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# Travel Characteristics and Vehicle Kilometres Travelled in Jaffna, Sri Lanka

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**Abstract:** *In the Northern Province most of the roads are rehabilitated in recent years as they were heavily deteriorated during the Guerrilla war. Therefore, a little is known about travel characteristics in Northern Province, Sri Lanka. This study investigates the characteristics of travel in Jaffna district estimating Vehicle Kilometres Travelled (VKT) and Personal Kilometres Travelled (PKT). Data were collected through the household travel surveys. The demographic information of traveller, mode of travel, and travel distance were recorded. The considered travel modes were car, van, jeep, motorbike, three-wheeler, and bicycle. VKT per year for every category of vehicles was estimated and considering a weighed factor VKT and PKT per person were estimated. Results showed that yearly VKT/PKT per male is higher than that of female and VKT/PKT values of an employed person is higher than others. Also VKT and PKT values of people with low household income travel less than people with high household income.*

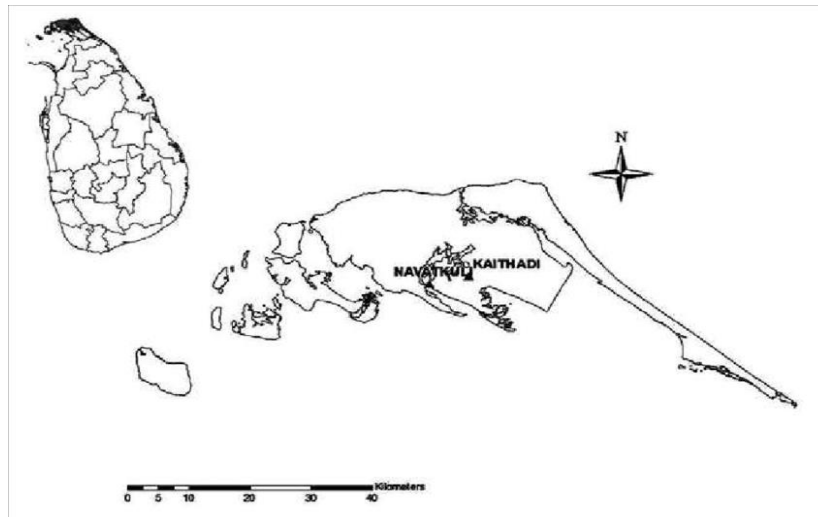
**Keywords:** *Vehicle Kilometres Travelled, Vehicle Miles Travelled, Traveller Characteristics*

## 1. INTRODUCTION

Sri Lanka is an island, therefore road transport is the dominant mode of transportation in Sri Lanka and a vital link that brings people and goods across the country. According to the 2012 Population and Housing Census reports, the country's population was 20,271,464 (DCS, 2012). The annual growth rate of the population is 1.0 percent over the past 31 years. The majority of the population (28.7 percent) is concentrated in the Western province making its population density 1,621 persons per sq.km as against the national average of 323 persons per sq.km. The percentage of urban sector population is reported as 18.3 percent followed by 77.3 percent in rural sector and the balance of 4.4 percent in the estate sector (DCS, 2012). Sri Lanka's road network is dense (roads per square kilometre) and well laid-out providing connectivity to the country's population and centers of economic activity. Also, the network density (the number of road kilometers per population) of Sri Lanka is among the highest in Asia (Wasantha and Jayasinghe, 2013).

This study was carried out in the northern part of Sri Lanka at Jaffna District that is shown in Figure 1. The Jaffna District has 17 local authorities which include a municipal council, three urban councils, and 13 divisional councils. The population of Jaffna District was 583,882 in 2012. According to the road statistics at Road Development Authority (RDA), Jaffna District has 380.9km of "A" class roads, 277.14km of "B" class roads, 472.35km of "C" class metal roads, 9.88km of "C" class gravel roads, 74.65km of "D" class metal roads, and 14.91km of "D" class gravel roads (RDA, 2007). The Jaffna peninsula, known as a war zone for over three decades due to the Guerrilla war and a limited knowledge exists about the travel characteristics in this district.

