Analysis on Transport Mode Choices of School Children in Colombo District, Sri Lanka

K.D.P. Damsara, G.L.D.I. De Silva and R.M.N.T. Sirisoma

Abstract: Traffic congestion on roads in peak hours has negatively impacted on a country's economy as well as the well-being of its citizens. In Sri Lanka, a major portion of the traffic during morning and afternoon peak hours is due to school traffic. It has been identified that the daily travel distances of school children are exceeding the limitations imposed by the Ministry of Education on home to school distance. As a result, students choose different transport modes to reach their schools based on many factors, which has resulted in more vehicles on roads during peak hours. The study focuses on identifying the daily travel distances and the respective transport mode choice of the students in Colombo district. In addition, the factors that affect the school children to avoid public transport modes were also analysed. The study has been divided into three phases as factor identification, mode choice and demand distribution. A quantitative approach has been used in developing the methodology and the data collection was conducted through a questionnaire survey in 28 selected schools in the study area, with a total sample size of 2,875. Stratified sampling technique was used to collect data from the different types of schools defined by the Ministry of Education. The study recommends a procedure to develop an improved public transport system for school trips considering network connectivity and system planning to attract more students into public transport services. Results of this study can be used to identify the most influencing factors for selecting a particular transport mode for school trips by the students and to identify optimum routes for school buses in order to improve the public transportation services with respect to the identified issues.

Keywords: Travel mode choice, School trips, Public transportation

1. Introduction

Colombo District consists of 402 functioning government schools, with a total student population of 374,995 [1]. Apart from the government schools, there are some private and international schools located in the district which consist of 68,828 students. The government schools have been categorized into three categories based on the availability of class rooms and resources as shown in **Table 1**.

Table 1 - School Categories [1]

Category	Description
Category A	schools which have classes in all streams up to advanced level
Category B	schools which have classes up to advanced level commerce and/or art streams, but no science stream
Category C	schools which have classes only up to grade 11 or below

Distance to school is one of the major factors considered when it comes to the enrolment of students for any government school in the country. But due to the uneven distribution of resources, a demand for certain schools exists in the country. If the popularity of the schools is measured based on the student population or grade 5 scholarship examination cut-off marks, majority of the popular schools are located in Colombo district. High attraction of school trips for these popular schools located in Colombo district has resulted in longer travel distances using several transport modes for school trips which has affected the traffic congestion on roads in peak hours.

Sisu-sariya is the only dedicated public transport service available for school children governed by the Sri Lanka Transport Board.

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There are 778 Sisu-sariya buses in operation over the country and only 23 buses are operating in Colombo district. Insufficient supply of public transport services to cater to the school trip demand in Colombo district has resulted in more usage of private transport modes among school children. Daily travel patterns of school children and the transport modes used for school trips should be thoroughly studied in order to construct a sustainable solution for the traffic congestion due to school trips in Colombo district. Therefore, the study focuses on identifying the transport mode choice of school children in the study area with respect to their school type and location along with identification of factors affecting their selection of transport modes. There are 402 functioning government schools, 30 government approved private schools and few international schools located in Colombo district [1]. Major portion of the school trips is attracted to the government schools located in the study area. Some private schools operate their own transport system for their students. Therefore, as an initiation, this study focuses on analysing the mode choice behaviour of students in government schools located in Colombo district.

2.   Literature Review

A trip is defined as moving from one place to another with the use of different transport modes. A trip generated from a household or a boarding place (hostel) and terminating in a school premises is called a school trip. Travel demand for school trips depend on several factors such as distance to school, popularity of the school, availability of resources, choice of school etc. The school choice varies on proximity, school type, authority of the school, extra-curricular activities, inner city student migration etc. [2]. Proximity or in other words nearness is a major factor that governs the school choice [2]. But the school type and the authority of the school may reduce the effect of proximity to the school choice.

Sri Lankan education system is generally state-funded and provide education is free of charge through government schools. Apart from that, there are few government approved private schools and international schools established under the approval of the Board of Investment (BOI) – Sri Lanka, providing education based on local syllabus prepared by the Ministry of Education as well as the British syllabus. There are 10,169 government schools (4,149,661 students) and 118 private schools (279,283 students) available in the country by 2019 as per the Annual report of Central Bank, Sri Lanka [1]. School education in the country consists of 13 years of schooling (Grade 1–13) broken down into four categories based on the age of a student as shown in **Table 2**.

