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Carpooling: A Step to Reduce Traffic Congestion in Sri Lanka

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Abstract: As a developing country, Sri Lanka is facing rapid urbanization which increases the need for mobility. Lack of comfort, safety and ride quality in public transportation modes such as busses and trains have lead people to use higher number of private vehicles on roads. This has caused heavy traffic congestion and higher demand for parking space in major cities. It further causes higher levels of air pollution, noise pollution and the lesser vehicular speeds which lead to inefficient use of the infrastructure provided. To address this issue carpooling can be adopted reducing the number of vehicle trips to the cities. Higher occupancy levels in vehicles facilitate shared journeys reducing the overall cost of total journeys. A study has been carried out through a survey to determine the preference for carpooling. Acceptance of carpooling is presented comparing age, gender variation and vehicle ownership of the community in Sri Lanka.

Keywords: Car Pooling, Ride Sharing, Traffic Congestion, Sri Lanka, Online Survey, Public opinion

1. INTRODUCTION

Requirement of mobility for humans has been increased with the undergoing rapid development in countries like Sri Lanka. Commuters who mainly use public transportation modes such as busses and trains always face issues related to safety, comfort and ride quality. Hence, people have been using private cars for their daily trips. Use of private cars leads to higher levels of air pollution in cities, parking problems, noise pollution, congestion, and resulting low transfer velocity (and, thus, inefficiency in the use of public resources) (Calvo *et. al*, 2006). A noticeable amount of fuel is wasted due to traffic congestion in peak hours (Seyedabrishami *et. al*, 2012). Carpooling has been adopted to address these issues by various countries.

Travelers are allowed to share a ride to a common destination in carpooling. Carpooling can include several forms of sharing a ride; casual carpooling, real-time carpooling and van pooling (Shaheen *et. al*, 2018). Carpooling is an easy and common ride sharing arrangement where the ride is shared by two or more individuals. For example, if two persons A and B would pool their cars, they must first be owners and drivers of cars. They will then organize among themselves as to who is to drive on which day or which route to follow, and so forth. Preferably, A and B would alternate driving on a daily or weekly basis, or on any other basis they prefer. There will not be any charges or fees involved (Dewan *et. al*, 2007).

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Carpooling tries to reduce the cost of journey for travellers who commute to work which not only will save their out of pocket cost but will also reduce the usage of most important non-renewable resource we have i.e. fuel, which is declining at rapid pace. Decades ago during the oil crisis in Europe, people were encouraged to share their vehicles. Carpooling provides benefits, firstly to the travellers or drivers who use their own vehicle to commute to work daily and needs some fellow passengers to share cost of fuel and other expenses. The second benefited party is the passengers who also travel to work daily but they either use public transport or use other modes of transportation which are less comfortable, unsafe and take more time than usual to reach their destination because of which they are pretty much exhausted (Joshi *et. al*, 2015).

The concept of carpooling is not new to the world, yet its successful implementation and operation in Sri Lanka is remarkably lagging compared to other countries.Traffic congestion in major towns like Colombo and Kandy has always remained as an unsolved problem during the past decades. Traffic congestion increases the travel time of commuters which results inefficient use of valuable time of the Sri Lankan workforce. Carpooling can be introduced to address this issue of traffic congestion, yet its acceptability and implementation among the general public has to be thoroughly analyzed. This research is focused on investigating the possible barriers and the likeliness for acceptance of carpooling concept by the community in Sri Lanka.

2. LITERATURE REVIEW

It is necessary to understand the vehicle population over the past and existing travel characteristics in Sri Lanka for the study. The following figure shows the growth of vehicle population in Sri Lanka from 2008.

