APPLICABILITY OF RIDESHARING USING PARATRANSITS: A CASE STUDY FROM A UNIVERSITY COMMUNITY IN SRI LANKA

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ABSTRACT

Recent increase in number of singly hired para-transit usage in Sri Lanka favors ride shared para-transit modes. Applicability of ridesharing is studied in a selected corridor by examining the attitude of the passengers and drivers. The undergraduates of University of Moratuwa (passengers) were selected as the population and one of the access road (between Katubedda junction and university) was selected as the study area with Three-Wheel (3W) mode as common para-transit mode in Sri Lanka. Structured questionnaire was used to gather users (3W passengers) preference and drivers willingness along with road side survey on 3W movements to study the existing situation in the study area. The study focused on effects of ridesharing on three aspects while identifying barriers for ridesharing implementation; (1) demand for 3W, (2) monetary benefit for 3W operators and (3) Environment. It is found that implementing ridesharing with pool of three passengers and with fare of LKR (Sri Lankan currency-Rupees) 20 (less than ⅓ of the current fare, LKR 70) per head; (1) increases 3W ridership by 42%, (2) increases daily profit of the drivers by 13.3% compared to the existing (average vehicle occupancy=1.4) operating cost and (3) Reduces emission cost per user by 50% per passenger. Barriers to ridesharing from users are reluctant to share rides with unknown passengers (stranger-danger) and also with opposite gender while that of from operators is the fear from peer operators like other 3W drivers and bus operators. Implementing ridesharing is certainly a win-win case for both users and operators.

Keywords: Ridesharing, Para transit, Three wheel, User behavior, Questionnaire survey

1. INTRODUCTION

Ridesharing is not a new concept to the world’s transportation. The roots of ridesharing goes back to the era of world war II where USA introduced ‘car sharing clubs’ to conserve resources, especially as rubber as it was a need of that era (Chan & Shaheen, 2012). Ever since, the concept of ridesharing has been used by people to protect resources to cope up with the challenges they faced. Today, it has evolved to the extent of ‘technology enabled ride matching’ where passengers can log on to websites to find another passengers who travel to the same destination.

The concept of ridesharing is a way of increasing the occupancy of the vehicle traveled and thus it will reduce the number of vehicle-kilometers traveled than a passenger travels individually. Also ridesharing is a promising approach to save the consumption of energy and it is a solution to assuage the traffic congestion while satisfying the transportation needs of the general public.

Three-Wheel (3W) is a commonly used Para-transit mode in Sri Lanka comparable to Tuk-Tuk in Thailand. 3W contribute 13.4% of all the vehicle modes in 2010 and it is tend to increase even further (DMT, 2013). The same trend is applicable to most of the other individually used modes such as cars. This may lead to higher traffic congestion, increased travel time and environment pollution due to the emission of greenhouse gasses.

As far as the impacts to the environment and safety are concerned, 3W is not the best mode for studying for ride sharing. However, considering the nature of the selected study corridor (Figure 2), there are only two options available for captive riders namely bus and 3W. During morning (± 08:00am SL time) peak, when university community rushing towards the university, buses stopped at "Katubedda junction" at least for about 10 min to get it packed using higher demand which forces some, affordable, users to switch to 3W. with passengers this utilize the following aspects can be highlighted.

The objectives of the research were to (1) quantify the future demand for 3W under ridesharing, (2) identify monetary benefit for 3W operators and (3) quantify environmental benefit while attempted to identify barriers in implementing ridesharing.

2. CONCEPT OF RIDESHARING

Numerous number of studies have been done in the areas of ridesharing, passenger and operator attitude towards ridesharing, benefits of ridesharing and barriers to implement ridesharing. However, there were no previous research done on ridesharing using 3Ws in Sri Lanka. Most of the previous research is based on carpooling. In the developed countries, standard modes like cars and vans are used for ride sharing whereas in developing countries relatively cheaper modes are used for ride sharing (in this case 3Ws). Comparing car and a 3W for the purpose of ride sharing, both modes in terms of ride sharing have few commonalities; (a) Spatial limitation (route choice), (b) temporal limitation (time of demand need to fall into a window). Therefore, in this study, "car pool" and similar concept were reviewed for applying those to the '3W-Ridesharing'.

