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Analysis of traffic growth on a rural highway: A case study from India

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Abstract

Over the years, the rate of traffic growth had always been a significant concern in the development of road infrastructures as it could either lead to premature failure of the pavement or could result in the wastage of valuable resources. The lack of proper study regarding the prediction of traffic growth has led to development of concerns in this field. The present study attempts to develop traffic forecasting models using the data collected from 2013 to 2017at the Paliyekkara toll plaza situated in southern part of India. The study identified Gross Domestic Product, population and vehicle ownership as the main factors that influence traffic growth and an exponential model was developed relating these factors with traffic volume. The proposed model was then validated by comparing the forecasted traffic with the actual traffic data of 2018. Further, on comparing with the output from existing models, it was concluded that the proposed model outperforms the available models as it had the least error in prediction. The study also modeled the variation in traffic volume that occurs in a year and this could be used to forecast the traffic for any particular month of any year.

Keywords: Traffic forecasting, Average Daily Traffic, Seasonal variation, Heterogeneous Traffic

1. Introduction

Traffic forecasting hasalways been an area of concern for urban planners and traffic engineers as it is essential for planning and developing infrastructural facilities. Traffic growth plays an important role in developing and improving highways which eventually benefits the national economy (Clark 1982; Read 1971). Accurate estimation of traffic growth is vital for transportation planning, implementation of traffic regulations, pavement designs, environmental impact analysis, and for other highway development needs. Looking towards the global demand for traffic growth, the lack of uniformity in approach by transport authorities and their lack of knowledge of how well the current method works makes it difficult to satisfy the outreach for traffic growth (Allen and Hamilton 2000).

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Average Daily Traffic (ADT) is a measure of traffic volume on a highway and it can be defined as the average number of vehicles passing a specific point during a 24-hour time period. ADT is found from traffic counted over a given time period which is greater than one day but lesser than one year and then averaged out to get the daily traffic. ADT is widely used in transportation planning, transportation engineering and retail location selection as it indicates the traffic demand of the facility. Average daily traffic estimates are used to monitor the growth in traffic on a roadway from year to year and is often used as a vital tool in the allocation of funds for the development of existing road infrastructure. Further, ADT is also used for analyzing the rate of traffic accidents on a roadway.

In India, the recent environmental conditions have made the situation worse by implementing further restrictions on traffic growth and highway facility development.IRC 108 (1996) lays down the guidelines for traffic prediction on rural highways as suggested by the Traffic Engineering Committee. IRC discusses models for traffic prediction based on past trends in traffic growth and uses economic indicator such as Gross Domestic Product (GDP) for the same. The model for traffic growth rate, as proposed by Jha et al. (2013), considers data of Gross National Product/Gross Domestic Product from 1961. The authors stated that Time Series (TS) analysis is more accurate than Trend Line Analysis and Econometric Analysis. They also stated that including econometric indicators with other relevant factors can better reflect the impact of components such as growth in the total number of users, as well as users', purchasing power to possess the latest technological advancements in the field of transportation. Factors other than GDP, such as population, agricultural output, industrial output, vehicle ownership etc., also play an important role in determining the change in traffic growth. Over the years, these factors have changed and traffic congestions have increased (Litman 2011; Marshall et al. 1997; Noland 1998; Prevedouros and Schofer 1989) and hence the applicability of available traffic forecasting models, that are just based on one or two factors, is questionable. The present study tries to identify the influence of multiple sets of factors that could directly affect the traffic growth rate of a typical highway.