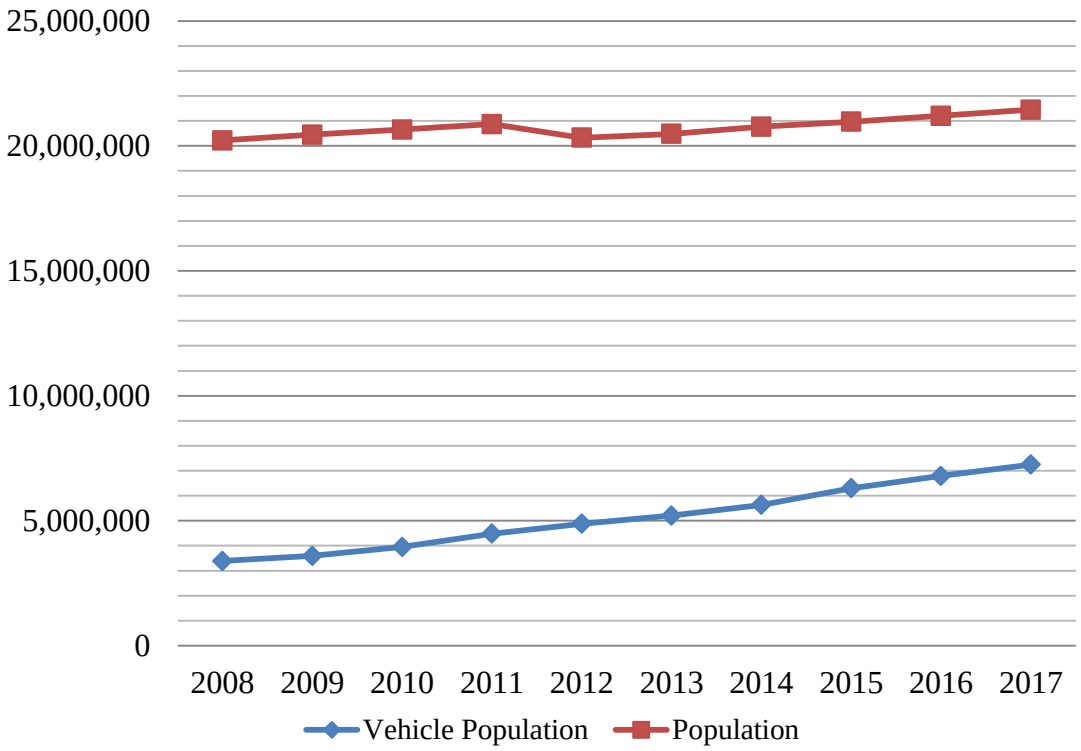

Figure 1. Vehicle population growth from 2008 in Sri Lanka

Table 1. Variation of vehicle population in year 2017

Vehicle type	Population
Motor cars	756,856
Three-wheelers	1,139,524
Motor cycles	4,044,010
Busses	107,435
Dual purpose vehicles	408,630
Motor lorries	352,275
Land vehicle tractors	362,445
Land vehicle-trailers	75,947
Total	7,247,122

The table shows the variation of vehicle population with vehicle type by the year 2017. The data on the graph in figure.01 and table 01 are according to the vehicle population statistics presented by Ministry of Transport and Civil Aviation in Sri Lanka. The population data has been obtained from Annual Report Central Bank Sri Lanka. The graph shows that the growth rate of vehicles is higher than the growth rate of population. Although the number of vehicles in Sri Lanka has increased, roads and related infrastructure has not been improved to a sufficient extent to cater those new vehicles added on to the Sri Lankan transportation network over the past decade.

2.1 Traffic Condition in Colombo, Sri Lanka

Being the capital of Sri Lanka, Colombo has become the city of most trip attractions and mainly-work trips. The graph below shows the variation of vehicles and passengers in to Colombo in 2015 (Average daily Traffic, 24 hour, two way, Source: INDI.CA).

