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SCHOOL OF GRADUATE STUDIES
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Modeling and Evaluation Bicycle Level of Service for Links

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**In partial fulfillment of the requirements for the degree of
Master of Science in Civil and Environmental Engineering**

(Road and Transport Engineering)

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Abstract

In urban parts of the world, share of bicycle mode of transport is declining due to lots of difficulties and dissatisfactions. These situations make the transportation system unsustainable in the long run. In addition to this, currently, bicycle transport system has not given more attention by the transport engineers and planners to improve the facility.

These days, there is no methodology widely used by engineers and planners in Ethiopia that will allow them to determine how compatible an urban roadway for allowing efficient operation of bicycles. As efforts to make environment friendly, bicycle should have more attention towards the improvement of facilities and number of users. Therefore, lots of time and energy used to develop highly reliable Bicycle Level of Service (BLOS) model that provide the transportation professionals for a suitable technique systematically to assess the bicycle service qualities.

This particular study focuses to develop new BLOS model and evaluate the performance of the bicycle transportation along the link that can used by transportation professionals and others to evaluate the capability of specific roadways to accommodate both motorists and bicyclists. Because of the geographical nature of the area and the number of bicycle user, this research selects Bahir Dar city as case study area. Thus, all data that are collected represents the desired complexity and variability in the attributes of multilane roads in city of Bahir Dar. Those data for the model development obtained and collected from questioner, recorded videos, and actual geometrical and traffic data measurements.

This research helps in assessing the factors affecting bicycle level of service through links and evaluating a method to determine BLOS for links under heterogeneous traffic conditions. Moreover, the developed bicycle level of service model based on the users' perceptions of links. This model incorporates perceived safety, comfort, and operations of the bicycle users. A sensitivity analysis carried out to understand the effects of influencing variables on the BLOS and the study identified passenger car unit has the highest influence on BLOS.

Finally, the resulting model is highly reliable in its applications and has a high coefficient of determination value ($R^2= 0.972$) with mean observations and provides a measure of the users' perspective on how well a link's geometric and operational characteristics meets the satisfactions of the users.

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Declaration

In the under designed, hereby declare that the Dissertation entitled “**Modeling and Evaluation Bicycle Level of Service for Links**” is my thesis work submitted to Addis Ababa University. It has not presented to any other University for the award.

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Abbreviation

BLOS	Bicycle Level of Service
ADT	Average Daily Traffic
HCM	Highway Capacity Manual
Ppk	Proportion of on street- Parking
NMT	Non-Motorized Traffic
AACRA	Addis Ababa City Road Authority
PCU	Passenger Car Unit
IRC	Indian Road Congress
%HV	Percentage of Harvey Vehicle

Chapter one

Introduction

1.1 General

Bicycling is an important part of the solution to many urban transportation issues. The growing increase in motor vehicle use is burdening cities with increasing problems and costs related to congestion, accidents, loss of amenity and space, noise, poor quality of life, poor accessibility, pollution, poor urban air quality and energy consumption, having adverse effects on both the natural and built environment (McClintok, 1992;). While bicycle being the green mode of transportation offers several benefits like no fuel requirement, easy ridership, door-to-door mobility and several health-related benefits; several cities in developing countries are facing challenges to accommodate on-street bicyclists safely. Unavailability of proper bicycle facilities and the conspicuous increase in motorized traffic on congested road networks have made the bicyclists to lucidly deprive for availing a smooth riding. In urban parts of Ethiopia, bicycle mode share is declining due to lots of difficulties and dissatisfactions and this situation make the transportation system unstable in the long run.

However, bicycle concerns nearly always neglected in transportation planning, construction, management. As efforts to make more environmental friendly facilities increasing, bicycles are getting more and more attention. In developing countries like Ethiopia due to rapid growth of economy, there is high motor vehicle traffic increment and this traffic flow condition is highly heterogeneous in which small to big vehicles move on the roadways without following any lane discipline among them. As result of this, the traffic flow condition generally perceived as a frustrating riding environment. Nowadays in Ethiopia there are no researchers have taken any initiative to quantify the operational conditions of on-street bicyclists by considering different traffic flow situation, driving behavior of road users and prevailing geometric conditions.

To overcome this problem and to give comfortable service for road users, efforts needed to develop highly reliable service prediction Bicycle Level of Service model to provide the transportation planners and engineers with a suitable technique systematically to assess the bicycle service qualities. Since Bicycle Level of Service describes the operational conditions and perceived levels of satisfaction of bicyclists within its geometric and traffic flow conditions of transportation facilities. Because of the flat geographical nature of the area and

the number of bicycle user, this research selects Bahir Dar city as study area to develop a new model and determine the level of service of bicycle at each section. This model may to recognize the degree of compatibility of a roadway to accommodate both bicyclists and motorists within the mainstream traffic flow in which it helps the transportation planners and engineers on their decision.

1.2 Problem Statement

A sustainable transportation systems should be seen as an economic production and market system that requires efficiency, hence the need for reduction of the direct and indirect cost of transport and time spend during the journey. Cycling has a major role to play in any sustainable transport strategy. It helps tackle congestion and local air pollution, as well as the emissions that cause climate change. However currently in urban parts of Ethiopia specifically in Bahir Dar bicyclist ride a bicycle with lots of difficulties and dissatisfactions. Hence, the bicycle mode share is declining globally making the transportation system unsustainable in the long run.

Presently, in Ethiopia there is no methodology widely accepted by traffic engineers and transportation planners that will allow them to determine how comfortable a given roadway is for allowing efficient operation of both bicycles and motor vehicles. The complexity involved in determining the bicycle level of service are the heterogeneous characteristics of the traffic operations and variability of users as result it is a great constraints on determining how existing traffic operations and geometric conditions affect a bicyclist's decision to use or not use a specific roadway.

Current practice includes the subjective evaluation of shared roadways to determine their compatibility to bicycle use. Consistent evaluations of the roads are virtually impossible without the same people being involved in subsequent years. As a result numerical and objective evaluation tool is need in determining the need for a shared on-road bicycle facility. Very few calibrated and transferrable models exist to estimate bicycle level of service sharing specific transportation facilities with motorized vehicles. One of the most urgent needs for a bicycle level of service model is to overcome one of the current barriers to develop a sequential bicycle demand simulation or forecasting model. These needs range from bicycle planning tools such as travel demand forecasting and objective measures of the urban area's road bicycle comfort to end-user products such as priority ranking of construction projects

and bicycle (route) suitability maps. Finally, an objective tool to assist in the development of bicycle suitability road maps needed.

1.3 Objective of the Study

The main objective of this study was to develop new Bicycle Level of Service (BLOS) model and evaluate the performance of the bicycle transportation.

The specific objectives were to:

- Identify the various influencing independent variables for determining bicycle level of service.
- Identify and test the relation between various influencing variables and the extent of each variable that affects BLOS.
- Develop a new model that representing the bicycle LOS of urban roads with mixed traffic condition.
- Evaluate and determine the comfort level of each section based on new BLOS model

1.4 Organization of Report

The report organized in to five chapters. This current chapter (Chapter one) consists of the introduction, need of study, statement of the problem and challenges and treats. Chapter two contains an extensive literature review of research on existing BLOS methods. Chapter three is describing the details on methodology (objective evaluation), defining study area, method of data collection. Chapter four explores preparation and development fittings and statistical analysis of bicycle level of service model, validation and sensitivity of the model, result and discussion. Finally, Chapter five concludes the report with summary, conclusions and recommendations.

1.5 Challenges and Treats

In this study, there are many constraints to perform and prepare well-organized bicycle level of service model. Some of them are Lack of:

- Primary data like bicycle user experts
- Secondary data regarding previous traffic data (ADT), peak hour traffic, and updated total number of bicycles and motor vehicles in the cities.
- Road geometry data and road network map.

- Updated existing pavement condition survey data
- Resources (the total budget allocated to do the research)

Traffic and geometric data's are too important to achieve the objective of this thesis, it found necessary to collect this data using skilled persons. Yet, since it was not easy to get skilled workers for the task, voluntaries have trained at reasonable expense. As a result, after skillfully trained, field observations have made on the current roads of Bahir Dar city.

Chapter Two

Literature Review

2.1 General

The primary focuses of this study are to develop and calibrate a new model and to determine level-of-service of bicycle activity on multi-lane urban road links in Ethiopian Context and prioritizing bicycle lane to enhance the operational efficiency. For this model, the study area Bahir Dar selected based on selective sampling technique.

This section explores the general over view of bicycle level of service system.

2.2 Bicycle level of service based on theoretical model

Bruce W. Landis (1994) developed an Interaction Hazard score (IHS) model on the basis of the aforementioned bicyclist interaction factors and incorporating some terms from the Epperson-Davis version of the RCI model. Moreover, this study considered two new variables such as, land use intensity on roadside areas and on-street parking frequency. The disadvantage of this model was not statistically calibrated and validated.

Linda B. Dixon (1997) focused on Bicycle and Pedestrian Level-of-Service Performance Measures and Standards for Congestion Management Systems. In this study bicycle LOS evaluation criteria include the provision of basic facilities, conflicts, speed differential, motor vehicle LOS, maintenance, and provision of transportation demand management (TDM) programs or multimodal links to transit. The method used for LOS performance measures based upon a points system and the points for individual segments can summed to provide a rating for an entire corridor. The bicycle performance measures were developed to evaluate and monitor existing streets and bicycle facilities.

The limitation of this study was the model used largely in a relative sense to evaluate street corridors and not used in providing information to area bicyclists. In addition, it was not to correlate these bicycle performance measures with bicyclists' perceptions.

2.3 Bicycle level of service based on Video-Graphic and Real time Survey

David. L. et al (1987) evaluated the safety and utility of shared-use facilities to provide engineers and planners comprehensive results that can used in planning, designing, and

constructing roadways shared by motorists and bicyclists. The field data collection consisted of following traffic stream vehicles along each of the selected sites and video-taping and taking photographs of the interactions between each motor vehicle followed and any bicyclists passed along the route.

The findings also indicated that paved shoulders and bicycle lanes generally result in similar interactions between motorists and bicyclists when compared with wide curb lanes they offer some distinct advantages to both user groups.

The demerit of this study was not including other factors that affect bicycle level of service such as percentage of heavy vehicles and pavement condition. Besides to this it only considers the interaction of motor vehicles to bicyclist but perception of bicyclist have a major impact on determination of bicycle level of service.

Sorton and Walsh (1994) revealed the importance of curb-lane and developed a Bicycle Stress Level model using curb-lane traffic volume, curb-lane width and average speed of traffic in the curb-lane parameters. Their project represented the first attempt to gather perspectives from people other than research team members; thus, the results were not based solely on the subjective interpretations of researchers.

This study also used videotape to assist in this effort and was able to show that bicyclists can recognize differences in the three variables and that these differences are consistently reflected in their stress level ratings. However, no additional variables that may have an effect on the bicycle stress level were included.

The results of the analysis were statistically inconclusive, but the general patterns from the study indicated that bicyclists could recognize the variations in traffic volume, lane width, and vehicle speed that affect perceived stress. The study authors also concluded that relationships exist between a bicyclist's experience or skill level and the amount of stress perceived.

Bicycle stress levels are easy to calculate because of only three input variables, but they do not incorporate other factors hypothesized to affect bicycle suitability.

Harkey et al, (1997), explored the implementation of development of the Bicycle Compatibility Index (BCI) in five state of U.S.A. This study validated a video-based methodology using a stationary camera.

In this study, heterogeneous traffic flow considered and inventory survey used as independent variables and mean comfort rate used as dependent variable in the model building. Apart from this, video graphic technique and questionnaire survey used for the collection of perceived satisfactions of road users. The good merit of the study was used well representative video graph and rate for each section. In addition, the developed BLOS model that considered one new variable such as, interruptions from intermittent public transits (*IIPT*). The major demerit of that methodology, the participant selected for rating the comfort level was none professionals and experts in the area of the field, those participants (users) may not have enough knowledge on transportation system to give proper judgment on road and traffic conditions.

The study conclude that provision of bicycle lane by utilizing existing width of the carriageway is improving satisfaction level of bicyclists without hampering the driving quality of motor vehicles.

Based on the merits stated above video graphic rating technique is easy to collect and represent the real striation of the data. Moreover, it is very important to participate different types of individuals at a time.

Bruce W. et al and Micahel T. (1997) developed statistically calibrated bicycle level-of-service model based on real-time perceptions from bicyclists traveling in actual urban traffic and roadway conditions. It might use with caution to estimate perceptions in extreme traffic conditions where study bicyclists might refuse to participate (e.g., high-speed facilities with high-truck volumes). In addition, video camera simulation may prove to be an option, if it calibrated with real-time observations.

This study stated that stepwise regression analysis was conducted using observations from the real-time course runs by the study participants. Finally equation below is developed.

$$\text{BLOS} = a_1 \ln(\text{vol}_{15}/L) + a_2 \ln[\text{SPD}_p(1+\% \text{HV})] + a_3 \ln(\text{COM15} * \text{NCA}) + a_4 (\text{W}_e)^2 + C$$

Where:

BLOS, perceived hazarded of the shared-roadway environment,

Vol₁₅, motor vehicle volume of directional traffic in 15-min time period,

L, total number of through lanes,

SPD_p, posted speed limit (a surrogate for average running speed),

- HV, percentage of heavy vehicles (as defined in the High-way capacity Manual),
- COM15, trip generation intensity of the land use adjoining the road segment (stratified to a commercial trip generation of 15, multiplied by the percentage of the segment with adjoining commercial land development),
- NCA, effective frequency per mile of no controlled vehicular access (e.g, driveways and on-street parking spaces),
- PC₅, FHWA's 5-point pavement surface condition rating, and
- W_e, average effective width of outside through lane ($W_e = W_t + W_1 - \sum W_r$, where W_t =total width of outside lane (and shoulder) pavement, W_1 =width of paving between the outside lane stripe and the edge of pavement, and W_r =effective width (reduction) due to encroachments in the outside lane.

This study concluded that pavement-surface conditions and striping of bicycle lanes mainly effects level of service. The limitation of this study was not consider the effect caused on motor-vehicle users due to shrinkage in existing carriageway width while providing a bicycle lane.

Noël et al. (2003) developed the Compatibility of Roads for Cyclist evaluation method as bicycle network evaluation tool for Quebec, Canada. The index built on the results of a survey to evaluate a variety of rural sites by cyclists and to understand their perceptions of comfort and safety relative to different elements of bicycle routes and the characteristics of rural.

On this study cyclists were intercepted at 24 different sites and asked to rate the route they were riding. The resulting index contains rating criteria for a number of different categories related to roadway and traffic characteristics. Each category is worth a set number of points, with the total index allowing a maximum of 100 points.

2.4 Bicycle level of service based on capacity

Highway capacity manual(2010) focuses on evaluating the multimodal performance of highway and street facilities using a set of methodologies, and associated application procedures, in terms of operational measures and one or more quality-of-service indicators. Level of service model developed based on perceived safety and comfort by traveler's point of view. Also given HCM 2010 presents the best available bicycle LOS for urban streets

shared traffic environment based on a bicycle LOS score model that includes variables determined from research on bicycle riders' perceptions of LOS.

The required input data used in the model are motorized traffic volumes, traffic speeds, heavy-vehicle percentage, presence of roadside parking, and pavement quality. The frequency of unsignalized intersections and driveways between traffic signals is also a factor in the LOS score value.

According to this manual higher vehicle volumes, a greater proportion of trucks and buses, higher vehicle speeds, and presence of road side parking all act to decrease a bicyclist's perceived comfort and traffic exposure. In addition, pavement quality affects bicyclists' ride comfort: the better the pavement quality, the better the LOS. To improve bicycle LOS provide striped bicycle lanes or roadway shoulders to reduce perceived hazardous sense of adjacent traffic operation. The bicycle LOS score for the segment I_{blink} calculated by using below equation.

$$I_{\text{blink}} = C + F_w + F_v + F_s + F_p$$

Where,

$I_{\text{b,link}}$, bicycle LOS score for link,

F_w , cross-section adjustment factor,

F_v , motorized vehicle volume adjustment factor,

F_s , motorized vehicle speed adjustment factor,

F_p , pavement quality

2.5 Outcomes of Literature

- Comprehensive review of research literature on development of bicycle level of service model in different parts of the world
- Understanding various influencing factors that are used to bicycle level of service model
- Review previous and existing data collection and interpretation methodologies
- Review of data analysis and hypothesis test used for development of bicycle level of service model.
- Draws the missing in each models development; such as most models uses as the dependent variable bicyclists perception rate in which this bicyclists have only riding quality but it needs enough knowledge on transportation system to give proper judgment on road and traffic conditions. For this specific study bicyclists perception survey collected from bicycle user who are Civil Engineering or related professionals in which it gives proper judgment on road and traffic conditions.

Chapter Three

Methodology and Data Collection

3.1 General

The bicycle level of service reflects the satisfaction level of bicyclists in terms of safety and comfort based on observed geometric and operational conditions of a variety of roadways. The correlation of these comfort levels with the conditions of the roadway in the development of the BLOS model allows the user to determine bicycle LOS for roadway links by incorporating these geometric and operational characteristics into the model.

The primary goal of the this study is to develop a methodology for deriving a bicycle level of service that can be used by transportation planners, traffic engineers, and others to evaluate the capability of specific roadway links to accommodate both motorists and bicyclists. The BLOS methodology is develop for urban roadway links (i.e., midblock locations that are exclusive of intersections) and incorporated those variables that bicyclists typically use to assess the “bicycle friendliness” of a roadway (e.g., outside through lane width, traffic volume, and vehicle speeds). The tool will allow practitioners to evaluate existing facilities to determine what improvements may be required, as well as to determine the geometric and operational requirements for new facilities to achieve the desired level of bicycle service.

One of the emphases of this study is to collect road geometric and traffic flow parameters data. From the selected corridors the geometric and traffic flow parameters data is used as independent variables and perceived satisfactions of bicycle users who are Civil Engineering or related professionals were assessed through a perception survey and the data was used as dependent variable for model development.

Once the data is prepared and arranged new BLOS model development, evaluation and calibration of a model carried out.

3.2 Identification of Study Area

Even though the users have been faced many constraints in bicycling; there are a number of bike rider in the city of Bahir Dar. This study asses different researches here in Ethiopia, it is not possible to get any calibrated and transferable models that estimate bicyclist’s perceptions

of the quality of service in the on-road link cycling environments in Ethiopia metropolitan areas today. Thus, because of the geographical nature of the area and the number of Bicycle user, Bahir Dar city is the selected city in Ethiopia for this particular study. Bahir Dar is located at geographic co-ordinates of 11°36'N37°23'E. Study links are located in the city center including Giorgis road, Mulalem road, Belay Zeleke road, Arba meter road, Hailesilase road, Geter Menged road and Beg Tera road. All geometric and traffic flow data have been collected from 24 links of multi lane with 4-lane and 6-lane in urban road. Thus, all data collected will represents the desired complexity and variability in the attributes of multilane roads in city of Bahir Dar. The sites selected for this study have a variety of on-street bicycle facilities that range in road widths, traffic volumes, and motor vehicle speeds. Figure 3.1 shows location of all 24 links of the study area.



Figure 3.1: Locations of all 24 links of the study area

3.3 Methodology Used for This Study.

Research had not done yet so far for the development of appropriate BLOS model under the influence of heterogeneous traffic flow conditions in our country. However, several researchers in the world developed BLOS models under the influence of homogeneous traffic flow conditions. Many study shows that different BLOS model have been developed based on different variables.