Table 2 - General Education System of Sri Lanka by the Age of a Student [1]

Category	Age (Grade)	Remarks
Primary school	5-10 (1-5)	Compulsory
Junior secondary school	11-14 (6-9)	Compulsory
Senior secondary school	15-16 (10-11)	Not compulsory (For G.C.E. O/L)
Collegiate	17-19 (12-13)	Not compulsory (For G.C.E. A/L)

The current legislation system has made the school education compulsory for all children under the age of 14 years in the country. However, education participation percentage of Sri Lanka has been identified as 94.4% for children aged between 5-9, 92.2% for children aged between 10-14 and reduced to 52.6% for children aged between 15-19 [3]. Poverty is one of the major reasons for leaving schools after the age of 14 years [4], along with other reasons such as not interested in education, engaged with family support economic activities etc. [5]. Mode choice or modal split is the third step of traditional four step model, where the trips distributed among origins and destinations in the study area are split into various transport modes [6]. Factors affecting the transport mode choice can be categorized into four broad categories as trip characteristics, household characteristics, zonal characteristics and network characteristics [6]. Transport mode used for school trips depends on several attributes such as age of the student, type of the resident area (rural/urban/semi-urban), gender of the student, household's monthly income, household's vehicle ownership, student's perspective towards active transportation and parental care giving [8]. Apart from that, utility of a particular transport mode is affected by the cost of using that particular transport mode and the weather of the area as well [2]. It has been found that 1% increase in vehicle travel time, resulted in 21% increase in the walking

probability for trips with shorter travel distances [12]. Supporting that, few other studies have also identified distance or travel time as one of the critical determinant factors of mode choice, specifically for school trips [13]. Individual preference or taste heterogeneity of the school children is a major factor that has not been considered in most of the studies conducted related to travel behaviour of school children [14]. Most of the time, use of active transport modes for school trips is affected by the parent's preferences as well. When considering the school locations, urban form, land use pattern of the area, connectivity to public transportation and availability of urban infrastructures also affect the choice of travel mode by the school children [11].

To evaluate the public transportation services available for school trips, three criteria can be used as efficiency, effectiveness and equity [12]. However, it has been revealed that the use of private transport modes for school trips have been increased in Colombo district compared to the rest of the country while the public transport mode share and the active transport mode share reduced [5].

Escorting children is the other common practice that can be seen in most of the school trips, which makes the children invisible as a transport consumer, since they are taken as a part of another trip [8]. Travel habits at a younger age are found to continue in future whereas children who do not use public transport modes in their younger age are less likely to be public transport users in their adult age [10]. Safety of the children while travelling to school is another major concern of parents which has impacted the travel mode choice of school children [11].

3.   Methodology

Colombo district was selected as the study area which consists of 13 Divisional Secretariat Divisions as shown in Figure 1. However, the study concerns school trips attracted to government schools located in the study area which covers about 85% of the total school trips attracted to the study area.

Figure 1 - Study Area

After a critical review of literature, a questionnaire survey was conducted in selected 28 schools in the study area with a total sample size of 2,875 students. Stratified sampling technique was used to collect data as total schools available in Colombo district were divided into subgroups (strata) based on the location, then randomly selected schools from each strata were used to perform the questionnaire survey. Furthermore, participants for the survey in the selected schools were also selected on a random basis. The sample includes five boys schools with a total sample size of 594 students, six girls schools with a total sample size of 681 students and 17 mixed schools with a total sample size of 1,600 students. When considering the school type, there were 12 Category A schools with a total sample size of 1,574 students, eight Category B schools with a total sample size of 758 students and eight Category C schools with a total sample size of 543 students. The sample sizes were selected for each category based on the total number of students studying in each category as a proportion to the total. However, the pandemic situation in the country has affected the later part of the data collection where it was initially planned to collect data from 32 schools but had to limit to 28 schools. The questionnaire was mainly focused on recording the respective transport mode used to travel to schools, origin destination data of school children, distance to school, travel time, travel cost, availability of vehicles at home, accessibility to public transport modes, whether the students were escorted by someone else and some other demographic factors.