2. Literature Review

With rapid rise in traffic, the necessity to predict traffic growth at a particular location has increased (Allen and Hamilton 2000; IRC 1996; Derwent et al. 1997; Hounsell 1989; Sarna and Agrawal 1990). Traffic growth pattern, with a reasonable degree of accuracy, is to be established in order to obtain the maximum magnitude of potential highway user's benefits and costs that satisfies the public interest (Memmott 1983).The studies carried out to predict traffic growth suggested that large number of samples have to be surveyed in order to obtain confidence in finding the average daily traffic (Chatterjee et al. 2012; Hounsell 1989; Jha et al. 2013; Kamplimath 2013; Koorey et al. 2000; Memmott and Buffington 1981; Frankfort 1997; Monica et al. 2001; Xia 1999). Existing models, which are being widely used to predict traffic growth, only consider economic factors such as GDP or GNP(IRC 1996; Jha et al. 2013). The urgent rise in traffic growth and the need to forecast traffic accurately can be initially associated with factors influencing economic growth (Emily 2013; Natalie 2014). Influence of other possible factors that could impact traffic growth at a particular location such as demographics, industrial output, agricultural output, car use, technology, social attitudes, technological changes, political approaches etc. were also studied by some of the researchers(IRC 1996; Julian 2018; Koorey et al. 2000; Memmott 1983; Monica et al. 2001; Talvitie et al. 1980; Xia 1999).Changes in traditional economic factors such as increase in fuel price, changes in vehicle use costs, income stagnation etc., which is impacted by major economic factors such as GDP/GNP, could also affect the rate of traffic growth (Angel 2016; Bastian; Anne; Borjesson 2016; Chatergee, K; Goodwin; Schwanen, T; Clark, B; Jain, J; Melia, Middleton 2018; Marzena 2016).

The efficiency of available models to predict ADT by only considering economic factors are questionable. Even though all the above-mentioned factors were found to influence traffic growth, the existing models failed to incorporate factors like fuel sale data, student enrolment data, vehicle ownership data, population data, etc. This paper attempts to predict the future traffic volume at a particular location in terms of individual vehicle types, as well as, combined mix of traffic. Along with economic factor, other factors such as per capita income, fuel sale data of India, educational institution enrolment data, population of South India, vehicle ownership of Kerala, population and vehicle ownership data were considered for model development.

3. Study Area Characteristics

The network of trunk roads that is owned by the Ministry of Road Transport and Highways of India is termed as National Highways. National Highway No 544 (previously NH 47), located in the southern part of India, was selected for this study. NH-544 is one of the main roads in the state of Kerala, connecting almost all of its districts (Preetha et al. 2017).In 2006, Government of India had entrusted National Highway Authority of India (NHAI) to undertake the widening of then existing 2-lane stretch to a 4-lane divided carriageway and strengthening of existing two lanes on built, operate and transfer (BOT) basis. The project was provisionally completed in December 2011 and for the purpose of toll collection, Paliyekkara toll plaza was established in 2012.

Paliyekkara toll plaza was selected as the source for traffic data collection. It is the largest toll plaza in the state of Kerala and has 12 lanes in total with 6 for each direction. The toll plaza is situated on NH-544 at Paliyekkara in Thrissur district. The development of road networks throughout the years in the selected location was observed with the help of Google Earth. It was observed that, two lane roads in 2002 were developed into four lane divided roads by 2013 to cope up with the increase in demand. In a span of just 10 years, the growth of traffic increased at a tremendous rate which the authorities in charge was not able to accurately forecast. This shows that efficient model for traffic forecast was not available or applicable at the particular location. After analyzing the development of road networks over the years, further details from the location was obtained through onsite visits.

4. Data Collection

For the purpose of forecasting traffic on the study stretch, several primary and secondary data were collected. The type of primary and secondary data collected are mentioned below in sections 4.1 and 4.2 respectively.

4.1. Primary Data

As per the classification already available from the toll plaza, three types of primary data were collected for this study.

- 10-day Unclassified Continuous Traffic Volume Count for each year without any seasonal variation (for the month of December) starting from 2013 to 2018 (Type P1)
- 10-day Unclassified Continuous Traffic Volume Count for each year with seasonal variation (for different months) starting from 2013 to 2018 (Type P2)
- Classified volume count of different types of vehicles for the collected 10-day Continuous Traffic Volume Count for both type of data collected (Type P3)

Type P1 consist of total ADT of vehicles passing through the location taken forthe same month through the years from 2013 to 2018 and is used to develop models to forecast future traffic. Type P2 consist of total ADT of vehicles passing through the location taken from different months during the same time period. This is used to analyze the variation of forecasted ADT of different months in a year. Type P3 consist of classified volume count of the previous two types of data and is used to analyze the increase in volumes of individual vehicular categories from 2013 to 2018.

4.2. Secondary Data

Other than traffic data, the following data that could influence traffic growth, were also collected.