VMT is one of the main variables used as a measure of a road network or vehicle fleet use. Estimates of VKT are used extensively in infrastructure planning for allocating resources, estimating vehicle emissions, computing energy consumption, and assessing traffic impact. In addition, the estimation of VKT by states or provinces is required for planning purposes, environmental monitoring, accident analysis, highway fund allocation, trend extrapolation, and estimation of vehicle emissions. Due to its high impact on policy decisions, it is critical to have a timely accurate estimation of VKT. VKT can be estimated in different methods and studies based on some different methods are discussed in flowing sections.



**Figure 1. The Study Area: Jaffna District of Sri Lanka**

### **1.1. Odometer reading (vehicle-based method)**

At regular vehicle inspections, the average distance travelled by the vehicles is determined and then multiplied by the number of road vehicles. It is mainly used by the Netherlands, Denmark, Latvia, and Switzerland (Leduc, 2008).

Shabadin et al. (2014) estimated VKT for car using odometer reading data obtained from selected car manufacturers. This method is expected to be reliable with high yielding number of samples as well as a good representative set of samples for Malaysia. The odometer reading of a car was recorded when the car was serviced at their respected service centre. Then the data were sent to headquarters for storage and future use. The odometer readings were collected from headquarters of Perodua, Proton, and Toyota. These data were recorded by the respective car manufacturers from all their service centres. Current odometer reading, current date, registration date, car model, and service centre branch were the variables requested from the car manufacturers. The data were collected for those who came for service from January to March 2013. A total of 239,916 and 91, 596 and 189,622 data have been provided by Proton, Perodua, and Toyota respectively. The total number of sample collected was 521,134. The study showed that the annual kilometers travelled by car has increased by 4,994 kilometers for year 2013 from 19,135 kilometers travelled for year 2007. The increasing trends factor may be due to possible increased of distance between home and work place that encourages people to travel more. This method is more reliable with a number of samples and it also can be used for the next development of VKT for car.

### **1.2. Traffic counts (road-based method)**

For one considered link, the VKT is calculated by multiplying the Annual Average Daily Traffic (AADT) by the length of the link (in km). VKT for a motorway area can then be obtained by adding up the VKT of each segment. It is the main methodology used for estimating VKT in Belgium, Finland, Estonia, Hungary, Czech Republic, Poland, Slovakia, Slovenia, the UK, and Sweden (Leduc, 2008).

Jung et al. (2017) estimated the VKT and on-road emissions using the traffic volume in urban based on registered vehicles and traffic volumes in Incheon city in South Korea. The objectives of the study were to determine a target city that demonstrates considerable effects from diesel trucks, to estimate the VKT based on observed traffic volumes and to compare the VKT of registered vehicles and traffic volumes in the target city. The estimation of VKT based on registered vehicles involves AADT which was obtained through traffic volumes surveys. The estimation of VKT based on traffic volumes processes need to set the target road and divide the unit section, check the collected traffic volumes from observed locations and estimate the traffic volumes for the unobserved locations, and calculate the VKT in the target area using the collected and estimated traffic volumes. In order to calculate the

VKT in the target urban area, this study collected traffic volumes from locations with automatic traffic recorder and locations with short period traffic counts. This study showed that most of the emissions from trucks with respect to registered vehicles were overestimated in comparison to those from applied traffic volume and travel speed due to differing VKT estimation methods.

### **1.3. Household travel survey**

A questionnaire is sent to every household with one or more cars which are requested to provide several information such as the number of kilometers driven by each vehicle during the whole year and unit consumption. It is generally used by some countries as a supplementary source of information.