Transport modes used by the students in the study area for school trips based on the following sub-categories were analysed separately.

  i.   Transport mode with respect to the travel distance
  ii. Transport mode with respect to the school category
  iii. Transport mode with respect to the gender of the student

iv. Transport mode with respect to the student's grade of study

v. Transport mode with respect to whether the student was engaged with any after school activities

vi. Transport mode with respect to the household vehicle availability of the students

If the main transport mode used for school trips differ from public transport modes, reasons to avoid public transport modes were analysed separately in order to identify the improvements to be made to attract more students to public transport services.

A sample O-D matrix was developed using the data collected through the questionnaire survey. The total number of destination zones were equal to 13 Divisional Secretariat Divisions (DSDs) in Colombo District. But all the school trips attracted to Colombo District were not originated from Colombo District. Therefore, total number of origin zones are equal to 15 in order to cater the school trips originated from other two districts of the province. However, there were only eight school trips attracted to the study area from other two bordering districts Kegalle and Ratnapura in the sample, which was 0.2% of the sample, hence neglected in the study. Then a distance matrix was developed using a network analysis carried out with the help of the Arc Map 10.5 software. DSD centres have been identified and the distances were calculated among each DSD centre with respect to the road network. The percentage of trips with respect to their distance from school has been calculated in this step. After that, the number of school age children who live in each DSD of the study area and the number of students that can be accommodated by the government schools located in those DSDs have been analysed separately in order to identify the imbalance of resource distribution in education system which has resulted in the need travelling longer distances to fulfil the educational needs of the children.

Finally, O-D patterns of the school trips in the study area has been analysed and presented as O-D desire lines based on the origin destination data collected through the questionnaire survey in order to identify the potential O-D pairs in which a high demand for school trips exist. Recommendations of the study have been provided at the end of this paper based on the analysis carried out as mentioned above.

4.   Results and Discussion

4.1 Daily Travel Distance of School Children in the Study Area

Daily travel distance of school children attracted to the schools located in the study area has been calculated based on the distance between origins and destinations of the sample and presented in a Trip Length Frequency Diagram (TLFD) as shown in **Figure 2**. As per the guidelines of school enrolment process for grade 1, home to school distance should be less than 2 km (mostly in 1 km radius range).
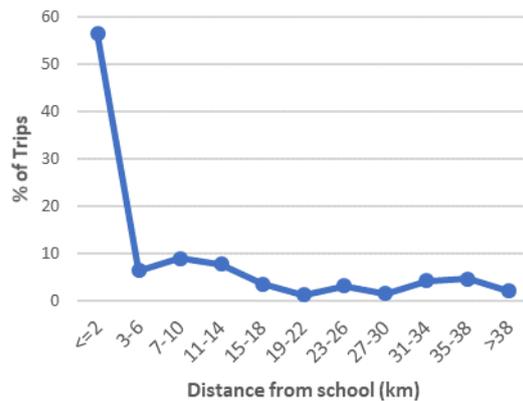

Figure 2 - Trip Length Frequency Diagram for School Trips

In the sample data collected, 44% of trips show longer than 2 km distance from the school and even it has reached up to 50 km of daily travel distance for some school trips. When finding the reasons for these higher trip lengths, it has been identified that imbalance of resource distribution in the study area was one of the major reasons for students to travel from one DSD to another in order to fulfil their educational needs. Therefore, the number of school children live in each DSD of the study area and the number of school children that can be accommodated by the schools located in those DSDs have been compiled by the author as shown in **Figure 3**.
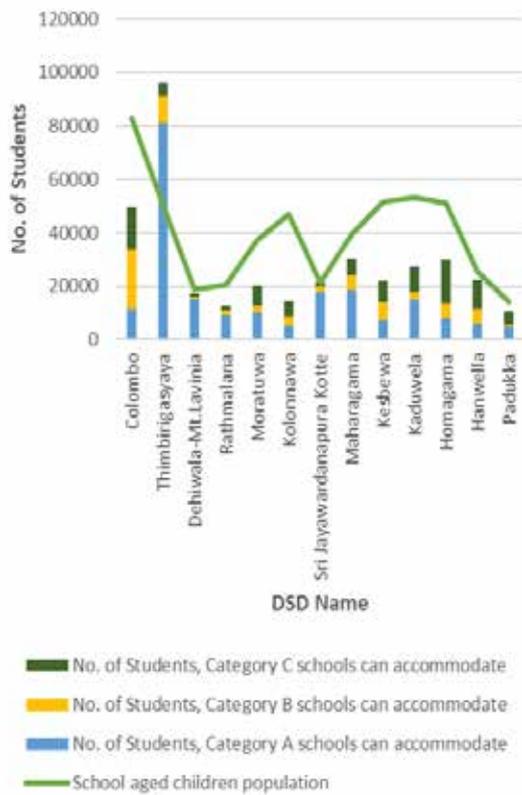
Figure 3 - Student Populations vs. Capacity of Available Government Schools in the Study Area

