RAILWAY BASED CONTAINER TRANSPORTATION TO GREENING SUPPLY CHAINS: A CASE STUDY IN SRI LANKA

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Abstract

The scale of export and importation has been rapidly increased in Sri Lanka recent past. Large percentage of this fall into local manufacturing industry which are scattered around number of export processing zones around the island. Due to road based container transportation, most of the highways experiencing traffic congestions especially around main cities and in Colombo city where the only container handling port is located. Not only the traffic congestion contribute CO_2 emissions but also the large number of trucks which transport containers are the major contributory factor of transportation related emissions. However, there is dearth of research on these issues in local context especially on the alternative mode of container transportation. Conversely, local railway network is connecting commercial hub with eastern, southern, northern and central regions of the island. Further, Sri Lanka Railways currently upgrades the track conditions to run high speed trains and rehabilitant northern line after the war. Therefore, this research focuses on to investigate the feasibility of adapting railways as a mode of container transportation in order to reduce CO_2 emissions during the container transportation. The inward and outward bound containers to the export processing zones from/to Colombo harbour are considered for this research. The in and out bound containers to the 11 export processing zones over the last year were analyzed to investigate the feasibility of converting transportation to railways since there should be reasonable number of containers necessary to run a freight train in economical manner. IN addition to the emission comparisons cost benefit analysis also carried out in this research. The results revealed that 4 out of 11 export processing zones have necessary quantities of containers which can be transported by railway mode. The level of direct emission reduction out of the transportation is significant and based on indirect factors such as traffic congestions, this value increases further. The baseline information and comparison were carried out according to IPCC guidelines.

Key words: Greening Supply Chains, Emission, Container Transportation, Railways, IPCC

1. Introduction

With the rapid economic development on post era civil war Sri Lanka needs an efficient and reliable freight transportation system. Presently most of the Inland freight being transported by roads with few exceptions (ex: certain percentage of fuel by CPC). Since most of main roads of the island still has single carriageway in most of the distances, and since container carrier trucks have some speed restriction (40 Kmph) most of the time, excessive traffic congestions can be observed in many highways. This has led to many problems such as increment of road accidents, excessive delaying of passenger transportation, road maintenance issues etc. Due to excessive congestions and traffic on motorways tons of green houses gasses especially CO2 emit to the environment annually. Conversely, railways was first introduced predominantly for freight transportation by the British's in 18^{th} century, presently only small percentage is transported by railways. Furthermore, railway network is covering wide range of Island from the commercial hub of Colombo towards central hills and Uva, southern and western coastal areas, north and east etc. However, presently only fuel is being transported on certain routes regular basis and container transportation through railways is minimal.

When considering about global freight transportation perspective, there are two rapidly developing areas: intermodal transportation and greening supply chain. Intermodal freight transport is the movement of goods in one and the same loading unit or vehicle by successive modes of transport without handling of the goods themselves when changing modes. Intermodal transport is considered as a contending mode in transport practice, and can be used as an alternative to uni-modal transport (Y.M. Bontekoning et al. 2004). Greening supply chain also one of the emerging area among the research community due mainly environmental problems especially this link with one of the serious global issues, climate change. Transportation is a major component of most of the supply chains. Excessive emission during the transportation directly affects with environmental issues such as climate change. Transportation is the most visible aspect of supply chains. Transportation related CO2 emissions amount to some 14% of total emissions, both at global and EU level (Stern, 2006; EEA, 2011). Transportation is also a main source for NOx, SO2, and PM (particulate matter or fine dust) emissions. McKinnon and Woodburn (1996), Piecyk and McKinnon (2010) have done studies of the most relevant factors for CO2 emissions in road transport. In order to minimize these adverse impacts, optimization and adaptation of Intermodal transportation will be one of the best possibilities. Many goods shipped through intercontinental chains are shipped nowadays in containers. The land part of such a chain occurs by truck, rail or inland barge. The rise of inland container terminals to facilitate inland ship-rail-road combinations can save thousands of truck kilometers in congestion sensitive areas and thus reduce the environmental impact. This also pertains for continental chains. The disadvantage of intermodal transport is that it requires more coordination than single mode transport (R. Dekker et al. 2012). Several foreign governments have been formulated carbon abatement strategies for freight transport. As the first stage, an analysis of GHG emissions from freight operations, disaggregated by transport mode has been performed. Attention has tended to focus on road transport, since that is the dominant mode of freight movement, accounting for the largest share of freight-related emissions within countries (A .C. McKinnon & M.I. Piecyk, 2009). As E. Andic, et.al., (2009) states, even after the green demand has been implemented, companies need to ensure that profit remains as a means and not as a goal, because of the extreme importance of sustainability. Once the supply chains become green, it is important that this process should continue in order to achieve long term, wide-ranging sustainability.