2.1. Types of Ridesharing

Ride sharing is considered under different concepts. Srivastava (2012) categorized it using car as depicted below in Figure1.

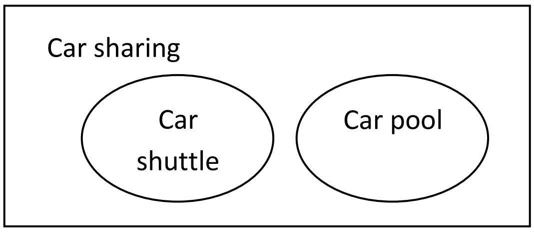

Figure 1: Venn diagram for Car Sharing, Shuttle and Pooling Relationship

Srivastava, (2012) explains that car sharing is a way of traveling which involves two or more passengers ride in a car. This category includes family trips, escorting friends who travel to the same destination or to a destination en route. Whereas car shuttle is about one or more passengers ride on the car for monetary considerations where there is a designated driver for the vehicle. Thirdly he explains about carpooling which is about a group of car owning people traveling in one vehicle regularly from one region to the other with a rotating basis of using their own vehicle. Comparing the above three explanations, ridesharing using 3Ws has more or less the same attributes which has in car shuttles.

2.2. Benefits of Ridesharing

It is imperative that passengers shift towards ridesharing only if there are clear benefits for them. This is also declared by Dewan & Ahmad (2007) and Horowitz & Sheth (1976), where they explain ridesharing will only increase significantly if there exist clear and direct incentives to the participants. Brownstone & Golob (1991) state that this is one of the function comes under Transport Demand Management (TDM) in USA, where they focus on the means which they can provide incentives to the passengers to promote ridesharing. Their research identifies the following four incentives / privileges that can be enjoyed by the commuters if they share rides;

- Reserved or other preferential parking for ride sharers.
- Direct carpooling and/or vanpooling cost subsidies by employers.
- Guaranteed rides home for ride sharers.
- Ability to travel on high occupancy vehicle lanes (HOV lanes)

Brownstone & Golob, (1991) claim that with all the above mentioned incentives, there would be a reduction in drive- alone commuters between 11 and 18 percent. Also it was found that commuters who have large households with multiple workers, longer commuters and larger work sites are more likely to ride share.

Horowitz & Sheth (1976) claim that studies on ridesharing incentives are based on the presumption that solo drivers can be induced to carpool by offering them direct incentives. Value of arrangement such as ridesharing is immense. Implementing real-time ridesharing in Beijing (China), 120 million liters of gasoline can be saved. The amount saved is equal to 2.3 million kilograms of carbon dioxide gas. Also this proposed service serves 25% additional taxi users while saving 13% of the total distance traveled as indicated by (Ma, et al., 2013). Dewan & Ahmad (2007) conducted a similar study and found that if carpooling system is implemented in New Delhi - India, it will be able to save 301,307 kiloliters of gasoline per year.

2.3. Barriers for Ridesharing

This section identifies the barriers towards ridesharing in the context of the countries such as USA, Canada. Amey (2010) identifies the challenges for ride share from a variety of perspectives which are described below.

2.3.1. Economic barriers

- *Favorable economics of all other modes*

Amey (2010) argues that ridesharing (in this research, author defines carpooling as ridesharing) has been challenged by the subsidies given for the other modes of transport (i.e. employer-paid parking, transit, vanpooling and cycling). It is discussed that parking subsidies are given to HOVs (High Occupancy Vehicles) to encourage ridesharing. But, with the employer-paid parking, employees will no longer feel the impact which parking price make on their disposable income and they tend to drive alone. Transits and van pooling can also be identified as modes of ridesharing which reduce the number of vehicle kilometers traveled in the network whereas cycling is an ‘emissions free’ mode of transport. Ergo transits, vanpooling and cycling can be identified as sustainable modes of transport as same as ridesharing (carpooling).