Landis (1994): Developed an Interaction Hazard score (IHS) model that considered two new variables including land use intensity on roadside areas and on-street parking frequency.

Davis (1995): proposed a Bicycle Suitability Rating (BSR) model, which signifies important roles of traffic volume and traffic speed in perceived satisfaction levels of bicyclists.

Highway Capacity Manual (2010 HCM): considered a wide range of factors such as the effective width of outside lane, mid-segment demand flow rate, number of through lanes, traffic speed, percentage of heavy vehicles and pavement conditions in this aspect. Moreover, other various models had developed to determine the current BLOS.

According to the above studies, for this specific study seven variables including traffic volume, traffic speed, effective width of outside lane, percentage of heavy vehicles, number of access point, pavement conditions and roadside development have selected for pilot study. The overall work flow for this particular study is describe in figure 3.2 and the details narrative and analysis of the models is clarified in chapter four.

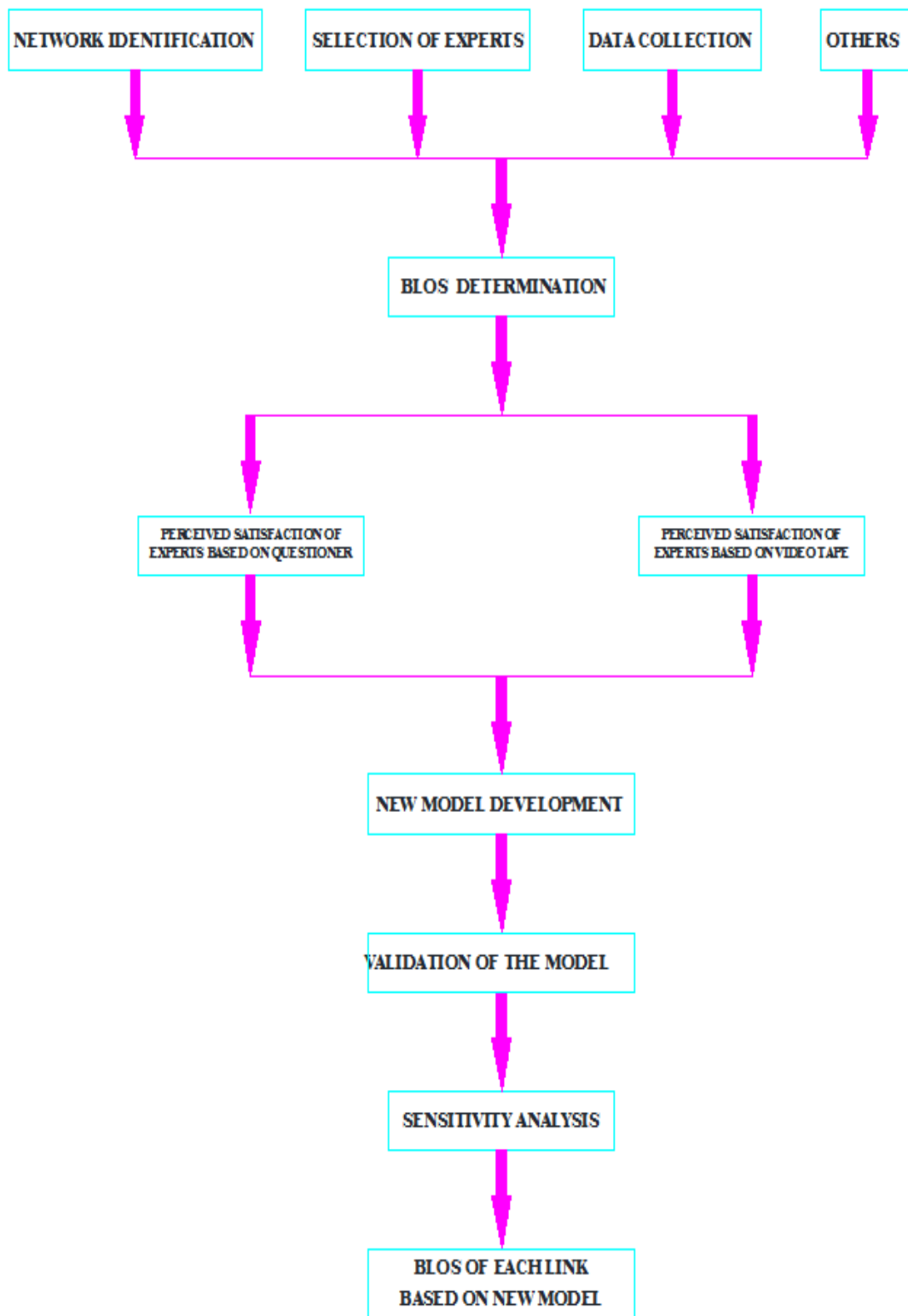


Figure 3:2 the overall work flow of the study

3.4 Data Collection

Data Collection in this study will represent the desired complexity and variability in the characteristics of multilane roads in the city of Bahir Dar. As a result, data collections for the development of the new BLOS model have been done using questionnaires, recorded videos, and actual geometrical and traffic data measurements.

3.4.1 Selection of Influencing Variables

According to the study of David L. et al, and Matthew K. (1997), the geometric elements that influence bicycle performance significantly in the shared-use roadway environment were included

- Number of lanes and directions of travel;
- Curve lane, bicycle lane, paved shoulder, parking lane, and gutter pan widths;
- Driveway density;
- Presence and type of sidewalks and medians; and
- Type of roadside development.

Bruce W. Landis (1994) selected the following relevant variables for consideration in the model-development process with respect to geometric elements, number of through lane cross-traffic generation (traffic flow turbulence), pavement surface condition, and available roadway width for bicycling.

Similarly, Haritha et al (2016), study were identified road width per direction and land-use pattern on roadside area significantly affecting the riding quality of bicyclists.

And also according to HCM 2010 the geometric elements that influence bicycle performance in the shared-use roadway environment defined as; the outside lane that serves motorized vehicles traveling along the segment, the bicycle lane adjacent to the outside lane (if used), and the outside shoulder. The outside shoulder used for on street parking. The width of each of these elements is mutually exclusive because they are adjacent (i.e., not overlapped) in the cross section. The outside lane width does not include the width of the gutter. If curb and gutter are present, then the width of the gutter is included in the shoulder width (i.e., shoulder width is measured to the curb face when a curb is present).

Other geometric element related data's that influence bicycle performance were including the number of access point, pavement condition rating and proportion of On-Street Parking Occupied.

Therefore, based on the selection of different variables on the above studies and current situation of Bahir dar city such as increasing of number motor vehicles, motor vehicle speed and on-street parking this study selects influencing variables which affects the satisfaction level of bicycle level of service. As a result, various geometric data, inventory data, traffic data and other related data have been collected and shown below sections.

3.4.2 Data Collection

Data collection is one of the methods used in this study to measure or asses all necessary field measurement and the safety and comfort level of each individual after observing the selected section of the road. One of the important criterions in such surveys is selection of participants. Most of previous studies uses as the dependent variable bicyclist's perception rate in which these bicyclists have only riding quality but it needs enough knowledge on transportation system to give proper judgment on road and traffic conditions. Due to this, for this specific study bicyclist's perception survey collected from bicycle users who are Civil Engineering or related professionals that enables proper judgment on road conditions. The Participants rated their satisfaction levels in terms of safety and comfort using a given Likert scale varies from one (users are extremely comfortable with the roadway for bicycle use) to six (users are extremely uncomfortable with the roadway for bicycle use).

Table 3:1 Comfort rate of participant scale

Scale	Comfort rate of participant
1	Extremely Comfortable or above 95% comfortable
2	Highly Comfortable or in between 75% to 95% comfortable
3	Comfortable or in between 50% to 75% comfortable
4	Less Comfortable or in between 25% to 50% uncomfortable
5	Uncomfortable or in between 5% to 25% uncomfortable
6	Extremely Uncomfortable or below 5% uncomfortable

However, before proceeding with this approach in the full-scale data collection effort and using all the variables as a final study, pilot study was been undertaken to check the consistency and reliability of a data as well to see the correlation of the dependent variables with that of independent variables. The details of the analysis of the pilot study discussed in chapter four.

3.4.3 Sampling Technique

Sampling is just a method or procedure for specifying how a sample will take from a population. In qualitative and quantitative research, most frequently used sampling techniques are purposive sampling, simple random, stratified sampling and cluster sampling. For this specific study, purposive sampling and simple random sampling techniques are used.

This study uses purposive sampling as Palys, T. describes it is particularly useful in the context of evaluation research and policy analysis, this strategy involves identifying who the major stakeholders are who are involved in designing, giving, receiving, or administering the program or service being evaluated, and who might otherwise be affected by it. Based on this, total of eight governmental offices that work on or related to transportation system are selected as the target populations of this study who are available in the study area. These selected target populations enable the study to get employees/staffs that work related to transportation system that allows getting proper judgment.

From the total of eight governmental offices selected by purposive sampling, this study uses Yamane's (1967) simplified formula to calculate sample sizes.

$$n = \frac{N}{1+N(e)^2}$$

Where:

n is the sample size,

N is the population size, and

e is the level of precision.

Based on this ‘N’ equals eight and ‘e’ equals 0.05 for 95% confidence limit, thus, using the above formula seven governmental offices are calculated. Finally, the study select a total of 60 employees who are volunteers, bicycle users and have BSc degree in Civil Engineering or related discipline. The detail number of samples and type described in table 3.2 used as dependent variable that rates their satisfaction level in terms of safety and comfort.

The sites selected for the study were located in Bahir Dar city that represent a range of road geometry and traffic conditions. Twenty-seven multi lane urban road links in the city found during field observation. Twenty-four (24) multi-lane urban road links selected using the above formula.

Table 3:2 Sample size and type for rate of peception

No	Organization Name	No of Sample	
		Male	Female
1	ANRS Road and Transport Bureau	8	2
2	Bahir Dar Institute of Technology	12	4
3	ANRS Urban and Development Office	5	1
4	Bahir Dar city Building Authority Office	6	1
5	Bahir Dar city Road Authority Office	4	2
6	Bahir Dar City Construction and House Development Branch Office	7	1
7	ANRS of urban development, housing and construction bureau	6	1
Total number		48	12

Accordingly, for final model development, self-administered questionnaire survey was prepared and, a total of sixty in total perceived ratings of 1,440 (24 links × 60 participants) who are voluntary and available Civil Engineering or related professionals bicycle users are

participated. The gender distributions of participants were 12 (20%) women and 48 (80%) men in total people.

3.4.3.1 Geometric Data

Geometric data are collected during inventory survey on multi-lane of 4-lane and 6-lane urban road segments including number of lanes, width of road way in one direction, width of outside lane, width of paved shoulder, width of sidewalk, width of median, width of gutter pan, width of bicycle lane, length of link, road side development, and surface type. The details of the data showed in tables below.

Table 3:3 Coordinate points of the study links

S.no	Link Name	Coordinates of starting and end points		Remark	
		X	Y		
1	From St Georgis to Papyrus hotel	324232.92	1282222.9	Start	Link one
		324230.5	1281486.1	End	
2	From Papyrus to Azewa hotel	324211.4	1281466.9	Start	Link two
		323901.17	1281471.4	End	
3	From Azewa hotel to Meskel square	323876.44	1281485.3	Start	Link three
		323881.13	1281922	End	
4	From Meskel square to Ghion hotel	323880.23	1281940	Start	Link four
		323981.43	1282421.6	End	
5	From Ghion hotel to Felegehiwot School	323968.56	1282470.1	Start	Link five
		322273.11	1282833.6	End	
6	From Felegehiwot School to ARTB	322205.37	1282813.9	Start	Link six
		321501.63	1282681.5	End	
7	From St Georgis to ARSO	324275.17	1282240.7	Start	Link seven
		324821.03	1282236.4	End	
8	From Papyrus hotel to Bahir Dar university main office	324272.72	1281450.8	Start	Link eight
		324991.11	1281442.5	End	
9	From Bahir Dar university main office to Poli Campus	325039.88	1282220.9	Start	Link nine
		325033.11	1281481.5	End	
10	From Benmas hotel to Noc oil	322863.98	1281218.1	Start	Link ten

		323820.61	1281472.4	End	
11	From Noc oil to Azewa hotel	322018.51	1281193.6	Start	Link eleven
		322015.36	1280721.8	End	
12	From Benmas hotel to Kidanemihiret church	322074.82	1280694.8	Start	Link twelve
		322777.11	1280690.8	End	
13	From Kidanemihiret church to AWWE	324228.83	1281426.3	Start	Link thirteen
		324224.07	1280714.9	End	
14	From AWWE to Noc oil	324273.05	1280680.9	Start	Link fourteen
		324993.31	1280670.8	End	
15	From Beg tera to Papyrus hotel	325067.73	1281460.4	Start	Link fifteen
		325767.35	1281447.6	End	
16	From Beg tera to Peda campus	325803.87	1282236.6	Start	Link sixteen
		325061.07	1282240.8	End	
17	From Bahir Dar university main office to Peda campus	325815.12	1281486.2	Start	Link seventeen
		325824.18	1282222.3	End	
18	From Bahir Dar university main office to Garment campus	325823.41	1282259.8	Start	Link eighteen
		325836.32	1283206.3	End	
19	From Garment enterprise to Poli Campus	322806.11	1281889.1	Start	Link nineteen
		322806.42	1282794.4	End	
20	From Garment campus to Garment enterprise	322854.46	1280693.9	Start	Link twenty
		324188.69	1280681.2	End	
21	From Garment enterprise to Abay mado	322056.49	1281220.3	Start	Link twenty one
		322766.78	1281219	End	
22	From Noc oil to Belay Zeleke	322808.02	1281172.4	Start	Link twenty two
		322806.14	1280710.7	End	
23	From Belay Zeleke to Stadium	325030.73	1281410.9	Start	Link twenty three
		325026.13	1280688.3	End	
24	From AWWE to Beg tera	322807.45	1281238	Start	Link twenty four
		322810.59	1281862.4	End	

Table 3:4 Summary of Inventory data

S.no	Link Name	Length of Link(m)	Width of roadway (m)	Width of Outside through lane (m)	Width of paved outside shoulder(m)	Width of bicycle lane(m)	Width of gutter pan	Width of median	Number of lane per direction
1	LINK ONE	723.7	9	3.5	2	0	0.4	2.0	2
2	LINK TWO	310.2	10	3.5	3	0	0.4	3	2
3	LINK THREE	436.7	9	3.5	2	0	0.4	6.5	2
4	LINK FOUR	492.1	9	3.5	2	0	0.4	6.5	2
5	LINK FIVE	1182.3	9	3.5	2	0	0.4	2.5	2
6	LINK SIX	716.1	9	3.5	2	0	0.4	2.5	2
7	LINK SEVEN	545.9	9	3.5	2	0	0.4	2.5	2
8	LINK EIGHT	718.4	10	3.5	3	0	0.4	2.5	2
9	LINK NINE	739.3	9	3.5	2	0	0.4	2	2
10	LINK TEN	989.9	13	3.5	2.5	0	0.4	3	3
11	LINK ELEVEN	471.9	9	3.5	2	0	0.4	2	2
12	LINK TWELVE	702.3	9	3.5	2	0	0.4	3	2

13	LINK THIRTEEN	711.4	9	3.5	2	0	0.4	2.5	2
14	LINK FOURTEEN	720.3	9	3.5	2	0	0.4	3	2
15	LINK FIFTEEN	699.6	13	3.5	2.5	0	0.4	3	3
16	LINK SIXTEEN	742.8	9	3.5	2	0	0.4	3	2
17	LINK SEVENTEEN	736.1	13	3.5	2.5	0	0.4	3	3
18	LINK EIGHTEEN	946.6	13	3.5	2.5	0	0.4	2.5	3
19	LINK NINETEEN	905.4	9	3.5	2	0	0.4	2	2
20	LINK TWENTY	1337	10	3.5	3	0	0.4	2.5	2
21	LINK TWENTY ONE	710.3	10	3.5	3	0	0.4	2.5	2
22	LINK TWENTY TWO	461.6	9	3.5	2	0	0.4	2.5	2
23	LINK TWENTY THREE	722.6	13	3.5	2.5	0	0.4	3	3
24	LINK TWENTY FOUR	624.4	9	3.5	2	0	0.4	2	2

3.4.3.2 Roadside Development

According to Badir Dar integrated development plan Bahir Dar city centre is dominantly a commercial district with a diverse land use characters. In the vicinity are located the city market, the bus terminal, financial institutions, hotels, and offices. In addition to these, areas for recreation, worship, and administration, including the office of the municipality found within this central district. Land uses such as residential and storage found here in a mixed manner.

This study collect roadside development data like a study conducted by Haritha et al (2016) in India, which has similar land use characteristics. Thus, commercial activities on roadside areas were rated on a 3-point scale where 1 represents high commercial activities, 0.5 represents medium commercial activities, and 0 represents minimal commercial activities. The roadside development categorized as high commercial area when the total length of the link covered with only commercial activities. Besides to this, the roadside development classified as medium commercial area when the total length of the link are cover with both commercial and non-commercial activities. On the other hand, when there is no commercial activity along the total length of the link, therefore, the roadside development classified as non-commercial area.

Table 3:5 Roadside development data

No	Link name	Roadside development
1	LINK ONE	1.0
2	LINK TWO	1.0
3	LINK THREE	1.0
4	LINK FOUR	0.5
5	LINK FIVE	0.0
6	LINK SIX	0.0
7	LINK SEVEN	1.0
8	LINK EIGHT	1.0
9	LINK NINE	0.0
10	LINK TEN	0.5
11	LINK ELEVEN	0.5

12	LINK TWELVE	0.0
13	LINK THIRTEEN	0.0
14	LINK FOURTEEN	0.0
15	LINK FIFTEEN	0.0
16	LINK SIXTEEN	0.0
17	LINK SEVENTEEN	0.0
18	LINK EIGHTEEN	0.5
19	LINK NINETEEN	0.0
20	LINK TWENTY	0.5
21	LINK TWENTY-ONE	0.5
22	LINK TWENTY-TWO	1.0
23	LINK TWENTY-THREE	0.0
24	LINK TWENTY-FOUR	0.5

3.4.3.3 Proportion of On-Street Parking

Proportion of On-Street Parking (Ppk) occupied is one of the important variable that will be used for model development and this variables represent the proportion of the segment's right-hand curb line on which parked vehicles are present during the analysis period.

Based on HCM 2010 manual, this study collects On-Street Parking data for during the analysis period in between access point on the specified links. In addition, the Proportion of On-Street Parking (Ppk) computed as the sum of the curb-line lengths occupied by parked vehicles divided by the link length. If parking is not allowed on the segment, then the proportion equals 0.0. If parking is allowed along the segment but the spaces are not used during the analysis period, then the proportion equals 0.0. If parking is allowed along the full length of the segment but only one-half of the spaces are occupied during the analysis period, then the proportion equals 0.50.

The number of access point along a link represents the count of un-signalized public street approaches to the segment. The details of the data described in table 3.6.