- Population of Kerala and adjacent states of Tamil Nadu, Karnataka and Andhra Pradesh from 2013 to 2018 (Type S1) (Population Census 2011).
- GDP of India from 2013 to 2018 (Type S2) (Implentation 2019)
- Vehicle ownership data of Kerala from 2013 to 2018 (Type S3) (Minsitry of Statistics and Programme Implementation 2017)
- GDP of India from 2013 to 2018 in percentage (Type S4) (Implentation 2019)
- Fuel sale data of India (Type S5)(Sales 2019)
- Student enrolment data of India (Type S6)(India 2019)

The southern part of India is comprised of four states, namely Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. Majority of the vehicles using the toll for different commutation purpose are from the southern part of India and hence population of South India was selected. This was found by adding the population of Kerala, Tamil Nadu, Karnataka and Andhra Pradesh obtained from Type S1. The total population of South India along with data of Types S2, S3, S4, S5 and S6comprised the secondary data set to develop the model for traffic forecasting.

5. Data Analysis

The National Highways Authority of India (NHAI)is an autonomous agency working under Government of India and is responsible for managing the National Highways network of the country. NHAI has classified vehicles into different categories in order to ensure the smooth working of the toll plaza. Vehicles were classified as CAR-JEEP-VAN (CJV), Light Commercial Vehicles (LCV), BUS/TRUCK and Multi-Axle vehicles. Although specific lanes are dedicated for each of the vehicular categories, drivers in India seldom follow it and hence the traffic to be dealt with at each of the individual tollbooth comprised of all the vehicular categories.

Significant increases in total number for each category of vehicles were noticed throughout the years. The most significant increase was observed for the type CJV and its volume grew from 8,707 vehicles in 2013 to 22,911 vehicles in 2018, which is more than twice of what was observed in 2013. BUS/TRUCK showed relatively lesser rate of growth in comparison with other vehicle types as it grew from 5,857 in 2013 to 8,655 in 2018. From Fig 1, it can be noted that major portion of the traffic in every year was contributed by CJVs, followed by LCVs, Multi-Axle and BUS/TRUCK.

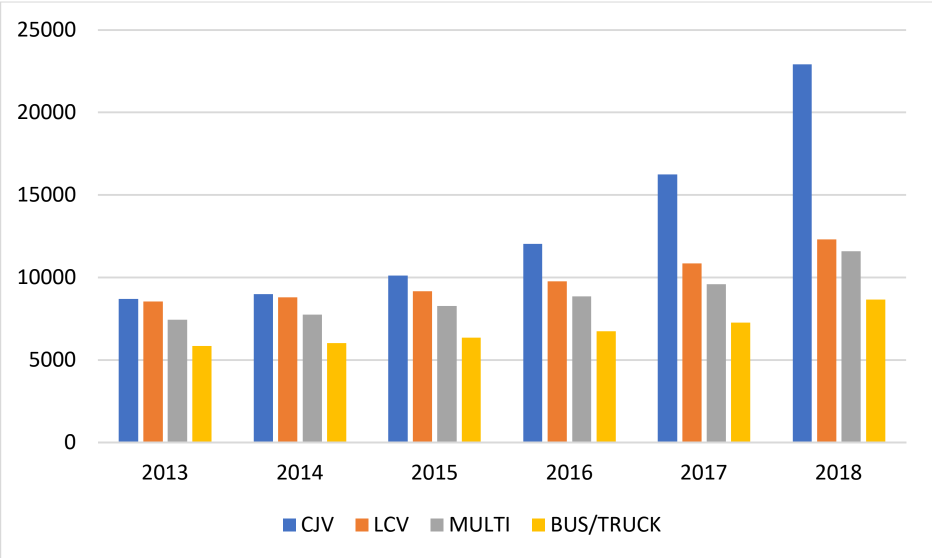


Figure 1: Increase in total volume of different vehicular categories from 2013 to 2018.