2.3.2. Social/ Behavioral barriers

- *Stranger – danger*

It is found that ridesharing between unknown travelers represents a small portion of shared-rides that takes place. According to (Amey, 2010), surveys have found that as little as 3% to 10% of shared-rides occur between / among unknown passengers whereas the majority of the shared-rides occur between / among family members, co-workers and neighbors. The statistics clearly states the phenomenon of ‘stranger danger’ has affected.

- *Reliability of service*

Amey (2010) points out that the perception of low reliability of the ride share arrangements is one of the largest behavioral challenges to overcome. Typically the passengers agree to share rides with a single driver for a long period of time with small changes as needed. In case the driver has an unexpected appointment of emergency, the passengers may not have a way to complete the return trip, which is unacceptable for many commuters. Both the passenger and the driver should understand the emergencies and adjust their perception to build-up the relationship over the time so that both of the parties will get benefited.

3. METHODOLOGY

3.1. Study Area

Access roads to the main entrance of University of Moratuwa were considered for this study to investigate ridesharing applicability. As depicted in Figure 2, among the three access roads (1) Campus road from Katubedda junction - AR1, (1) Campus road from Piliyandala - AR2 and Molpe road - AR3, AR1 was selected due to high 3W movements compared to others. There are two main three-wheel parks located at "Katubedda junction" and at the University. Two busses are being operated in the selected road link (route number 255, 255/1) with a 10 minute headway on average.

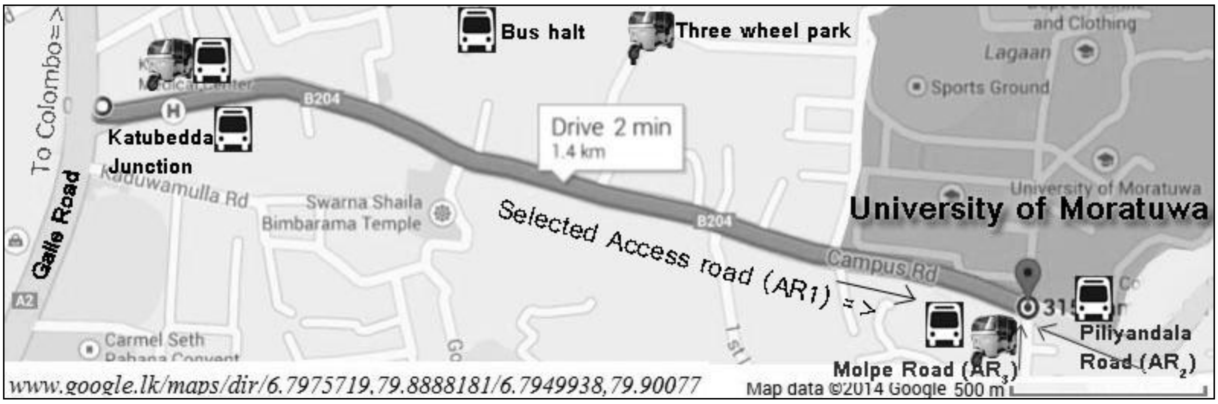

Figure 2: Location of the study area *(URL: http://goo.gl/maps/QvPEd)*

3.2. Sample of the Study

The population for this study was university community consists of staff members, post graduates and undergraduates of University of Moratuwa (6,000 students in total) as majority of the 3W users along AR1 are fall in to that category. The appropriate sample size was considered as 361 with 95%confidence level and 5% margin of error (Krejcie & Morgan, 1970) and the responses were collected from a structured online questionnaire. From the 3W number plate survey it was found that there are 37 three-wheel operate in the day time. From that a random sample of 17 three-wheel drivers were interviewed with the aid of structured questionnaire. The research was carried out in three stages (1) Online questionnaire survey, (2) road side number plate survey and (3) interview with three-wheel drivers.

3.3. Online Questionnaire Survey for Passengers

An online questionnaire was prepared and circulated via emails to collect responses from the academic staff members, non-academic staff members, post graduates and the undergraduates of University of Moratuwa, who employed/studied in the university during the period of the research (Dec 2013 – Jan 2014). The online questionnaire survey was three fold. The first part of the questionnaire was addressed to collect passenger's demographics (age, employment category, income etc.) and present travel related characteristics (vehicle ownership, general access mode to the university etc.).

