internal staff and suppliers face numerous difficulties when carrying out procurement activities in day to day business due to excessive paper work. E-procurement is used globally to avoid such additional efforts by automating much of the process. E-procurement stands for internet based platform solutions which reduce paperwork as well as minimising required time to carry out procurement efficiently and effectively. Procurement card (P-Card) is one of the emerging concepts in e-procurement. P-Cards are used as a card with a specified financial budget allocation for organisational users representing the procurement or other functions. It provides a unique gateway for the employees to procure items needed for the organisation with minimum hassle.

2. Background

Across the globe there are many upcoming technologies focused in reducing the impact of procurement related problems. But when it comes to Sri Lanka, there is a visible void in that department with Sri Lankan companies falling behind in adopting procurement cards and other e-procurement solutions. This research aims to identify the knowledge gap and understand why Sri Lankan corporate have failed to adopt to procurement cards and other e-procurement solutions. Consequently, this research would provide information to academics and industry practitioners on how to adopt e-procurement solutions and gain a competitive advantage to succeed at a local and global level.

3. Methodology

This study was conducted through semi-structured interviews at ten medium and large scale companies operating in Sri Lanka covering diverse sectors such as FMCG (fast moving consumer goods), retail, pharmaceuticals, food, beverages,

tobacco as well as services. Procurement and supply chain managers of the participating company were subjected to the above said semi-structured interviews which were built after a thorough literature review. Both qualitative and quantitative data were collected during the aforesaid interviewing process. While the qualitative data sizes up the knowledge gap and identifies the challenges faced in adopting e-procurement solutions in Sri Lanka, the pool of quantitative data which is evaluated using statistical tools reinforces the inferences made using the qualitative data pool.

4. Analysis

The research highlighted that 8 out of the 10 companies subjected to investigation are still restricted to using the outdated, manual purchasing methods which are proven to be inefficient. This is further accentuated by analysing the extensive lead times of local purchasing items at those companies. The average lead time for a Sri Lankan company to procure local items comes to around 3 to 4 weeks, as per this study. In addition to the rigours of the manual procurement process, it creates ripple effects at the downstream of the chain by creating unnecessary delays and inefficiencies at the points of invoice auditing, invoice processing and verification. Moreover, it takes time for company budgets and purchase requests to receive approval. All this affects the business operations of our organisations in a negative light. What struck the researches most was that awareness regarding the “procurement card” solution or e-procurement was present at only 30% of the case companies.

5. Conclusions

This research highlights that Sri Lankan companies have plenty of room to excel and build a competitive advantage by augmenting their efficiency using e-procurement solutions to replace outdated, manual, inefficient procurement practices. The research identifies that there is a massive gap in awareness about the functionalities of e-procurement solutions in Sri Lanka while also identifying that there is a key concern among the research participants with regard to the cost of such a service. However, the encouraging finding is that companies are eager to adopt to such a system in spite of their concerns regarding the hassle in converting all their processes and the disruptions that would be caused during the transition period. Companies that were the focus of this research which were using semi-automated procurement methods were already reaping a cost, time and quality advantage in their procurement operations - which may or may not flow along the rest of the supply chain. Changes in people attitude should also be bought up to get the exact benefit.

Further research on e-procurement awareness and adoption in the public sector as well as a case study on the implementation of such services at one or more Sri Lankan companies would enrich the knowledge sphere. It would also be beneficial to find out what would constitute a successful e-procurement system in Sri Lanka and to what extent companies and its employees would be willing to change their operations and processes to conform and adopt to such an e-procurement system.

Keywords: *e-procurement, procurement card, supply chain management, e-procurement adoption, e-collaboration*

Impact of Information Sharing on Supplier-Buyer Relationship and Supply Chain Performance

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1. Introduction

Supply chain management is defined as the integration of key business processes, from original supplier to end-user, to provide products, services and information. Supply chain management has emphasised the overall and long-term benefit of all parties on the chain through cooperation and information sharing. In the current competitive context, information is a vital factor in any supply chain as a primary driver and it has become a crucial activity in supply chain management [2]. The proper information sharing within a supply chain allows firms to access data across their supply chains, allowing them to collaborate in activities such as sales, production, and logistics and ultimately enhance the supply chain performance through integrated information network [3]. However, the benefits of sharing information among supply chain members are not always the same as they depend on the supply chain structure and its operational characteristics. World leading companies have successfully adapted supply chain management concepts in to practice and have successfully reached to the competitive edge within their own market segments. For instance, Zara, Apple, Proctor & Gamble, Walmart have secured their supply chain through the established information sharing network and strategies based on information sharing and collaboration.

