Traffic Behaviours at Minor Roads in Southern Part of Sri Lanka

Tissa U. Liyanage, Ruwantha G. Wimalasiri , Gayashan Dalpethado

Abstract: The importance of rural road improvements through integrated road transport accessibility for rural economic development has been identified in the recent past by the Government of Sri Lanka. Road improvement project namely iRoads project has considered the short length access roads for improvements to certain standards with good surfacing even though the ownership of these roads does not belong to Central Road Development Authority. Traffic levels of each road are captured overnight and the weekly variations are also surveyed and such data are analysed with reference to various attributes to evaluate the relationships with that of traffic flow levels. The population density of roads, urban and rural nature, connectivity to the other road classes such as A and B Class Roads, road length, etc have been used as the independent variables to check the relationship for variations with the traffic levels. The weekly variations of the traffic levels at rural roads are also evaluated with the data collected overnight for seven days. The precision of the traffic data is assured as all field data are recorded by using the video technology and the classified traffic data have been used to analyse if there are any significant mode choice behaviour of the rural road users in the province.

The usefulness of this research is that it will contribute to future traffic forecasting of roads of the similar nature and will be decided based on the statistic confidence of the expected traffic analysis outputs. Fixing the night time traffic expansion factors, weekly variations and their significance and the variations over the geography, development of annual average daily traffic factors using a large database, average vehicle composition factors that can be used for forecasting mode based traffic flows when only the total counts are available in similar conditions, are some of the important outcomes of the analysis. Series of analysis using statistical analysis techniques is included as the methodology for data analysis. It is expected that the outcomes will be useful to shortcut the data collection effort in future for rural road development projects and decision making for prioritization of the rural project roads for investment opportunities at the planning stages.

Keywords: Rural Roads, Traffic Expansion Factors, Mode Choice, AADT,

1. Introduction

The Southern Province of Sri Lanka is a large geographical area consisting of Galle, Matara and Hambantota Districts. The major income sources for the vast majority of the people in this region are farming and fishing. This region consists of many important landmarks including several wildlife sanctuaries, attractive beaches, world heritage and ancient cities. [1]

The development of the short length access road system is an important factor in order to improve the connectivity between communities, socioeconomic centres bridging the people and their needs with the city centres. Therefore, improving those roads will be significantly contributed to the social and economic development of this region.

The analysis of the traffic behaviour in those access roads is very important in decision making in future developments. However, there are many drawbacks in ordinary data collecting processes. Most of the time, the manual classified count method is used for traffic surveys and it is challenging task to gather precious data with the expected accuracy. A new methodology was adopted with the latest available technology to capture very precise data during the study.

This research paper intended to analyse the variation of traffic levels with the several independent variables and develop the factors such as average night time factor, weekday average daily traffic factor and average vehicle composition factor for future traffic forecasting of roads with similar nature. The required data

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is taken from the traffic survey which was recently carried out for developing Road Asset Management System (RAMS) in Southern province under the iRoad Programme.

2. Objectives

The rural roads are highly important infrastructure to sustainable operation of the national highways economically with the large investments put on them with time. Maintenance and proper management of such access roads are needed to be done with time and the assert management of such roads are important for implementing effective maintenance programs after the capital investigations to make sure that they are in good condition at the operation level for the intended life cycle. Following are the main objectives of this research paper.

- To check the relationship for variations of traffic characteristics with respect to independent variables such as urban and rural nature, road length, bus routes and non-bus routes, by road connectivity etc
- To identify the weekly variation of the traffic levels at rural roads for establishing the future forecasting factors for different weekdays