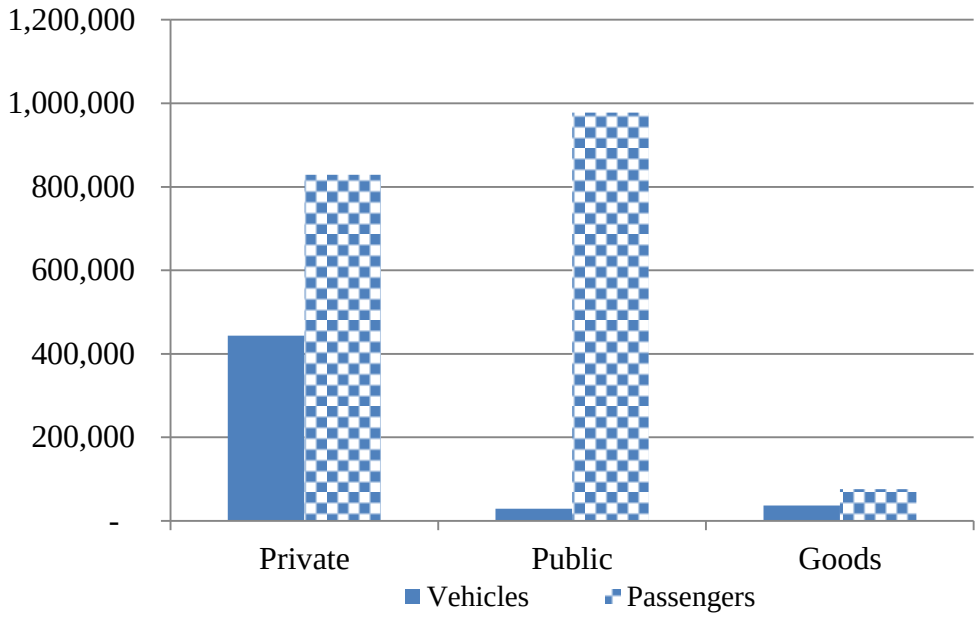

Figure 2. Variation of vehicles and passengers in to Colombo in year 2015

Vehicles and passengers entering Colombo have been separated in to three main categories namely private vehicles, public vehicles and goods carrying vehicles in this graph. Although the highest number of passengers is related to public vehicles, the highest number of vehicles entering to Colombo is related to private vehicles. The figure shows a significant and clear difference between private vehicles and other vehicles. This further proves the fact that private vehicles are a major contribution to the traffic congestion in Colombo, Sri Lanka.

A total of 1.9 million passengers enter the city of Colombo via road network in a usual weekday and the majority is using public transportation modes. 52% of the passengers use the public transportation modes (Busses and Vans) while 44% use private vehicle to enter the city and 87% of the vehicles that enter the city are private vehicles. The following table shows the composition of passengers using private vehicles to enter Colombo.

Table 2. Private vehicle utilization by passengers while entering Colombo

Vehicle Type	Number of Vehicles
Cars	169,448
Three Wheelers	113,481
Motorbikes	102,783
Vans	57,874

The analysis has further been brought down to the fact that the occupancy of a private vehicle is 1.87 passengers per vehicle and for busses 33.6 passengers per bus. It further states that average vehicle speeds drop to 17 km/h in peak hours.

2.2 Traffic Condition in Kandy, Sri Lanka

Kandy is a major tourist attraction and a destination for Buddhist pilgrims because of the sacred Temple of Tooth relic. However Kandy has become another city with heavy traffic congestion and environmental pollution in Sri Lanka due to its economic and cultural value.

Kumarage et. al, 2014 presents the existing traffic flow condition in the Kandy city. Two way twenty four hour traffic flow data is summed up to a total of 112,107 vehicles and 636,536 passengers entering the city from the major corridors. The table below shows vehicles' and passengers' utilization of available corridors when entering the city.

Table 03: Utilization of major corridors when entering Kandy (Two way-24 Hour flow)

Corridor	Number of Vehicles	Number of Passengers
Sirimawo Bandaranayaka MW	20,486	127,581
William Gopallawa MW	21,306	125,284
Katugasthota	34,317	217,678
Polgolla Road	4,051	8,310
Sirimalwatta Road	4,282	11,644
Hewaheta Road	19,447	103,995
Ampitiya Road	8,281	42,044
Total	112,170	636,536

About 59.5% of private vehicles or 51,000 vehicles which enter the city have their trip ends within the central business district (Kumarage et. al, 2014). The demand for parking has increased and this inadequacy of proper parking facilities at city has led the drivers to park by the road side. It reduces the space for mobility of vehicles on roads causing bottlenecks and congestion.