2. Research Objective

In the Sri Lankan context, companies focus on information sharing and integrated information systems. For instances, especially in the apparel industry, they tend towards systematic information sharing through the supply chain across their up-stream and down-stream supply chain members. Research has focused on information sharing and its impacts.

The present study aims at identifying the impact of information sharing in supplier buyer relationship and its impact on supply chain performance on the apparel industry in Sri Lanka. The main objectives of the study are as follows:

1. Identify the Supplier-buyer relationship in the context of information sharing.
2. Identify the Performance Evaluation Criteria in Supply Chain Performance.
3. Identify the Supply chain performance in the context of Information sharing and supplier buyer relationship.

3. Research Methodology

Figure 1 below depicts the conceptual framework adopted in this research to achieve the above mentioned research objectives.

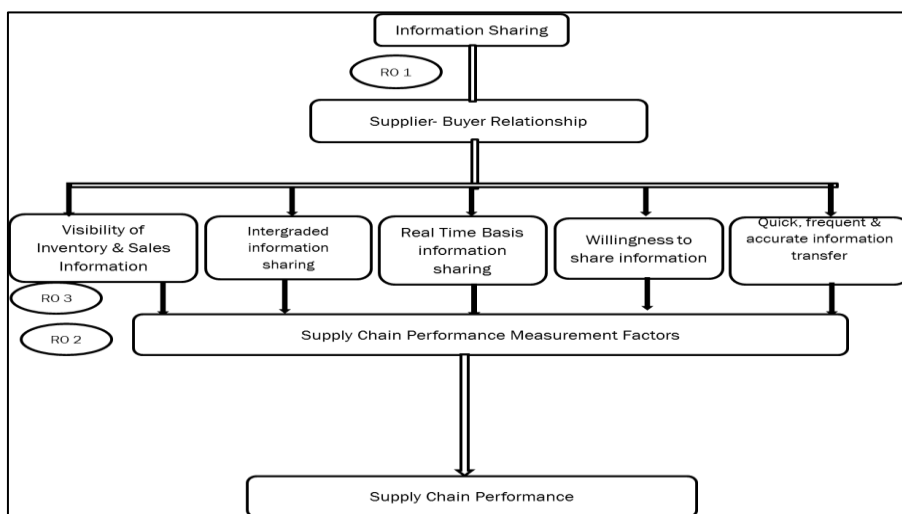


Figure 10 Conceptual Framework

A questionnaire was developed based on the literature survey. Data collection was carried out using two methods: online questionnaire and mail survey. The sample was selected under the non-probabilistic approach. It was important to identify the respondents who were involved in managing suppliers and information relevant to the logistics operations. Qualitative and quantitative approaches were used appropriately to achieve identified objectives of the study: To identify the impact of information sharing over supplier-buyer relationship, a qualitative approach was used, whereas quantitative approach was used to identify impact of those factors on the supply chain performance along with the enhanced supplier buyer relationship due to the proper information sharing. Hence, the questionnaire comprised of both structured questions and open-ended questions. Structured data were collected using Likert Scales and analysed using non-parametric analysis, namely, chi-square analysis. The data collected through open ended questions were analysed using content analysis.

4. Analysis

Based on the analysis, five factors that affect supply chain performance were identified. This includes integrated information sharing, visibility of inventory and sales information, real time basis information sharing, willingness to share information and quick, frequent and accurate information transfer within the supply chain. These factors were ranked based on their importance on supply chain performance. These factors have effect on the following performance measures: profitability, process innovation, lead time, customer responsiveness, on-time delivery, delivery speed and reliability, inventory days, product innovation, productivity and inventory cost. Relationship between the five factors and performance measures were analysed using non-parametric analysis. Accordingly, several hypotheses were tested to measure the relationship. For instance,

H₀: Integrated information system will not impact on improve the company profitability

H₁: Integrated information system will impact on improve the company profitability

Based on the hypothesis analysis it was identified that, out of the five factors, the quality of the information has a strong relationship on the performances of the supply chain in apparel industry. Furthermore, there is a high correlation between integrated information sharing and supply chain profitability. The research found that factors such as quick, frequent and accurate information transfer, process innovation and integrated information system have a significant correlation with lead time reduction of operations.

5. Discussion and Conclusion

The research empirically proves that information sharing impact on supply chain performance. This goes with respect to the integrated information sharing, visibility of inventory and sales information, real time information sharing, willingness to share information and quick, frequent and accurate information transfer within the supply chain. Furthermore, the study proves that information sharing impacts the supplier-buyer relationship; and as a result, many companies heavily invest in information systems to enhance the effective and integrated information sharing along the up-stream and down-stream supply chain for achieving long-term benefit of enhancing the supply chain performance. It is further demonstrated that the information sharing impacts on buyer-supplier relationship either in a positive or negative way. It shows that undue information sharing has negative bearing on the

supplier-buyer relationships; hence, it is vital to share only the essential information to increase the efficiency and effectiveness.