DETR (1997) stated that traffic is forecasted to increase mostly because of the increase in economic activities and life expectancy of the people. It also stated that increasing car ownership is the main factor leading to increase in traffic over the years. Based on the findings from earlier research regarding the factors influencing traffic growth, different factors such as per capita income, fuel sale data of India, educational institution enrolment data of Kerala, Gross Domestic Product, population of south India, vehicle ownership of Kerala, percentage increase in Gross Domestic Product and vehicle ownership data were investigated for their impact on ADT. A correlation analysis between ADT and potential factors influencing it was conducted in SPSS and the result is presented in Table 1.

Table 1: Correlation of ADT with different factors chosen for modeling.

Factors	Population of Kerala	Population of South India	GDP	GDP in percentage	Vehicle Ownership	Fuel sale data	Student Enrolment
Pearson Correlation	0.944	0.945	0.964	-0.198	0.963	-0.381	-0.908

Table 1 provides the correlation of ADT with different factors chosen for modeling traffic growth. Factors such as population of Kerala, population of South India, GDP and vehicle ownership showed high correlation with ADT. Since most of the commercial as well as non-commercial vehicles using the toll plaza belonged to the southern states of India, population of South India was selected rather than population of Kerala. Meanwhile, other factors such as GDP in percentage, fuel sale data and student enrolment data showed negative correlations. An increase in GDP points towards a rise in domestic production of the country, which should ideally translate to more number of vehicular trips. However, an opposite trend was observed in this case and this might be due to the influence of regional factors pertaining to the site. Similarly, increase in student enrolment and sale of fuel should also contribute to a rise in the number of vehicles using the highway. Information regarding fuel sold and student enrolment were respectively taken from the data provided by petroleum industry and educational institutions. The negative correlation of fuel sale and student enrolment with ADT might be due to the lack of prominent gas stations or prominent educational institutions in the immediate vicinity of the site considered for this study. Regardless of the aforementioned reasons, negative correlation of these factors with ADT appears absolutely illogical and hence, based on the fundamental criterion of regression analysis, these factors were not considered for model development. The factors such as GDP, population of south India and vehicle ownership data were finalized for modelling the future traffic.
Economic factors have the potential to influence factors such as land use and demographics. Therefore, it is important to look at the economic change when considering traffic growth predictions (Koorey et al. 2000). The population data from 2013 to 2018 of states comprising the southern part of India (namely Kerala, Tamil Nadu, Andhra Pradesh and Karnataka) were used to calculate the total population of south India(Population Census 2011).
The traffic flows through the toll plaza were regulated through 12 lanes, with 6 lanes allotted to traffic in each direction. Each lane of the toll plaza was regulated by workers to collect the required data for its smooth functioning. Data were collected either manually or automatically. Since traffic levels along the study stretch varied significantly during different periods within a year, the effect of seasonal variation on traffic volume cannot be neglected. In order to reduce the impact of such variations on traffic volume, care was taken to collect data for the same month of every year. Traffic data for the month of December from 2013 to 2018 were collected. The month of December was chosen for this study as the year end marks higher flows of commercial and non-commercial vehicles due to influence of festive season. Since majority of the vehicles crossing the toll consisted of vehicles from the same state, vehicle ownership of the state in which the toll was situated was individually taken into account for the study purpose. Details of the secondary data collected are given in Table 2.

Table2:Details of secondary data.

Year	GDP (in US$ Purchasing Power Parity)	Vehicle Ownership	Population
2013	5,371	7,618,245	256,727,332
2014	5,797	8,048,673	260,899,980
2015	6,255	8,547,966	264,084,796
2016	6,697	9,421,245	267,249,005
2017	7,183	10,171,813	270,391,927
2018	7,783	11,030,037	273,512,911

6. Model Development

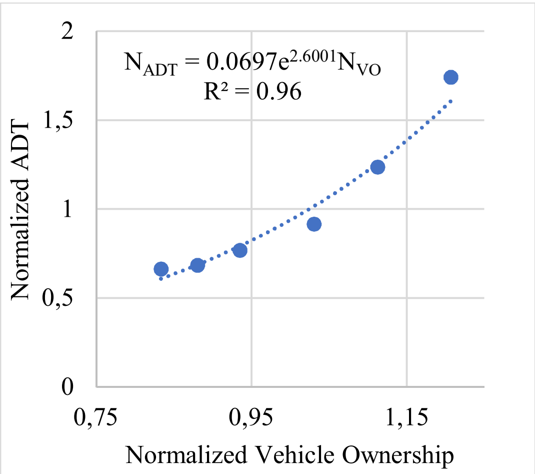
The different factors that were chosen for model development such as ADT, GDP, population of South India and vehicle ownership has different ranges varying from 4 digit numbers for GDP to 9 digit numbers for population of South India. In order to remove any bias in the model towards the variable of higher magnitude, every factor was normalized by dividing each with its corresponding average value. The generalized normalization formula used for the same is given by Equation 1.