3. Review of traffic Behaviours at Access Roads

Access roads provide the primary linkage between homestead and the national highway network. They provide connectivity from homes and farms to markets, public access to essential health, education, civic facilities etc. These are the basis, and important for the local area and national economic development of all countries of the world. Low volume access roads are defined as roads having average daily traffic (ADT) less than 1000 vehicles per day but typically roads with ADT up to 2000 is considered in this category. Many low volume roads consist of the single lane with gravel or even more native surfacing. In Sri Lanka, there are about 70% of low volume rural roads among all the roads while 30% is the other highways[3]. The lack of accessibility to rural roads has been identified as one of the main causes of poverty among rural people. Performance evaluation of the rural roads in LAO PDR has been given high interest in 2009 as foreign funded projects [4]. Rural access roads have rarely been dealt with by government projects. Due to financial constraints, the cost efficiency and the small number of beneficiaries, the priority of policy makers and donor agencies to take care of these roads is low. Therefore, rural communities suffer from poor road conditions [5]. Type of vehicles on the specific road can be considered as one of the main features of that road. Also, knowledge of how traffic flows varies for different vehicle classes may be very useful when designing programmes for axle load control, design of roads improvement upgrading schemes and setting maintenance programmes and priorities [6].

When the existing situation of the southern part of the country is considered agriculture is the predominant economic activity. It contributes about 30% of provincial gross domestic product and about 48% of jobs. The level of poverty by province was proportional to the rural share of its population. Eighty percent (80%) of the population in Southern Province is rural with a poverty level of about 40%[2]. Operation of public transport is very important as per the above data where everyone will get good connectivity to the nearest main arterial that will connect them to the city centres. In rural areas, the people are more concerned about deficiency in the quantity of transport rather than the quality of the vehicles as most of the routs are only for short distance[6].

4. Approach Methodology

In this analysis, 125 number of roads in Southern province are considered and the data of 24 hour traffic survey carried out from February to April in 2019 is used for the comprehensive statistical analysis. The roads sample has been chosen in order to represent the entire Sothern province as shown below,

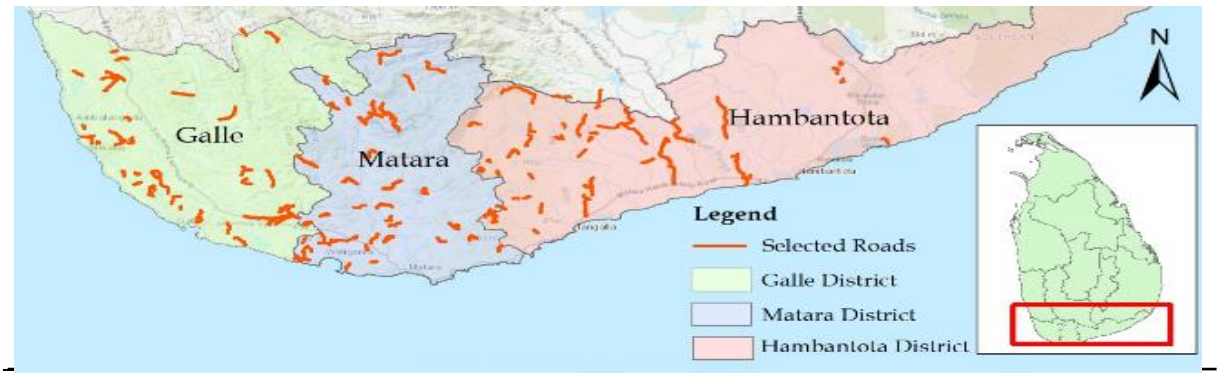

Table 4.1: Sample Distribution among Districts

District	Road Sample size (Nos)
Galle	40
Matara	47
Hambantota	38
Total	125

The selected road sample consists of well-categorised samples in order to represent all the land uses such as urban, semi-urban and rural. The condition of all the roads in the whole data sample is the same and all the roads were newly constructed within one-year period and completed with lane marking and required other road furniture. Further, the location of the traffic survey is selected by considering the following aspects in order to maintain uniformity of the data,

- The survey is done within the 500m distance from the Road Start.
- Well away from areas having high local traffic such as with short trips, to avoid repetitive trips.
- Traffic counts were taken in normal working days (ie Tuesday, Wednesday, and Thursday).