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Keywords: *information, information sharing, supplier-buyer relationship, supply chain performances*

SUPPLY CHAIN RISK AND GOVERNANCE

A Case Study Approach to Explore Supply Chain Disruptions in Sri Lankan Retail Supermarket Industry

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1. Introduction

This research study emphasised on investigating the supply chain activities in retail supermarket industry and the disruptive events that can cause supply chain operations. Sri Lankan retail supermarket industry has very little published academic knowledge. This study intended to fill the gap created by lack of academic knowledge in Sri Lankan supermarket chain industry. This study has used international supermarket chains' best practices and related academic literature to develop frameworks to local context in identifying disruptions in retail supply chain. International academic literature was used to identify and define supply chain operations in Sri Lankan supermarket chains and to identify disruptions that are common in the industry.

2. Methodology

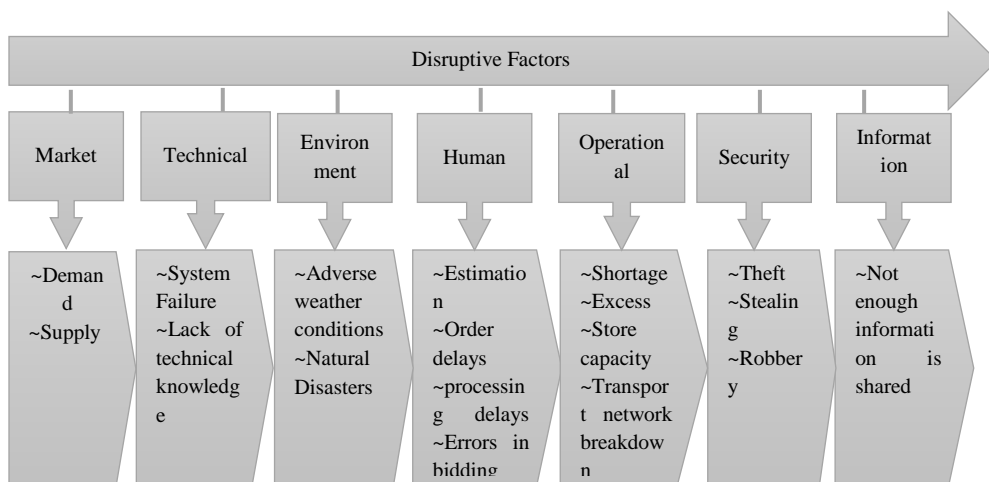
To identify disruptions in supermarket industry, information was collected from three big supermarket chains in the industry. Non-probability convenient sampling method was adopted to select the companies that could be easily accessed with information. Series of in-depth interviews were carried out among operational and managerial level employees to collect extensive information. A semi-structured questionnaire was used as a framework to obtain information while carrying out interviews. Further, to gain more insight in to the studied interviews, unstructured questions were asked to find more case study based information. Any secondary data available on internet as papers, articles etc. were also used in discussions. Triangular method was used to cross-reference and to verify findings between the different sources.

The literature on supply chain risks and vulnerability used to support the base for identifying disruptions in supply chains. Traditionally, studies of supply chain disruptions approached the issues from either demand-side uncertainties or supply

side disruptions (Joonget. al, 2013[1]). Studies later identified further influencing categories to supply chain taking demand and supply as a base. Adegeoke et. al, 2008 [2] identified miscellaneous risks in addition to demand and supply risks. In the process of identifying disruptions in maritime wheat supply chain, Saut,2011[3], identified security and safety, service related factors, infrastructure related issues, market, organisation and relationships, etc., also as disruption points/levels/categories.

3. Findings

Figure 1 depicts the key factors that are causing the disruptions in the supermarket supply chains developed by referring to existing research studies on related areas as well as the author's learning through interviews and discussions during the research.



Source: Author

Figure 1: Key Supply Chain Disruptive Factors in Supermarket Industry

Research study identified direct disruptions that are known to supply chain personal as well as that are indirectly disrupting the supply chain flow on which the responsible persons are assigning less focus. Each factor is found in detail using the information collected from primary and secondary sources.