In the second part of the questionnaire, respondents were asked about their willingness to share ride under different circumstances given below;

- Sharing a ride with a friend(s).
- Sharing a ride with a person in university other than friends.
- Willingness to wait for some other person to join with rideshare.
- Willingness to share rides if one of the colleagues/ friends has already joined with ride sharing.

Seven level likert scale was used to identify the willingness of the passengers towards ridesharing.

Table 1: Measurement of variables and scale

Level	Level Value
Definitely will not	1
Very unlikely	2
Somewhat unlikely	3
Cannot say	4
Somewhat likely	5
Very likely	6
Definitely will	7

3.4. Three-wheel Number Plate Survey

A three-wheel number plate survey was conducted for 12 hours on a day time to identify the present 3W movements of the study area along with bus counts bus arriving and departing patterns were observed at the two bus stops adjacent to each 3W parks (as shown in Figure 2). The survey was conducted from 08:00am to 08:00pm on a Wednesday (18th Dec 2013). The survey was conducted using four enumerators who were strategically located at places so that the observer can observe both bus movements and 3W movements. Two of the observers gathered data about the busses (bus arrival time and departing time) and 3Ws (departing time, number of passengers on board) while other two observers observe only about the arriving time of the 3Ws and alighting passengers from each 3W.

This survey results were used to analyze the demand for 3Ws in different times of the day. Also it was used to identify the trips which were run between the selected access road and beyond the selected access road. These results were then cross-checked with planned interview with the 3W drivers (explained below). The average 3W occupancy was also measured using the data in order to identify the current situation along the selected corridor.

3.5. Personal Interviews With 3W Operators

Finally an interview was conducted with the 3W drivers from the 3W parks at Katubedda junction and in front of the main entrance of the university. The demographics factors of drivers and average daily trips operated within the selected corridor (AR1) were collected in addition to their opinion on ridesharing and barriers to it.

3.6. Analyzing the Effectiveness of Implementing Ridesharing

To calculate the variation of the trips under the existing system and proposed system of ridesharing, responders were asked a question about their current frequency as well as the future frequency of using 3Wers in the selected corridor. The below Table 2 shows the frequency related options given to the respondents and corresponding numerical values as per weekly basis.

The respondents were asked about their usage of 3Wers under the existing operating system and under ridesharing. In the existing system the vehicle occupancy can be vary from 1 to 3 depending on passenger's choice with LKR 70 per trip whereas in ridesharing it is expected to keep the vehicle occupancy at 3, so that 3 passengers can get together and share the fare. In ridesharing situation, it is expected to offer this service at a reduced fare of about LKR 60 which translates the fare per passenger as LKR 20. Based on Q1 and Q2, as given in Table 3, the respondents were subdivided into several categories as illustrated below in Figure 3.

Table 2: Frequency of 3W usage

Frequency	Frequency of trips per week
Never[1]/ Rarely	0
1 time / week	1
2 times / week	2
3 times / week	3
4 times / week	4
5 times / week	5
6 times / week	6
1 time / day	7
2 times / day	14
3 times / day	21
4 times / day	28

Table 3: Questions about trip frequency

(Q1) Existing system	**(Q2) Ridesharing**
In any case if you use a 3Wer for the last trip, how often do you use a 3Wer to complete the last trip? (Respondent were allowed to select a frequency as shown in Table 2)	If Three-wheel ride-sharing exists with reduced fare, what will be your future trip frequency using three-wheel**?** (Responder were allowed again a frequency from Table 2)