Figure 1: Locations of Selected Roads

Moreover, the new technology adopted IP cameras are used to collect the traffic counts instead of manual classified data count in order to improve the accuracy of the traffic count with the least possible human errors. In addition to that well-qualified personnel are used for the data extracting to increase the accuracy of the analysis. Special web-based software was developed and used to extract the data.

Figure 2: Interface of Data Extracting Software

The primary data have been comprehensively used to analyse in order to achieve the expected objectives of the research. Mainly the quantitative analysis has been carried out by using statistical analysis techniques.

5. Analysis

Various aspects of variable attributes have been tested using a large number of 24hrs traffic database for understanding factors affecting for traffic behaviours of selected Roads in Southern Province. Vehicle classification of the data was available for 11 categories and for the convenience, all the categories were summarized for four categories as two-wheelers (motorbikes), three-wheeler, four wheelers (car/van/ jeep) and goods vehicles. The coefficient of variance of each category analysis has been tested to make sure that the average night time factors that are compared under various parameters are statistically stable before make comparison and conclusion of the analysis.

5.1. Variation of Traffic Behaviour with Respect to the Land Use

Mainly, three land use categories have been considered for this analysis. Based on the distance from the Southern Coastal Line. Colombo - Galle - Hambantota – Wellawaya Highway (A002) is the third longest highway in the island which starts from Colombo and runs to Uva Province through the Southern Province. It traverses parallel to the coastal line at the southern province and all the major cities are located on this major national highway. The population density is high with a large number of commercial and recreational entities along A002 Road across the Southern Province. The land use category for the classification was considered as follows,

Table 5.1: Classification Criteria of Land Use

Distance from the Coastal line	Category Name
Below 5 km	Urban
5km-15km	Semi-Urban
Over 15km	Rural

The analysis shows that the night time factors with respect to 12 hours day traffic is varied significantly with reference to the urban, semi-urban and rural land use. The night time factor for 12 hours day time traffic for rural area is the lowest having the factor of 1.30 times the 12 hours while it gives 1.37 for urban roads. The night time factor with respect to 16 hours day traffic is not varied with reference to the land use pattern and it results in an approximate value of 1.04. As the selected roads are access roads the traffic level after 10 PM has decreased drastically and only 4% of the 16-hour traffic

was observed during the study irrespective of the land use. Further, the analysis indicates that the 12-hour Night Time Factor (NTF) is increasing from rural to urban roads.

The coefficient of variance (CoV) for the analysis made by categories is lower than when it considers all roads together. However, the CoV for all remains at low values (less than 30%) showing that the variations between roads for night time factors fall within an acceptable level for deciding for future use as a steady factor for different land use categories.

Table 5.2: Variation of NTF with Land Use

Expansion Factor Type	Average Night Time Factor			
	Rural	Semi-Urban	Urban	All Roads
24/12	1.30	1.36	1.37	1.34
24/16	1.04	1.04	1.04	1.04

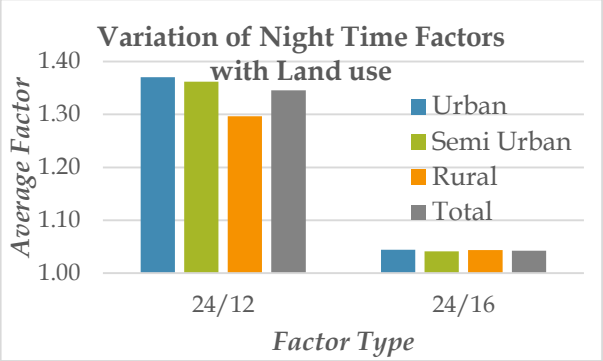

Figure 3: Variation of NTF with Land Use

The Study reveals that the composition of Goods vehicles is increased with the reduction of urban density. 36.0% of the employed population of Southern Province is on the agriculture sector [2] and the wide use of goods vehicles like light trucks are often used even for personal trips. This will have a direct impact on the increase of the goods vehicle composition in rural land use.