The research study touched on an important aspect of the industry that has never been addressed in any existing research finding or academic knowhow: It revealed that industry personnel lack knowledge in their supply chains, its disruptions and what could be done to mitigate the impacts arising from supply chain disruptions. Identifying disturbances can clear the big picture of the supply chain network's bottlenecks. This can allow the management to take necessary actions in advance, in order to maintain a smooth flow of quality supply on time, leading to better

customer satisfaction. Identified disruptions could also be used to improve supply chain operations and benefit the Industry. Taking corrective action will help the supermarket industry to improve efficiency levels and will enable higher profits together with highly satisfied set of customers.

4. Conclusion

The research study identified key factors that are causing disruptions in supply chains of retail supermarket industry. The significance of the factors is being discussed as opposed to the current practices in the supermarkets. Further research to explore this area is highly recommended.

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Keywords: *Supply chain, disruptions, retail supermarket chains, supply chain disruptions, supply chain management*

Identifying the Risk Factors of Global Sourcing in the Large Scale Apparel Industry in Sri Lanka

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1. Introduction

Virtually any industry which is globally dispersed shares one common goal: to increase profitability, mainly by reducing costs. Research has identified purchasing as one key logistical activity where the practitioners could enhance profits through leveraging costs. Hence, industries around the globe appreciate sourcing as one of the best strategies to achieve this objective. Global sourcing is an important factor, especially in the internationalisation of the production process of a business. The term “Global Sourcing” is used to describe the practice of sourcing of goods and services of higher quality across geopolitical boundaries. Global sourcing often aims at exploiting global efficiencies such as low cost skilled labour, low cost raw material and other economic factors including concessions on import/export taxes and trade tariffs [1].

Sri Lanka is one of the major high quality garment suppliers in the world. Purchasing raw material is the main stage of the apparel supply chain in view of fulfilling the garment supply. If raw materials are not abundant in one's own country, then producers could lower their supply risk by sourcing from global suppliers. Despite the importance of this factor, the literature shows that there has not been sufficient formal research carried out focusing on risk factors that the Sri Lankan apparel manufacturing companies face in global sourcing.

2. Research Objective

The main research objective is to understand the risk factors of global sourcing in Sri Lankan large scale apparel industry and to find strategies to mitigate those risks.

The three main objectives for this research are:

1. Understanding the risk factors of global sourcing in the Sri Lankan large scale apparel industry.
2. Evaluating the likelihood and impact of the risk factors in the industry.
3. Finding the strategies to mitigate those risks.

3. Research Methodology

This research uses a quantitative research approach and focuses on identifying the global sourcing risk factors of large-scale apparel manufacturing firms in Sri Lanka. A questionnaire was designed to gather data from the large-scale apparel companies where the risk was assessed using the probability of occurrence of an unexpected event and the severity of the impact caused by that event. There are nearly 300 apparel manufactures in Sri Lanka. However, 15 large-scale apparel manufactures accounted for more than 80% of the total apparel export income of Sri Lanka (Export Development Board, Sri Lanka). Therefore, these 15 companies were considered as the sample of the research. Both an online questionnaire and word document questionnaire were developed to gather data. Questionnaires were sent to the identified executives who were involved in procurement and who were above the middle management level. At least three responses were obtained from each company.

4. Analysis

Risk matrix approach, which is a semi quantitative method that is widely used in risk assessment, was used to analyse the data. The probability of occurrence of an unexpected event and severity of the consequence of that unexpected event were considered as the two variables required to build the risk matrix [2]. Accordingly, this study developed a risk matrix to assess the risk factors and their level of exposures to the industry. Based on the analysis, this study identified 26 potential risk factors related to global sourcing operations in the garment industry. These risk factors were categorised into nine groups under both internal and external risk factors. When analysing organisation-specific risk factors, it was observed that both internal and external risk factors figured around high probability and high severity region in the risk matrix demonstrating different assessments form different firms in the large scale apparel manufacturing segment of the industry.

As illustrated in Figure 1, three internal risk factors were identified in the critical zone including Material Cost, Quality Assurance Cost and Quality. These factors generate a critical level of risk exposure on global sourcing of large scale apparel manufacturers in Sri Lanka. On the other hand, on analysing external factors, it was found that four factors, namely price fluctuations, exchange rate risks, cultural & religious barriers and high custom duty and taxes, were located in the critical zone as shown in the Figure 2. Those factors generate a critical level of risk exposure on global sourcing of large scale apparel manufacturers in Sri Lanka. Finally risk mitigating methods were identified by referring to general practices and published research literature on risk management.