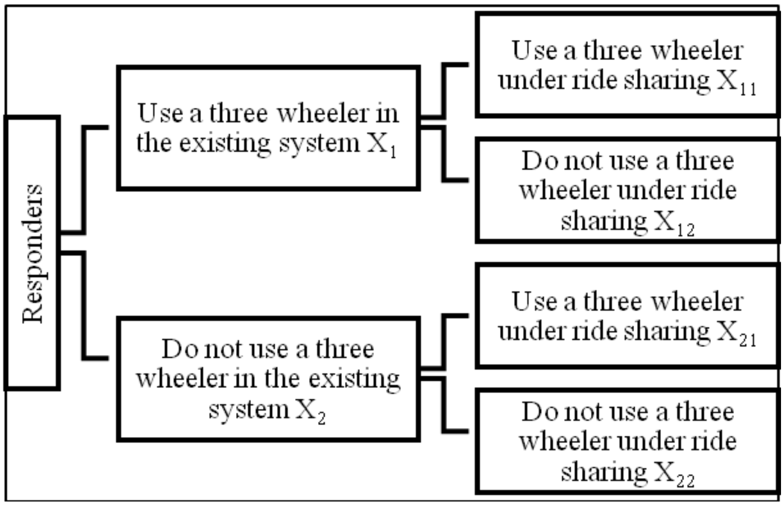

Figure 3: Method of analyzing the effectiveness of ridesharing

The above categorizations, shown in Figure 3, were elaborated below.

X_1 : Expected number of trips by the students in the existing system

X_2 : Expected number of trips by the students in the existing system who do not use a 3W to come to university (= 0)

X_{11} : Expected number of trips by the students who continue to use a 3W to come to university when ride sharing is implemented.

[1] The responders who selected ‘rarely’ or ‘never’ was considered as passengers who do not use a three wheeler for the purpose of this analysis (worst case scenario).

X_{12} : Expected number of trips by the students who do not willing to use ridesharing though they use a 3W in the existing system
X_{21} : Expected number of trips by the students who newly attracted to 3W by the implementation of ride sharing
X_{22} : Expected number of trips by the students who do not want to use 3W in any given method (= 0)

By multiplying the number of responses for each category (from Figure 3) with relevant trip frequency value (from Table 3), the expected number of 3W passenger trips can be calculated. The calculated total passenger trip divided by vehicle occupancy is the 3W demand (D) also known as number of 3W trip would be generated by the users. Therefore, existing demand for 3W (D_1) will be calculated using Equation 1 as given below where the current average occupancy of the 3W (O_1) was found to be 1.4 from road side occupancy count made during number plate survey.

$$D_1 = (X_1 / O_1) \tag{1}$$

The future demand for 3W combined from normal and ridesharing (D_2) can then be calculated using Equation 2 as given below where ridesharing vehicle occupancy (O_2) is assumed to be three (3) while that of normal 3W (continued to operate under existing scenario) is assumed to be one (1).

$$D2 = [(X_{11}+X_{21})/O_2] + X_{12} \tag{2}$$

Ridesharing could be said applicable if newly attracted 3W demand (D_2 - D_1) promises the benefit to the 3W operators in terms of net profit.

3.7. Calculating the Environmental Impacts

The emission cost for any vehicle operates in a given corridor can be calculated by the Equation 3 (Kumarage & Weerawardana, 2013) given below. It has been taken in to account that volumes of specific emissions are directly proportionate to the quantity of the type of fuel consumed. The emission cost for a vehicle type j on a link k during the time period t can be expressed as;

$$TEC_{j,k,t} = V_{j,k,t} \times F_{j,t} \times E_{j,t} \times D_{j,t} \tag{3}$$

Where;

$TEC_{j,k,t}$ -Emission cost by a vehicle type j on link k during time period t.
$V_{j,k,t}$ -Flow of vehicle type j on link k during time period t.
$F_{j,k}$ -Fuel consumed per unit distance traveled by vehicle type j at on a link k.
$E_{j,k}$ -Estimated value of emission cost per liter of fuel for vehicle type j at on link k selected based on average link speed.
$D_{j,k}$ -Distance traveled by vehicle type j in link k.

According to Department of National Planning of Sri Lanka (2001), it is calculated that the total emission cost per liter of fuel for a 3W was LKR 0.62.

4. RESULTS AND DISCUSSION

Altogether 364 responses were collected from the questionnaire survey and during data refining, there were 7 responses found with errors. Therefore only 357 (=364-7) responses were taken for the rest of the analysis. Out of those responses 334 responders were undergraduates of the University of Moratuwa. Since negligible number of responses from others (staff members and post graduates), the responses only from the undergraduates (334) were considered in this research. Out of the 334 responders, again only 189 responders were using the selected study corridor (AR1) to university thus this study analyzed only those 189 responses.