Table 3:6 Access and parking length of the study area

No	Link Name	Link Length	Access Length							Total Length of parking(m)	Number of Access points
			Starting to 1	1 to 2	2 to 3	3 to 4	4 to 5				
1	LINK ONE	723.7	Access Length	84.7	97	60.4	96.4	385.2		4	
			Parking Length	5	85	50	80	55	275		
2	LINK TWO	310.4	Access Length	84.9	75.9	110.9	38.7			3	
			Parking Length	5.0	15	90.0	5		115		
3	LINK THREE	436.7	Access Length	238.8	197.9					1	
			Parking Length	40	20				60.0		
4	LINK FOUR	492.1	Access Length	197.4	67.5	197.6	29.6			3	
			Parking Length	20.0	10	20	5		55.0		
5	LINK FIVE	1182.3	Access Length	There is no access point in between						0	
			Parking Length	15					15		
6	LINK SIX	716.1	Access Length	156.6	267.2	292.3				2	
			Parking Length	50.0	0	15			65.0		
7	LINK SEVEN	545.9	Access Length	197.5	230.6	117.8				2	

			Parking Length	60.0	100	25		185	
8	LINK EIGHT	718.4	Access Length	74.1	278.3	366.0			2
			Parking Length	5.0	50	75		130.0	
9	LINK NINE	739.4	Access Length	174.0	315.1	132.1	118.2		3
			Parking Length	10.0	20	10	10	50.0	
10	LINK TEN	989.9	Access Length	534.7	267.9	105.4	82.0		3
			Parking Length	40.0	40	90	10	180.0	
11	LINK ELEVEN	471.9	Access Length	120.2	275.9	75.8			2
			Parking Length	25.0	40	5		70.0	
12	LINK TWELVE	702.3	Access Length	98.67	162.0	107.3	292.1	42.2	4
			Parking Length	10	8	17	5	0	
13	LINK THIRTEEN	711.4	Access Length	215.0	340	156.4			2
			Parking Length	10.0	30	25		65.0	
14	LINK FOURTEEN	720.3	Access Length	171.4	182.4	164.8	201.7		3
			Parking Length	5	15	10	25	55.0	
15	LINK FIFTEEN	699.7	Access Length	100	45				1
			Parking Length	268.0	128			145.0	
16	LINK SIXTEEN	742.8	Access Length	492.4	160.9	32.1	57.4		3

			Parking Length	10	5	0	5		20	
17	LINK SEVENTEEN	736.2	Access Length	70.6	73.14	168.9	160.4	223.0		4
			Parking Length	0	10	15	40	25	90	
18	LINK EIGHTEEN	946.6	Access Length	645.3	175.1	126.1				2
			Parking Length	65.0	45	55			165.0	
19	LINK NINETEEN	905.4	Access Length	600.8	121.2	59.1	124.4			3
			Parking Length	20.0	5	0	20		45.0	
20	LINK TWENTY	1337	Access Length	280.2	797.1	260				2
			Parking Length	25	200	25			250	
21	LINK TWENTY ONE	710.3	Access Length	285.5	163.6	261.2				2
			Parking Length	90	20	30			140.0	
22	LINK TWENTY TWO	461.6	Access Length	99.9	104.8	151.3	105.5			3
			Parking Length	25.0	45	25	10		105.0	
23	LINK TWENTY THREE	722.6	Access Length	543.4	179.2					1
			Parking Length	10.0	10				20.0	
24	LINK TWENTY FOUR	624.4	Access Length					246.9		4
				125.1	153.1	49.2	50.1			
			Parking Length	0.0	10	5	5	25	45	

3.4.3.4 Traffic Data

A) Traffic volume count

A typical traffic stream on all categories of roads in Bahir Dar, comprise of both Motorized (MT) as well Non-Motorized (NMT) vehicles. According to HCM (2010) the analysis period is in the range of 0.25 to 1h based on the assumption that traffic conditions are steady during the analysis period (i.e., systematic change over time is negligible). For this reason, in this study, fifteen-minute traffic data have used to reflect the worst conditions.

In order to encompass a good image about the traffic flow condition, repeated visual visits taken. From these repeated visual visit and pilot road traffic surveys taken for expected peak periods of traffic flow (i.e. from 8:30 to 10:30 AM and from 4:30 to 6:30 PM) on randomly selected five representative links a decision on the peak flow period time is arrived. Thus, the study determines peak hour traffic from 5:00 to 6:00 PM and finds the peak fifteen-minute from 5:45 to 6:00 PM.

Based on this and according to AACRA 2003 manual vehicle classification the traffic volume counted separately for all 24 links as shown in table 3.7.

Table 3:7 AACRA 2003 manual vehicle classifications

Class	Motorized Vehicle Type	Axles	Description	Non -motorized Vehicle Type
1	Motor cycle	-	Motor cycle and Tri Motor cycle (Bajaj)	Bicycle
2	Cars	2	Cars, Utility, Minibus and 4WD	
3	Light	2	Bus and 1Axle truck	
4	Medium	3	2 rear axle truck	
5	Heavy	4	4 axle truck	

(Source: AACRA 2003 manual)

For analysis, this mixed traffic must convert into passenger cars unit (PCU). This PCU value is depends on the characteristics of vehicle, traffic stream, roadway, environment and control

and climatic conditions. However, there is inadequate research that specifies PCU values of in Ethiopia. Therefore, for this particular study, Indian Road Congress (IRC-106, 1990) for urban roads in plain areas under heterogeneous traffic flow conditions were used to convert the traffic flow volume to equivalent PCUs/h. See table 3.8 IRC PCU value.

Table 3:8 PCU values recommended by the Indian Road Congress (IRC)

Vehicle Type	Equivalent Passenger Car Unit Factors
Bicycle	0.4
Motor cycle and Tri Motor cycle (Bajaj)	0.5
Cars, Utility, Minibus and 4WD	1.0
Truck or Bus	2.2

For this study, the Peak 15 minute numbers of passenger car unit for each links for all 24 links shown in the Table 3.9.

3.4.3.5 Percent of Heavy Vehicles

A heavy vehicle defined as any vehicle with more than four tires touching the pavement. The percentage of heavy vehicles represents the count of heavy vehicles that arrive during the analysis period divided by the total vehicle count for the same period.

In this study, the summarized vehicular composition, their volume traffic count and percentage of heavy vehicle tabulated in table 3.9.

Table 3:9 Traffic count and percentage of heavy vehicle

Link Name	Vehicle Classification and their Peak 15 minute traffic volume (from 5:45 to 6:00 PM (Through movement))						Total Peak 15 minute number of passenger car unit	Percentage of Heavy Vehicles (%HV)
	Bicycle	Motor cycle and Tri cycle (Bajaj)	Cars(Util ity, minibus and 4WD)	Light(bus)	Mediu m	Heavy		
Link 1	41	265	162	30	26	0	439	11
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 2	39	220	124	40	30	3	411	16
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 3	24	88	100	15	1	1	191	7.5
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 4	15	95	65	0	5	0	130	2.8
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 5	28	100	67	4	3	0	144	3.5
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 6	55	73	78	3	7	0	159	4.5
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 7	22	159	199	23	9	1	360	8
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 8	22	172	55	9	5	0	181	5.5
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 9	8	35	54	0	0	0	75	0
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 10	7	189	179	45	7	0	391	12

PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 11	6	85	66	3	0	0	118	2
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 12	19	115	25	2	0	0	94	1.1
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 13	33	171	54	6	5	0	177	4
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 14	18	76	62	2	3	0	119	3.2
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 15	18	90	77	3	3	0	142	3
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 16	1	37	66		1	0		
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 17	6	29	80	1	1	0	102	1.8
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 18	22	87	103	6	5	4	188	6.5
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 19	31	109	48	3	2	0	125	2.5
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 20	10	61	149	9	6	4	226	8
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 21	10	63	138	10	6	2	211	8
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 22	39	219	77	20	10	5	280	9.5
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 23	35	120	35	2	1	0	115	1.5
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		
Link 24	14	101	52	4	1	0	120	3
PCU value	0.4	0.5	1.0	2.2	2.2	2.2		

3.4.3.6 Motor Vehicle Speed

The other important traffic flow parameter that influence bicycle performance was motor vehicle speed. This speed measured using spot speed measurement of travel times as vehicles traverse thirty meter measured distance at the location of mid-block of each link and calculated by dividing the length with that of travel time. Alternatively, we can use the posted speed as shown in figure 3.3. For this study, the 85th percentile spot speeds used because it gives a general description of motor vehicle speeds. The 85th percentile motor vehicle speeds of most vehicles at each link have computed and ranges from 25 km/h up to 60 km/hr and the details shown in the Appendix B.

Table 3:10 Sample 85th percentile motor vehicle speed at St. Georgis to Papirus hotel

From St Georgis to Papirus hotel	Vehicle Type										
	Tri-cycle (Bajaj)				Cars, Utility, Minibus and 4WD				Bus and One Axle truck		Remark
No. of Vehicles	1	2	3	4	1	2	3	4	1	2	
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	4.32	4.15	4.32	4.5	4.9	5.14	4.7	4.5	5.14	5.27	
Speed(km/hr)	25	26	25	24	22	21	23	24	21	20.5	
85th Percentile speed of each vehicle type(km/hr)	25.55				23.55				20.93		
85th Percentile speed of all vehicles(Km/hr)	25										



Figure 3:3 Posted speed photo taken from study site at St. Georgis to Papirus hotel

Chapter Four

Analysis, Results and Discussion

4.1 General

Bicycle level of service model is a tool that will allow practitioners to evaluate existing facilities based on several factors to determine what improvements may be required, as well as to determine the geometric and operational requirements for new facilities to achieve the desired level of bicycle service. In this study, expert's perception surveys on several geometric and operational traffic factors are used, based on subjective rating. Moreover, the main aim of this study was to develop a methodology for deriving a bicycle level of service that could use by transportation planners, traffic engineers, and others to evaluate the capability of specific roadways link to accommodate both motorists and bicyclists.

Nowadays there are a lot of statistical analysis software's for the development of an equation but for this specific study uses SPSS, Statistical Package, version 17.0 which is a powerful, user-friendly software for the manipulation and statistical analysis of data. SPSS software used to determine the correlation, the reliability, and significance of each variable and used to carry out regression BLOS model with the help of influencing factors. The model was developed using randomly selected 70% data sets (around 17 links) and rest 30% data (about 7 links) were kept reserved for model validation. In these chapter, preparation and development fittings and statistical analysis of bicycle level of service model, validation and sensitivity of the model, intermediate results such as graphical representation, tabular data and preparation using GIS layers presented and thoroughly discussed.

4.1.1 BLOS Model Development

This study sought to develop mathematically express BLOS model, for urban road links by considering the existing roadway and traffic conditions that affect bicycle users, or level of accommodation in shared traffic environment. The analysis process in developing the preliminary model carried out the following steps:

- Identify relevant independent variables affecting bicycle level of service,

- Develop combined or transformed model using relevant independent variables and mean rating for each roadway links (across subjects) as the response variable in step-wise regression.
- Test the significance of independent variable coefficients in developed models for the best configuration of each variable (or combinations or transformed thereof), and establish the coefficients for the variables (or combinations or transformed thereof) that result in the best-fit regression model.

4.1.1.1 Identification of Independent Variables

Based on the study of Bruce W. Landis (1994) and Haritha et al(2016), a comprehensive, Pearson's correlation analysis of the final data was carried out over a wide range of road attributes collected from the study corridors to identify the influencing variables. Accordingly, this study carried out a pilot study to select the influencing independent variables.

On this pilot study, twenty bicycle users who are Civil Engineering or related professionals participated. The gender distributions of participants were 5 (25%) women and 15 (75%) men in total people. Each participant asked a short question about the satisfaction level after finishing his or her course of ride. The Participants rated their satisfaction levels in terms of safety and comfort using a given Likert scale varies from one (users are extremely comfortable with the roadway for bicycle use) to six (users are extremely uncomfortable with the roadway for bicycle use).

In view of the above, all necessary independent variable data have been collected in five (5) randomly selected links for the pilot study; the perceived satisfactions of users on twenty participants rate which represent an extensive range of combinations of variables assessed and summarized in table 4.1 and its Pearson correlation is shown in table 4.2 too.

Table 4:1 Summary of Pilot Data

Link name	Road width	Peak 15 minute number of passenger car unit	effective width of the outside through lane(m)	Roadside Development	85th Speed of motor vehicles(km/hr)	Pavement Condition	Number of side street along the link	percent of heavy vehicle/15-minute	mean rate
From St Georgis to Papyrus hotel	9	395	3.3	1	28	5	4	7	3.8
From Papyrus to Azewa hotel	10	310	4	1	30	4	2	11	3.7
From peda main gate to Garment campus	9	145	4.5	1	45	5	1	4.5	30
From Garment enterprise to Poli Campus	9	120	4.8	0	55	5	2	2.5	2.3
From AWWE to Beg tera	9	275	3.5	1	35	5	2	6	3.7

Table 4:2 Correlations of variables and statistical test results

Dependent Variables		Independent Variables						
		Peak 15 minute number of passenger car unit	effective width of the outside through lane(m)	Roadside Development	85th Speed of motor vehicles(km/hr)	Pavement Condition	Number of side street along the link	percent of heavy vehicle/15-minute
Mean Comfort Rate of participants	Pearson Correlation	0.897**	-0.900**	0.901**	-0.979**	-0.308**	0.470**	0.766**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.002	0.001	0.000

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

The participants rated their satisfaction levels in terms of safety and comfort using a given Likert scale varies from one (users are extremely comfortable with the roadway for bicycle use) to six

(users are extremely uncomfortable with the roadway for bicycle use). These indicates that participant rate increased when their satisfaction level decreased.

Accordingly from the above table,

1) The correlation between number of passenger car (PCU) and percentage of heavy vehicles with a mean comfort rate have a value of 0.897 and 0.766 respectively. The result shows positive excellent correlation. The increasing number of passenger car and percentage of heavy vehicle increase the mean comfort rate value indicates decreased level of comfort for the bicyclist.

2) The correlation between speeds of motor vehicle with a mean comfort rate has a value of -0.979. The result shows negative excellent correlation. On the other hand, the increasing of speed of motor vehicle decrease the mean comfort rate value that indicates it increases level of comfort for the bicyclist.

3) The correlation between effective outside through lane width with a mean comfort rate have a value of -0.900 which is good negative correlation. Increasing the effective outside through lane width reduces the mean comfort rate value, indicating an increased level of comfort for the bicyclist.

4) The correlation between roadside developments with a mean comfort rate has of 0.901 which is positive good correlation with mean rate of comfort. The presences of commercial development along the roadside increase the mean comfort rate value, indicating decrease level of comfort for the bicyclist.

5) The correlation between numbers of side street along the link with a mean comfort rate has of 0.470 which is below average positive correlation with mean rate of comfort. The increasing of numbers of side street along the link increase the mean comfort rate value, indicating decrease level of comfort for the bicyclist.

6) The correlation between pavement condition with a mean comfort rate has a value of -0.308 which is below average negative correlation. Increasing the pavement condition index reduces the mean comfort rate value, indicating an increased level of comfort for the bicyclist.

After performing Pearson's correlation analysis over a wide range of road attributes, most of the independent variables, (From peak hour peak fifteen minute number of passenger car unit, effective width of the outside through lane, roadside development, 85th speed of motor vehicles, percent of heavy vehicle/15-minute) have high correlation value with that of dependent variables at a significance level of 0.01.

The rest two (Pavement Condition and Number of side street along the link) number of variables are less correlated and not significant.

The overall R^2 value of the above data have **1.00** and the details is attached in appendix-E

Based on the above pilot study results, this particular study selected five independent variables having good correlation with dependent variables for final study.

Based on their Pearson correlation significance value ($p < 0.001$) the influencing independent variables used for this study are:

- Total road width in one direction;
- Outside through lane, paved shoulder, parking lane, and gutter pan widths;
- Passenger car unit (PCU) during peak fifteen minute of the day;
- 85th percentile speed of motor vehicle;
- Curb-line length occupied by parked vehicles on the roadway during study period and
- Type of roadside development.

4.1.1.2 Video Graphic Survey

Several previous studies like Landis et al. (1997) and Jensen (2007) use video graphic survey to obtain the perspectives of bicyclists(road users) in which participants view numerous roadway links captured on videotape and rate these segments with respect to how comfortable they would be riding there under the geometric and operational conditions shown. Video graphic survey were shown a representative video clip from each link illustrating a variety of conditions including lane configuration, shoulder configuration, average traffic volume and speed, heavy vehicle presence, presence of curb, gutter pan, median facilities and land use.

However, before proceeding with this approach in the full-scale data collection effort, pilot study was been undertaken for validating the video technique rating that is, determining how well the

participants' comfort ratings of various geometric, traffic volume, and speed conditions recorded when watching a videotape compared with the participants' comfort ratings after finishing his or her course of ride.

During the survey session, the five prepared videotapes projected on a wide screen, and the volume of speakers adjusted to replicate the real traffic sound. In this way, a simulated environment created, and each participant developed a feeling as if riding a bicycle on the shown a link.

The participants rated their satisfaction levels in terms of safety and comfort for each of the five locations while watching the video containing 40-second clips from each site and while finishing his or her course of ride. The participants spent 3-5 minutes and rated five videos. The rating was obtained based on Participants had roughly 10–15 second between successive video clips and observation to make their perceived ratings. Finally, by counting the number of matching of rate by participants using video and observation, thus the study have result 72% of the participants' video ratings matched reasonably well to the field ratings for all variables examined. The details of the data showed in below table 4.3.