Figure 3: Street parking in Kandy

Another 14,000 vehicles or 16.3% of private vehicles pass through the city and around another 20,000 vehicles arrive through minor roads such as Ampitiya Road and Rajapihilla Mawatha.

The city caters for 10,182 busses having an average occupancy level of 42 passengers per vehicle and 85,000 private vehicles having an average occupancy level of 2.15.

2.3 Carpooling and Benefits

The issues of traffic congestion, environmental pollution and fossil fuel wastage in major cities can be addressed by reduction of number of vehicle trips entering in to city from the existing road network. This type of reductions is focused on maximizing the movement of the people. The current occupancy level of a private vehicle in the above mentioned cities is around 2 persons per a vehicle. The occupancy levels can be further increased which in turn reduces the number of vehicles on the road and the travel times. Strategies that can be considered to reduce travel demand to employment centres at peak commute time are carpooling, vanpooling, staggered work hours and compressed work weeks (Dewan et. al, 2007).

BePooler is an emerging carpooling platform in Italy. With BePooler, a company of 1000 employees can reduce the total distance covered by employees by 90,000 km in 12 months, with 10 tonnes of CO_2 emitted less. Its members shared 30,000 trips, equal to 600 000 km saved, which have made it possible to avoid the emission of 78,000 kg of CO_2 (Bresciani et. al. 2018). Three ride-sharing scenarios were applied in Dublin, where the travel distance and CO_2 reduction effects were examined. When carpooling was introduced for commuting on weekdays, approximately 12,600 tons of CO_2 was reduced, which corresponded to approximately 706,428 euros (Gargiulo et. al 2015).

Empirical and anecdotal evidence indicates that carpooling provides numerous societal benefits, such as reductions in energy consumption and emissions, congestion mitigation, and reduced parking infrastructure demand. Individually, carpooling users can benefit from shared travel costs, travel time savings from high occupancy vehicle lanes, reduced commute stress and often preferential parking and other incentives (Cohen et. al. 2016, (Chan and Shaheen, 2012). It has been identified that if no additional travel is required to pick up passengers, adding one additional passenger for every 100 vehicles would reduce the national annual fuel consumption by 0.80–0.82 billion gallons per year in the US (Jacobson et. al, 2009).

Carpooling can be adopted in order to address the need for minimizing the number of private cars entering the cities in Sri Lanka specially at the peak hours. An increased occupancy level in the vehicles is the main aim to achieve higher benefits from the available transportation infrastructure. However the government should encourage the use of carpooling in urban areas by means of programmes, which include funding of carpooling demonstration projects, and the encouragement of local authorities to establish schemes by various means including distribution of information (Dewan et. al, 2007).

A fundamental study was carried out in order to investigate the opinion of the general public in implementation of carpooling and the travel behaviour of the road users. The methodology adopted is described in the following section.

3. METHODOLOGY

Data acquisition was carried out through an online survey form distributed among more than 1,000 persons. The survey form was sent via email for the workforce in major towns in Sri Lanka, mainly Kandy and Colombo. The survey targeted the daily commuters. Google forms feature was used and the number of respondents for the survey form was 259. The return rate of responses was 26%. The form included a brief description on carpooling providing an introduction about the subject. The questions asked in the survey form were to obtain a general idea about the travel patterns and vehicle ownership details from the public.

The survey form was divided in to five main sections and the questions were categorized under each section. The sections included details about the person, his or her travel requirement, vehicle ownership and travel behaviour, preference in sharing the ride (Carpooling), the suggestions for improvement of the carpooling service including their own views.