4.1. Future Demand for Three-Wheel Trip Under Ridesharing

The calculations based on the data collected is summarized in the table given below. The values which will be taken for the analysis is highlighted in Table 4.

Table 4: Summary of the data collected and calculations

Frequency		(1)		(2)		(1/1)		(1/2)		(2/1)		(2/2)	
Description	f	X_1	f X_1	X_2	f X_2	X_{11}	f X_{11}	X_{12}	f X_{12}	X_{21}	f X_{21}	X_{22}	f X_{22}
Never & Rarely (0)	0	0	0	119	0	0	0	0	0	0	0	34	0
1 time / week (1)	1	28	28	0	0	6	6	2	2	17	17	0	0
2 times / week (2)	2	14	28	0	0	11	22	0	0	28	56	0	0
3 times / week (3)	3	6	18	0	0	5	15	0	0	10	30	0	0
4 times/ week (4)	4	2	8	0	0	9	36	0	0	1	4	0	0
5 times / week (5)	5	2	10	0	0	10	50	0	0	1	5	0	0
6 time / week (6)	6	0	0	0	0	1	6	0	0	3	18	0	0
7 times / week (7)	7	10	70	0	0	13	91	0	0	13	91	0	0
14 times / week (14)	14	8	112	0	0	8	112	1	14	10	140	0	0
21 times / week (21)	21	0	0	0	0	2	42	0	0	2	42	0	0
28 times / week (28)	28	0	0	0	0	2	56	0	0	0	0	0	0
		Σfx_1	**274**	Σfx_2	**0**	Σfx_{11}	**436**	Σfx_{12}	**16**	Σfx_{21}	**403**	Σfx_{22}	**0**

Demand for 3W under existing and future could be then calculated using Table 4 and equations (1) and (2) as shown below.

$$D_1 = (X_1 / O_1) = 274/1.4 = 196 \text{ trips per week}$$

$$D_2 = [(X_{11} + X_{21})/O_2] + X_{12} = (436+403)/3 + 16 = 280+16 \text{ trips per week}$$

Though calculation of future demand (D_2) has two components (ride sharing and conventional 3W ride). The majority of the trips are generated through ride sharing (280) and while continued to using 3W under conventional method is only 16 and it is neglected for rest of the calculations.