Table 4:3 Rating of participants using video graphic and field survey

Link Name	Comfort Rate by Observation	Comfort Rate by Video	Mean Comfort Rate by Obs.	Mean Comfort Rate by Video	Exact comfort Rate Match	Different by one rate	Different by two rate
Link One	5	5	4.1	3.8	0		
Link One	3	5	4.1	3.8			2
Link One	4	3	4.1	3.8		1	
Link One	5	5	4.1	3.8	0		
Link One	4	4	4.1	3.8	0		
Link One	3	3	4.1	3.8	0		
Link One	3	3	4.1	3.8	0		
Link One	4	4	4.1	3.8	0		
Link One	5	3	4.1	3.8			2
Link One	4	4	4.1	3.8	0		
Link One	5	5	4.1	3.8	0		
Link One	4	4	4.1	3.8	0		

Link One	4	3	4.1	3.8		1	
Link One	5	5	4.1	3.8	0		
Link One	4	4	4.1	3.8	0		
Link One	4	4	4.1	3.8	0		
Link One	5	3	4.1	3.8			2
Link One	4	4	4.1	3.8	0		
Link One	4	2	4.1	3.8			2
Link One	3	3	4.1	3.8	0		
Link Two	3	4	3.85	3.7		1	
Link Two	4	3	3.85	3.7		1	
Link Two	5	5	3.85	3.7	0		
Link Two	3	3	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	5	4	3.85	3.7	0		
Link Two	3	3	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	3	3	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	5	5	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	5	3	3.85	3.7			2
Link Two	3	3	3.85	3.7	0		
Link Two	3	3	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	3	4	3.85	3.7		1	
Link Two	4	3	3.85	3.7		1	
Link Three	3	3	3.2	3	0		
Link Three	2	3	3.2	3		1	
Link Three	4	3	3.2	3		1	
Link Three	5	5	3.2	3	0		
Link Three	2	2	3.2	3	0		
Link Three	4	4	3.2	3	0		
Link Three	4	4	3.2	3	0		
Link Three	3	2	3.2	3		1	

Link Three	3	3	3.2	3	0		
Link Three	2	2	3.2	3	0		
Link Three	3	3	3.2	3	0		
Link Three	4	4	3.2	3	0		
Link Three	3	2	3.2	3		1	
Link Three	3	3	3.2	3	0		
Link Three	3	3	3.2	3	0		
Link Three	3	2	3.2	3		1	
Link Three	4	4	3.2	3	0		
Link Three	3	3	3.2	3	0		
Link Three	4	2	3.2	3			2
Link Three	2	3	3.2	3		1	
Link Four	3	3	2.2	2.3	0		
Link Four	1	1	2.2	2.3	0		
Link Four	2	2	2.2	2.3	0		
Link Four	3	1	2.2	2.3			2
Link Four	2	2	2.2	2.3	0		
Link Four	1	3	2.2	2.3			2
Link Four	1	1	2.2	2.3	0		
Link Four	2	2	2.2	2.3	0		
Link Four	2	3	2.2	2.3		1	
Link Four	3	3	2.2	2.3	0		
Link Four	3	3	2.2	2.3	0		
Link Four	1	3	2.2	2.3			2
Link Four	2	2	2.2	2.3	0		
Link Four	3	3	2.2	2.3	0		
Link Four	2	2	2.2	2.3	0		
Link Four	3	3	2.2	2.3	0		
Link Four	2	2	2.2	2.3	0		
Link Four	3	3	2.2	2.3	0		
Link Four	2	2	2.2	2.3	0		
Link Four	3	3	2.2	2.3	0		
Link Four	2	2	2.2	2.3	0		
Link Four	3	2	2.2	2.3		1	
Link Five	4	4	3.8	3.7	0		
Link Five	2	4	3.8	3.7			2
Link Five	3	3	3.8	3.7	0		
Link Five	4	4	3.8	3.7	0		

Link Five	4	3	3.8	3.7		1	
Link Five	3	3	3.8	3.7	0		
Link Five	4	3	3.8	3.7		1	
Link Five	4	4	3.8	3.7	0		
Link Five	3	3	3.8	3.7	0		
Link Five	4	3	3.8	3.7		1	
Link Five	5	5	3.8	3.7	0		
Link Five	4	4	3.8	3.7	0		
Link Five	3	3	3.8	3.7	0		
Link Five	4	4	3.8	3.7	0		
Link Five	5	5	3.8	3.7	0		
Link Five	3	3	3.8	3.7	0		
Link Five	5	5	3.8	3.7	0		
Link Five	5	4	3.8	3.7		1	
Link Five	4	4	3.8	3.7	0		
Link Five	3	3	3.8	3.7	0		
Percentage of rate of comfort match					72%	18%	10%

Generally, this study concluded that the video rating methodology are a valid technique for obtaining realistic perspectives of bicyclists as related to their comfort levels under varying roadway conditions for the pilot study.

Accordingly, for final study, the twenty-four prepared videotapes projected on a wide screen, and the participants spent 20-24 minutes and rated 24 videos. The rating was obtained based on Participants had roughly 15–20 second between successive video clips to make their perceived ratings.

4.1.1.3 Effective Road width

One of the major factor that affect the shared traffic environment and influencing variables for BLOS model is a roadway width. Thus to provide safe and comfortable shared traffic movement for both motorized and non-motorized (Bicycle) available roadway width must be identified and measured. Fortunately due to their low speed and safety aspect the majority of bicycle users use outside through lane and shoulder for through flow in shared traffic environment. Due to this the existence of on- street parking, width of outside through lane and shoulder may reduce. For this,

reason bicycle users forced to change their lane and merge with motorized vehicles in which it affects comfort and safety of bicyclists because of different driving behavior nature. By considering, proportion of on street parking the outside through lane and shoulder width should adjusted to find the effective outside through lane.

Thus, for this study the adjusted effective outside through lane of each link calculated using 2010 HCM exhibit 17-21 and the details presented table 4.4.

Table 4:4 HCM exhibit 2010

No.	Condition	Variable when condition is satisfied	Variable when condition is not satisfied
1	$P_{pk}=0.0$	$W_t=W_{ol}+W_{bl}+W_{os}$	$W_t=W_{ol}+W_{bl}$
2	$V_m>160\text{veh/h}$ or street is divided	$W_v=W_t$	$W_v=W_t(2-0.005 V_m)$
3	$W_{bl}+W_{os}^*<4.0\text{ft}$	$W_e= W_v -10*P_{pk}>0.0$	$W_e= W_v +W_{bl}+W_{os}^*-20*P_{pk}>0.0$

Source: (HCM 2000 exhibit 17-21)

Where:

W_t , total width of the outside through lane, bicycle lane, and paved shoulder

W_{ol} , width of outside through lane

W_{os}^* , adjusted width of paved outside shoulder;

if curb is present $W_{os}^* = W_{os} - 1.5 > 0.0$, otherwise $W_{os}^* = W_{os}$ (ft);

W_{os} , width of paved outside shoulder (ft);

W_{bl} , width of bicycle lane = 0.0 if bicycle lane not provided (ft);

W_v , effective total width of outside through lane, bicycle lane, and shoulder as a function of traffic volume (ft);

p_{pk} , proportion of on-street parking occupied (decimal);

V_m , mid segment demand flow rate (veh/h)

However, to figure out the effective width of outside through lane, first the proportion of On-Street Parking must computed and identify whether the variables condition satisfied or not.

4.1.1.4 Proportion of On-Street Parking

Proportion of On-Street Parking (Ppk) occupied is one of the important variable that will used for estimating the effective width of the outside through lane and this variables represents the proportion of the segment's right-hand curb line on which parked vehicles are present during the analysis period.

Based on the data presented in table 4.5, the proportion of On-Street Parking Occupied (Ppk) computed by sum of the curb-line lengths occupied by parked vehicles divided by the link length. If vehicle parking along the link not allowed the value of Ppk equals zero.

$$Ppk = \frac{\sum_{n=1}^{\infty}(CL)}{L} \text{-----eqn.1}$$

Where:

CL=Sum of the curb-line lengths occupied by parked vehicles

L= Total link length

Using the above formula the proportion of On-Street Parking Occupied (Ppk) value of all links computed.

The step of computation of Ppk of link 1 shown below and other link values of Ppk tabulated in table 4.5. Based on table 4.5 the Sum of curb-line length occupied by parked vehicles of link 1 is =275meter and its total Link length=723.7meter.

Therefore using equation 1 the value of Ppk of link 1 0.38.

That is, the result of link one is $Ppk = \frac{275}{723.7} = 0.38$

Table 4:5 Geometry data and its results for proportioning of On-Street Parking

No	Link name	Link length (m)	Curb-line length occupied	Ppk
1	LINK ONE	723.70	275.00	0.38
2	LINK TWO	310.40	115.00	0.37
3	LINK THREE	436.70	60.00	0.14
4	LINK FOUR	492.10	55.00	0.11
5	LINK FIVE	1182.30	15.00	0.01
6	LINK SIX	716.10	65.00	0.09
7	LINK SEVEN	545.90	185.00	0.34
8	LINK EIGHT	718.40	130.00	0.22
9	LINK NINE	739.40	50.00	0.07
10	LINK TEN	989.90	180.00	0.18
11	LINK ELEVEN	471.90	70.0	0.10
12	LINK TWELVE	702.30	95.0	0.14
13	LINK THIRTEEN	711.40	65.00	0.09
14	LINK FOURTEEN	720.30	55.00	0.08
15	LINK FIFTEEN	699.70	145.00	0.20
16	LINK SIXTEEN	742.80	20.00	0.03
17	LINK SEVENTEEN	736.20	90.00	0.12
18	LINK EIGHTEEN	946.60	165.00	0.17
19	LINK NINETEEN	905.40	45.00	0.05
20	LINK TWENTY	1337.00	250.00	0.19
21	LINK TWENTY-ONE	710.30	140.00	0.20
22	LINK TWENTY-TWO	461.60	105.00	0.23
23	LINK TWENTY-THREE	722.60	20.00	0.03
24	LINK TWENTY-FOUR	624.40	45.00	0.07

As it shown in table 4.5 and once the value of Ppk and its condition of satisfaction is determined, the step to compute of the effective width of outside through lane of link 1 is shown below and other value of effective road width with the same procedure of link 1 are tabulated in table 4.5.

As it indicated in table 4.5, the value of Ppk of link 1 is 0.38, which is different from zero, and the street divided. This value indicates the second condition is satisfied for the above particular link. Therefore to compute the value of effective road width the following steps have done.

First Step:- calculate effective total width of outside through lane, bicycle lane, and shoulder as a function of traffic volume and median type.

$$W_t = W_{ol} + W_{bl},$$

Where:

W_t = total width of the outside through lane, bicycle lane, and paved shoulder

W_{ol} = width of outside through lane

W_{bl} = width of bicycle lane = 0.0 if bicycle lane not provided (ft);

As it is shown in the table 4.2 $W_{ol} = 11.5$ ft and $W_{bl} = 0$ ft of link 1

From this the value of total width $W_t = 11.5 \text{ ft} + 0 = 11.5 \text{ ft}$

Second Step: calculate effective outside through lane width as a function of Ppk. since summation of $W_{bl} + W_{os}^* < 4$ ft for all data in this study condition three of (HCM exhibit 17-21) satisfied to compute the value of **We**.

Where:

W_{os}^* , adjusted width of paved outside shoulder; if curb is present $W_{os}^* = W_{os} - 1.5 > 0.0$, otherwise $W_{os}^* = W_{os}$ (ft); curb is present in link one.

But the value of $W_{os}^* = W_{os} - 1.5 > 0.0$. Since from table 4.5 the value of $W_{os} = 6.7$

$W_{os}^* = 6.7 - 1.5 = 5.2 \text{ ft}$ which is greater than 0 and this shows the condition is satisfied

Therefore, $W_{bl} + W_{os}^*$ is 5.2ft which is not less than 4ft the formulation of **We** on Variable when condition is not satisfied is selected.

That is **We** = $W_{ol} + W_{bl} + W_{os}^* - 20 * Ppk$

In the above example link (link1) the value of $W_{ol} = 11.5\text{ft}$, $W_{bl} = 0$, $W_{os}^* = 5.2\text{ft}$ and $P_{pk}=0.38$

Using the above data the value of $W_e=9.1\text{ft}$ which is equal to $=2.8\text{m}$.

The procedure of link 1 is applied to all links and the results of all links W_e are summarized in table 4.6.

Table 4:6 Effective outside through lane width

No	Link name	Ppk	Wol	Wos	Wbl	We
1	LINK ONE	0.38	3.5	2	0	2.8
2	LINK TWO	0.37	3.5	3	0	3.8
3	LINK THREE	0.14	3.5	2	0	4.2
4	LINK FOUR	0.11	3.5	2	0	4.4
5	LINK FIVE	0.01	3.5	2	0	5.0
6	LINK SIX	0.09	3.5	2	0	4.5
7	LINK SEVEN	0.34	3.5	2	0	3.0
8	LINK EIGHT	0.22	3.5	3	0	4.9
9	LINK NINE	0.07	3.5	2	0	4.6
10	LINK TEN	0.2	3.5	3	0	4.8
11	LINK ELEVEN	0.18	3.5	3	0	4.9
12	LINK TWELVE	0.1	3.5	2	0	4.4
13	LINK THIRTEEN	0.14	3.5	2	0	4.2
14	LINK FOURTEEN	0.23	3.5	2	0	3.7
15	LINK FIFTEEN	0.09	3.5	2	0	4.5
16	LINK SIXTEEN	0.08	3.5	2	0	4.6
17	LINK SEVENTEEN	0.03	3.5	2	0	4.9
18	LINK EIGHTEEN	0.2	3.5	3	0	4.8
19	LINK NINETEEN	0.03	3.5	2	0	4.9
20	LINK TWENTY	0.12	3.5	2.5	0	4.8
21	LINK TWENTY-ONE	0.17	3.5	2.5	0	4.5
22	LINK TWENTY-TWO	0.07	3.5	2	0	4.6
23	LINK TWENTY-THREE	0.05	3.5	2	0	4.8
24	LINK TWENTY-FOUR	0.19	3.5	2	0	4.9

4.1.2 Model Parameters, Fittings and Statistical Analysis

In the previous chapter, the preliminary procedure for developing BLOS is the identification of influencing independent variables based on running pilot study. Once afterwards selecting the relevant independent variables and perceived satisfaction of users as dependent variables, a step-wise regression analysis carried out.

Generally, the overall analysis carried out in this particular study following three steps.

1. Check all tests(correlation, significance level, R^2 value etc...) of independent variables
2. Development of several combined or transformed forms of important road attributes and employed in the step-wise regression analysis to test the significance of their coefficients in developed models.
3. Most suitable BLOS model satisfying several significance criteria selected.

4.1.3 Performance, Tests and Quality of the Data

After collecting and analyzing a wide range of independent variable data the performance, tests and quality of a data have been interpreted in terms of several statistical parameters such as: a Pearson correlation, level of significance, reliability etc. For doing the above test, the study uses the overall data including Effective width and summarized in table 4.7.

Table 4:7 Summarized selected seventeen Link data's

No.	Link Name	Independent Variables						Dependent Variable
		Road width (m)	PCU (veh./15min)	Effective width(m)	Speed (km/hr)	% HV	Roadside development	Mean Comfort Rate
1	LINK ONE	9	439	2.8	25	11	1	4.7
2	LINK TWO	10	411	3.8	28	16	1	4.5
3	LINK THREE	9	191	4.2	42	7.5	1	3.1
4	LINK FIVE	9	144	5	52	3.5	0	3.0
5	LINK SIX	9	159	4.5	50	4.5	0	3.1

6	LINK SEVEN	9	360	3	30	8	1	4.2
7	LINK EIGHT	10	181	4.9	48	5.5	1	3.0
8	LINK NINE	9	75	4.6	60	0	0	1.5
9	LINK ELEVEN	9	118	4.4	54	2	0.5	2.3
10	LINK THIRTEEN	9	177	4.5	50	4	0	3.0
11	LINK FIFTEEN	10	142	4.8	52	3	0	2.8
12	LINK SIXTEEN	9	88	4.9	60	1	0	1.6
13	LINK EIGHTEEN	13	188	4.5	45	6.5	0.5	2.9
14	LINK NINETEEN	9	125	4.8	54	2.5	0	2.3
15	LINK TWENTY-ONE	10	211	4.8	40	8	0.5	3.1
16	LINK TWENTY-TWO	9	288	3.7	35	9.5	1	3.9
17	LINK TWENTY-THREE	9	115	4.9	55	1.5	0	2.1

Based on the above table the correlation between the perceived satisfaction of the rate of the users (dependent variable) and independent variables have done in table 4.8.

Table 4:8 Correlations of dependent variables with independent variables and statistical test results

Dependent Variables		Independent Variables				
		number of passenger car unit peak volume/15 minute	effective width of the outside through lane	85th percentile speed of motor vehicles	Roadside Development	% of Heavy vehicle/peak 15 minute
Mean Comfort Rate of participants	Pearson Correlation	0.952**	-0.792**	-0.958**	0.735**	0.906**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000

** Correlation is significant at the 0.01 level (2- tailed)

The participants rated their satisfaction levels in terms of safety and comfort using a given Likert scale varies from one (users are extremely comfortable with the roadway for bicycle use) to six

(users are extremely uncomfortable with the roadway for bicycle use). These indicates that participant rate increased when their satisfaction level decreased.

Accordingly from the above table,

1) The correlation between number of passenger car (PCU) and percentage of heavy vehicles with a mean comfort rate have a value of 0.952 and 0.906 respectively. The result shows positive excellent correlation. The increasing number of passenger car and percentage of heavy vehicle increase the mean comfort rate value indicates decreased level of comfort for the bicyclist.

2) The correlation between speeds of motor vehicle with a mean comfort rate has a value of -0.958. The result shows negative excellent correlation. On the other hand, the increasing of speed of motor vehicle decrease the mean comfort rate value that indicates it increases level of comfort for the bicyclist.

3) The correlation between effective outside through lane width with a mean comfort rate have a value of -0.792 which is good negative correlation. Increasing the effective outside through lane width reduces the mean comfort rate value, indicating an increased level of comfort for the bicyclist.

4) The correlation between roadside developments with a mean comfort rate has of 0.735 which is positive good correlation with mean rate of comfort. The presences of commercial development along the roadside increase the mean comfort rate value, indicating decrease level of comfort for the bicyclist.

5) All variables are significant at the level 0.01 ($p < 0.001$) based on Pearson's correlation.

For developing the most suitable model, several combined or transformed forms of step-wise regression analysis for each variable was carried out to select best-fit linear function. Thus, as it is shown in table 4.9 based on the value of R^2 best-fit function is selected for each independent variable.