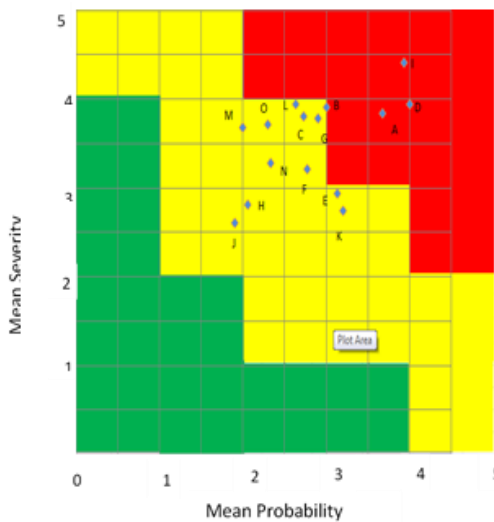


Figure 1: Internal Risk Factors –Risk Matrix.

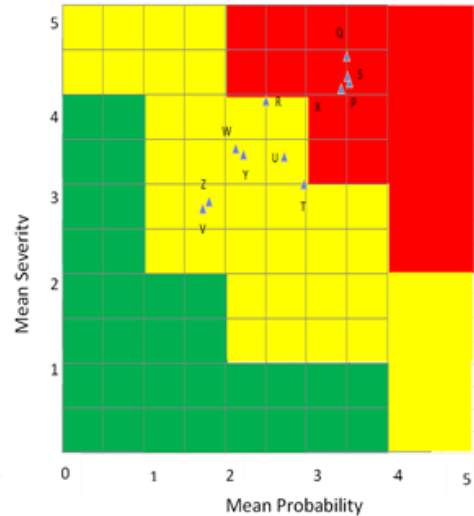


Figure 2: External Risk Factor Risk Matrix.

A-Material Cost
B-Transport cost
C-Inventory carrying cost
D-Quality assurance cost
E-Maintain the material inventory level
F-Risk of using third party service providers
G-Transportation delays
H-Border crossing procedure
I-Quality
J-Willingness to share technologies and information
K-Order system & cycle time
L-Communication capability
M-Information outsourcing
N-Information system security
O-Information accuracy

P-Price fluctuations
Q-Exchange rate risks
R-Miscommunication with foreign suppliers
S-Cultural & Religious Barriers
T-Standard procedures for negotiation and contracting
U-Political involvement
V-War, terrorism
W-Risk of standards and regulations between countries
X-Increase in custom duty and taxes
Y-Natural disasters
Z-Diseases, viruses

5. Discussion and Conclusion

Every business organisation contains various risk elements while doing the business. This study shows that there are a number of global sourcing risk factors faced by large-scale apparel manufacturing firms in Sri Lanka. Among them, quality risk, quality assurance risk and exchange risk are considerably high. Different strategies are suggested to mitigate these critical risk factors. This includes better supplier relationships and coordination to increase flexibility,

supplier development to enhance the quality of the materials supplied, as well as involving the supplier from the concept design stage to enhance performance for both supplier and manufacturer. Furthermore, use of standard testing would assure the quality of the materials and products. In order to mitigate the risk in currency fluctuation, it is recommended to implement proactive strategies to identify the risks and to mitigate them, so that operations can be planned proactively to face such risks.

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Keywords: *Apparel; Global Sourcing; Global sourcing risk; Risk matrix*

Use of Information & Communication Technology Applications in Supply Chain Management: The Case of Small and Medium Scale Manufacturing Enterprises in Sri Lanka

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1. Introduction

Small and Medium scale Enterprises (SMEs) in Sri Lanka play a major role in the Sri Lankan economy. As per the Sri Lankan government statistics, around 80% of businesses come under the category of SMEs and contribute to over 50% of the Sri Lankan Gross Domestic Production (GDP). These SMEs belong to different sectors such as agriculture, manufacturing, construction and services. In the manufacturing sector, 96% of industrial units are SMEs.

With the use of proper supply chain management (SCM), manufacturing SMEs can survive market conditions and compete even with large scale manufacturing companies. Use of Information and Communication Technology (ICT) applications help companies to execute the SCM strategy more effectively. However, the use of ICT applications in the SCM among manufacturing SMEs is an area which needs attention in the Sri Lankan context. Suitable ICT applications can transform the traditional SCM function to gain a distinct edge over competitors. Therefore, this research identifies to which extent manufacturing SMEs are currently using ICT applications in the SCM and, furthermore, explores the main reasons for the lack of ICT application usage in SCM, providing suggestions to improve this situation.

2. Research Methodology

The data collection segment of this research was done by conducting a survey questionnaire consisting of fifteen questions. The survey was done on a sample size of thirty-two manufacturing SMEs in Sri Lanka. As there was no specific definition of manufacturing SMEs in Sri Lanka, any company producing a tangible product with an annual turnover less than Rupees 600 million and employing less than fifty people were considered as manufacturing SMEs. This definition was formed based on two definitions given by the Central Bank of Sri Lanka (2012) and the

Department of Small Industries in Sri Lanka (2002). The collected data were analysed using descriptive statistical testing and hypothetical testing methods. Furthermore, an extensive literature survey was carried out to support the findings from the survey.