$$\text{Normalized Data} = \frac{\text{Individual data of a particular year}}{\text{Average data of all the years considered}} \qquad (1)$$

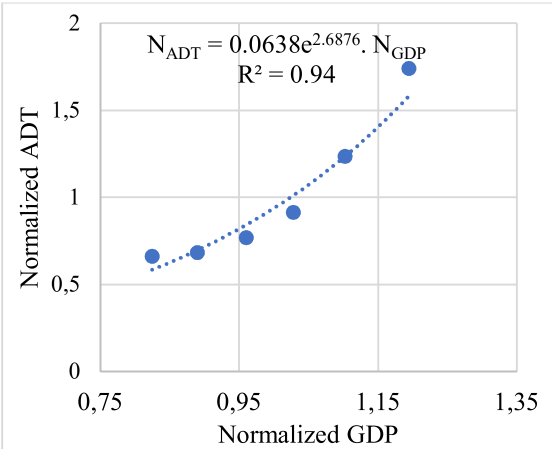
As an example, the normalized data set for the vehicle type CJV is given in Table 3. In order to visualize the general trend in the variation of dependent variable (N_{ADT}) with the explanatory variables (N_{GDP}, N_{VO}, N_P), graphs were plotted between them. Typical graphs that show such trend for the vehicle type CJV are given in Figure 2.

Table 3: Normalized data set for CJV

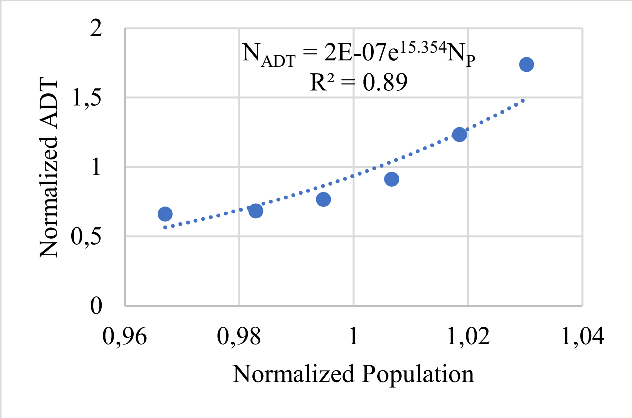
Year	Normalized ADT (N_{ADT})	Normalized GDP (N_{GDP})	Normalized Vehicle Ownership (N_{VO})	Normalized Population (N_P)
2013	0.661	0.824	0.833	0.967
2014	0.683	0.889	0.880	0.982
2015	0.767	0.960	0.935	0.994
2016	0.914	1.028	1.030	1.006
2017	1.234	1.102	1.112	1.018
2018	1.739	1.194	1.207	1.030



(a) Normalized ADT vs Normalized Vehicle Ownership



(b) Normalized ADT vs Normalized GDP



(c) Normalized ADT vs Normalized Population

Figure2:Relationship between Normalized ADT and factors influencing it

From the graphs corresponding to the vehicle type CJV, it is observed that factors such as GDP, population of South India and vehicle ownership bear exponential relationships with ADT. Similar relationships were obtained for the remaining vehicle types as well i.e. namely LCVs, Multi-Axle and BUS/TRUCK. Thus, the general expression for the ADT model is given in Equation 2.

$$N_{ADT} = e^{a_1.N_{VO}} + e^{a_2.N_{GDP}} + e^{a_3.N_P} + c_1 \qquad (2)$$

where, c_1 is a constant.