Majid et al. (2014) investigated the impact of housing development design on VMT over the decades in Iskandar, Malaysia. Twenty-four housing area developed within decades of pre-1980s to the 2000s were selected and travel diaries of their randomly selected households were recorded from those housing areas. The first step of data collection gathered from geographical Information System (GIS) unit of the Iskandar regional development authority. Next stage of data collection began with distribution of travel diaries and questionnaires among the households in the sampled housing developments to gather their VMT data and household information. Two survey methods were used for this purpose. The first survey method conducted by distributing travel diary and questionnaires within the sampled housing developments. The second survey method involving face-to-face household survey for additional respondents. The results showed that VMT is also affected by non-urban from factors such as income, car ownership, public transport, etc. the study allowed us to conclude that urban forms play a very significant role in determining the amount of VMT generated by household in Iskandar Malaysia and the trend of housing developments in Iskandar Malaysia lately seem to encourage higher household VMT.

Weerasekara and Amarasingha (2017) estimated VKT based on number of household daily trips, which were collected through the interviews. All trips made by random household members were surveyed and the total number of kilometers each travelled was derived during the previous 12 month in southern province. In this study, age, gender, employment status, household monthly income, and residential area were considered to get the variation of VKT. According to this study, male drivers and passengers travelled more compared to females during 2016 in Southern province. The age group of 25-34 travelled more and age between 55 and 64 elderly people travelled less. This study concluded that it could help to understand crucial information on traffic volume and the growth of traffic around southern province, Sri Lanka.

### **1.4. Fuel consumption**

The volume of road traffic is estimated from information about fuel supply and fuel consumption as derived from estimates of kilometers driven per fuel liter for typical types of vehicles. It is mainly used by France, Austria, and Portugal (Leduc, 2008).

Hossain and Gargett (2011) estimated VKT from state/territory fuel sales in Australia. Their research paper described an approach for estimating quarterly VKT by vehicle type by fuel type from the state/territory fuel sales data for all eight states/territories in Australia. They followed two basic steps to collect the data. The first step was done on an annual basis, and linked the annual estimates of VKT to state/territory fuel sales. Once that linkage was established on an annual basis, the second step reversed the procedure, linking quarterly fuel sales to quarterly estimates of VKT by state/territory.

## **2. METHODOLOGY**

The survey method was selected to estimate the VKT for this study as the travel characteristics could easily explored using this method. VKT can be vary by some factors like age, gender, employment status, household monthly income, and residential area factors. Therefore, those factors included in the questionnaire to get the variation of VKT/PKT. Initially a pilot study was conducted by distributing

60 questionnaires among the randomly selected road users and sample size was calculated using the coefficient of variation obtained at this pilot survey. The Equation (1) was used to calculate the sample size (Weerasekara and Amarasingha, 2017).

$$\text{Sample size} = \frac{(\text{coefficient of variation})^2 \times (\text{standard normal variant})^2}{(\text{Level of accuracy})^2} \quad (1)$$

When Jaffna district was considered, the sample size was come up with 224 with 90% of level of accuracy. After the data collection during July 2017, VKT was estimated for each traveller and multiplied by weighed factors. These were derived considering socio-economic information of whole population, to obtain the total VKT value avoiding the sampling errors. Weighed VKT was calculated for each type of vehicle considering traveller's gender, age, employment status, and living area. The comparisons of VKT/PKT values between different variables were carried out using *t-tests*. The travel characteristics of each of the mode is then investigated.

### 3. RESULTS AND DISCUSSION

The VKT and PKT in Jaffna district and varies with gender, residential area, employment status, age category and household income.

#### 3.1. Vehicle Kilometres Travel in Jaffna district

The VKT per male and female were 2,144 and 408 respectively in 2017. In addition, PKT per male was 5,590 and for female, it was 730 in 2017. VKT and PKT of males were statically higher than that of females at 98% ( $p= 0.016$ ) and 97% ( $p=0.029$ ) significant level. Based on predicted census data 80% of the people live in rural area and 20% of people live in urban area of Jaffna district. The VKT value of rural residencies was 2,069 km and urban residencies that was 408 km during 2017. Also, rural passenger travelled 5,241 km and urban passenger travelled 1,080 km during 2017. A rural residential person travelled more than an urban residential person that may because they need to travel more distances as most of trip attractions were in urban areas. Employment status is another important factor. The VKT per employed person was 2,370 and unemployed person it was 182. Moreover, the obtained results showed that VKT of employed traveller statically higher than that of unemployed traveller at 96% of level of accuracy ( $p=0.043$ ). This may be because an employed person needs to travel more for work and work-related activities compared to others. The PKT per employed person was 5,590 and for unemployed person, it was 730.