3. Findings

As per the research findings, 74% of the manufacturing SMEs currently use non-ICT related methods to communicate with people within the organisation. 88% of manufacturing SMEs use face-to-face meetings for internal communication purposes, while the use of telephone and written documents are 78% and 69% respectively. Electronic mail (e-mail) is used only by 53% of the companies for internal communication purposes. Video conferencing and intranet use is very rare in these SMEs. When it comes to communication with external parties, almost all the companies use telephones. But e-mail is used by 78% of companies as an ICT related external communication mode compared to all other traditional modes.

When it comes to the availability of SCM functions in manufacturing SMEs, reverse logistics is not available in 25% of the SMEs, making it the least available function of all SCM functions. The second least available function is inbound transportation which is not available in 16% of all SMEs. Furthermore, a majority of the SCM functions such as demand planning, procurement, material handling and warehouse management, order management, manufacturing, customer relationship management, and sales and marketing are based on a mix of both paper and appropriate ICT applications. Especially, the logistics related functions are mainly based on paper work. When the overall SCM function is considered, 49% of the manufacturing SMEs are more paper-based than ICT application-based, while only 25% of the companies are more ICT application-based. When it comes to online banking, 69% of the manufacturing SMEs use online banking facilities but their usage frequency is not consistent. 66% of the manufacturing SMEs maintain a website for their company, but only 3% of companies use it for electronic commerce (e-commerce) purposes. Although 47% of the manufacturing SMEs are not using any type of social media for e-commerce purposes, 50% of the manufacturing SMEs manage an official Facebook page as the most popular social media channel.

High maintenance costs associated with the ICT applications is a major reason for manufacturing SMEs to use less ICT applications in the SCM function since most of the available ICT applications are sophisticated. As these SMEs are recruiting skilled labour, they do not incur high training costs in implementing ICT applications. With the high computer literacy level of the top management, implementation of ICT applications cannot be a major difficulty leading to the lack

of use of ICT applications. Due to the low prices of ICT products, the implementation of ICT applications in SCM cannot be a barrier for these organisations.

In order to improve the use of ICT in SCM, customised ICT applications which are suitable for use in SMEs need to be introduced. Furthermore, steps should be taken to improve the SCM domain knowledge in the manufacturing SMEs, while making them realise the importance and benefits that can be achieved in their organisations by using ICT applications in the SCM functions. As SMEs are focusing on recruiting skilled workers rather than training them further, the government needs to provide better knowledge and training to these possible employees beforehand through vocational trainings, etc. With the proper drive from the top management, implementation of ICT can be done even by outsourcing the ICT services to an affordable service provider.

4. Conclusion

In conclusion, the use of ICT applications in the SCM of manufacturing SMEs is inadequate. Therefore, Sri Lankan manufacturing SMEs are more into traditional paper-based SCM. Furthermore, improving the knowledge of good practices in SCM is an area that needs to be paid attention in order to improve the use of ICT applications in manufacturing SMEs. With the support of the Government and other relevant stakeholders, improvements to SCM in manufacturing SMEs can be achieved upon selecting the use of suitable ICT applications.

Keywords: *Small & Medium scale Manufacturing Enterprises, Information & Communication Technology, Supply Chain Management, Sri Lanka*

WAREHOUSE AND INVENTORY MANAGEMENT

Enhancing the Efficiency of Inventory Management in FMCG Industry

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1. Introduction

The decision on how much inventory to keep in hand can be identified as one of the key decisions to make in manufacturing, retail and many production industries in various businesses [1]. Basically, inventory is one of the most important items of current assets of an organisation, which permits smooth process of operation, production and sales process [2]. As such, proper management of inventory level is essential, since it leads to reduce the total inventory cost which constitutes a significantly high portion of the total logistics cost [3].

Inventory management is particularly important in the Fast Moving Consumer Goods (FMCG) sector, as the manager's target would be to reduce the logistics cost due to the shorter shelf life time and lower profit margins associated with the sector. According to the research, maintaining appropriate stock level refers to the proper management of the inventory of the company, and it can be identified as one of the most critical factors when it comes to FMCG industry. Hence this research will focus on how to enhance the efficiency of inventory management in FMCG industry.

2. Research Objective

As discussed earlier, inventory management becomes a key factor in most of the businesses. Especially when it comes to FMCG sector, firms cannot even think of a successful business without proper management of inventory.