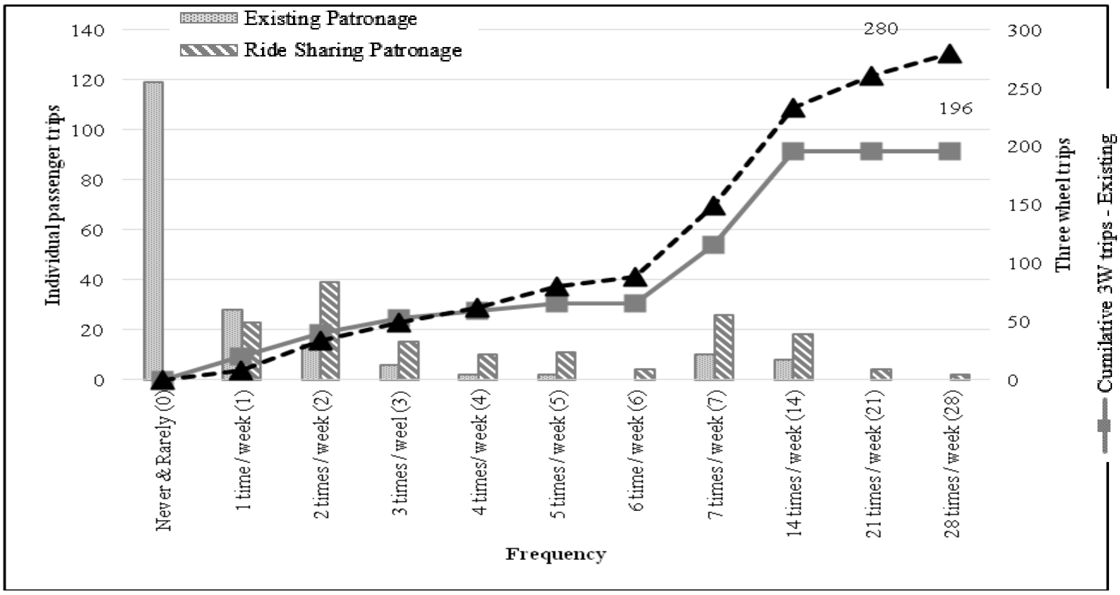

Figure 4: Comparison of Existing system and Ridesharing

The 'x' axis of Figure 4 represents the frequency of using a 3W per week while the 'y' axis on the left indicates the number of responses for each trip frequency in the existing system and ridesharing one and the 'y' axis on the right indicates the cumulative 3W trips traveled per week.

Based on interview conducted with 3W drivers, it was found that they run 15 trips on average in a given day. According to Figure 4, the cumulative trips traveled per week in the existing system is 196 while the cumulative trips per week in ridesharing has increased to 280. Therefore implementation of ridesharing will increase 42% ([280-196]/196) of the total trips traveled than in the existing system. With the increase of 42% of trips, a 3W operator will be able to increase his 3W trips on a given day from 15 to 22.

4.2. Monetary Benefit Three-Wheel Operators

According to daily basis calculation shown in Table 4, a 3W driver will have at least 22 trips per day if ridesharing is implemented. The Table 4 also attempts to calculate the monetary benefit in implementing ridesharing for a single operator per day where fuel economy* is assumed to be remained same even though weight (kg) carried under ridesharing would be higher than existing system as the vehicle occupancy increases. It is clear that ridesharing will increase their daily profits by 13.3%.

Table 5: Monetary benefits to 3W operator on daily basis

Criteria	Calculation method	Cost elements		% increase / decrease
		Existing	Ridesharing	
Fare per trip (LKR)	a	70	60	14.2%↓
No of 3W trips	b	15	22	42%↑
Trip Distance – two way(km)	c	2.8	2.8	-
Fuel Price (LKR)	d	162		
Fuel Economy (km/liter)*	e	22 (Assumed same)		-
Maintenance cost (LKR per km)	f	1.92 (Assumed same)		-
Calculation				
Daily Income (LKR)	g = a×b	1,050.00	1,320.00	25.7%↑
Daily fuel usage (liters)	h = b×c/e	1.91	2.80	46.6%↑
Daily fuel expenses (LKR)	i = h×d	309.27	453.60	46.6%↑
Maintenance cost (LKR)	j = b×c×f	80.64	118.27	46.6%↑
Daily profit (LKR)	l = g-i-j	660.09	748.13	13.3%↑

4.3. Environmental Benefit

Though implementation of ridesharing will increase the number of trips run by 3Ws in the selected corridor, it is quantified in Table 5 that ridesharing save both per user costs of fuel and emission (monetary value) approximately by 50%. The Equation (3) was used to calculate the emission cost per week.

Table 6: Conversion of Environmental Impacts into Monetary Values

Criteria	Calculating method		Existing	Ridesharing
Fuel Economy (km/ Liter)	a	$= F_{j,k}$	15	22
Trip distance (km)	b	$= D_{j,k}$	2.8	2.8
Number of Trips per week	c	$= V_{j,k,t}$	196	280
Vehicle occupancy	d	$= O$	1.4	3.0
Total number of passengers/week	g	$= V_{j,k,t} \times O$	274	840
Fuel Consumption per week (liters)	h	$= V_{j,k,t} \times D_{j,k} / F_{j,k}$	25.0	35.6

Per passenger fuel usage (liter / passenger)	i = F/E	0.09	0.04
Emission cost per liter of gasoline (LKR)	$E_{j,k}$	0.62	0.62
Emission cost per week (LKR)	$TEC_{j,k,t} = V_{j,k,t} \times F_{j,k} \times E_{j,k} \times D_{j,k}$	15.5	22.1
Per passenger emission cost (LKR / passenger)	$K = TEC_{j,k,t}/G$	0.06	0.03