When considered the age groups, as shown in Figure 2, a person in the age between 25 and 34 years travelled more compared to other categories. Also a person at the age group of 55 and 69 travelled less compared to others. However, these are not statistically significant differences.

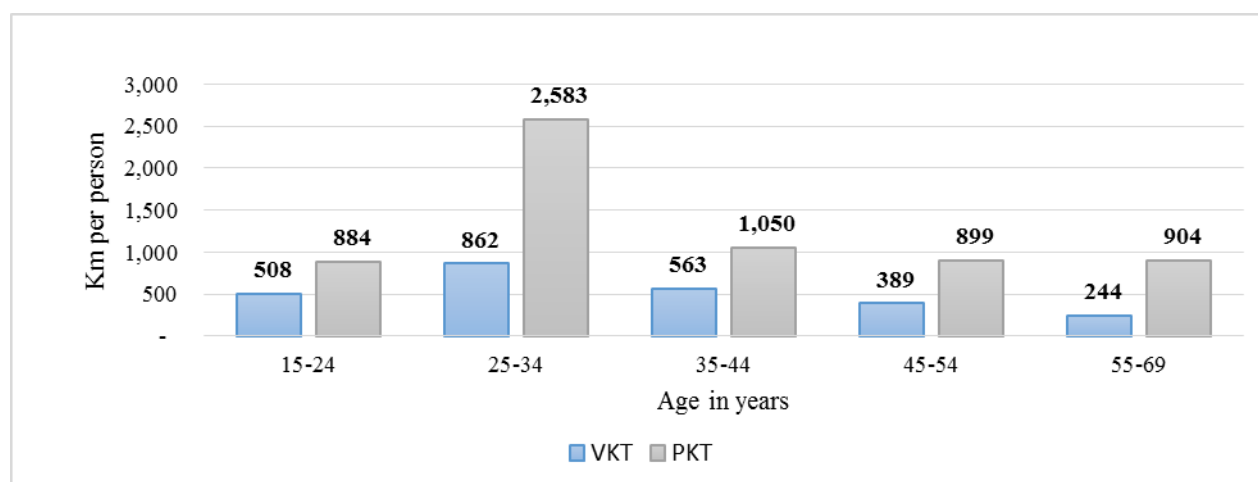


Figure 2 Weighed VKT and PKT of Jaffna District by Age during 2017

As shown in Figure 3, a person with the household income between Rs. 175,000 and 200,000 travelled more compared to other categories ( $p=0.0026$ ) with the VKT of 27,225 km. A person with household income below Rs. 25,000 travelled less compared to other categories ( $p=0.014$ ) with VKT of 5,340 km. The passengers whose monthly income between Rs. 150,000 and 175,000 travelled more compared to others ( $p=0.2005$ ). The passengers whose monthly income below Rs. 25,000 travelled less compared to others ( $p=0.0808$ ).