This study aims to answer two main research problems:

- What are the factors that affect the efficiency of inventory management in FMCG sector?
- How to enhance the efficiency of inventory management with respect to FMCG sector?

3. Research Methodology

This study was carried out in two phases using a mixed research approach, where a qualitative approach was followed by a quantitative approach. The first phase uses a qualitative approach where a comprehensive literature analysis was carried out using around 50 journal papers to identify the factors that impact on the efficiency of inventory management in FMCG industry. This analysis identifies 36 factors that effect on the performance of the FMCG sector around the world. Based on the results, a questionnaire was developed to identify the factors that affect the inventory management and the performance of the FMCG industry.

Based on the factors identified from phase 1, a questionnaire was developed and a survey was carried out. The following hypothesis was formulated to identify the significance of all factors identified through existing literature:

- *H_x - The factor affects to the efficiency of inventory management in FMCG industry*

Data were collected from both local and international companies who are involved in the FMCG sector to identify the gap on the strategies implemented. The survey was carried out using an online questionnaire, which distributed to the potential participants via email. Data were collected from respondents who were actually involved in inventory management operations in FMCG sector. Questionnaires were distributed to 75 FMCG companies around the world, and only 35 companies responded back, so that the response rate was 74.5%. These companies were selected from small scale to large scale operations which handled different volumes per day. The scale of the company was decided by considering the number of employees in the company. This was carried out to ensure fair distribution of data in order to avoid their biasness and to increase their reliability.

4. Analysis

The analysis was carried out using SPSS statistics software. Chi-square testing was used to identify the importance of factors and their level of impact on the performance of the FMCG industry in Sri Lanka. The research statistically proves that pre-identified factors such as collaboration, information sharing, accuracy of information, use of modern technology in warehousing has a strong relationship with the efficient management of inventory in FMCG industry in Sri Lanka. However, according to the analysis it was observed that the factors that are related to quality standards have a very low impact on the inventory performance in FMCG industry in Sri Lanka, whereas it is significantly important in inventory management in international companies in the sector.

Furthermore, the analysis shows that several inventory control methods and strategies such as Vendor Managed Inventory (VMI) system, advanced demand planning methods, maintaining perpetual inventory system, vertical integration, frequent reviews and SKU rationalisation, are now widely used in view of enhancing the efficiency.

Moreover, the study provides a better understanding of the difference between the inventory management strategies and policies between local and international companies in the FMCG industry. Based on the analysis it was observed that local firms still rely heavily on traditional inventory control methods whereas the international firms have shifted toward external integration with suppliers and distribution network to achieve better supply chain performance through efficient inventory management systems. According to the analysis, international FMCG companies mainly focus on full vertical integration to capture the maximum benefits whereas local firms mostly focus on basic strategies such as information sharing (but not real time) and arm's length collaborations.

5. Discussion and Conclusion

In conclusion, this research recommends to improve the local FMCG industry by adopting appropriate strategies that are implemented by the international FMCG inventory management industry, such as:

- The use of much more granular stock management system, which means, instead of using simplistic methods to determine stock levels such as simple SKU segmentation approaches, the usage of more attributes associated with each SKU to create a much larger number of item classes such as lead times, supply and demand variability, consumption patterns, etc.
- Use of sales, inventory and operations planning (SI&OP) instead of sales and operations planning (S&OP). Addition of the specific inventory decisions into the S&OP plan leads to decisions being made on target inventory levels, necessary to support the demand and supply plans.
- Use of distributed order management tools (DOM) to reduce the complexity. These DOM solutions can improve inventory levels in multi-channel environments.

The outcome of this research provides insights into industry partners of the FMCG industry to enhance the efficiency of their operations in inventory management and to improve their overall business performance.

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Keywords: *inventory management, efficiency, inventory management strategies, FMCG industry, supply chain*

Methodology to Enhance Warehouse Performances using Lean Concepts

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1. Introduction

Lean principles and continuous improvement strategies such as six sigma, Value Stream Mapping, standard work and 5S can be used as major tools to reduce non-value adding activities and to optimise the overall performance in the supply chain of an organisation. Although the concept originated in manufacturing industry (Toyota), its basics can also be successfully applied to service industry, and one such promising industry is warehousing.

Warehousing plays a crucial role in supply chain management in an organisation, where the activity, most of the time, involves only in managing the movement of goods efficiently according to customer requirements, but not in owning the good. Thus handling the goods movement efficiently leads to good profit. Lean application in a warehouse can improve its visibility, material flow, work organisation and standardisation of processes. Here, according to the problem area and counteraction of the company, this study turns to the problems of improvement of efficiency and value adding through the implementation of lean principles in the warehouse [1].