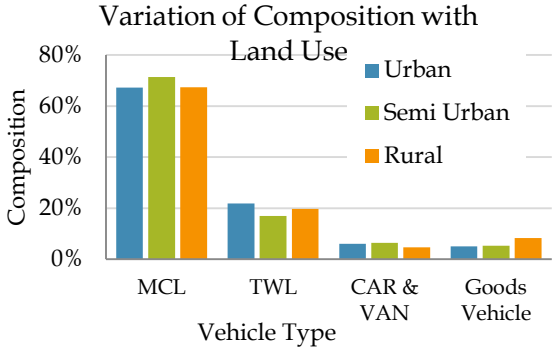

Figure 4: Variation of Traffic Composition with Land Use

5.2. Variation of Traffic Behaviour with Respect to the Road length

These considered roads consist of different road lengths with a significant variation from 400m to 15 km. The length of the road gives the indication of the catchment size of the road. As the length of the access road is increased the characteristics of the road will not be the same. Therefore, in order to check the variation of Average Night Time Factor, vehicle composition and the traffic volume with respect to the road length, five (05) road length categories are considered based on the road lengths of the collected data samples.

In accordance with this analysis, the night time factor with respect to 12 hours day traffic is varied significantly with the road length. The Night time factor for the roads which the length is more than 3km is the lowest having 1.31 while it gives the highest value of 1.37 for roads which are having a length between 1km and 2km. The night time factor with respect to 16 hours day traffic is not varied significantly with reference to the length of the roads as per the analysis. The coefficient of variance (CoV) for the analysis made by categories is lower than when it considers all roads together in this analysis also. Further, the CoV indicates that the variations between roads for night time factors fall within a statistically acceptable level for deciding for future use as a steady factor for different road length categories since they are low values.

Table 5.3: Variation of NTF with Road Length

Type	Average Night Time Factor Variation					
	<1km	1km-2km	2km-3km	3km-5km	>5km	All roads
24/12	1.32	1.37	1.35	1.31	1.31	1.34
24/16	1.04	1.04	1.04	1.04	1.05	1.04

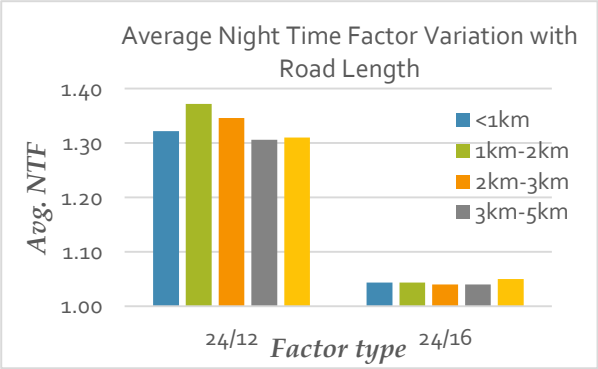

Figure 5: Variation of NTF with Road Length

The composition of three wheelers is increasing from the short length roads up to the 2-3 km

roads and then descends. The behaviour of the motor bikes is the inverse of the three-wheelers where a high number of motor bike percentage is observed on short length roads and with the increasing of the length, the composition of it decreases until 2-3 Km length roads and then increases. Highest four-wheeler vehicle composition is observed on the roads with a length higher than 5 km.