For the ease of modelling, the non-linear model presented in Equation 2 could be converted to linear form by taking natural logarithm on both sides and the relation obtained is given in Equation 3.

$$\ln(N_{ADT}) = a_1.N_{VO} + a_2.N_{GDP} + a_3.N_P + c_2 \qquad (3)$$

where, N_{ADT} - normalized ADT
N_{VO} - normalized vehicle ownership
N_{GDP} - normalized GDP
N_P - normalized population
c_2 - constant (= $\ln(c_1)$)
a_1, a_2 and a_3 are the coefficients of normalized vehicle ownership, normalized GDP and normalized population respectively.

Using the model presented in Equation 3 as the base, the model forecasting ADT in terms of individual vehicle types as well as for combined traffic were developed. The details of the models are summarized in Table 4.

Table 4:ADT models for different types of vehicles.

SI. No	Type	Model	Adjusted R^2
1	CJV	$\ln(ADT_{CJV}) = 1.758*(N_{VO}) + 5.710*(N_{GDP}) - 27.666*(N_P) + 21.497$	0.944
2	LCV	$\ln(ADT_{LCV}) = .705*(N_{VO}) + 1.198*(N_{GDP}) - 5.932*(N_P) + 4.015$	0.940
3	MULTI AXLE	$\ln(ADT_{MULTI}) = .482*(N_{VO}) + 3.395*(N_{GDP}) - 14.639*(N_P) + 10.761$	0.968
4	BUS/TRUCK	$\ln(ADT_{BUS/TRUCK}) = 0.484*(N_{VO}) + 0.920*(N_{GDP}) - 3.453*(N_P) + 2.026$	0.998
5	COMBINED	$\ln(ADT_{combined}) = 3.429*(N_{VO}) + 11.223*(N_{GDP}) - 51.752*(N_P) + 38.299$	0.930

7. Model Validation

The ADT models presented in Table 4 were developed using data collected from 2013 to 2017. The data collected for the year 2018 was kept aside for the purpose of validation. The volumes of different vehicle types in terms of ADT for 2018 were forecasted using the developed models and the forecasted ADT was then compared with the traffic data collected from the field in the same year. The result of this comparison is given in Table 5.It could be seen from Table 5 that the forecasted ADT for December 2018 using the developed models gave an error of less than 10% on comparison with the actual data collected from the field. In all of the cases, the proposed models slightly under-predict the ADT values. The total ADT values in the month of December for the years 2013 to 2018 were predicted using the developed model (combined model) and was compared with the actual ADT measured in the field. A plot between them is given in Figure 3 in which the points fall close to the 45-degree line indicating the model's accuracy in prediction.

Table 5: Comparison of model-predicted output with field data

Type	Forecasted ADT for December, 2018	Actual ADT for December, 2018	Percentage Error
CJV	22,309	22,911	-2.63 %
LCV	11,941	12,326	-3.12 %
MULTI AXLE	12,499	13,450	-7.61 %
BUS/TRUCK	8,855	9,656	-8.29 %

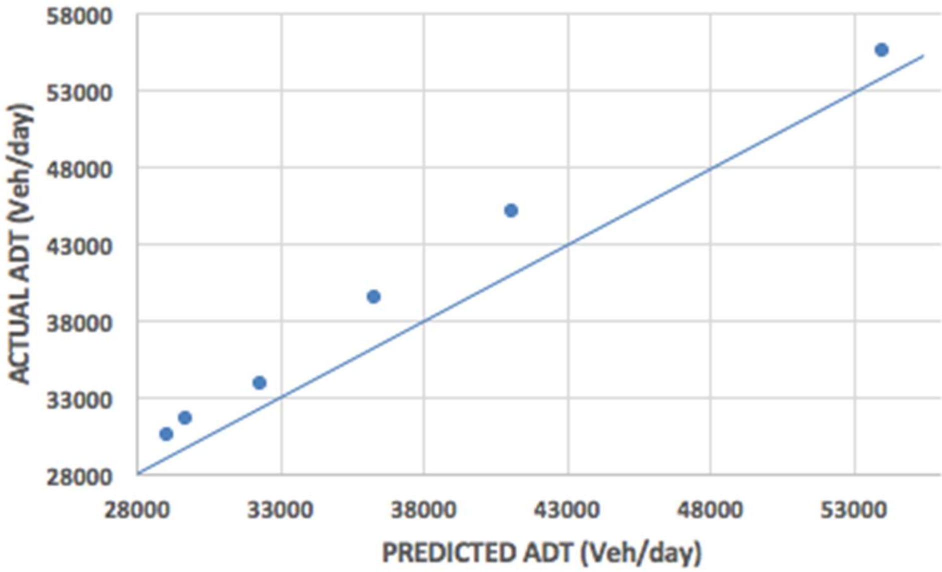


Figure3:Variation of predicted to actual ADT in the month of December for the years from 2013 to 2018.