The study focused first on identifying the possibility of applying Lean Concept into warehouse operation. Secondly, it aimed to develop a methodology to identify Non-Value Adding Activities (NVAAs) in the system using Lean tools and then to determine suitable Lean tools to mitigate or remove those NVAAs from the system, hence enhancing the performance of the warehouse operation. Due to the time and finance constraints, research was conducted in a way which included the features of the case study approach.

2. Methodology

First objective of the study was attained through a thorough literature survey which proved that basic concept of Lean could successfully be implemented in warehousing industry. Here, due to financial and time constraints, Case study method [2] was selected to achieve the objectives of the research by taking a single warehouse for the sample containing all the essential and standard characteristics and qualities of a typical warehouse. This approach made it possible to conduct the research within the given timeline and within the available limited financial

resources. Next, a thorough work study was carried out followed by a time study, in order to understand the current operations procedures of the warehouse. To achieve the second objective, basic Lean principles [3] were applied into the warehouse operation procedure in the below mentioned order: Firstly, Value Adding Activities (VAAs) and Non-Value Adding Activities (NVAAs) were identified through an analysis of the current scenario which was carried out with the data collected from the work study, interviews with management and every level of the operational staff, KPI performance reports, using Lean tools like standardised work (Standard Operation Procedures preparation-SOPs), regression analysis and fish bone analysis in the selected FMCG warehouse containing the standard features of a typical warehouse scenario. Secondly, using all these data, a value stream map was developed to visualise the current scenario. Thirdly, after identifying NVAAs in the process, recommendations were made to mitigate or reduce the effects of NVAAs to the process while enhancing the overall performances.

3. Research Findings

Table 1: Non Value Adding Activities in the System

Category	NVAAs
Over Production	Poorly predicted forecasting plan (difference of 14%, actual vs. predicted and 11.65% difference in manpower planning)
Waiting	Supplier arrival delays (23.81%), KPI manually generating (1.25 hrs. of supervisors' time), Long time to pick tasks (28% of the Operation), MHE handling delays (22 min daily), Longer approval process
Unnecessary Transport	Higher outlet returns (average Rs 3792742.645 worth goods per month)
Over Processing	Complex Return process
Excess Inventory	Return stocks stored within the facility
Unnecessary Motion	Return process, Higher on demand replenishment tasks, Increased pick overrides (increased by 8.5 per line)
Defects	Increasing DC damages (34.57% than allowed limit value)
Unused employee creativity	High employee turnover (4.6%), Misused work force resources in repacking department, New recruits reducing the pick rates

With identified NVAAs or wastages in the system (Table 1, above) as the outcome of the study, a methodology or a framework was proposed such that the operation could reduce its Lead time by 12 hours (Table2, below).

Table 2: Recommendations to Optimize the Warehouse Performances with the Respective Lean Tool

Recommendation	Lean Tool in use
Proper resource allocation system with More accurate demand predictions done by the Warehouse Management	Heijunka/ Demand Leveling and Capacity Planning
Reducing the number of late suppliers and absent suppliers using a fine system, strict slot allocation procedure and mandatory confirmation of their arrival	KPI and Work Simplification
Common frame work to generate KPI reports within all departments in the warehouse	Automation
More focus on employee performance development programmes	Root cause analysis and Team Development
Encouraging dynamic replenishment over on demand replenishment using flexible work hours so when the picking starts all the pick faces have 100% capacity.	Work Balancing
Generating MHE tasks separately in picking so that all the high racks tasks can be done within a short period of time without pallets being kept in aisles for a long time	Work Balancing
Getting the approval to change Master data in the system so that receiving process can be speed up by eliminating the time wasted waiting until the mother company changes it every time	Work Simplification
Modifying the return process in such a way that suppliers or delivery vehicles do not have to waste time by travelling several time to the return department but getting the relevant return stock at the receiving bay or dispatching bay respectively	Work Balancing, Cellular Manufacturing and Work Simplification
Reducing the storage time of returns with the strict KPIs for suppliers and customer	KPI
Reduce damaged within the facility with the use of strict KPI parameters for both employees and suppliers	KPI
Using GPS to add more efficiency to the Fleet management process	Automation
Develop and maintain employees' positive attitude towards the operation system with Lean tools	5S, Kanban, Six Sigma
Reducing the Lead time in the operation	Due to above all tools

As the final step of seeking perfection, continuous improvement tools are embedded in these recommendations, ensuring the sustainability of the performance enhancements in the operation, and providing a methodology to be followed in order to enhance performance in warehousing using Lean Concept.

References

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