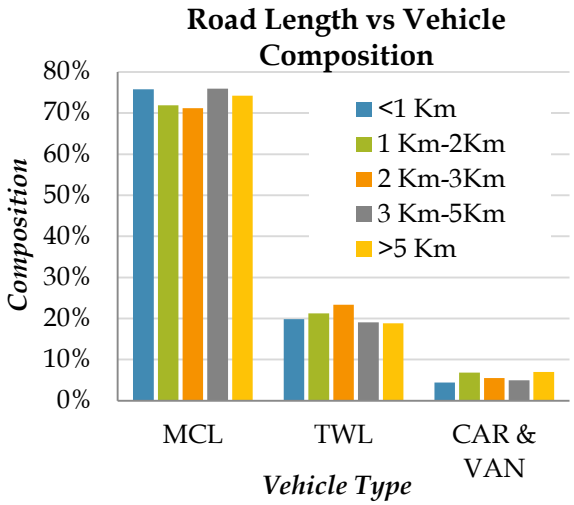

Figure 6: Variation of Vehicle Composition with Road Length

Analysis to check the variation of traffic volume with the road length shows that there is no significant relationship among them. But the Figure 7 shows that most of the short length urban roads are having a high traffic volume while the roads with semi-urban and rural land use have recorded a comparatively low volume for the same length.

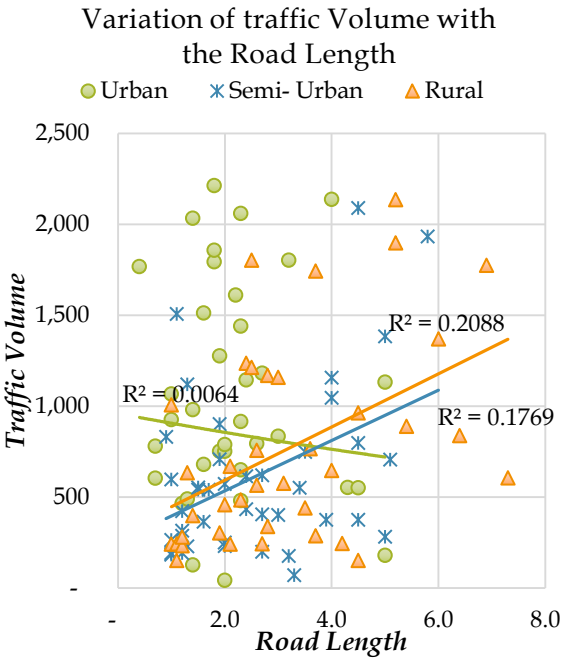

Figure 7: Variation of Traffic Volume with Road Length

5.3. Variation of Traffic Behaviour with Respect to the Bus routes and Non-bus routes

The availability of public transportation systems can be a significant factor which affects the traffic behaviour of a road. Since the main public transportation mode which is available in this area is buses, the impact of bus routes to the average Night Time Factor is considered in this analysis.

The analysis shows that there is no significant variation in Night Time Factor with respect to the bus routes or non-bus route in both 12 hours and 16 hours day traffics. Therefore, it indicates that the Night Time Factor is not significantly dependent on the availability of public transport supply. Further, since the VoC is in the acceptable range, these values can be used for future use as steady factors.

Table 5.4: Variation of NTF with Availability of Public Transport

Type	Average Night Time Factor Variation		
	Bus routes	Non bus routes	All roads
24/12	1.34	1.35	1.34
24/16	1.05	1.04	1.04

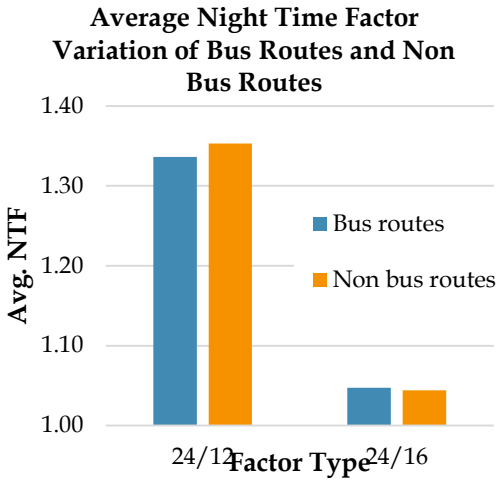

Figure 8: Variation of NTF with Availability of Public Transport

Southern Province, having a comparatively low per capita income of SLR 460,569 indicates the significance of the need for the public transport services. As most of the selected roads for the study are access roads, frequent route bus services are not available. Vehicle composition

of the roads with route buses and without route buses are compared in the analysis. It gives a clear indication that the composition of the motor bikes and three wheelers are low in the roads with bus routes. The model shift of the users is observed from motorbikes and three wheelers to the buses where available. Composition of the cars when the route buses are available is high so that it does not relate with the availability of route buses and it's clearly seen that the motorbike and the three wheelers are used heavily in the absence of route buses as an alternative to fulfil their mobility needs.