Table 4:9 Type of correlation between mean comfort rate and variables

Variables	Type of Correlation between mean comfort rate and variables							
	Linear (R ²)	Std. error	Logarithmic (R ²)	Std. error	Exponential (R ²)	Std. error	Power (R ²)	Std. error
Passenger car unit(PCU)	0.937	0.824	0.965	0.609	0.919	0.325	0.962	0.223
Effective width of outside through lane (We)	0.850	1.267	0.870	1.180	0.855	0.437	0.873	0.408
% of heavy vehicles	0.857	1.237	-----	-----	0.844	0.452	-----	-----
85 th percentile speed of motor vehicles	0.770	1.570	0.887	1.103	0.773	0.546	0.878	0.386
Roadside development	0.674	1.871	-----	-----	0.661	0.667	-----	-----

Mean comfort rate of Experts

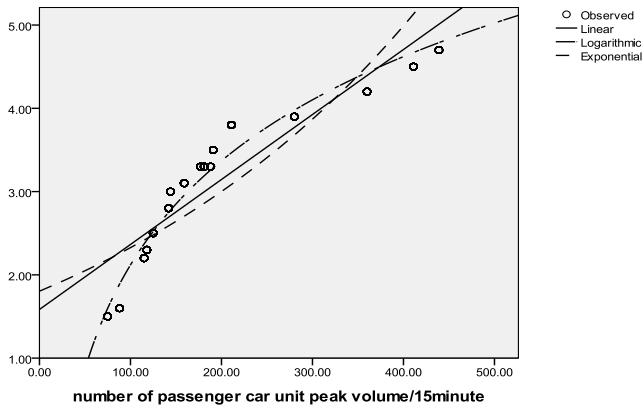


Figure 4:1 Correlation b/n mean comfort rate and We

Mean comfort rate of Experts

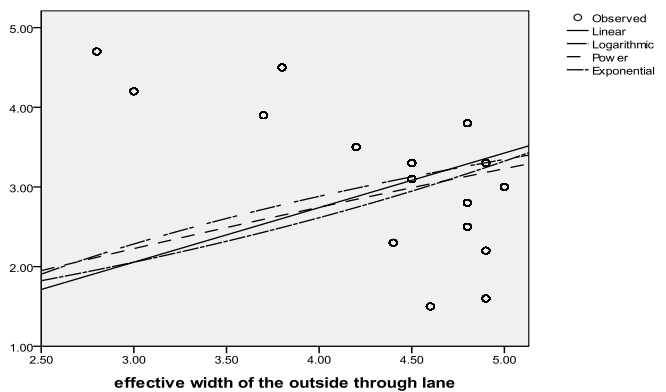


Figure 4:2 Correlation b/n mean comfort rate and PCU

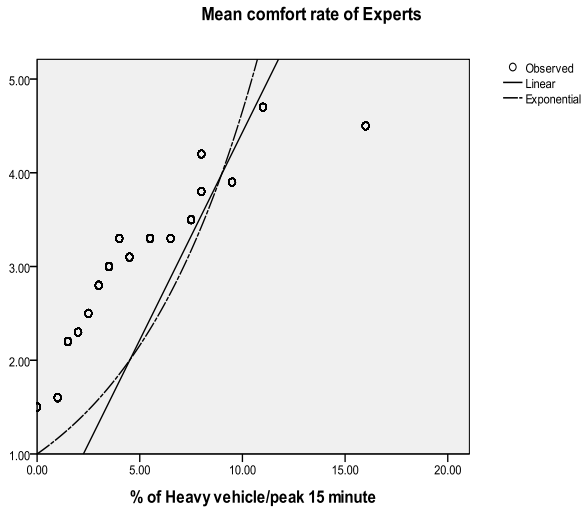


Figure 4:3 Correlation b/n mean comfort rate and %HV

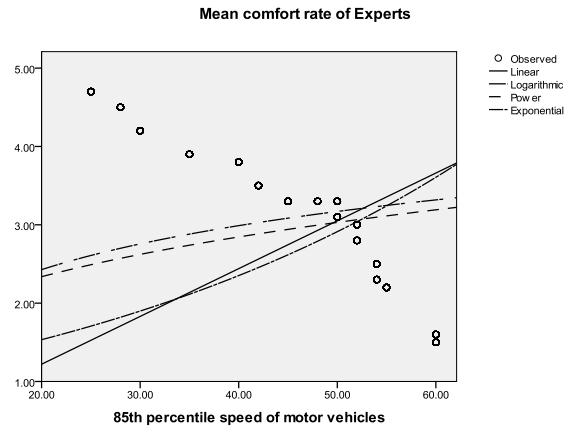


Figure 4:4 Correlation b/n mean comfort rate and Speed

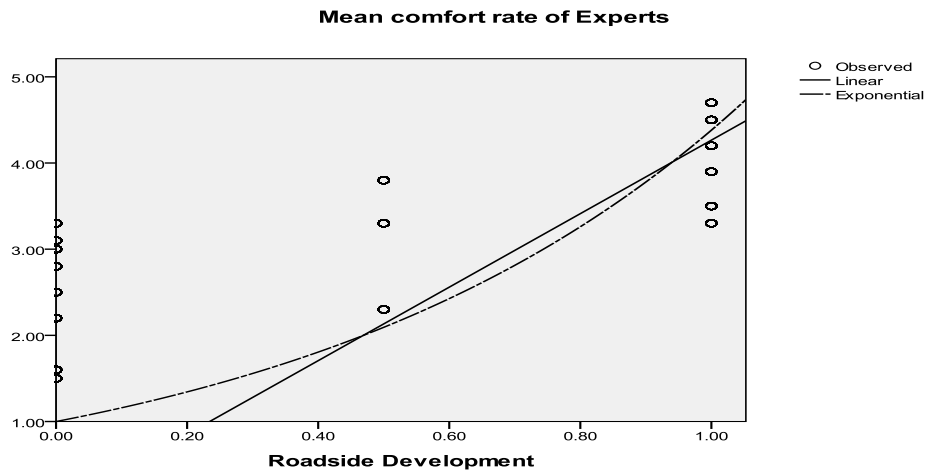


Figure 4:5 Correlation between mean comfort rate and roadside development

As shown in the above table and figures the best-fit functions selected based on best R^2 value and confer below

- 1) The number of passenger car unit and speed of motor vehicles have best R^2 (0.967) value in a logarithmic functions.
- 2) Effective outside through lane width have best R^2 (0.887) value in a power function.
- 3) Speed of motor vehicle have best R^2 (0.887) value in a logarithmic functions.
- 4) Since, the percentage HV and roadside development have high possibility to be zero (0) value, no possibility to transform these variables in to logarithmic and a power function because it

makes undefined. Therefore based on the table 4.6 those variables have a best value of R^2 (0.857, 0.674) respectively in a linear function.

4.1.4 Model Formulation

After analyzing, testing, checking combined or transformed all the influencing variables the first hypotheses of the Bicycle level of service (BLOS) model expression have been developed and showed below.

$$\text{BLOS} = a_1 * f(X_1) + a_2 * f(X_2) + a_3 * f(X_3) + a_4 * f(X_4) + \dots + a_n * f(X_n)$$

Where:

BLOS, Bicycle Level of Service Score which is dependent variable (output)

$X_1, X_2, X_3, X_4, \dots, X_n$, independent variables which can be an individual, combination of two or more or transformed form (input data)

$a_1, a_2, a_3, a_4, \dots, a_n$, Estimated coefficients of independent variables

The above hypothesis was developed by step-wise regression analysis using randomly selected 70% data sets; in total perceived rating of 1,020 (17 links*60 experts). The rest 30% of the data sets 420 (7 links *60 experts) from the total perceived rating were kept reserved for model validation.

Based on review of previous study and established best-fit function recommended in the previous section with a mean comfort rate, a step-wise several regression analyses have carried out using SPSS software and the coefficients of each sub-function is determined and summarized in table 4.10.

Table 4:10 Coefficients of variables and statistical test results

Variables	Coefficient	t-statistic	p-value
$\ln(\text{PCU}_{15}/\text{RW})$	1.402	39.749	0.000
$\ln(\text{speed} * (1 + \% \text{HV}))$	0.424	18.976	0.000
We	-0.179	-8.699	0.000

(1+RD)	-0.186	-10.321	0.000
Constant	-2.369	-20.920	0.000

From the above table:

1) the coefficient of the function of $\ln(PCU_{15}/RW)$ and $\ln(\text{speed}*(1+\%HV))$ are positive; which means the comfort level is high when those variable is decreasing and vice versa.

2) The coefficient of the function of We and $(1+RD)$ are negative; which means the comfort level is high when those variable is increasing and vice versa.

Based on the above table (coefficients of each variable function) and the hypothesis developed above, the general BLOS model developed and presented below.

$$\text{BLOS} = 1.402 * \ln(PCU_{15}/RW) + 0.424 * \ln(\text{speed} * (1 + \%HV)) - 0.179 * We - 0.186(1 + RD) - 2.369$$

This model have an R^2 value of 0.972 with high significant level ($P < 0.01$).

Where, BLOS, Bicycle level of service score of shared-roadway environment

RW, Road width in one direction (m)

PCU, Number of passenger car unit in 15 minute time period (PCU/15 minute)

Speed, 85th percentile speed of motor vehicles (km/hr)

HV, Percentage of heavy vehicles

We, Effective outside through lane width (m)

RD, Road side development on roadside area

4.1.5 BLOS Model Validation

The preliminary model was validated using 30% of total data sets, which is 420 (7 links *60 experts) perceived satisfaction of the rate. Those were reserved for validation purpose and not used in model building.

The following process under taken in validating the model:

- (a) Calculate the observed mean comfort rate of each link,
- (b) Estimate the predicted BLOS using the developed preliminary model in section 4.4

(c) Test for the best-fit regression by plotting observed perceived mean rate of comfort and predicted BLOS score.

Accordingly using the new developed model, the value of predicted BLOS of the selected seven sections computed and shown in table 4.11.

This is an example the way to compute the predicted value of BLOS of link 4 (the data for each variable taken from table 4.11).

$$\text{BLOS} = 1.402 \cdot \ln(\text{PCU}_{15}/\text{RW}) + 0.424 \cdot \ln(\text{speed} \cdot (1 + \% \text{HV})) - 0.179 \cdot \text{We} - 0.186(1 + \text{RD}) - 2.369$$

$$\text{BLOS} = 1.402 \cdot \ln(130/9) + 0.424 \cdot \ln((42 \cdot (1 + 2.8)) - 0.179 \cdot 4.4 - 0.186(1 + 0.5) - 2.369$$

BLOS of link 4 = 2.46

Table 4:11 Model validation data

No	Link Name	Road width (m)	PCU (Veh./15minute)	Effective width(m)	Speed (km/hr)	%HV	Road side Development	Mean Rate	BLOS Predicted
1	LINK FOUR	9	130	4.4	42	2.8	0.5	2.60	2.46
2	LINK TEN	10	391	4.9	30	12	0.5	3.90	4.14
3	LINK TWELVE	9	94	4.2	55	1.1	0.0	1.80	2.00
4	LINK FOURTEEN	9	119	4.6	50	3.2	0.0	2.40	2.51
5	LINK SEVENTEEN	13	102	4.8	55	1.8	0.0	1.90	1.61
6	LINK TWENTY	10	226	4.9	40	8	0.5	3.80	3.34
7	LINK TWENTYFOUR	9	120	4.6	48	3	0.5	2.20	2.39

After determination of observed mean rate of comfort and predicted BLOS score; the model validation graph were plotted by considering observed perceived mean rate of comfort of experts BLOS scores obtained represented as X-axis and predicted BLOS scores represented as Y-axis. As it shown in figure 4.6, the graph has high correlation R^2 value of 0.899. Therefore, from these observations one can concludes the above model significantly satisfies the required criteria of model validation.

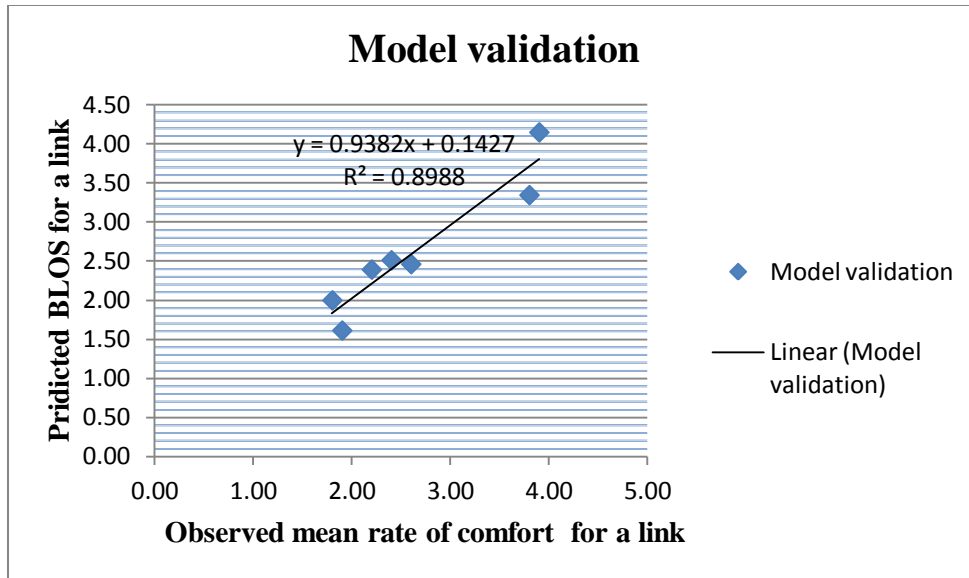


Figure 4:6 Regression plot for Bicycle level of service (BLOS) model validation

4.1.6 Sensitivity Analysis

For better understand the effects that changes in the variables within the model building sensitivity analysis was carried out using Equations 3a and 3b (Gandomi et al. 2003).

$$S_i = \frac{N_i}{\sum_{i=1}^n N_i} * 100 \text{-----} 3a$$

$$N_i = f_{\max}(x_i) - f_{\min}(x_i) \text{-----} 3b$$

Where:

S_i = is the sensitivity of i^{th} variable calculated in percentage;

N_i = difference between maximum value ' $f_{\max}(x_i)$ ' and minimum value ' $f_{\min}(x_i)$ ' of the predicted BLOS score over i^{th} input variable, those were calculated by putting the maximum and/or minimum values of i^{th} input variable and mean values of each remaining inputs in developed BLOS model ' $f(x)$ '; and n is the number of input variables.

Based on the above equations S_i (%) values are estimated for each input variable and ranked in Table 4.12.

Table 4:12 Effects of Variable Changes within the BLOS Model

Variables	Road width	PCU	Effective width	Speed	%HV	Roadside Development
S _i (%)	-17.51	83.50	-13.13	12.79	41	-6.40
Rank	3	1	4	5	2	6

As it is observed in the above table the variables with the largest effect on the BLOS score are the peak fifteen minute traffic volume (PCU) and percentage of heavy vehicles; the peak fifteen minute traffic volume (PCU) and percentage of heavy vehicles increased the BLOS score by 124.5 %, indicating an reduces level of comfort for the bicyclist. Increasing the effective width in terms of the bicycle lane, paved shoulder, or the outside through lane also reduces the BLOS score, as does the presence of on-street parking with also increases the index. On the other hand, an increase in motor vehicle speeds (SPD) increases the BLOS score, indicating a lower level of comfort for the bicyclist.

4.1.7 Bicycle Level of Service Designation

Once the BLOS model was developed and BLOS scores obtained, bicycle level of service criteria were stratified based on the results of applying the model to the sites included in this study. To remain consistent with the Highway Capacity Manual, six LOS designations (A through F) defined.

The distribution of overall mean comfort level ratings (averaged across all subjects) by site were first examined. The mean perceived rating obtained in this study is around 3.00, which corresponds to the LOS class ‘C’. The site with the lowest rating produced a mean of 1.50; the site with the highest rating resulted in a mean of 4.70. With this in mind, the extreme values noted above (1.50 and 4.70) are represents the point at which virtually all bicyclists feel comfortable riding and the point at which virtually no bicyclists feel comfortable riding under a given set of roadway conditions respectively. The conditions included in this study rated by the participants included a broad range of conditions. According to the study of David L.et al, this study determine between these extremes, percentiles along the line can then be selected and used to represent the break points between the various LOS designations as shown in the figure 4.7.

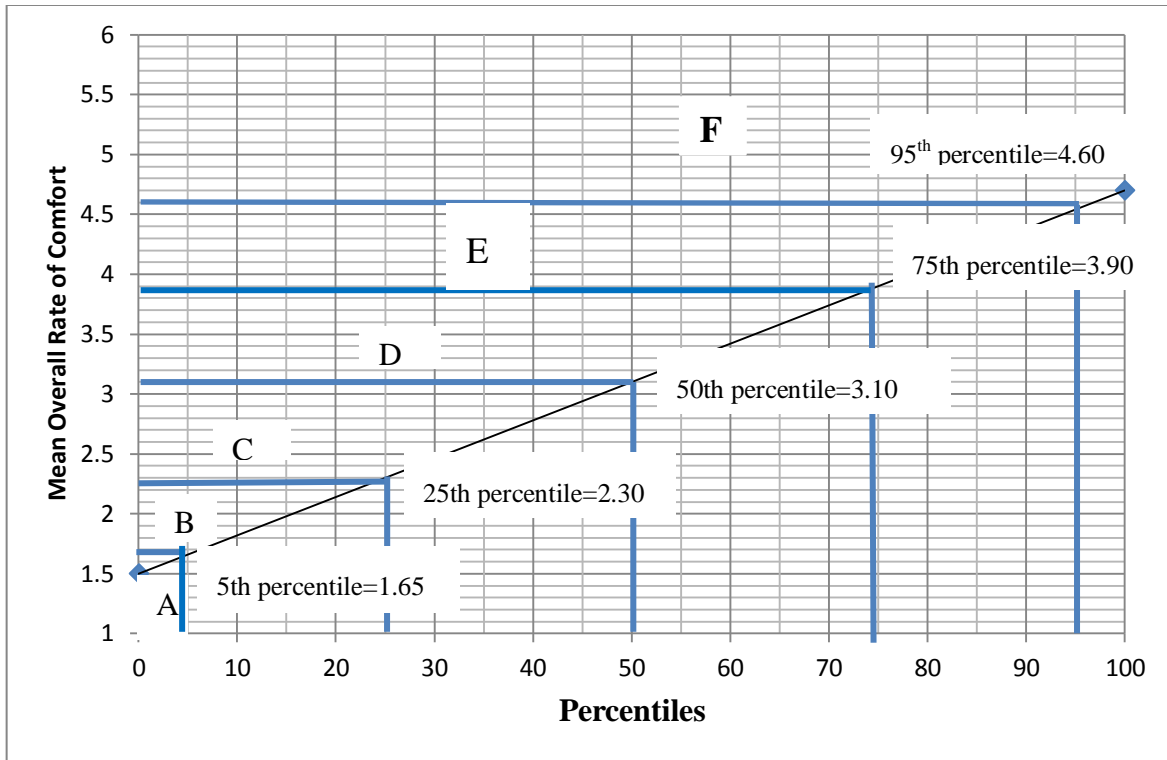


Figure 4:7 Distribution of BLOS scores used in establishing level of service designations

The 50th percentile along the line corresponds to a mean overall rating of 3.10. Since there are six levels of service (A through F), the rating corresponding to the 50th percentile (3.10) selected as the break point in the middle of the scale between LOS C and LOS D (see table 4.13). The break points between the other levels selected to reflect a slightly greater concentration of scores surrounding the 50th percentile and a very low concentration at the extremes. Extending 25 percent from either side of the 50th percentile results in a 75th percentile along the line corresponding to a mean overall rating of 3.90 and a 25th percentile corresponding to a value of 2.30. These values selected as the breakpoints between LOS D and LOS E, and LOS C and LOS B, respectively.

To define the breakpoint between LOS E and LOS F, the 95th percentile selected. From figure 4.7, this percentile corresponds to the mean overall rating of 4.60. On the other end of the scale, the 5th percentile was selected as the breakpoint between LOS A and LOS B, equivalent to a mean overall rating of 1.65.

Table 4:13 BLOS Ranges Associated with Level of Service Designation

BLOS	BLOS Range	Comfort Level
A	<1.65	Extremely Comfortable
B	1.66 - 2.30	Highly Comfortable
C	2.31 -3.10	Comfortable
D	3.11 -3.90	Less Comfortable
E	3.91 -4.60	Uncomfortable
F	> 4.60	Extremely uncomfortable

4.2 Results

The aim of this study was to develop a new model that representing the bicycle LOS of urban roads with mixed traffic condition and to evaluate the existing bicycle LOS on twenty-four multi-lane urban roadways in city of Bahir Dar metropolitan city. Many of the literature show that a higher value of BLOS score indicates a low level of service. The developed model gives BLOS in the range of one to six. The overall results of the study areas were include bicycle LOS ratings of A, B, C, D, and E on twenty-four links.

4.2.1 Map Generation and Spatial Data Preparation

At its most simple level of use, a GIS is a powerful and efficient tool for generating color-coded maps and graphic displays that may, depict existing road conditions, work programs, and maintenance schedules, among many other applications. One of the first applications for GIS was its development for display and analysis of the Highway Performance Monitoring System. With a GIS application, once the base maps are generated and the attribute data are linked to the geographical objects, it is easy to produce a variety of visual aids by classifying and symbolizing according to specific attributes.

4.2.2 Road Condition Data Base and Analysis Module

Road Condition Surveys and Analysis used to assess or describe the state of being, or readiness for use, of those elements managed. In this module, all representative of non-geographic information (attribute data) like Road width, PCU, Effective width, speed, percentage of heavy vehicle, and Roadside development, along with its own BLOS score link section details feed in to GIS. The figure 4.8 below shows the existing road condition indices and charts.