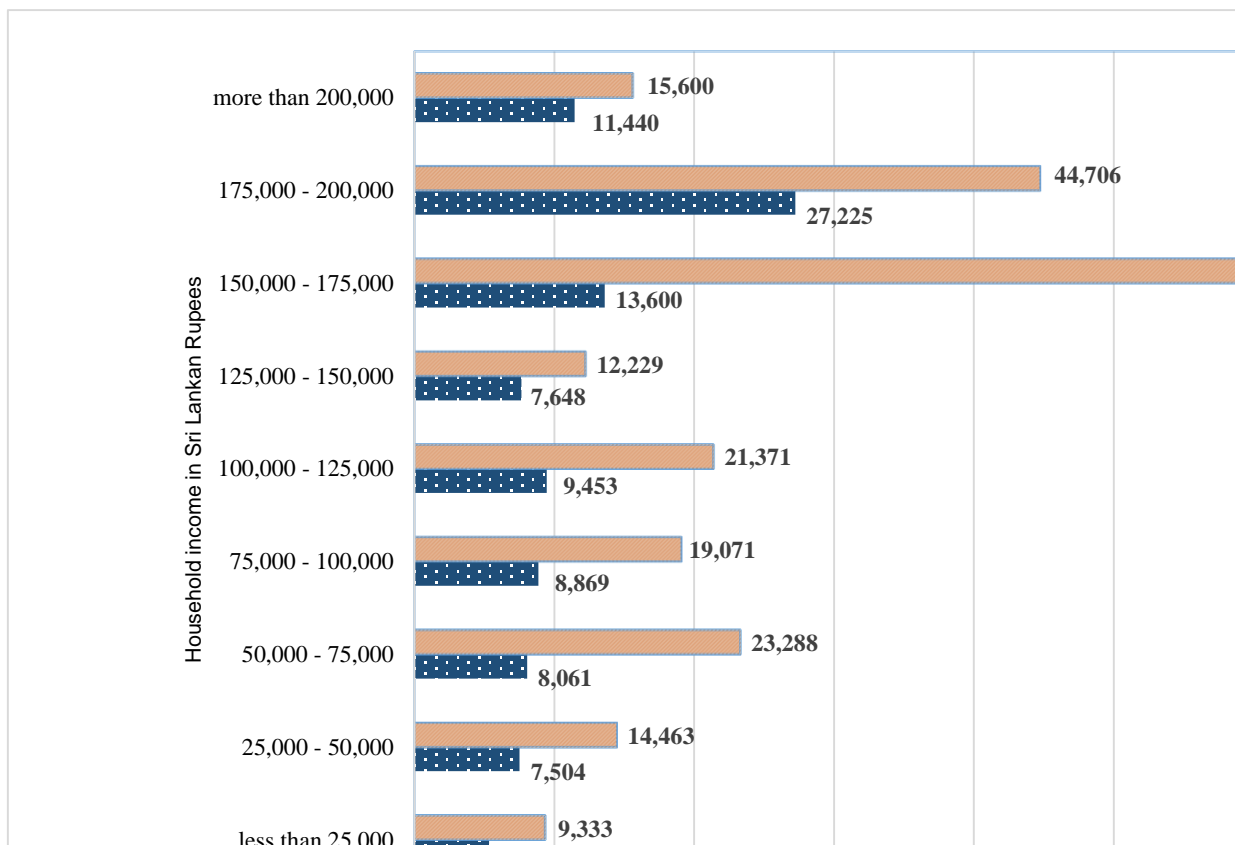


Figure 3 Weighted VKT and PKT of Jaffna District by Household Income during 2017

### 3.2. Characteristics of travellers in Jaffna district

The behaviour of the travellers varies with the preference of the mode they use for travel. In this study, travel modes were categorized under eight different categories; walking, car, van, jeep, motorcycle, three-wheeler and bicycle. The weighed PKT by gender is shown in Table 1. It shows that males, irrespective of the travel mode selected, travelled more compared to females. Both males and females selected motorcycles as the predominant travel mode. However, the kilometers travelled by the motorcycle was comparatively less for females compared with males. Based on the responses obtained from survey, an average male travelled 2141.1km using vehicles and walked 47.3km in 2017. Similarly, females travelled 407.8 km by vehicles and walked 7.3 km.

Table 1 Classification of Weighed PKT of Jaffna District, Sri Lanka by Gender during 2017

Category	Walk	Car	Van	Jeep	Motorcycle	Three-wheeler	Bicycle
Male (Weighed PKT: km/person in 2017)	47.3	380.5	278.1	182.8	922.9	257.8	119.0
Female (Weighed PKT: km/person in 2017)	7.3	57.3	33.6	-	233.7	25.9	57.3

Table 2 shows the PKT of different modes of in Jaffna district by urban/rural nature of their home location. The predominant mode for people in rural areas was the motorcycle while for people in urban areas that was the car. The vehicle usage of an average person in rural area was 2,067.3 km while that was for an average person in urban areas was 481.5 km.