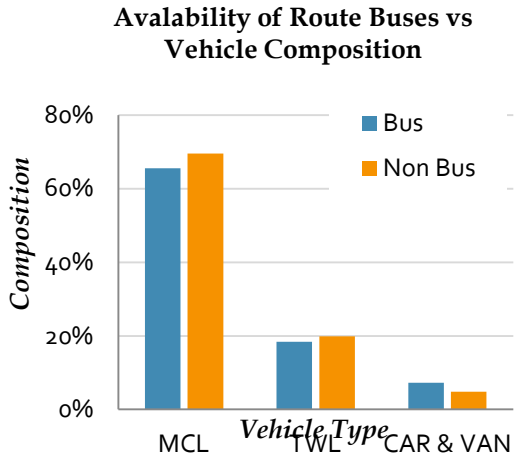

Figure 9: Variation of Traffic Composition with availability of Public Transport

5.4. Variation of Traffic Behaviour with Respect to the Traffic Volume

The traffic volumes of the considered roads are in a wide range from 42 vehicles to 4,754 vehicles per 24 hours having an average of 909 vehicles. Therefore, this analysis is done in order to check the variation of the average Night Time Factor and vehicle composition with respect to the traffic volume.

Although the traffic volumes are varied significantly in the observed data, as per the analysis it shows that there is no significant variation in the average night time factor of both 12 hours and 16 hours day traffics with the variations of traffic volume.

Table 5.5: Variation of NTF with Traffic Volume

Type	Average NTF Variation with Traffic Volume			
	Below 1000	1000-2000	Over 2000	All Roads
24/12	1.34	1.33	1.35	1.34
24/16	1.04	1.05	1.05	1.04

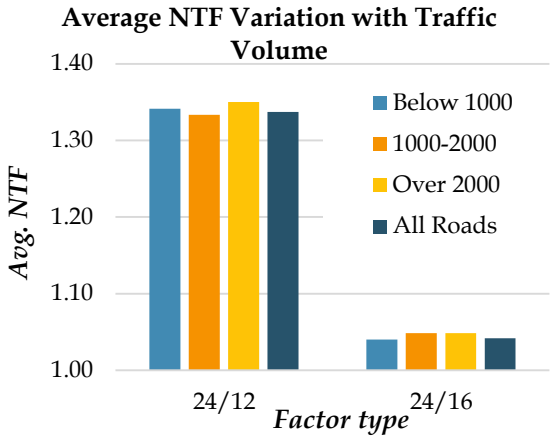

Figure 10: Variation of NTF with Traffic Volume

When the traffic composition variation with respect to the traffic volumes is considered it's clearly seen that composition of the four wheelers is increased with a considerable level at the roads where its traffic volume is higher than 2000 vehicles per 24 hours on a normal working day while the composition of the motor bikes is reduced. Three-wheeler composition is steady around 20% despite the traffic volume variation.