When focus to local context, dominant medium for freight transportation is through highways. With current economic development focus in Sri Lanka, change in imports and exports of goods shows a positive trend (Figure 1). Although highway network is expanding as an infrastructure development in Sri Lanka, increase in vehicle population has caused road traffic congestion and situation will get worst if freight transportation is also continue with trucks through highways. Furthermore, many export oriented local manufacturers tends towards incorporating green concepts throughout their supply chain (adapting green building concepts for manufacturing plants as their first step).

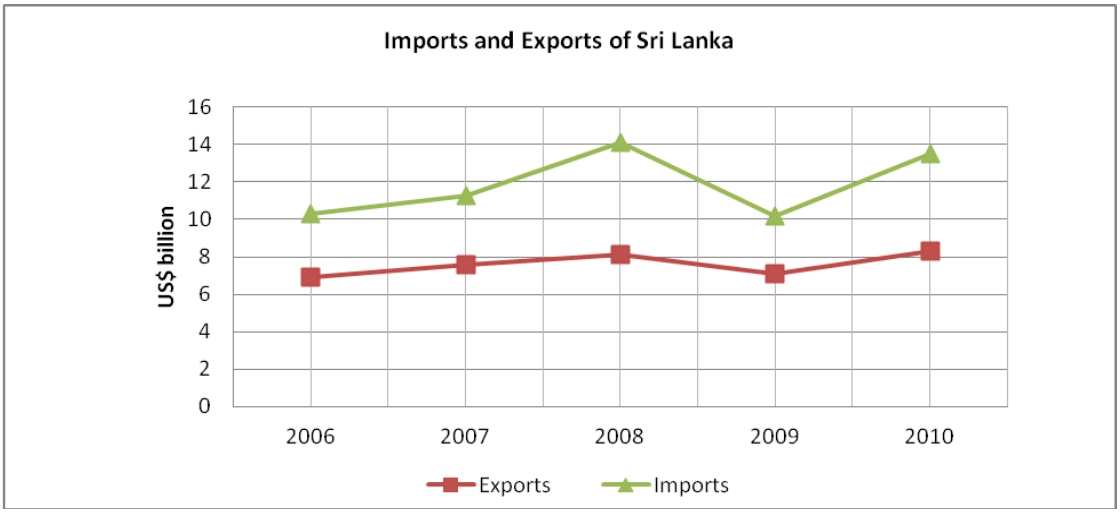

Figure 1: Imports and Exports of Sri Lanka – 2006:2010 (Central Bank of Sri Lanka, 2011)

Many foreign markets currently they cater, promotes green concepts especially to convert green supply chains due to the customers preference shifts. Specially, current market focus towards green production drives manufacturers to implement green concept not within their facility complexes but beyond boundaries. In outside the factory, since the transportation is the biggest contributor of energy utilization and CO_2 emission, managing it in a proper way enables manufacturers not only to get competitive advantage but can contribute to the society as a green initiator. Therefore there is a motivation to find an alternative mode to replace the inefficient, high Carbon emitting highway based freight transportation to intermodal transportation with the help of railway network in Sri Lanka as an initiative to greening supply chain. Rest of the paper is as follows. Section 2, presents the proposed methodology adapted in our research. This follows by the case study which includes analysis and results too. Conclusion and future directions of the research is given in section 4.

2. Methodology

The main focus of this research was to greening the supply chain in local manufacturing sector. Most of the export oriented manufacturing industries import most of the raw materials and process and add value and export them back. Hence transportation related activities plays a dominant role in supply chains. In order to greening the supply chains by reducing the emission during the transportation activities, feasibility of intermodal transportation has been investigated. Since most of the export oriented manufacturing organizations are concentrated within Board of Investment (BOI) export Processing Zones (EPZ), zones which are within the radius of 20km from the existing railway network were selected to investigate the feasibility to convert freight transportation to intermodal manner.

The proposed Methodology consists of three main phases. Each of them sub divided further as shown in Figure 2. First phase was to identify whether significant emission reduction can be achieved by introducing intermodal transportation system. For that general emission comparison was done between train and 10 wheeler truck. Then in the second phase, locations of zones and travelling distances from Colombo harbour to zones along highways and rail tracks were analyzed and checked whether zones are situated in the feasible range from rail tracks compare to highways. Finally data of container imports and exports of each zone were collected to identify zones which have required container movement frequency to accommodate trains for transportation. BOI zones which satisfy all above requirements considered as feasible zones to introduce proposed system.