The first section queried about the general details of the person such as gender, educational qualification and profession. The section regarding the travel requirement included the questions such as distance of travel, number of trips, travel mode and parking availability. The third section included the details such as vehicle ownership and travel companions. The fourth section questioned whether they are willing to accompany someone else in their vehicles or whether they are willing to be accompanied by someone else and their willingness to join an online carpooling community. The final section of the questionnaire asks whether they are satisfied by the existing transportation system and their suggestions to improve and promote the carpooling among the community.

The data were collected using an online survey form and statistical analysis was carried out using Microsoft Excel.

4. DATA ANALYSIS

4.1 General Background Details of the Respondents

The characteristics of the 259 respondents of the recorded sample of data have to be considered in analysing phase. All the respondents were Sri Lankan citizens and a total of 181 males and 78 females had responded to the online survey form distributed and the characteristics of the sample are shown in the table below.

Table 4. Characteristics of the respondents

Parameters		**Number**	**Percentage (%)**
Gender			
Female		78	30.1
Male		181	69.9
Age (years)			
23>		2	0.8
23		3	1.2
24		7	2.7
25		29	11.2
26		93	35.9
27		73	28.2
28		28	10.8
29		9	3.5
30		2	0.8
31-40		9	3.5
>40		4	1.5
Average: 26.8	**Minimum: 20**		**Maximum: 69**
Education background			
Graduated / tertiary		218	84.2
Postgraduate		34	13.1
Up to A/L		3	1.2
Other		4	1.5
Profession			
Government employed		43	16.6
Private sector		188	72.6
Retired		2	0.8
Self employed		3	1.2
Unemployed		23	8.9

The table above represents the details about the educational qualification and the background details of the respondents. Among the respondents, 84.2% have up to tertiary or graduate level educational qualification, 13.1% have educational qualification up to postgraduate qualification and 1.2% have education up to advanced levels.

The authors intended to have an idea about the age and the profession of the respondents and the variation of the data recorded from the survey carried out. The average

age was recorded as 26.8 years while the majority of the respondents were employed in the private sector and the percentage was recorded as 72.6%.