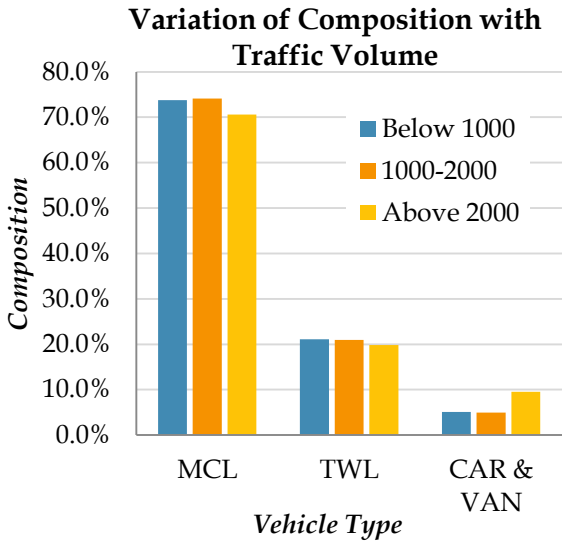

Figure 11: Variation of Vehicle Composition with Traffic Volume

5.5. Variation of Traffic behaviour with Respect to the Connectivity of Roads

The connectivity of a road also plays a major role in the traffic behaviour of a road. Therefore, the connectivity of the roads is considered as a variable factor to analyse the variation of the average Night Time Factor (NTF) and the vehicle composition.

As per the analysis, the average NTF with respect to 12 hours daily traffic is varied

significantly with the type of connectivity. It results in the maximum value of 1.43 in Class B – Class B connector roads and a minimum of 1.30 in Class A to other road type connector roads. It shows that the Class B to Class C connector roads and Class C to Class C connector roads result in approximately equal values. However, in accordance with the analysis, there is no significant variation in Average night time factor with respect to 16 hours daily traffic with the type of connectivity. Further, Since the CoV for all factors remains at low values (less than 30%), they can be used for deciding in future uses as a steady factor for different types of connectivity.

Table 5.6: Variation of NTF with Road Connectivity

Type	Average Night Time Factor			
	A to All	B to B	B to C	C to C
24/12	1.30	1.43	1.34	1.35
24/16	1.04	1.05	1.04	1.05

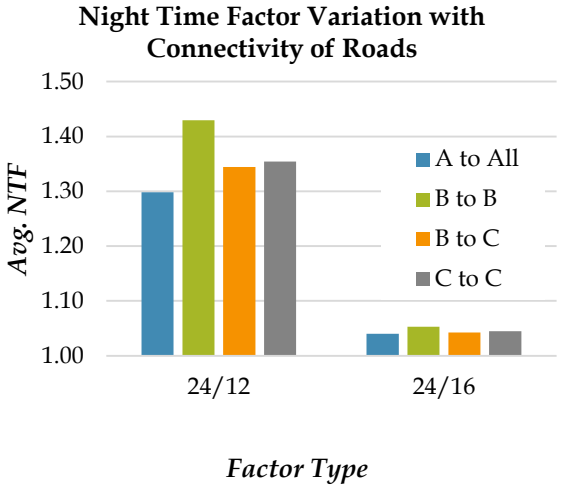

Figure 12: Variation of NTF with Road Connectivity

Access roads connected to A Class Roads which connects major cities have recorded the lowest percentage of motor bikes while recording the highest three-wheeler composition. Composition of the motor bikes has recorded increasing towards the connecting to lower class roads. This is basically due to the local roads has a comparatively high volume of motor bikes than the A class or B class roads which passes through the main nodes. Three-wheeler composition is highest at the access roads from the A class roads, lowest at the access roads connecting to B class roads at both ends and increases gradually.

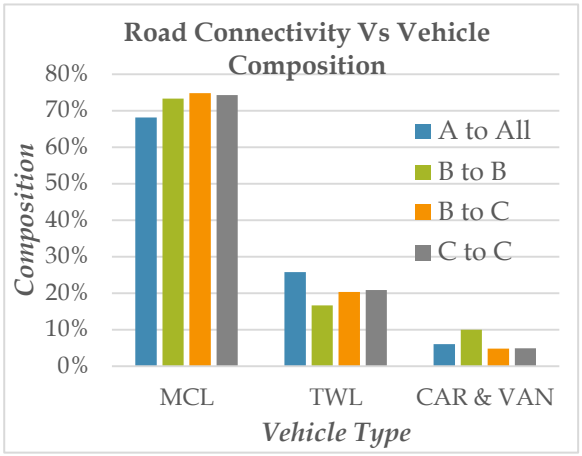

Figure 13: Variation of Vehicle Composition with Road Connectivity

5.6 Variation of Traffic Composition with respect to the road classification

The type of road is a significant factor in variation of the traffic composition in roads. In Sri Lanka, the main considered road types are Express ways, National roads, Provincial Roads, Local Authority roads and other roads. In here, the vehicle composition of these access roads is compared with the vehicle composition of the National roads in Southern province.