8. Discussion

In India, guidelines for the evaluation and development of highway infrastructure are based on the norms laid down by the Indian Road Congress (IRC). IRC-108 (1996), which is used as the guideline for traffic prediction on rural highways in India, provides a geometric model for traffic forecasting based on different sets of factors. Some researchers have also tried to develop better models by including those parameters that are likely to influence traffic growth. This section compares the output of the model proposed in this study with models from previous studies.

The traffic data collected from the field in the year 2018 was used for the purpose of comparison. Different existing models and the proposed model were used to forecast the traffic (in ADT) of 2018. Since the available models do not give the forecasted traffic in terms of individual vehicle type, the proposed model for the combined traffic (given in the last row of Table4) was used for estimating the traffic of 2018.Table 6 gives the summary of the comparison along with the error in prediction for all the models considered. It could be seen that the proposed model and IRC model under-estimates traffic volume, while Jha et almodel highly over-estimates the traffic volume. Moreover, the error in prediction is lesser for the proposed model in comparison to the others, indicating that the approach proposed in this study is best suited to forecast the future traffic on Indian highways.

Table 6: Comparison of proposed model with those from similar research.

Name	Model	Forecasted traffic volume (in ADT)	Traffic volume (in ADT) from field survey	Percentage Error in prediction
Proposed Model	$\ln(ADT_{combined}) = 3.429*(N_{VO}) + 11.223*(N_{GDP}) - 51.752*(N_P) + 38.299$	530,470	555,042	-4.42 %
IRC 108-1996	$P_n = P_o(1+r)^n$	512,708	555,042	-7.62 %
Jha et al Model	$\text{Log}(T) = 2.695*\text{Log}(GNP)-7.708$	682,626	555,042	22.99 %

In the above table, P_n = Traffic in the n^{th} year, P_o = Traffic flow in the base year, r = annual rate of growth of traffic, expressed in decimals, n = number of years, T = Total vehicular population, GNP = Gross National Product (in US$), GDP = Gross Domestic Product (IN US$), P = Traffic volume.

9. Seasonal Variation

ADT refers to the average traffic volumes being estimated based on the traffic survey conducted for a short period. But within a year, traffic volumeis found to be higher than average for some part of the year and lower for some others, indicating that the traffic fluctuates a lot. This section tries to model the variation of traffic for different months of a year. For this, data were collected for few days during all the months of 2018 at the selected toll plaza. Traffic volumes were found to be higher during the starting and ending months of the year and were relatively lower during the months in the middle of the year.

The proposed model for traffic forecast was based on the data collected for the month of December for the years 2013-2017 and hence the ADT estimated by it will be for the same month. So, if the ADT for any other months needs to be estimated, then some correction factor is to be applied to the proposed model. This adjustment factor could be found by plotting the variation in the ratio of ADT for various months in a year to the ADT of December for the same year. This variation is represented in Figure 4 which shows a second-degree parabolic relationship. The ADT of any month in a particular year can be found out by multiplying the ADT of December from the combined model with the adjustment factors for the corresponding month.