4.4. Barriers for Ridesharing

4.4.1. Stranger – danger

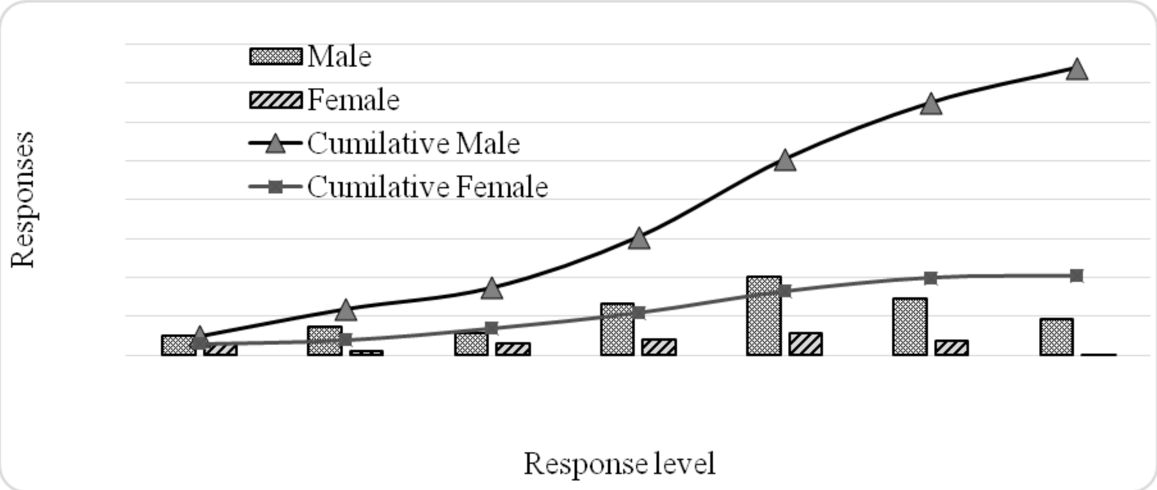

Figure 5: Willingness to share rides with strangers

The behavior of 'stranger-danger' is observed in this study based the responses from the online questionnaire. Cultural barrier from gender is also observed from Figure 5. Especially female users are reluctant to share rides with strangers when analyzing the cumulative curves.

4.4.2. Reluctance to change

Explained the fact that ridesharing increases three-wheel trips to the drivers, the drivers were not convinced to brace the concept and implement ridesharing. Interview with drivers reveals that 59% (Figure 6) of the drivers were reluctant to implement ridesharing as they believe that there will be some 3W operators will continue to operating under current model and then it turn out to be peer pressure for ridesharing operators. They also mentioned that implementing ridesharing may create issues with the bus operators as more passengers would shift for 3W from bus thus reduces income for bus operators.

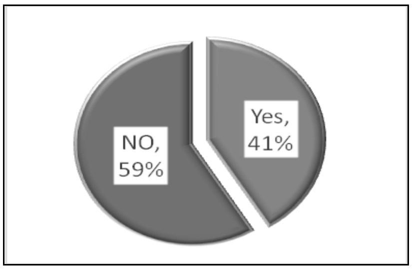

Figure 6: Willingness of operators to change to ridesharing

5. CONCLUSION

Based on research analysis and findings, implementing ridesharing is certainly as a win-win case for both users and operators and ridesharing is highly applicable along this selected corridor with following proven benefits;
(1) Increases future demand for three-wheel (ridership) under ridesharing by 42%,
(2) increases daily profit of a driver by 13.3% under ridesharing with vehicle occupancy of 3.0 and fare per trip of LKR 60, translated to LKR 20 per head, compared to the existing operation with average vehicle occupancy of 1.4 and fare per trip of LKR 70,
(3) Energy efficient by saving about 50% of fuel cost per passenger while saving emission cost per user also by 50%.

Users from Sri Lanka shows the following barriers in implementing ridesharing; (1) Attitudinal issue of 'stranger-danger' (insecure feeling with unknown passenger) and (2) cultural issue of 'gender' (dislike to travel with opposite gender) while 3W operators are also reluctant to implement ridesharing as they believe that there will be some 3W operators will continue to operate under current model and then it turn out to be peer pressure for ridesharing operators. They also mentioned that implementing ridesharing may shift a portion of passengers from 'bus' to '3W' and they believe this would create unnecessary problems between 3W operators and bus drivers.

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