It can be clearly seen that the number of school aged children live in each DSD except the Thimbirigasyaya and Sri Jayawardenapura Kotte DSDs exceeds the number of students that can be accommodated by the available government schools. This imbalance of resource distribution has resulted in school trips with longer travel distances in the study area.

When considering the daily travel distances of school children in each school categories separately, Category A schools show a lesser percentage of students located near to the school compared to other school types as shown in **Figure 4**.
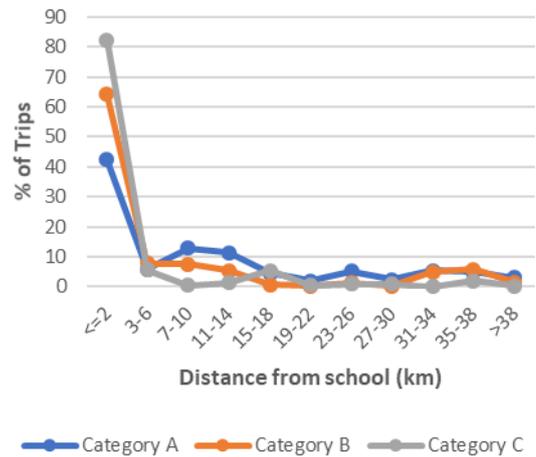
Figure 4 - Trip Length Frequency Diagram for each School Category

Category C schools show 82% of trips originated from less than 2km distance from the schools, but Category A and Category B schools only have 42% and 64% trips respectively originated from less than 2km distance from the school. Therefore, most of the school trips with higher distances are attracted to Category A and Category B schools in the study area as it is allowed to apply for any school after the grade 5 scholarship exam and also after O/L if preferred stream of study is not available in the present school. Further, admission based on different other categories such as old boy/girl, brother/sister category, armed forces and other professional category quota also in effect.

4.2 Transport Modes Used for School Trips

The composition of transport modes used for school trips in the study area is shown in **Figure 5**.
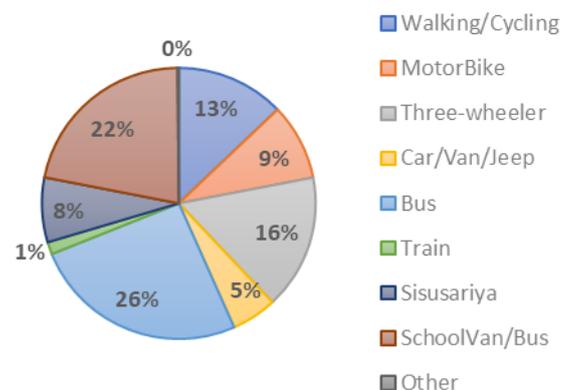

Figure 5 - Composition of Transport Modes used for School Trips

As it is shown in the above figure, buses are the most commonly used transport mode for school trips when considering the whole study area along with school van/bus services and three-

wheelers as the second and third transport mode, respectively. However, trains show only 1% share because of the limited railway tracks available in the study area. In order to clearly interpret the transport modes used by the school children, those vehicle categories have been re-categorized into walking/cycling as active transport mode, bus, train and Sisu-sariya bus service as public transport mode, motorbikes, three-wheelers, car/van/jeep and other modes as private transport mode and private school transport services including both school vans and school buses separately as shown in **Table 3**.