Initially, CO_2 emission amounts per kilometer run from both train and 10 wheeler truck was calculated using the eq (1) suggested by IPCC-Road Transport (IPCC v2_3_Ch3 Mobile Combustion). Results of this calculation confirms that railway mode of freight transportation reduces the CO_2 emission compared to existing highway based mode.

CO_2 EMISSION FROM TRANSPORTATION

$$Emission = \sum_{a} [\,Fuel_a \ x \ EF_a\,] - eq\ (1)$$

Where:

Emission = Emission of CO2 (kg)

$Fuel_a$ = Fuel Consumption (l)

EF_a = Emission factor (kg/l). This is equal to the carbon content of the fuel multiplied by 44/12.

a = Type of fuel (e.g. petrol, diesel, natural gas, LPG etc.)

Next, distances from each and every EPZ to Colombo harbour were calculated by considering normal routes use by the container carriers. Furthermore, closest railway station to each and every EPZ was identified with road distances from zones to identified closest railway stations and rail track distances between those stations to the harbour. Analyzed distances to identify which zones were in the feasible range to introduce intermodal transportation. Then past data of container imports and exports from these EPZs were collected separately and analyzed the number of containers in and out from zones per day. Based on that factor, zones which do not have adequate number of container movement within a day to introduce a train to move them were identified. Once that is finalized, the emission gains (CO_2 reduction) out of mode change or intermodal transportation was calculated.