Table 5.8: Variation of ADT factors with respect to the land use

Day	Galle			Matara			Hambantota		
	Urban	Semi	Rural	Urban	Semi	Rural	Urban	Semi	Rural
Monday	1.05	1.15	1.06	1.03	1.01	0.93	0.96	1.05	1.02
Tuesday	1.00	1.16	0.99	1.02	1.09	0.95	1.09	1.12	1.12
Wednesday	0.98	1.10	0.95	1.07	1.00	0.95	0.95	1.05	1.02
Thursday	0.97	1.03	0.97	0.91	1.02	0.99	0.96	1.04	0.97
Friday	1.00	0.79	1.03	0.93	0.84	0.96	0.88	1.00	1.02
Saturday	0.99	0.84	1.02	0.99	1.19	1.14	1.14	0.86	1.03
Sunday	1.00	1.08	1.00	1.08	0.93	1.11	1.07	0.93	0.86

The traffic compositions of considered national roads and main collector roads are taken from a manual traffic survey which is conducted in 2017 in Southern province and district boundaries. In here, the vehicle compositions of national and main collector roads which are intersected by the district boundaries in Southern province are considered for the analysis.

The analysis shows that the traffic composition at these access roads is significantly different from that of the main collector roads and national roads. The Motor cycle composition of access roads are relatively higher than that of Class A and Class B roads. The composition of three-wheelers is not varied significantly in all the road types. In access roads, the compositions of car, van, bus and good vehicles are considerably lesser than the other road types.

Road Type	MCL	TWL	CAR	VAN	BUS	Goods Vehicle
A Class Roads	33	19	13	8	7	20
B Class Roads	44	21	9	6	4	16
Access Roads	68	20	4	2	1	6

Table 5.7: Variation of traffic composition with respect to the road classification (%)

5.7 Variation of ADT factors with respect to the land use

The variation of Average Daily Traffic factor with respect to the land use types is analyzed in this research. The ADT factors are calculated by using the data from a traffic survey which was carried out for 7days using IP cameras. Therefore, these factors can be used for forecasting of ADT values of roads with same conditions in future uses. The Table 5.8 Shows the ADT factors for different land uses with respect to the day of traffic count was done.

6. Conclusion and Recommendations

Various factors affecting the variation of road traffic characteristics in Southern Province were tested in this research using a significant and large traffic database collected using modern techniques. The traffic analysis was mainly carried out to see how the night time factors (NTF) are affected by various related characteristics. The research outcome indicates that the NTF at access roads are significantly varied with the land use type or the geography of the roads. Traffic composition at these access roads is very much different to that of the main distributors and collector roads and national roads. It indicates that the traffic compositions significantly vary with the presence of the route buses at the access roads that from the other roads. More two-wheelers are observed to be used at non-bus routes compared with the bus routes. The variations of the traffic composition with respect to the total traffic volume are also significant in the access roads. It is also revealed that there is significant variation of the NTF with respect to the road end connectivity to the other road types. More traffic in the night time observed at access roads where it has both ends at national roads (B to B Class connectivity).

Since all above analysis are statistically confidence to state that the variations within the selected attributes are very low and hence the results shall be accepted to be used in future forecasting of the NTFs in similar conditions of roads without doing surveys for 24 hours. The results shall be used for various traffic forecasting purposes, considering the traffic compositions, variations of land use, road length, total traffic volume etc using the calibrated factors indicated in this research. The calibrated NTFs shall be used for extrapolation of 24 hours traffic from the 12 hours traffic for various purposes such as decisions for pavement designs, prioritisation of roads for improvements, regarding the public transportation improvements etc.

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