Table 3 - Modal Share for each Transport Mode Category

Mode	Modal share
Active Transport Mode	13 %
Public Transport Mode	35 %
Private Transport Mode	30 %
School Van/Bus Services	22 %

Public transport modes have the highest modal share (34%) for school trips in the study area, while active transport modes were the least popular mode category among school children, and the private transport modes have a considerable share (35%) along with the school van/bus services (22%).

In order to have an in depth understanding of the transport mode choices of the school children and the factors affecting their mode choice, it has been analysed with respect to different sub categories as follows.

i. Transport Mode vs. Travel Distance

The transport mode used with respect to the daily travel distance of school children has been analysed separately as shown in **Figure 6**.
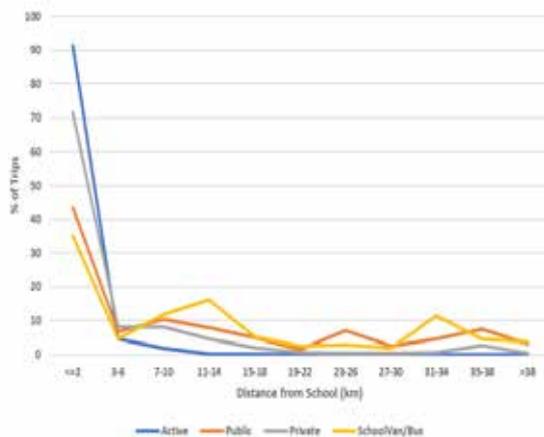

Figure 6 - Percentage of Trips Used by each Transport Mode vs. Distance

91 % of the active transport mode users (walking and cycling) originated within 2km radius from the schools. At the same time, 71% of the private transport mode users were also living within 2km range from the school which has contributed to the higher congestion on roads in the peak hours. When the distance from school increases, public transport modes and school van/bus services become more popular among the school children.

ii. Transport Mode vs. School Category

Students in different school categories show different patterns in transport mode selection for their school trips as shown in **Figure 7**.
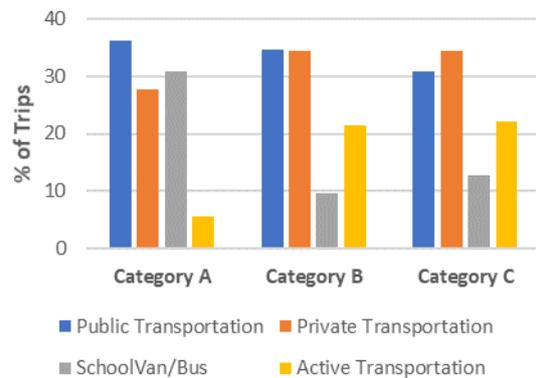

Figure 7 - Transport Mode Selection Based on the School Type

Public and private transport modes are the prime mode of travel among the students of category B & C schools while school van/bus services along with public transport modes are much popular among the school children of category A schools. Active transport modes are comparatively popular among the students of category C schools, because they show more than 80% of trips generated within 2 km distance from the school. Supporting that, it has been found by another study that school children would prefer to walk or cycle not more than 15 minutes time interval for their daily school trips [11]. The active transport users identified in the study also live in near proximity to their schools proving that school children do not prefer to use active transport modes for longer travel distances or trips with longer travel times.

iii. Transport Mode vs. Gender

The transport modes used by the male students and female students have been analysed separately in order to identify the most popular transport modes among each gender category.
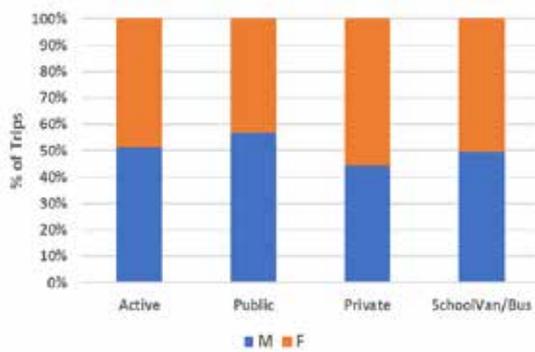
Figure 8 - Transport Mode vs. Gender