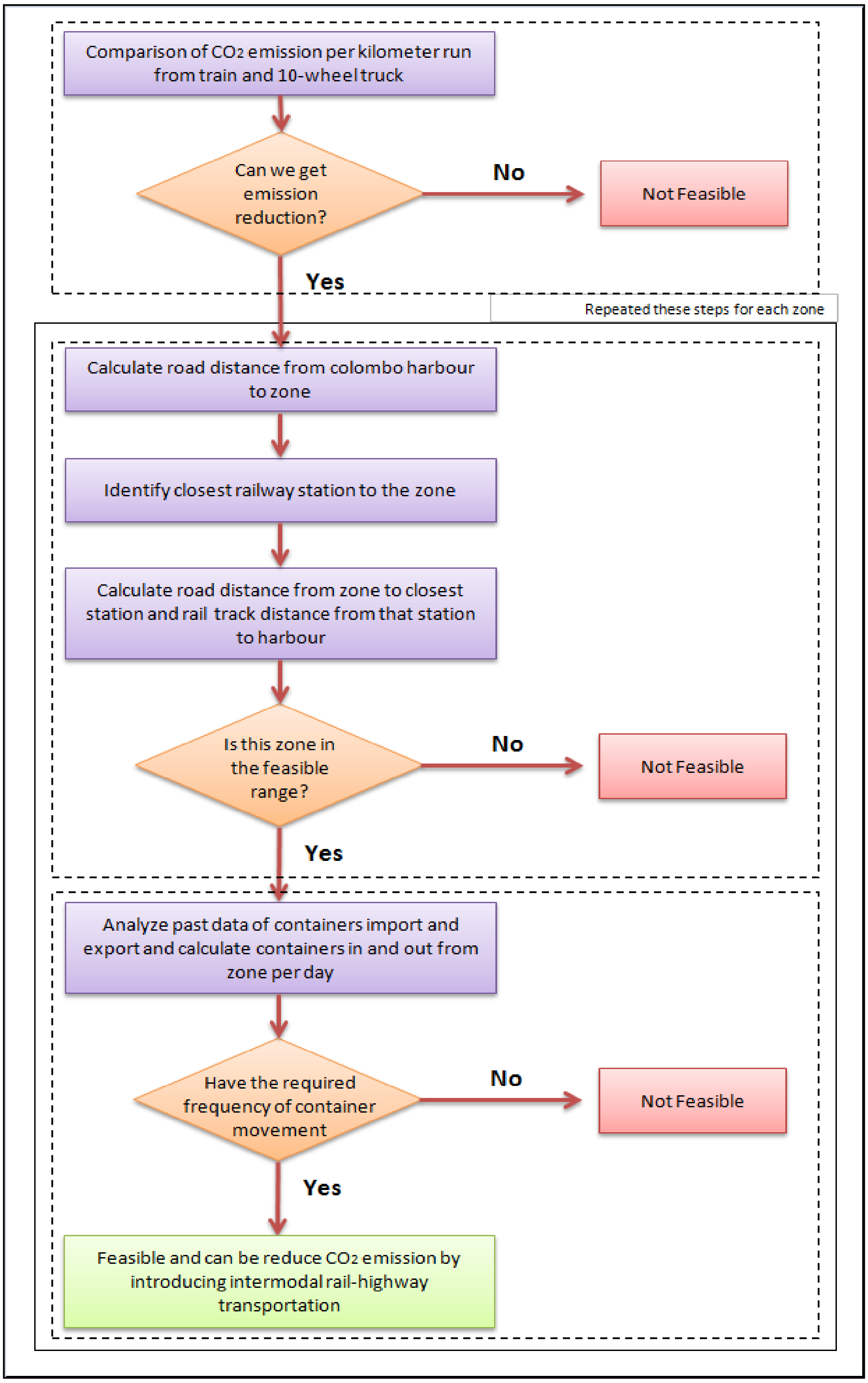

Figure 2: Methodology

3. Analysis and Results

Initially CO_2 emissions from railways hauls by diesel locomotives and 10 wheeler trucks were calculated by the governing equation given by IPCC. Table 1 shows the CO_2 emission when transporting 40 feet container in both with load and without load conditions for the distance of one kilometer from a train and a truck separately. Fuel consumption of both modes was taken and CO_2 emission was calculated using the emission factor for Diesel fuel (IPCC v2_3_Ch3 Mobile Combustion).

Table 1: Comparison of CO_2 Emission from Train and Truck

	With Load		Without Load	
	10 Wheeler Truck	Train	10 Wheeler Truck	Train
Fuel consumption (liters/km)	0.67	2	0.33	1
CO_2 Emision Factor (Kg CO_2 / liter)	2.68	2.68	2.68	2.68
CO_2 Emision per kilometer (Kg CO_2 / km)	1.79	5.36	0.89	2.68
Twelve 40 ft containers can be transported by a train at a time.				
CO_2 Emision per 40 ft container (per kilometer) (Kg CO_2 / Container x km)	1.79	0.45	0.89	0.22

In the next stage, travelling distances by 10 wheeler trucks and trains from /to harbour and EPZ were calculated. Relevant data for each zone is shown in left side of the Table 2. Then closest railway stations considered and calculated distances to be travelled by train and truck in the proposed method (shown in right side of the Table 2).

Table 2: Comparison of Travelling Distances from Rail and Truck modes

Road Transport Distances (From Colombo Harbour to Zone)			Rail + Road Transport Distances (From Colombo Harbour to Zone)		
Existing Method (10 Wheeler Truck)			Proposed Method (Rail + 10 Wheeler)		
No.	Zone	Distance (km)	Closest Railway Station to Zone	Distance (From Rail) (km)	Distance (From 10 Wheeler)(km)
1	Katunayake	29	Katunayake	32	2
2	Biyagama	24	Kalaniya	7	15
3	Sethawaka	47	Avissawella	61	4
4	Koggala	132	Koggala	129	1
5	Horana	50	Panadura	21	18
6	Watupitiwala	45	Veyangoda	37	8
7	Kandy	133	Katugasthota	126	16
8	Malwaththa	38	Veyangoda	37	5
9	Mihirigama	58	Mihirigama	50	6
10	Polgahawela	75	Polgahawela	74	2
11	Mawathagama	115	Kurunagala	95	11

Then comparison of CO_2 emission for one trip from harbour to EPZs is presented in Table 3. For both existing truck transportation and proposed intermodal (train + truck) method considered and it can be seen that considerable CO_2 emission reduction can be achieved from proposed method.

Table 3: Emission Comparison for one trip to each zone

		Emision (Kg CO_2) per 40 ft Container					
		Existing (per 40 ft container)			Proposed (per 40 ft container)		
No.	Zone	**With Load**	Without Load	Total (for a whole trip)	**With Load**	Without Load	Total (for a whole trip)
1	Katunayake	51.81	25.91	77.72	18.06	9.03	27.09
2	Biyagama	42.88	21.44	64.32	29.85	14.93	44.78
3	Sethawaka	83.97	41.99	125.96	34.46	17.23	51.70
4	Koggala	235.84	117.92	353.76	59.01	29.50	88.51
5	Horana	89.33	44.67	134.00	41.65	20.83	62.48
6	Watupitiwala	80.40	40.20	120.60	31.03	15.51	46.54
7	Kandy	237.63	118.81	356.44	84.99	42.49	127.48
8	Malwaththa	67.89	33.95	101.84	25.67	12.83	38.50
9	Mihirigama	103.63	51.81	155.44	33.17	16.58	49.75
10	Polgahawela	134.00	67.00	201.00	35.65	17.82	53.47
11	Mawathagama	205.47	102.73	308.20	62.20	31.10	93.30