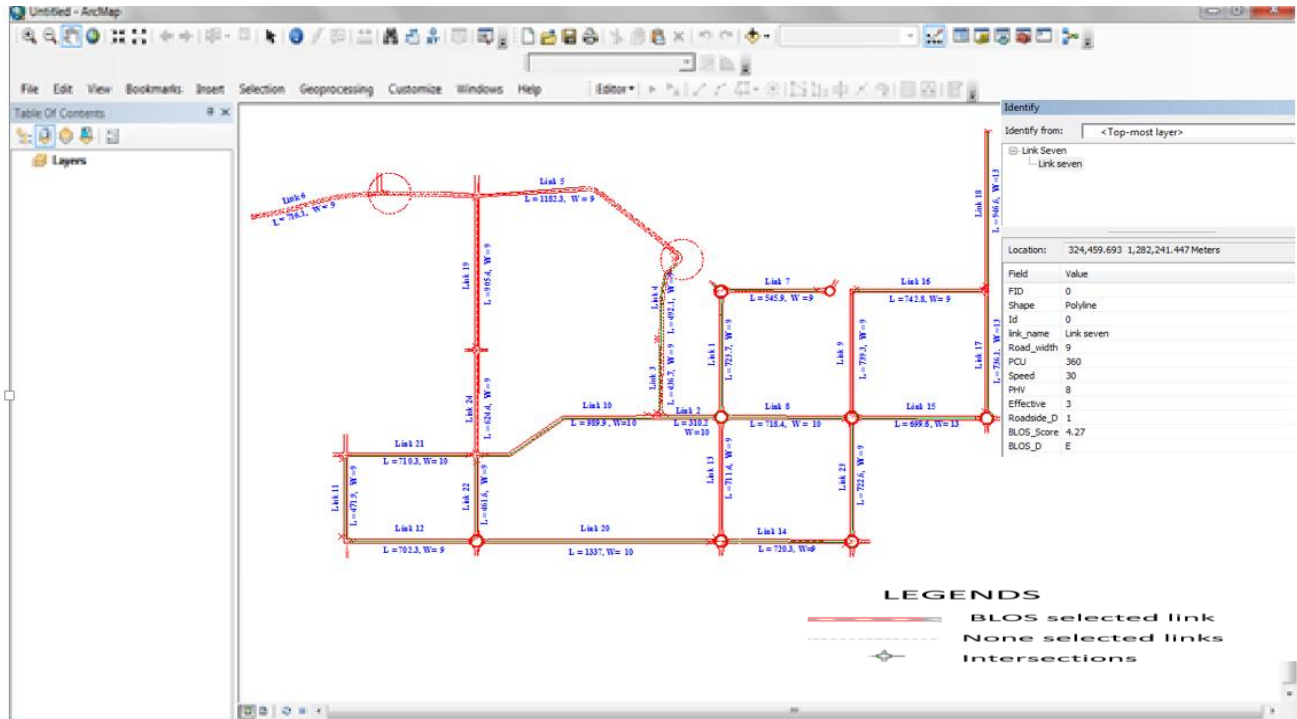


Figure 4:8 The spatial and attributes data of the selected network

4.2.3 BLOS Database Module

BLOS database module describing the mean comfort rate of each links, have described, and identify the links using GIS tools. The details of this modules described in the following section.

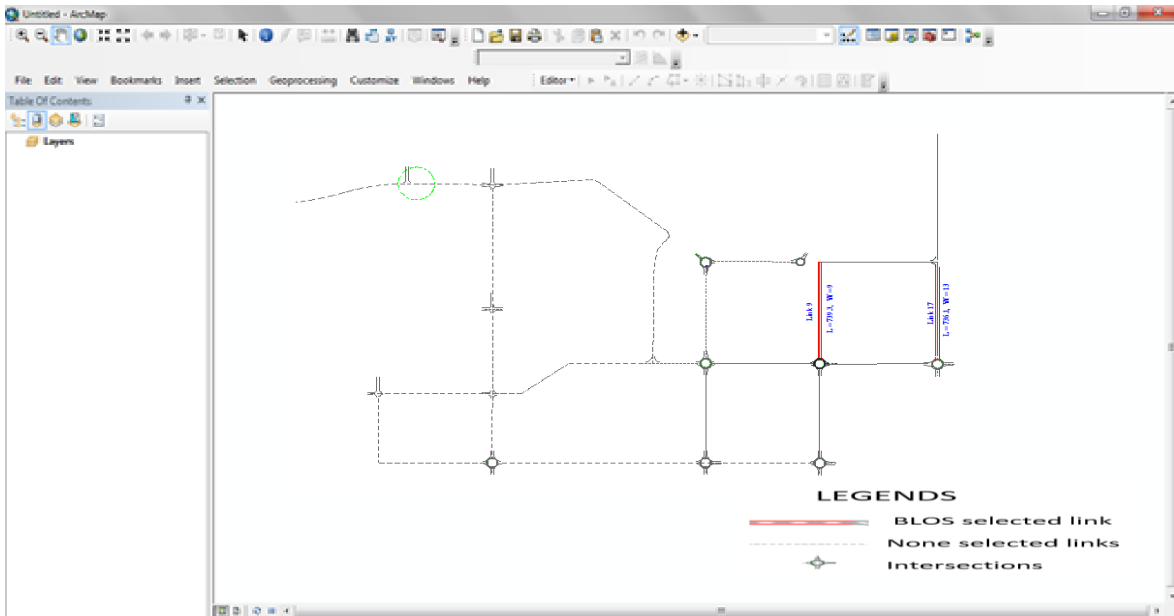


Figure 4:9 BLOS A Module

Based on the above figure 4:9 two links, link nine and seventeen are lies below 1.65, which is extremely comfortable condition for riding bicycle. This comes due-to:

- 1) Both links have low number of passenger car unit and percentage of heavy vehicles,
- 2) Links have wide enough effective outer side lane width for safe bicycle riding and
- 3) The roadside development along the links is low commercial zone.

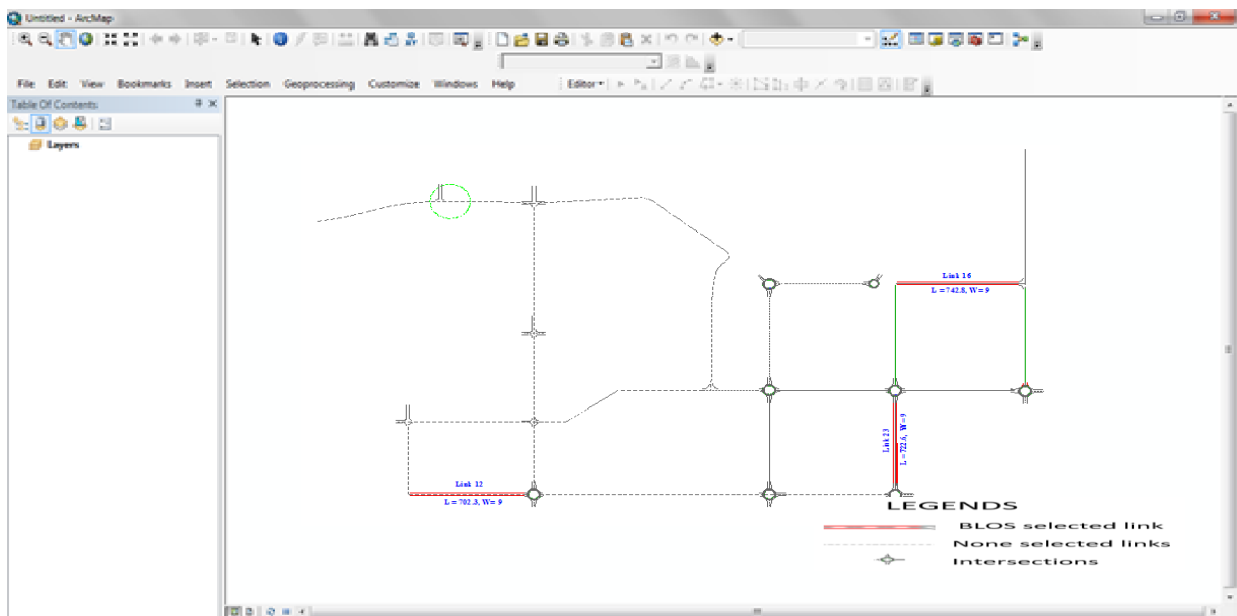


Figure 4.10 BLOS B Module

Based on the above figure 4:10 three links, link twelve, sixteen and twenty are lies in between 1.66 to 2.30, which is highly comfortable condition for riding bicycle. This comes due-to:

- 1) links have low number of passenger car unit and percentage of heavy vehicles,
- 2) Links have wide enough effective outer side lane width for safe bicycle riding and
- 3) The roadside development along the links are low commercial zone.

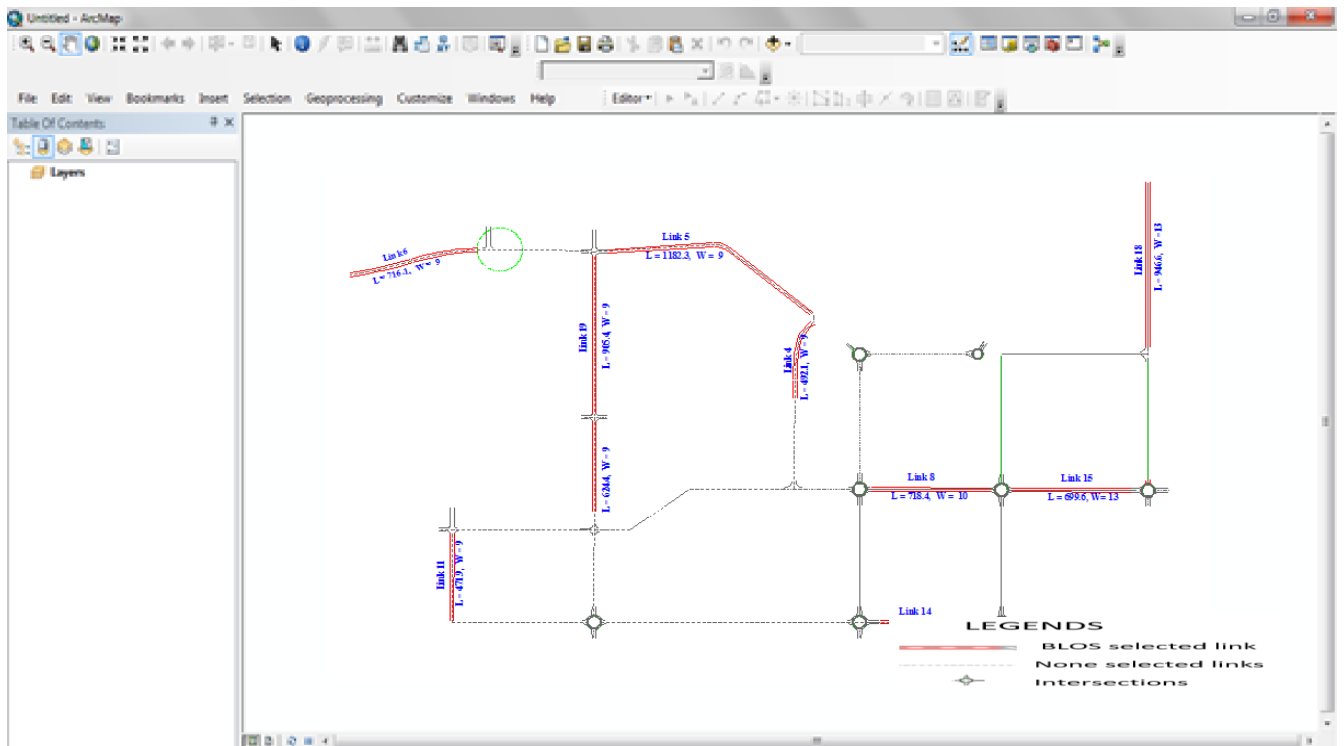


Figure 4:11 BLOS C Module

Based on the above figure 4:11 ten links, link 4, 5,6,8,11,14,15,18,19 & 24 are lies in between 2.31 to 3.10, which is comfortable condition for riding bicycle. This comes due-to:

- 1) All links have medium number of passenger car unit and percentage of heavy vehicles relative to the others,
- 2) The proportion of on street parking along the links are below ten percent
- 3) Links have wide moderate effective outer side lane width for safe bicycle riding and
- 4) The roadside development along the links are also average in commercial zone.

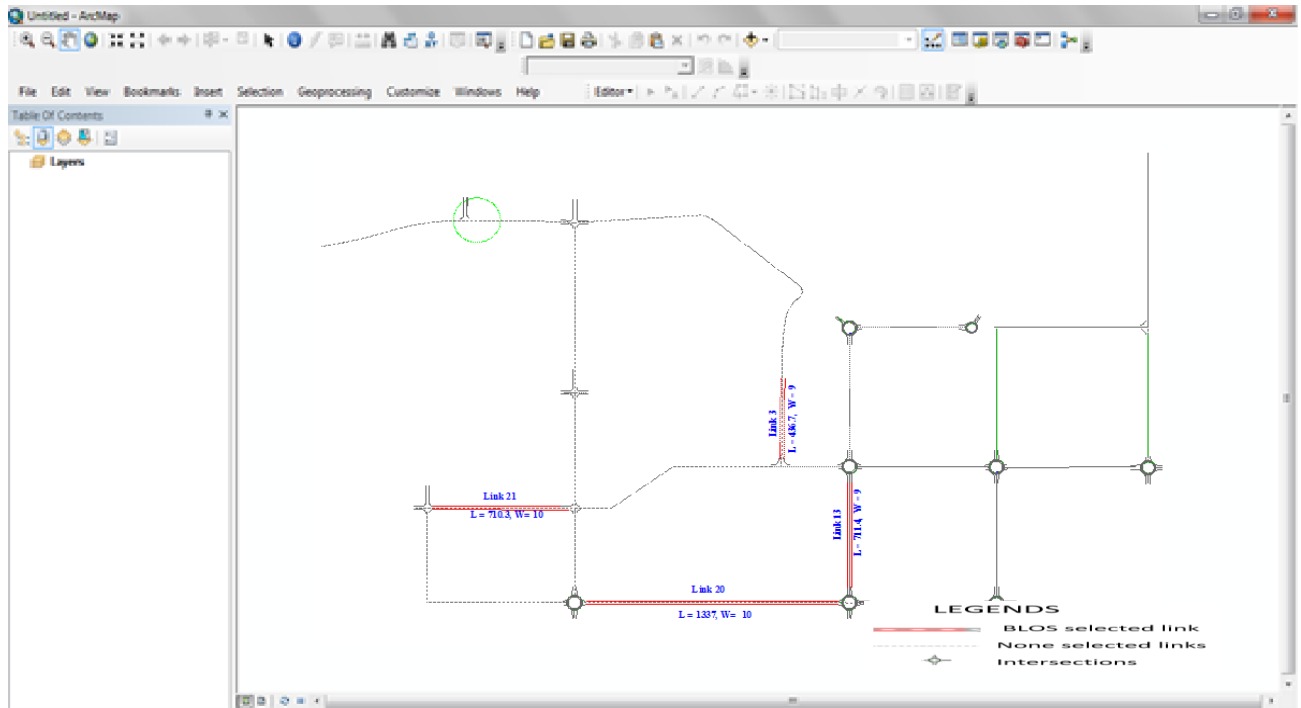


Figure 4:12 BLOS D Module

Based on the above figure 4:12 four links, link 3, 13, 20 & 21 are lies in between 3.11 to 3.90, which is less comfortable condition for riding bicycle. This comes due-to:

- 1) All links have high number of passenger car unit and percentage of heavy vehicles relative to the others,
- 2) Links have less effective outer side lane width for safe bicycle riding and
- 3) The roadside development along the links is also high in commercial zone.

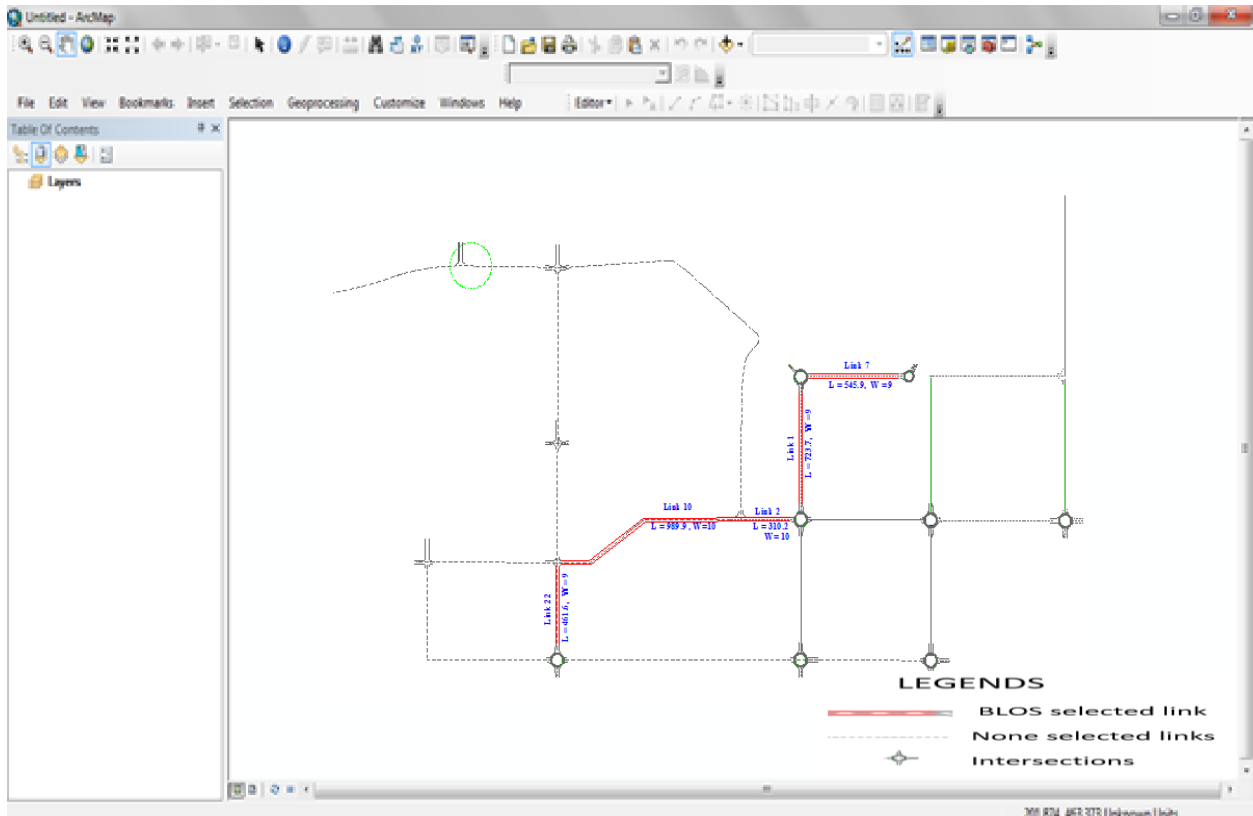


Figure 4:13 BLOS E Module

Based on the above figure 4:13 five links, link 1, 2, 7, 10 & 22 are lies above 3.91, which is uncomfortable condition for riding bicycle. This comes due-to:

- 1) All links have high number of passenger car unit and percentage of heavy vehicles relative to the others,
- 2) Links have less effective outer side lane width (about 2.8m) for safe bicycle riding
- 3) The roadside development along the links are also high in commercial zone.