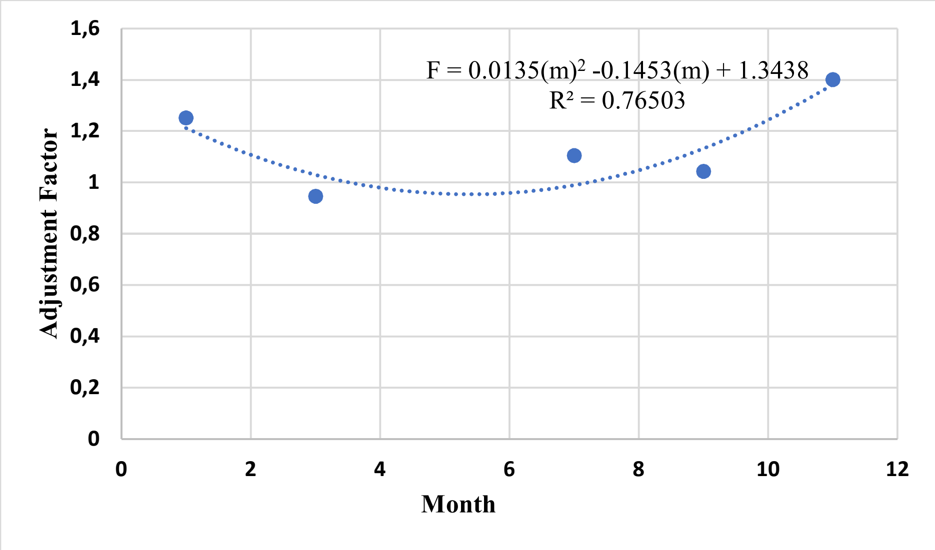


Figure4: Analysis of Seasonal Variation.

The adjustment factor for seasonal variation (F) of ADT is given by Equation 4.

$$F= 0.0135(m)^2 -0.1453(m) +1.3438 \quad (4)$$

where,*m* represents the month of the year, i.e., *m*=1 for January, 2 for February, etc.

It can be observed from Figure 4 that the developed model sometimes under predicts or over predicts the value of adjustment factor. This may be because of the fact that the values of all influencing factors were the average value of a particular year and there could be monthly variations in the values of influencing factors as well. However, such kind of data is hard to collect and hence, the proposed adjustment factor will give a reasonable estimate of ADT for a particular month.

Conclusions

Traffic growth is an important aspect for efficient planning of future road networks. Accurate estimation of traffic growth is vital for transportation planning, implementation of traffic regulations, pavement designs, environmental impact analysis, and for other highway development needs. The objective of this study was to develop traffic forecasting models in terms of individual as well as combined vehicle types namely CJV, LCV, MULTI AXLE and BUS/TRUCK in order to predict the Average Daily Traffic in the n^{th} year. Data collected from Paliyekkara toll plaza, situated in southern part of India, were used to develop relationship between traffic growth and factors influencing it. The primary data collected includes 10 days unclassified as well as classified volume count of different types of vehicles passing through the toll from the year 2013 to 2018. In order to avoid seasonal variations in ADT, data for the month of December was used for modeling purpose. Primary data from different months for the year 2013 to 2018 were also collected the variation in traffic flows during different periods within a year. The data used for the purpose of modeling future traffic also included GDP, vehicle ownership, population of Kerala, GDP in percentage, fuel sale data, student enrolment and population of South India for the above-mentioned years.

Different factors that are likely to influence traffic flow were analyzed and correlated with the traffic volume in terms of ADT. Factors which showed highest correlation with ADT were GDP, vehicle ownership and population of South India. Individual models relating each of these factors with the ADT of different types of vehicles were developed with the help of data available for the year from 2013 to 2017. The developed model was validated by comparing the forecasted traffic with the actual ADT value of 2018. The proposed model was also compared with the other traffic forecasting models available from previous research. It was found that the developed model predicted ADT values much closer to the actual ADT obtained from the site as compared to the existing models. This implies that the method proposed in this study is better suited to predict the future traffic on Indian Highways. Further, traffic data of different months for years from 2013 to 2017 were also collected to study the variation in traffic flows that occur within a year. The ADT of different months was represented as a fraction of ADT of December for that same year and this ratio was found to maintain a particular trend. This relationship could be used to deduce the correction factor which could be used to forecast the traffic volume for any month in a year.

This study proposes a methodology for that could be adopted to forecast the traffic at a particular location. This study had considered some of the main factors that influences the increase in traffic volume. Still, there are many other factors that could potentially impact the traffic growth and this could provide better models. Further, the method proposed is developed and validated based on data collected from only one location. Since the factors considered are not localized ones, the method could be check for its applicability to other highways in India and abroad. This could be considered in future researches.

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