Finally, containers in and out from EPZs per day were analyzed to check whether it satisfies the minimum requirement of containers which fit to a train (with 12 wagons). Four zones were identified as feasible zones to introduce proposed intermodal freight transport programme.

Table 4: Container In/out from Zones which are selected as feasible per Day

Average Containers In/Out from feasible zones					
No.	**Zone**	**In**		**Out**	
		Per month	**Per day**	**Per month**	**Per Day**
1	Katunayake	319	11	871	29
2	Biyagama	308	10	620	21
3	Sethawaka	273	9	168	6
4	Kandy	25	1	260	9

In the Table 5, emission gains from each feasible EPZs were presented. According to the figures more than 50% of CO_2 emission due to freight transportation can be reduced by implementing proposed intermodal transportation system.

Table 5: Expected Emission Reduction by Implementing Intermodal transportation (per month)

Expected Emission Reduction After Introducing Proposed Freight Transportation System					
No.	**Zone**	Total		Reduction from Proposed Method	
		From 10 wheeler truck (kg CO_2)	From rail + 10 wheeler truck (kg CO_2)	Amount (Kg CO_2)	%
1	Katunayake	92486.8	32235	60252	65%
2	Biyagama	59688.96	41552	18137	30%
3	Sethawaka	55548.36	22798	32750	59%
4	Kandy	101585.4	36332	65253	64%

This analysis reveals that out of 14 EPZs based on current in/out container volumes, only 4 EPZ's have the required number of container movements to operate the intermodal manner in financial viably. With the introduction of intermodal freight transportation even these 4 EPZ's alone will save 1503 tons of CO_2 annually which helps greatly to convert SC's relevant to the manufacturing industries operating in these EPZs. Therefore, Sri Lanka manufacturing sector along with government should focus on this option seriously without wasting time by considering not only the green potential but by considering the indirect benefits as well.

These analysis and calculations were carried out by considering number of assumptions. It was assumed that inland transhipment ports will be available in the closest railway stations. The investment necessary to operate transhipment ports were not taken into consideration. Load factor for the existing locomotive of Sri Lanka government railways were taken as 40 for low land and 60 for highland. Furthermore, it was found that at least one train should originate from and to between each EPZ and from harbour to operate this in economically sustainable manner. Therefore, in the process of selecting the feasible EPZ's the number of containers available for a one train in both directions were taken into account. And it was found that in order to operate freight trains in an economical manner at least 12 40TEU containers should be included one trip with current market prices of freight forwarders.

4. Conclusion

The significance of rail based transportation has been investigated in this study towards greening the supply chain. In order to achieve the objectives, the existing transportation system has been studied and then proposed system was implemented on that. The proposed system is sort of intermodal transportation, which is combination of rail and road. The most prominent zones were selected for this study and transportation mode is finalized by checking the feasibility, profitability and emission as well. According to general comparison of emission from train and 10 wheeler truck, it can be seen that we can achieve more than 50% overall emission reduction if we shift freight transportation from 10 wheeler truck. From calculations of distances from zones to railway network, we observed all zones were in the feasible range. But when we analyze container in and out frequency at each zone, out of 11 considered zones only 4 satisfied our requirement of availability of containers to arrange at least one train per two day time period. (Since train can accommodate twelve 40 feet containers at a time)

Furthermore, there are number of significant indirect benefits as well in the proposed approach. It is obvious that we can reduce indirect emission due to traffic jams generated by 10 wheeler trucks when transporting freight from harbour through vehicle populated highways. Even If the government improves existing rail tracks and expand rail network, we can introduce this intermodal freight transportation system to industrial areas which are situated outside the BOI zones which will enhance the income of government treasury directly. In addition, the road maintenance costs will be reduced drastically if the freight transported in intermodal manner. However, it has to be noted that proposed method can be only implemented with private –government partnership, since government single handedly cannot handle this due to the lack of faith among the private sector. As future research, proposed intermodal freight transportation system can be optimized by taken into account of more economical factors and to extend this service to other manufacturing organizations which are located outside the EPZs.

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