4.3 Discussion

In this study, different methods for bicycle level of service model development of road link, based on subjective, based on video graphic survey and based on real time perception survey have discussed. The aim of this study was to develop a new model that representing the bicycle LOS of urban roads with mixed traffic condition and to evaluate the existing bicycle LOS on twenty-four multi-lane urban roadways in city of Bahir Dar metropolitan city.

Following are discussion on the methods and results from the research estimation of bicycle level of service through road links in urban Bahir dar.

➤ Video Graphic Survey

A common practice have been adopted by different fellows and agencies to expressed and modeled bicycle level of service (BLOS) by the help of video graphic survey(**Harkey et al, (1997), Haritha. et al, (2016), David. L. et al(1987) and Sorton and Walsh (1994)**). Though convenient to use, video graphic survey the above study tries to check the percentage of the matching on video rating with that of field observation.

These survey techniques have a limitation while they are selecting a user's. The percentage of matching of video rating with that of field observation is **43.6%**. However, as it is attempt in these paper users (raters) are totally **professionals** and the percentage of matching video rating with that of field observation at a pilot study is **72%**, which is acceptable. As it is shown, the percentage of matching of this study has larger value than others this comes due to the number of samples used in this particular study is higher than other studies.

➤ Selection of Independent Variables Selection

According to the studies (**Harkey et al, (1997), Haritha. et al, (2016), Bruce W. Landis (1994), Linda B. Dixon (1997), HCM 2010 e.t.c.** the selection of independent variables are not clearly defined. Mostly used required input data in the model are motorized traffic volumes, traffic speeds, heavy-vehicle percentage, presence of parking, and pavement quality. But, those variables are not considered the influence of one independent variable to the other independent variable.

For this particular study, the initial selected independent variables are seven, and after several tests have done in the pilot study, five variables were selected for final study. The

range of the Pearson `s correlation of those independent variables are from **excellent (0.979) to highly (0.766)** correlated.

- According to the studies (**Harkey et al, (1997), Haritha. et al, (2016), Bruce W. Landis (1994), Linda B. Dixon (1997), HCM 2010 e.t.c.** higher vehicle volumes, a greater proportion of trucks and buses, higher vehicle speeds, presence of parking and absence of a bicycle lane or paved shoulder (BL) all act to decrease a bicyclist's perceived comfort. On this particular study similar with the other studies the largest effect on the BLOS score are the peak fifteen minute traffic volume (PCU); percentage of heavy vehicles; effective width in terms of the bicycle lane, paved shoulder, or the outside through lane; the presence of on-street parking and motor vehicle speeds (SPD).

- **Model Development**

As these studies show, (**Harkey et al, (1997), Haritha. et al, (2016), Bruce W. Landis (1994) and HCM 2010 e.t.c.** the performance, tests and quality of data have been interpreted using several statistical parameters such as: Pearson correlation, level of significance, reliability and step-wise linear regression for the model development. Likewise, this particular study uses universally acceptable statistical parameters for model development in which they are very simple and understandable for all types of user.

- Developed new bicycle level of service (BLOS) model using stepwise linear regression and has a highly reliable coefficient (**$R^2 = 0.972$**) and define bicycle level of service through road links under heterogeneous traffic conditions. In Ethiopia, mostly heterogeneous traffic conditions present due to the presence of different classes of vehicles without lane discipline.

- **Calibration and Validation of models**

This approach was extended to take an accountability for accuracy of the developed model. In this case, **except Bruce W. et al (1997) and Haritha. et al, (2016)** most studies are not calibrating and validating their models. Those two studies are validating their models at an R^2 value of **0.73 and 0.9099** respectively. For this study, the bicycle level of service model was validated with 30% total data sets, which is 420 (7 links *60 experts) perceived satisfaction of the rate **at R^2 value of 0.8988, which is acceptable.**

Chapter Five

Conclusion and Recommendation

5.1 General

In developing countries like Ethiopia due to rapid growth of economy, there is high motor vehicle traffic increment and this traffic flow condition is highly heterogeneous in which small to big vehicles move on the roadways without following any lane discipline among them. As result of this, the traffic flow condition generally perceived as a frustrating bicycle riding environment. Thus this study have taken initiative to quantify the operational conditions of on-street bicyclists by considering different traffic flow situation, comfort rate of road users and prevailing geometric conditions.

This study helps in assessing the factors affecting bicycle level of service through links and thus evaluating a method to determine BLOS for links under mixed traffic conditions. The developed bicycle level of service model accurately represents the users' perceptions of links. This model incorporates perceived safety, comfort, and operations. Data for the model were obtained from questioner, recorded videos, and actual geometrical and traffic data measurements. The resulting model is highly reliable in its applications and has a high coefficient of determination value ($R^2= 0.972$) with mean observations and provides a measure of the users' perspective on how well a link's geometric and operational characteristics meets his or her needs.

5.2 Conclusion

Bicycling is an important part of the solution to many urban transportation issues, especially in developing country like Ethiopia, because of paucity of available funds. This study has analyzed the bicycle activity on multi-lane urban road links under the influence of heterogeneous traffic flow conditions. By using the relevant road attributes as independent variables in the model building, a step-wise regression based BLOS model has been developed in this study. The tool allows practitioners to evaluate existing facilities to determine what improvements may be required, as well as to determine the geometric and operational requirements for new facilities to achieve the desired level of bicycle service.

Following are the find outs from the research estimation of bicycle level of service through road links in urban Bahir dar.

- These paper users (raters) are totally **professionals** and the percentage of matching video rating with that of field observation at a pilot study is **72%**, which is acceptable.
- For this particular study, the initial selected independent variables are seven, and after several tests have been done in the pilot study, five variables are selected for final study. The range of the Pearson `s correlation of those independent variables are from **excellent (0.979) to highly (0.766)** correlated.
- On this particular study similar with the other studies the largest effect on the BLOS score are the peak fifteen minute traffic volume (PCU); percentage of heavy vehicles; effective width in terms of the bicycle lane, paved shoulder, or the outside through lane; the presence of on-street parking and motor vehicle speeds (SPD).
- Developed new bicycle level of service (BLOS) model using stepwise linear regression and has a highly reliable coefficient (**$R^2 = 0.972$**) and define bicycle level of service through road links under heterogeneous traffic conditions. In Ethiopia, mostly heterogeneous traffic conditions present due to the presence of different classes of vehicles.

- For this study, the bicycle level of service model was validated with 30% total data sets, which is 420 (7 links *60 experts) perceived satisfaction of the rate at **R² value of 0.8988, which is acceptable.**
- Bicycle level of service criteria stratified based on the results of applying the model to the sites included in this study. The bicycle LOS evaluations tested on twenty-four multilane roadways links in Bahirdar. The results were BLOS ratings of 8.3 percentage of A, 12.5 percentage of B, 41.7 percentage C, 16.7 percentage D, and 20.8 percentage E on these corridors. These shows above sixty percent of links are comfortable for riding bicycle under the existing operational and geometrical conditions of the shared roadways environment.

5.3 Recommendation

- From this study, above sixty percent of links are comfortable for riding bicycle under the existing operational and geometrical conditions of the shared roadways environment. However to develop sustainable transportation systems in terms of production of economy, improving community health and reduction air pollution, the city must improve the existing infrastructure to increase number of bicycle users.
- Besides, transportation safety problem solutions should also be action based in: legislation, regulation, enforcement, education, engineering, and encouragement such as provide separate lane by marking for bicycle use only.
- Many communities have significant underlying demand for bicycle transport. That is, people would bicycle more frequently if they had suitable facilities and transport system. However, these needs have covered by various challenges: bicycle transportation with mixed vehicular traffic environment without lane regulation prevalent in the study areas.

5.4 Scope of Future Work

Proportion of On-Street Parking occupied is one of the important variables that will be used for model development and this variable represent the proportion of the segment's right-hand curb line on which parked vehicles are present during the analysis period.

This study collects On-Street Parking data only during motor traffic demand peaks period in between access point on the specified links. In addition, the Proportion of On-Street Parking (Ppk) computed as the sum of the curb-line lengths occupied by parked vehicles divided by the link length. If parking is not allowed on the segment, then the proportion equals 0.0.

Due to the limited scope of the study, this study focuses data collection only during motor traffic demand peaks period. But it could give the chance with better outcome if the data collection includes off peak periods too; as On-Street Parking demand may increase during this period. So, further study can be conducted with a wider scope considering the above scenarios.

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Appendix A- Questionnaire Survey Form

Code _____

Date _____

QUESTIONNAIRE

The purpose of this survey is to measure the quality of the existing roadway level of service and the bicycle itself from perspective of Bahir Dar cyclists for future bicycling improvement. This project is being undertaken in partial fulfillment of the requirements for the award of Master's Degree (M.Sc.) in **Road and Transport Engineering** in the above institution. Participation is voluntary and all answer will remain confidential. Please kindly complete this questionnaire as honestly as you can. All information supplied will be use solely for the purpose of this study. Your cooperation will be highly appreciated.

SECTION A – PERSONAL INFORMATION

1. Demographics

1.1. Gender Male Female

1.2. Age -----

1.3. Education Degree Masters PHD

1.4. How would you classify yourself as a biker?

Experienced Moderate Beginner

1.5. Current Responsibility in the Organization _____

SECTION B

This part is directly concerns about factors that are used to measure the existing Bahir Dar city bicycle transportation level of service. By considering the road width, occupied parking space, traffic volume, presences of heavy vehicle and speed of motor vehicle conditions rate riding comfort by using a tick mark (√) in the open space for each specific link.

S.No	Question	Rate Of Comfort					
		1	2	3	4	5	6
1	How comfortable you are riding on this specific link?						

Note : The 1 to 6 scale are

1. **Extremely Comfortable or above 95% comfortable**
2. **Highly Comfortable or in between 75% to 95% comfortable**
3. **Comfortable or in between 50% to 75% comfortable**
4. **Less Comfortable or in between 25% to 50% uncomfortable**
5. **Uncomfortable or in between 5% to 25% uncomfortable**
6. **Extremely Uncomfortable or below 5% uncomfortable**

For further Comment use the open space below

Address: Telephone +251-918-78-74-84

Gmail account: heniy02@gmail.com

Thank You

Appendix B-

Pilot Study Data Collection Form and Results

Geometric Data Collection form for Pilot Study

Date: _____

Link Name: _____

Sheet No.: _____

Time from: _____ to _____

Weather: _____

Data collector: _____

Geometric data	Width of roadway	Width of paved shoulder	Width of On street parking lane	Width of side walk	Width of median	Width of gutter pan	Width of curb
Length (m)							
Pavement Condition	1 (Worst condition)		5(Excellent surface quality)				
	1	2	3	4	5		
Roadside Development	1(High commercial)		0.5 (medium commercial)		0 (low commercial)		
Presence of lane marking	Yes			No			
Presence of street light	Yes			No			

	Access names							Total Length (m)	Number of Access points
	Starting to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7		
Access Length									
Parking Length									

Correlations between mean comfort rate and independent variables

Pilot study output.spv [Document1] - SPSS Statistics Viewer

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Input

- Log
- Correlations
 - Title
 - Notes
 - Active Dataset
 - Descriptive Statistics
 - Correlations
- Log
- Reliability
 - Title
 - Notes
 - Active Dataset
 - Scale: ALL VARIABLES
 - Case Processing Summary
 - Reliability Statistics
 - Inter-Item Correlation Matrix
 - Inter-Item Covariance Matrix
 - ANOVA with Friedman's
- Log
- Regression
 - Title
 - Notes
 - Active Dataset
 - Variables Entered/Removed
 - Model Summary
 - ANOVA
 - Coefficients
 - Excluded Variables

Correlations

		Peak 15 minute number of passenger car unit	Roadside Development	effective width of the outside through lane	85th Speed of motor vehicles	Pavement Condition	Number of side street a long the link	percent of heavy vehicle/hour	Mean Comfort Rate of Experts by observation
Peak 15 minute number of passenger car unit	Pearson Correlation	1	.625**	-.919**	-.951**	-.296**	.784**	.723**	.897**
	Sig. (2-tailed)		.000	.000	.000	.003	.000	.000	.000
	N	100	100	100	100	100	100	100	100
Roadside Development	Pearson Correlation	.625**	1	-.683**	-.813**	-.250**	.102	.652**	.901**
	Sig. (2-tailed)	.000		.000	.000	.012	.312	.000	.000
	N	100	100	100	100	100	100	100	100
effective width of the outside through lane	Pearson Correlation	-.919**	-.683**	1	.887**	.018	-.687**	-.527**	-.900**
	Sig. (2-tailed)	.000	.000		.000	.863	.000	.000	.000
	N	100	100	100	100	100	100	100	100
85th Speed of motor vehicles	Pearson Correlation	-.951**	-.813**	.887**	1	.426**	-.558**	-.842**	-.979**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000	.000
	N	100	100	100	100	100	100	100	100
Pavement Condition	Pearson Correlation	-.296**	-.250**	.018	.426**	1	.102	-.845**	-.308**
	Sig. (2-tailed)	.003	.012	.863	.000		.312	.000	.002
	N	100	100	100	100	100	100	100	100
Number of side street a long the link	Pearson Correlation	.784**	.102	-.687**	-.558**	.102	1	.237*	.470**
	Sig. (2-tailed)	.000	.312	.000	.000	.312		.017	.000
	N	100	100	100	100	100	100	100	100
percent of heavy vehicle/hour	Pearson Correlation	.723**	.652**	-.527**	-.842**	-.845**	.237*	1	.766**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.017		.000
	N	100	100	100	100	100	100	100	100
Mean Comfort Rate of Experts by observation	Pearson Correlation	.897**	.901**	-.900**	-.979**	-.308**	.470**	.766**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.002	.000	.000	
	N	100	100	100	100	100	100	100	100

** . Correlation is significant at the 0.01 level (2-tailed).
* . Correlation is significant at the 0.05 level (2-tailed).

SPSS Statistics Processor is ready

Model test and summary results

Pilot study output.spv [Document1] - SPSS Statistics Viewer

File Edit View Data Transform Insert Format Analyze Graphs Utilities Add-ons Window Help

Input

- Log
- Correlations
 - Title
 - Notes
 - Active Dataset
 - Descriptive Statistics
 - Correlations
- Log
- Reliability
 - Title
 - Notes
 - Active Dataset
 - Scale: ALL VARIABLES
 - Case Processing Summary
 - Reliability Statistics
 - Inter-Item Correlation Matrix
 - Inter-Item Covariance Matrix
 - ANOVA with Friedman's
- Log
- Regression
 - Title
 - Notes
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 - Variables Entered/Removed
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 - Coefficients
 - Excluded Variables

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000 ^a	1.000	1.000	.00000

a. Predictors: (Constant), percent of heavy vehicle/hour, Number of side street a long the link, Roadside Development, effective width of the outside through lane

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	46.560	4	11.640	.	. ^a
	Residual	.000	95	.000		
	Total	46.560	99			

a. Predictors: (Constant), percent of heavy vehicle/hour, Number of side street a long the link, Roadside Development, effective width of the outside through lane
b. Dependent Variable: Mean Comfort Rate of Experts by observation

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.019	.000			
	effective width of the outside through lane	-.440	.000	-.368		
	Roadside Development	.839	.000	.492		
	Number of side street a long the link	.079	.000	.113		
	percent of heavy vehicle/hour	.054	.000	.225		

a. Dependent Variable: Mean Comfort Rate of Experts by observation

SPSS Statistics Processor is ready

Validation of video graphic survey results

Link Name	Comfort Rate by Observation	Comfort Rate by Video	Mean Comfort Rate by Obs.	Mean Comfort Rate by Video	Exact comfort Rate Match	Different by one rate	Different by two rate
Link One	5	5	4.1	3.8	0		
Link One	3	5	4.1	3.8			2
Link One	4	3	4.1	3.8		1	
Link One	5	5	4.1	3.8	0		
Link One	4	4	4.1	3.8	0		
Link One	3	3	4.1	3.8	0		
Link One	3	3	4.1	3.8	0		
Link One	4	4	4.1	3.8	0		
Link One	5	3	4.1	3.8			2
Link One	4	4	4.1	3.8	0		
Link One	5	5	4.1	3.8	0		
Link One	4	4	4.1	3.8	0		
Link One	4	3	4.1	3.8		1	
Link One	5	5	4.1	3.8	0		
Link One	4	4	4.1	3.8	0		
Link One	4	4	4.1	3.8	0		
Link One	5	3	4.1	3.8			2
Link One	4	4	4.1	3.8	0		
Link One	4	2	4.1	3.8			2
Link One	3	3	4.1	3.8	0		
Link Two	3	4	3.85	3.7		1	
Link Two	4	3	3.85	3.7		1	
Link Two	5	5	3.85	3.7	0		
Link Two	3	3	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	5	4	3.85	3.7	0		
Link Two	3	3	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	3	3	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		

Link Two	5	5	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	5	3	3.85	3.7			2
Link Two	3	3	3.85	3.7	0		
Link Two	3	3	3.85	3.7	0		
Link Two	4	4	3.85	3.7	0		
Link Two	3	4	3.85	3.7		1	
Link Two	4	3	3.85	3.7		1	
Link Three	3	3	3.2	3	0		
Link Three	2	3	3.2	3		1	
Link Three	4	3	3.2	3		1	
Link Three	5	5	3.2	3	0		
Link Three	2	2	3.2	3	0		
Link Three	4	4	3.2	3	0		
Link Three	4	4	3.2	3	0		
Link Three	3	2	3.2	3		1	
Link Three	3	3	3.2	3	0		
Link Three	2	2	3.2	3	0		
Link Three	3	3	3.2	3	0		
Link Three	4	4	3.2	3	0		
Link Three	3	2	3.2	3		1	
Link Three	3	3	3.2	3	0		
Link Three	3	3	3.2	3	0		
Link Three	4	4	3.2	3	0		
Link Three	3	2	3.2	3		1	
Link Three	3	3	3.2	3	0		
Link Three	3	3	3.2	3	0		
Link Three	3	2	3.2	3		1	
Link Three	4	4	3.2	3	0		
Link Three	3	3	3.2	3	0		
Link Three	4	2	3.2	3			2
Link Three	2	3	3.2	3		1	
Link Four	3	3	2.2	2.3	0		
Link Four	1	1	2.2	2.3	0		
Link Four	2	2	2.2	2.3	0		
Link Four	3	1	2.2	2.3			2
Link Four	2	2	2.2	2.3	0		
Link Four	1	3	2.2	2.3			2
Link Four	1	1	2.2	2.3	0		
Link Four	2	2	2.2	2.3	0		
Link Four	2	3	2.2	2.3		1	

Link Four	3	3	2.2	2.3	0		
Link Four	3	3	2.2	2.3	0		
Link Four	1	3	2.2	2.3			2
Link Four	2	2	2.2	2.3	0		
Link Four	3	3	2.2	2.3	0		
Link Four	2	2	2.2	2.3	0		
Link Four	3	3	2.2	2.3	0		
Link Four	2	2	2.2	2.3	0		
Link Four	3	3	2.2	2.3	0		
Link Four	2	2	2.2	2.3	0		
Link Four	3	2	2.2	2.3		1	
Link Five	4	4	3.8	3.7	0		
Link Five	2	4	3.8	3.7			2
Link Five	3	3	3.8	3.7	0		
Link Five	4	4	3.8	3.7	0		
Link Five	4	3	3.8	3.7		1	
Link Five	3	3	3.8	3.7	0		
Link Five	4	3	3.8	3.7		1	
Link Five	4	4	3.8	3.7	0		
Link Five	3	3	3.8	3.7	0		
Link Five	4	3	3.8	3.7		1	
Link Five	5	5	3.8	3.7	0		
Link Five	4	4	3.8	3.7	0		
Link Five	3	3	3.8	3.7	0		
Link Five	4	4	3.8	3.7	0		
Link Five	5	5	3.8	3.7	0		
Link Five	3	3	3.8	3.7	0		
Link Five	5	5	3.8	3.7	0		
Link Five	5	4	3.8	3.7		1	
Link Five	4	4	3.8	3.7	0		
Link Five	3	3	3.8	3.7	0		
Percentage of rate of comfort mach					72%	18%	10%

Appendix C-

Traffic Census Survey Form

Date: _____

Direction: _____

Link Name: _____

Sheet No.: _____

Time from: _____ to _____

Weather: _____

Data collector: _____

Put an oblique stroke (/) for each vehicle in consecutive squares.