**Table 2 Classification of Weighed PKT of Jaffna District Sri Lanka by Urban/Rural Nature during 2017**

Category	Walk	Car	Van	Jeep	Motorcycle	Three wheeler	Bicycle
Rural Area(Weighed PKT: km/ person in 2017)	49.5	272.3	280.3	142.9	1,047.2	203.2	121.0
Urban Area (Weighed PKT: km/ person in 2017)	5.1	165.5	31.4	39.9	109.4	80.4	54.9

When PKT by employment status is considered, the vehicle usage for an average employed person was 2,367.0 km and for an average unemployed that was 181.8 km as shown in Table 3. Therefore, an employed person travelled more compared to an unemployed person. The predominant mode for employed people was motorcycles and that was also the most predominant mode for unemployed people.

**Table 3 Classification of PKT of Jaffna District Sri Lanka by Employment Status during 2017**

Category	Walk	Car	Van	Jeep	Motorcycle	Three-wheeler	Bicycle
Employed (Weighed PKT: km/ person in 2017)	49.6	431.0	304.0	182.3	1,068.0	277.0	105.3
Unemployed (Weighed PKT: km/ person in 2017)	5.1	7.3	7.8	0.5	88.6	6.7	71.0

The vehicle usage was very high for age categories of 25-34 years and 35-44 years compared to other age categories as shown in Table 4. For people in age category of 15-24 years, the motorcycle was most predominant mode followed by bicycle. That may be because the most people from that age category were students and mostly their affordability is limited with those type of vehicles.

**Table 4 Classification of PKT of Jaffna District Sri Lanka by Age Category during 2017**

Category	Walk	Car	Van	Jeep	Motorcycle	Three wheeler	Bicycle
15 – 24 (Weighed PKT: km/ person in 2017)	11.0	30.3	16.9	0.6	269.6	71.5	118.2
25 – 34 (Weighed PKT: km/ person in 2017)	6.5	189.3	193.0	0.8	363.2	105.8	9.8
35 – 44 (Weighed PKT: km/ person in 2017)	2.8	95.1	25.3	0.2	314.7	99.4	25.5
45 – 54 (Weighed PKT: km/ person in 2017)	0.1	89.6	76.6	39.3	161.1	6.9	2.1
55 – 69 (Weighed PKT: km/ person in 2017)	34.4	33.5	-	142.0	47.9	-	20.73

#### 4. CONCLUSIONS

This study mainly investigates the variation of VKT, PKT of travellers with respect to five socio demographic factors; gender, residential area, employment status, age, and monthly household income. A household travel survey was conducted in Jaffna district during July 2017. According to survey outcomes, VKT/PKT of male is higher than that of female. Also, most predominant mode was the motorcycle among both males and females. The employed people travelled more than the unemployed people. Both employed and unemployed travellers preferred motorcycle as their transportation mode. The predominant mode among the rural residential people was motorcycle

whereas the car was the predominant mode among the urban residential people. The people from high household income level travelled more and people from low household income level travelled less.

The accuracy of data depended on responses of road users that required them recall their travels of previous 12 months. Sometime they might not remember the travel data accurately. Also the sample size of this study was small, this may affect the result of this study. Face to face interview is better than distributing questionnaires, this might helpful to get more accurate results. To increase more accuracy, more social demographic factors can be considered and weighed factors can be added. Estimation of VKT is an important factor in transport planning, allocating resources, estimating vehicle emissions, computing energy consumption and accessing the traffic impact. This data can be helpful to understand transportation behaviour of Jaffna district. By doing surveys covering all the districts in Sri Lanka, the VKT of average person of Sri Lanka can be estimated.

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