Active and public transportation modes are slightly more popular among male students while private transport modes and school van/bus services are more popular among female students in the study area considering the safety while travelling. But in general, gender was not found to be a major influential factor for transport mode choice among school children in the study area based on the above analysis.

iv. Transport Mode vs. Grade of study
The choice of transport mode with respect to the grade of study was analysed separately as shown in **Figure 9**.
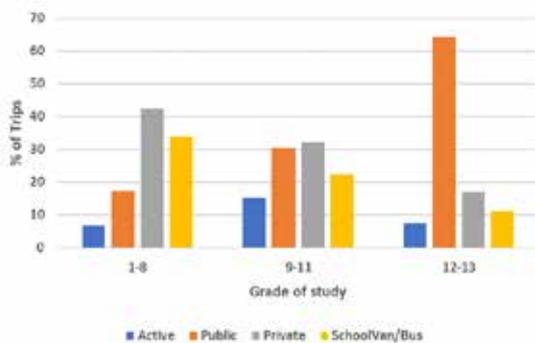

Figure 9 - Transport Mode vs. Grade of Study

As can be seen from the above figure, public transport modes become popular among students when they advance to higher grades of study. 64% of the students who are in advanced level classes (12 and 13) use public transport modes for their daily school trips. Private transport modes are more popular in lower grades where, 42% of the students in below grade 8 and 32% of the students in grade 9-11 uses private transport modes as their main mode of travel to school. This shows that age of the student or the grade of study is an influential factor for use of public transport modes for school trips in the study area.

v. Transport Mode vs. After school Activities
It has been identified that after school activities affect the transport mode choice of school children, because 32% of the students who were engaged with after school activities have selected private transport modes as their main mode of travel while the students who were not engaged with after school activities have only 25% share on private transport modes. All the other modes have comparatively decreased their modal share when students engaged with after school activities as shown in the **Table 4**.

Table 4 - Effect of After School Activities on Transport Mode Selection

Travel Mode	After school Activities - YES	After school Activities - NO
Active	12%	15%
Public	34%	36%
Private	32%	25%
School van/bus	21%	24%
TOTAL	100%	100%

vi. Transport Mode vs. Vehicle Availability at Home
Vehicle availability vs. transport mode selection has been analysed and the results revealed that 36% of the students who owned private vehicles in their households, uses them for their school trips while only 9% of them use active transport modes to reach their schools which is a 17% decrease compared to the students with no vehicle at home. It can be assumed that the students who have private vehicles at their homes have higher household income levels compared to other students. 24% of the students who have vehicles in their households use school van/bus services for their school trips which is an 8% increase compared to the students who have no vehicles in their households.

4.3 Reasons to Avoid Public Transport Modes
The reasons to avoid public transport modes for school trips were questioned from the students who were not using public transport modes as their main mode of travel. Those reasons were identified in two broad categories, i.e. major reasons and minor reasons. Major reasons were the travel time and waiting time, accessibility and security. Minor reasons were identified as comfort, reliability and non-availability of vehicles as shown in **Figure 10**.
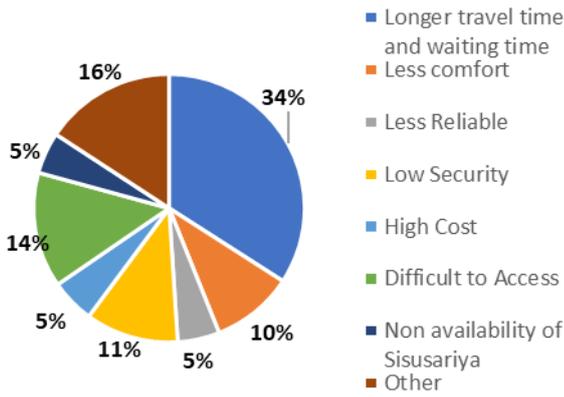
Figure 10 - Reasons to Avoid Public Transport Modes

Travel time and the waiting time incorporated with the public transport services were the main demotivating factors for students to avoid public transport modes in the study area. Accessibility to the public transportation and the security of the passengers were contributing to the choice of public transportation modes as 14% and 11%, respectively. Some of the other reasons mentioned above were the availability of private vehicles in homes, residing near to the school etc. which contributes 16% cumulatively to the choice of public transport services.