	No. of Vehicles	Total	Remark
Bicycle			
Motor Cycle and Bajaj			
Cars, Utility, Minibus and 4WD			
Bus and One Axle truck			
Medium truck 2 axle truck			
Heavy truck or 4 axle truck			

Appendix D-

Geometric Data Collection Form for Final Study

Date: _____

Link Name: _____

Sheet No.: _____

Time from: _____ to _____

Weather: _____

Data collector: _____

Geometric data	Width of roadway	Width of paved shoulder	Width of On street parking lane	Width of side walk	Width of median	Width of gutter pan	Width of curb		
Length (m)									
Roadside Development	1(High commercial)		0.5 (medium commercial)		0 (low commercial)				
	Access names							Total Length (m)	Number of Access points
	Starting to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7		
Access Length									
Parking Length									

Appendix E-

Motor vehicle speed survey form

Date: _____

Link Name: _____

Sheet No.: _____

Time from: _____ to _____

Weather: _____

Data collector: _____

Vehicle Type	Tri-cycle (Bajaj)				Cars, Utility, Minibus and 4WD				Bus and One Axle truck		Remark
	1	2	3	4	1	2	3	4	1	2	
No. of Vehicles											
Trap length(m)											
Travel time(S)											
Speed(km/hr)											
85th Percentile speed of each vehicle type(km/hr)											
85th Percentile speed of all vehicles(Km/hr)											

85th percentile motor vehicle speed

Link one	Vehicle Type										
	Tri-cycle (Bajaj)				Cars, Utility, Minibus and 4WD				Bus and One Axle truck		Remark
No. of Vehicles	1	2	3	4	1	2	3	4	1	2	
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	4.32	4.15	4.32	4.5	4.9	5.14	4.7	4.5	5.14	5.27	
Speed(km/hr)	25	26	25	24	22	21	23	24	21	20.5	
85th Percentile speed of each vehicle type(km/hr)	25.55				23.55				20.93		
85th Percentile speed of	25										

all vehicles(Km/hr)											
Link two											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	4.3	4.5	4.32	4.69	4.01	4.15	3.95	3.51	4.6	4.9	
Speed(km/hr)	25.1	24.0	25.0	23.0	26.9	26.0	27.3	30.8	23.5	22.0	
85th Percentile speed of each vehicle type(km/hr)	25.1			29.2				23.3			
85th Percentile speed of all vehicles(Km/hr)	28.0										
Link three											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	3.85	3.37	2.57	2.84	3.08	2.7	2.57	2.49	4.1	3	
Speed(km/hr)	28.1	32.0	42.0	38.0	35.1	40.0	42.0	43.4	26.3	36.0	
85th Percentile speed of each vehicle type(km/hr)	40.2			42.8				34.6			
85th Percentile speed of all vehicles(Km/hr)	42.0										
Link four											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	2.57	3.85	3.32	3	2.65	2.51	2.66	2.49	3.6	2.77	
Speed(km/hr)	42.0	28.1	32.5	36.0	40.8	43.0	40.6	43.4	30.0	39.0	
85th Percentile speed of each vehicle type(km/hr)	39.3			43.2				37.6			
85th Percentile speed of all vehicles(Km/hr)	42.0										
Link five											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	2.24	2.5	2.35	2.45	2.07	2.11	1.96	2.05	2.46	2.56	
Speed(km/hr)	48.2	43.2	46.0	44.1	52.2	51.2	55.1	52.7	43.9	42.2	

85th Percentile speed of each vehicle type(km/hr)	47.2			54.0				43.6		
85th Percentile speed of all vehicles(Km/hr)	52.0									
Link six										
Trap length(m)	30	30	30	30	30	30	30	30	30	30
Travel time(S)	2.7	2.45	2.51	2.65	2.25	2.03	2.23	2.07	2.6	2.66
Speed(km/hr)	40.0	44.1	43.0	40.8	48.0	53.2	48.4	52.2	41.5	40.6
85th Percentile speed of each vehicle type(km/hr)	43.6			52.7				41.4		
85th Percentile speed of all vehicles(Km/hr)	50.0									
Link seven										
Trap length(m)	30	30	30	30	30	30	30	30	30	30
Travel time(S)	4.23	3.58	3.85	3.82	3.85	3.99	3.85	3.37	4.12	3.88
Speed(km/hr)	25.5	30.2	28.1	28.3	28.1	27.1	28.1	32.0	26.2	27.8
85th Percentile speed of each vehicle type(km/hr)	29.3			30.2				27.6		
85th Percentile speed of all vehicles(Km/hr)	30.0									
Link eight										
Trap length(m)	30	30	30	30	30	30	30	30	30	30
Travel time(S)	2.7	2.57	2.43	2.34	2.45	2.25	2.25	2.16	2.84	2.4
Speed(km/hr)	40.0	42.0	44.4	46.2	44.1	48.0	48.0	50.0	38.0	45.0
85th Percentile speed of each vehicle type(km/hr)	45.4			49.1				44.0		
85th Percentile speed of all vehicles(Km/hr)	48.0									
Link nine										

Trap length(m)	30	30	30	30	30	30	30	30	30	30		
Travel time(S)	2.5	2.16	2.54	2.29	1.74	1.86	1.8	1.8	2.07	1.85		
Speed(km/hr)	43.2	50.0	42.5	47.2	62.1	58.1	60.0	60.0	52.2	58.4		
85th Percentile speed of each vehicle type(km/hr)	48.7				61.1				57.4			
85th Percentile speed of all vehicles(Km/hr)	60.0											
Link Ten												
Trap length(m)	30	30	30	30	30	30	30	30	30	30		
Travel time(S)	3.92	4.18	4.03	4.44	3.62	3.85	3.37	3.95	4.6	3.82		
Speed(km/hr)	27.6	25.8	26.8	24.3	29.8	28.1	32.0	27.3	23.5	28.3		
85th Percentile speed of each vehicle type(km/hr)	27.2				31.1				27.6			
85th Percentile speed of all vehicles(Km/hr)	30.0											
Link eleven												
Trap length(m)	30	30	30	30	30	30	30	30	30	30		
Travel time(S)	2.2	2.34	2.25	2.16	1.96	1.95	2.57	2.16	2.45	2.07		
Speed(km/hr)	49.1	46.2	48.0	50.0	55.1	55.4	42.0	50.0	44.1	52.2		
85th Percentile speed of each vehicle type(km/hr)	49.6				55.3				51.0			
85th Percentile speed of all vehicles(Km/hr)	54.0											
Link twelve												
Trap length(m)	30	30	30	30	30	30	30	30	30	30		
Travel time(S)	2.19	2.45	2.07	2.57	1.86	2.16	1.96	2.16	2.34	2.25		
Speed(km/hr)	49.3	44.1	52.2	42.0	58.1	50.0	55.1	50.0	46.2	48.0		
85th Percentile speed of each vehicle type(km/hr)	50.9				56.7				47.7			

85th Percentile speed of all vehicles(Km/hr)	55.0									
Link thirteen										
Trap length(m)	30	30	30	30	30	30	30	30	30	30
Travel time(S)	2.57	2.25	2.16	2.57	2.1	2.25	2.4	2.2	2.34	2.29
Speed(km/hr)	42.0	48.0	50.0	42.0	51.4	48.0	45.0	49.1	46.2	47.2
85th Percentile speed of each vehicle type(km/hr)	49.1				50.4				47.0	
85th Percentile speed of all vehicles(Km/hr)	50.0									
Link fourteen										
Trap length(m)	30	30	30	30	30	30	30	30	30	30
Travel time(S)	2.22	2.26	2.57	2.34	2.1	2.2	2.16	2.4	2.45	2.75
Speed(km/hr)	48.6	47.8	42.0	46.2	51.4	49.1	50.0	45.0	44.1	39.3
85th Percentile speed of each vehicle type(km/hr)	48.3				50.8				43.4	
85th Percentile speed of all vehicles(Km/hr)	50.0									
Link fifteen										
Trap length(m)	30	30	30	30	30	30	30	30	30	30
Travel time(S)	2.63	2.29	2.51	2.25	2.16	2.07	2.16	2.07	2.25	2.07
Speed(km/hr)	41.1	47.2	43.0	48.0	50.0	52.2	50.0	52.2	48.0	52.2
85th Percentile speed of each vehicle type(km/hr)	47.6				52.2				51.5	
85th Percentile speed of all vehicles(Km/hr)	52.0									
Link sixteen										
Trap length(m)	30	30	30	30	30	30	30	30	30	30
Travel time(S)	2.07	1.9	2.03	1.95	1.78	1.85	1.79	1.86	2.13	1.79
Speed(km/hr)	52.2	56.8	53.2	55.4	60.7	58.4	60.3	58.1	50.7	60.3

85th Percentile speed of each vehicle type(km/hr)	56.2			60.5			58.9				
85th Percentile speed of all vehicles(Km/hr)	60.0										
Link seventeen											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	2.25	2.4	2.11	2.23	1.96	1.94	2.16	2	2.07	1.99	
Speed(km/hr)	48.0	45.0	51.2	48.4	55.1	55.7	50.0	54.0	52.2	54.3	
85th Percentile speed of each vehicle type(km/hr)	49.9			55.4			54.0				
85th Percentile speed of all vehicles(Km/hr)	55.0										
Link eighteen											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	2.7	2.57	2.4	2.57	2.4	2.84	2.35	2.63	2.45	2.51	
Speed(km/hr)	40.0	42.0	45.0	42.0	45.0	38.0	46.0	41.1	44.1	43.0	
85th Percentile speed of each vehicle type(km/hr)	43.7			45.5			43.9				
85th Percentile speed of all vehicles(Km/hr)	45.0										
Link nineteen											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	2.15	2.4	2.34	2.29	2.11	1.97	2.03	2.16	2.07	2	
Speed(km/hr)	50.2	45.0	46.2	47.2	51.2	54.8	53.2	50.0	52.2	54.0	
85th Percentile speed of each vehicle type(km/hr)	48.9			54.1			53.7				
85th Percentile speed of all vehicles(Km/hr)	54.0										
Link twenty											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	2.76	2.69	2.71	2.84	2.7	2.7	3.08	2.84	3	3.08	

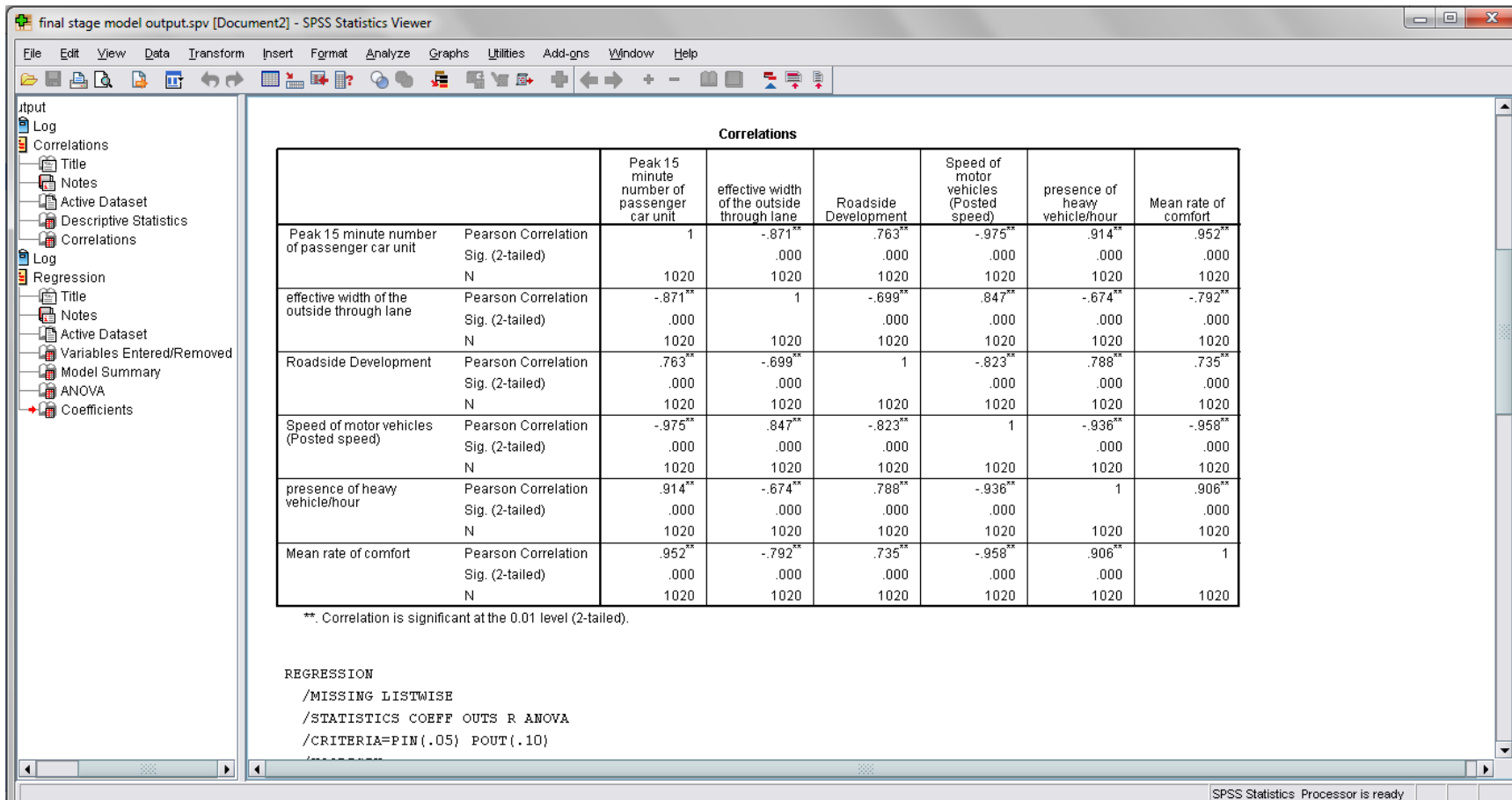
Speed(km/hr)	39.1	40.1	39.9	38.0	40.0	40.0	35.1	38.0	36.0	35.1	
85th Percentile speed of each vehicle type(km/hr)	40.0				40.0				35.9		
85th Percentile speed of all vehicles(Km/hr)	40.0										
Link twenty-one											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	3.48	3.27	2.91	3.08	2.61	2.7	3	2.7	3.17	2.76	
Speed(km/hr)	31.0	33.0	37.1	35.1	41.4	40.0	36.0	40.0	34.1	39.1	
85th Percentile speed of each vehicle type(km/hr)	36.2				40.8				38.4		
85th Percentile speed of all vehicles(Km/hr)	40.0										
Link twenty-two											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	3.85	3.72	3.37	3.6	3.08	3.08	3.48	3	3.17	3.48	
Speed(km/hr)	28.1	29.0	32.0	30.0	35.1	35.1	31.0	36.0	34.1	31.0	
85th Percentile speed of each vehicle type(km/hr)	31.1				35.6				33.6		
85th Percentile speed of all vehicles(Km/hr)	35.0										
Link twenty-three											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	
Travel time(S)	2.4	2.11	2.57	2.16	1.85	1.96	2	1.96	2.25	2.16	
Speed(km/hr)	45.0	51.2	42.0	50.0	58.4	55.1	54.0	55.1	48.0	50.0	
85th Percentile speed of each vehicle type(km/hr)	50.7				56.9				49.7		
85th Percentile speed of all vehicles(Km/hr)	55.0										
Link twenty-four											
Trap length(m)	30	30	30	30	30	30	30	30	30	30	

Travel time(S)	2.34	2.57	2.63	2.25	2.7	2.4	2.29	2.2	2.25	2.45	
Speed(km/hr)	46.2	42.0	41.1	48.0	40.0	45.0	47.2	49.1	48.0	44.1	
85th Percentile speed of each vehicle type(km/hr)	47.2				48.2				47.4		
85th Percentile speed of all vehicles(Km/hr)	48.0										

Appendix F-

Model Parameters, Fittings and Statistical Analysis Results

Correlation between mean comfort rate and independent variables



Model test and summary results before transformation and combination of variables

final stage model output.spv [Document2] - SPSS Statistics Viewer

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Output Log Correlations Title Notes Active Dataset Descriptive Statistics Correlations Log Regression Title Notes Active Dataset Variables Entered/Removed Model Summary ANOVA Coefficients

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.966 ^a	.933	.933	.23061

a. Predictors: (Constant), presence of heavy vehicle/hour, effective width of the outside through lane, Roadside Development, Peak 15 minute number of passenger car unit, Speed of motor vehicles(Posted speed)

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	754.241	5	150.848	2836.608	.000 ^a
	Residual	53.924	1014	.053		
	Total	808.165	1019			

a. Predictors: (Constant), presence of heavy vehicle/hour, effective width of the outside through lane, Roadside Development, Peak 15 minute number of passenger car unit, Speed of motor vehicles(Posted speed)

b. Dependent Variable: Mean rate of comfort

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients		t	Sig.
		B	Std. Error	Beta			
1	(Constant)	4.630	.284			16.323	.000
	Peak 15 minute number of passenger car unit	.004	.000	.437		9.249	.000
	effective width of the outside through lane	.227	.033	.164		6.846	.000
	Roadside Development	-.208	.031	-.105		-6.655	.000
	Speed of motor vehicles (Posted speed)	-.069	.004	-.822		-16.634	.000
	presence of heavy vehicle/hour	-.015	.007	-.069		-2.095	.036

Double click to edit Pivot Table

SPSS Statistics Processor is ready H: 265, W: 617 pt.

Model test summary results after sveral transformation and combination of variables

SPSS Statistics Viewer - *final stage model output.spv [Document2]

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- Regression
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 - Coefficients

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.986 ^a	.972	.972	.14993

a. Predictors: (Constant), effective width of the outside through lane, In of speed multiplied by pluse one %HV, Roadside development plus one, In of passenger car unit per raod width

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	785.349	4	196.337	8734.431	.000 ^a
	Residual	22.816	1015	.022		
	Total	808.165	1019			

a. Predictors: (Constant), effective width of the outside through lane, In of speed multiplied by pluse one %HV, Roadside development plus one, In of passenger car unit per raod width

b. Dependent Variable: Mean rate of comfort

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.369	.113		-20.920	.000
	In of passenger car unit per raod width	1.402	.035	.765	39.749	.000
	In of speed multiplied by pluse one %HV	.424	.022	.236	18.976	.000
	Roadside development plus one	-.186	.018	-.094	-10.321	.000
	effective width of the outside through lane	-.179	.021	-.129	-8.699	.000

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