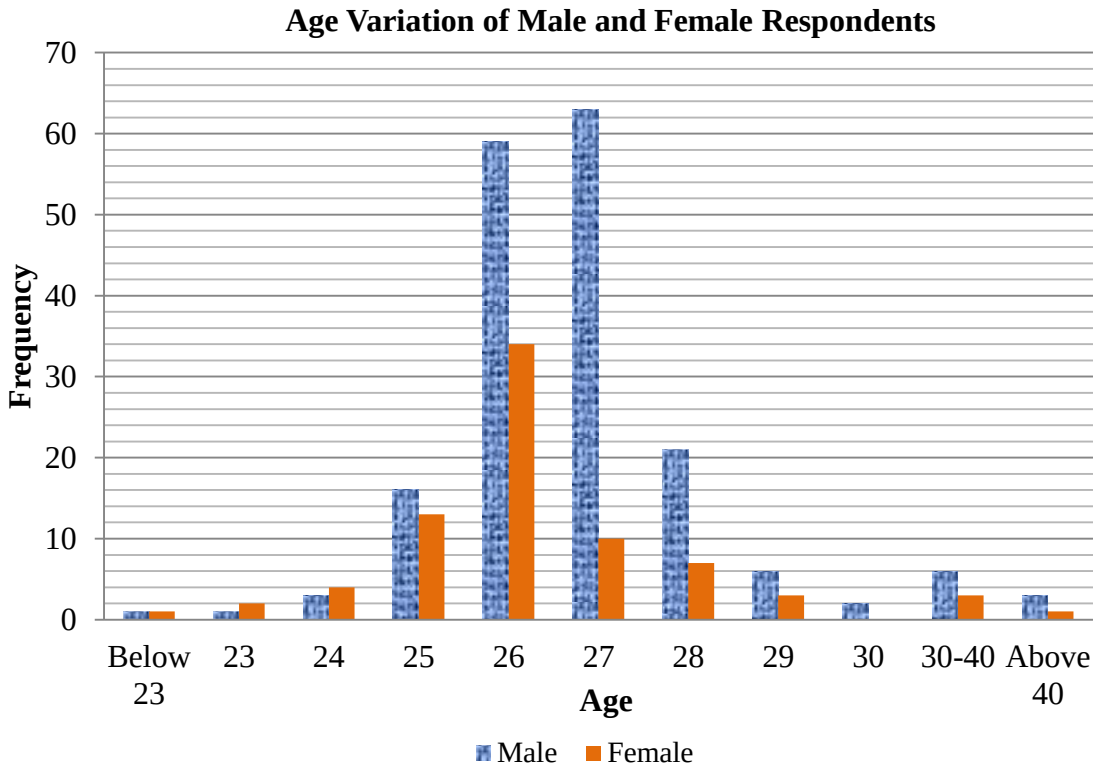

Figure 4: Age variation with gender distribution of respondents

4.2 Vehicle Ownership Details and Travel Behavior

Out of the total responses 54% of the respondents who answered questionnaire owned a vehicle and 7% of them owned two vehicles while 37% of them do not own a vehicle.

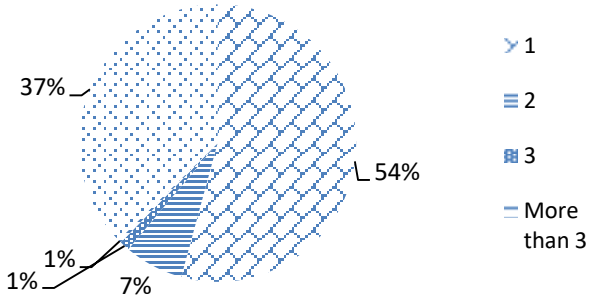

Figure 8: Vehicle ownership details of the respondents

Table 5. Variation of gender with the number of vehicles owned

Gender	No of vehicles you own					Total
	0	1	2	3	> 3	
Female	44	31	1		1	77
Male	49	107	17	5		178
Prefer not to say	4					4
Total	97	138	18	5	1	**259**

. The above table shows the gender variation of vehicle ownership of the respondents. The authors intended to study the number of persons, the vehicle owners used to accompany in their vehicles at the present stage. A total of 64.4% of vehicle owners answered that they do not accompany anyone on their work trips. Hence increasing the occupancy levels in private owned vehicles is possible according to the study. The table given below shows the variation of vehicle ownership and the respective percentages of vehicle owners who do not accompany someone else on their work trips.

Table 6. Percentage of vehicle owners who travelled alone

Vehicle ownership	**Number**	**%**
1	**91**	**65.94**
<25	9	6.52
25-40	82	59.42
40<	0	0
2	**12**	**66.67**
<25	0	0
25-40	12	66.67
40<	0	0
3	**2**	**40.00**
<25	0	0
25-40	2	40.00
40<	0	0

The analysis further shows that 72% from the total number of vehicle owners have given yes as the response when they were asked whether they would like to accompany someone else in their vehicle. The following table shows the variation of their responses.

Table 7. Preference in accompanying others with varying vehicle ownership

Number of Vehicles Own	**Willingness to accompany someone else**			**Total**
	No	**May be**	**Yes**	
Own 1 vehicle	**11**	**31**	**96**	**138**
Female	3	9	19	31
Male	8	22	77	107
Own 2 vehicles	**2**	**0**	**16**	**18**
Female	0	0	1	1
Male	2	0	15	17
Own 3 vehicles	**0**	**1**	**4**	**5**
Male	0	1	4	5
Total	**13**	**32**	**116**	**161**
% by total owners(162)	**8.02**	**19.75**	**71.60**	

When the respondents were asked whether they are willing to join an online based carpooling community the following answers were obtained as shown in the table.

Table 8. Preference in joining online system for carpooling varying with gender

Gender	No	May be	Yes
Female	12	13	51
Male	16	29	132

It was found out that 84% of the total respondents had answered yes when they were asked whether they would like to download a mobile application that could assist in carpooling.