4.4 O-D Patterns of the School Trips

O-D patterns of the school trips have been represented by using O-D desire lines generated through analysing the origin and destination data of the sample responses collected through the questionnaire survey. A sample O-D matrix was developed using the collected data and expanded to the actual population using the calculated expansion factors. The sample was first expanded to the total student population of the particular school using the following formula.

$$EXP(1) = \frac{tot_{school}}{tot_{sample}} \qquad ...(1)$$

Where,

$EXP(1) = Expansion\ factor\ for\ school\ (n)$
$tot_{school} = Total\ no.\ of\ students\ in\ school\ (n)$
$tot_{sample} = No.\ of\ trips\ attracted\ to\ school\ (n)$
$in\ the\ sample$

Then the expanded number of trips attracted to sample schools located in a particular DSD were added together and expanded into total number of students in schools located in that particular DSD using **Equation 2**.

$$EXP(2) = \frac{TOT_{school}}{exp\_tot_{sample}} \qquad ...(2)$$

Where,
$EXP(2) = Expansion\ factor\ for$ DSD (j)
$TOT_{school} = Total\ No.\ of\ students\ in$ government schools located in DSD j
$exp\_tot_{sample} = Total\ expanded\ sample\ trips$ attracted to schools located in DSD j

The estimation of the O-D trips was destination constrained, because the expansion factors calculated using the number of students in the government schools located in the study area which was equal to the number of school trips attracted to each destination zone of the study area. O-D desire line were developed based on the trip distribution data as shown in **Figure 11**.
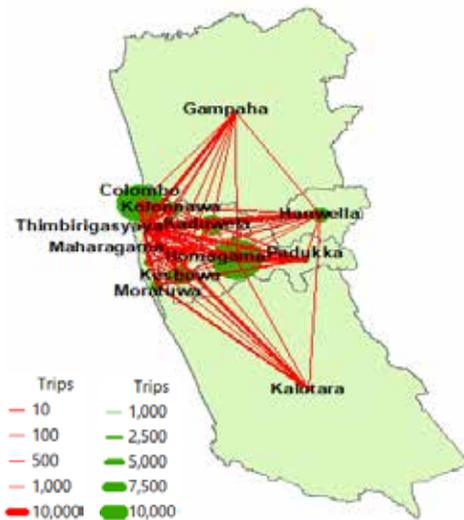

Figure 11 - O-D Desire Lines for School Trips

In Figure 11, the green coloured circles show the intra-zonal trips in the study area while red coloured lines represent the Inter-zonal trips. There are five origin-destination pairs inside the study area that can be identified with more than 5,000 home to school trips distributed per day as Kolonnawa to Colombo, Padukka to Homagama and from Kaduwela, Hanwella, Padukka area to Thimbirigasyaya. Apart from that, Thimbirigasyaya DSD has shown over 5,000 school trips attracted from Kalutara and Gampaha Districts per day, which were identified as External-Internal trips attracted to the study area.

Apart from the major findings of the study, 35% of the students in the sample were escorted by their parents to the schools as a part of another

trip which made them invisible as a transportation service consumer.

5. Conclusion & Recommendations

This paper was targeted on analysing the factors affecting the transport mode choice for home to school trips attracted to Colombo district. There were mainly six factors considered in the study as distance to school, school type, gender of the student, grade of study, engagement with after school activities and household vehicle availability. The variation of transport mode choice with respect to those factors was analysed. Main reasons to avoid public transport modes as the main mode of travel for home to school trips were identified as higher travel time, longer waiting time, poor accessibility and low security. Further, the higher demand that exists for school trips for 5 origin-destination pairs inside the study area were highlighted. This study recommends to address the identified factors which made students away from public transport services for their school trips as well as to supply adequate public transport services to cater the higher demand for school trips identified in particular O-D pairs. Since there are some well-established private and international schools located in the study area, it is expected to extend this study for students in those schools as well, in order to incorporate all the school trips attracted to Colombo district. Further, the study sets the background to develop a mode choice model for school trips followed by a demand model for school trips in the study area.

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