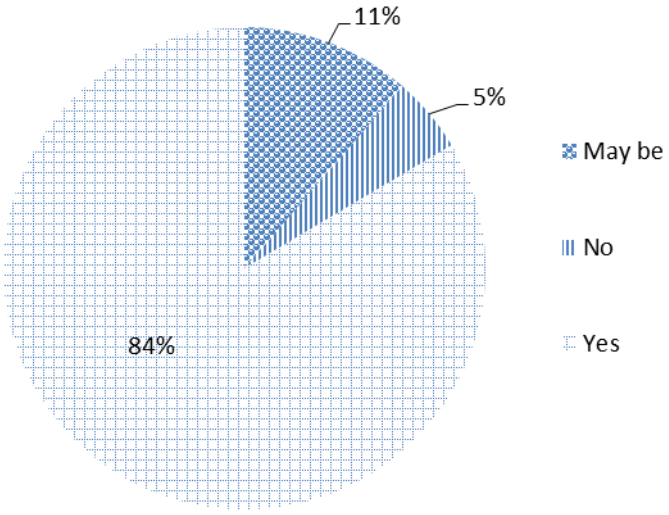

Figure 9: Preference to download online based carpooling application

The analysis further revealed that less than 15% of the respondents were satisfied with the present condition of the transportation system in Sri Lanka with respect to travel time, traffic congestion and cost of travelling.

4.3 Discussion Suggestions

About 68% of respondents of age 25-30 are willing to accept carpooling. A percentage of 62% of the total females who owned a car had answered “yes” for the willingness to accompany someone else and the percentage is 72% when considering the males who owned a car. The percentage is more than 88% when considering the males who owned two cars. The percentage of acceptance to accompany another in their vehicle is higher of males compared with the females and when the vehicle ownership increased, the percentage of acceptance also has increased.

Ensuring the safety of the passengers, condition of the vehicle, driver’s details were some of the key concerns of the respondents of the survey. Carpooling users (specially female) must be concerned in safety as they share the ride with the other travellers in the vehicle. Majority of the respondents agreed on publishing their personal details and travel details if an online based network was implemented. Prior understanding about the co-passengers was requested by the respondents as suggestions.

5. CONCLUSION

According to the analysis from the survey, it has been determined that the average distance of daily travel considering the work trips (from the town of residence to the place of work) of the respondents is 18 km/day (one way) in weekdays. Further the average number of trips is calculated to be 1.5 where those trips are distributed in the categories of shopping trips, school trips, other office work trips and etc.

About 59.5% of the vehicle owners who own one vehicle in the age category of 25-40 are used to travel alone while 66.7% of the vehicle owners who own two cars in the same age category travel alone. From the total of single vehicle owners 69.6% likes carpooling while 55.8% are males. From the total of two vehicle owners 88.9% likes carpooling and 83.3% are males. Multiple vehicle owners show a higher percentage of preference for carpooling and this may be due to the willingness to rent their vehicles. However this scenario should be further analysed.

Reduction of the number of vehicles on Sri Lankan roads can be achieved by increased occupancy in vehicles through carpooling. Analysis of the scenario in Colombo city for private cars (section 2.1) and incorporating the travel distance of the respondents revealed that when the average occupancy of vehicles entering to the city was increased up to 3.5 persons/vehicle, the travel distance was reduced by 2.8 million vehicle kilometres. It was an average reduction of more than two hundred and fifty thousand litres of fuel per day.

The study shows that the community is ready to accept carpooling as a solution to transportation problems in major cities in Sri Lanka. However, promoting carpooling should be accompanied with government policies for the development of the nation such as high occupancy lanes with lower usage charges at expressways and highways, congestion pricing to reduce number of vehicles at peak hours and promoting of carpooling by employers. Carpooling should be more generalized among the public and attitudes of the general public should be changed in order to adopt carpooling within the city limits. Moreover; implementation carpooling platforms requires utilization of information technology along with above government policies.

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