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# PERFORMANCE ASSESSMENT AND IMPROVEMENT OF A THREE-LEGGED INTERSECTION AT NEW PLAZA, KATHMANDU

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## ABSTRACT

New Plaza Intersection, located in Anamnagar, is a three-legged intersection that suffers from severe congestion during the peak hours. This place consists of a number of educational institutions, banks, consultancies, offices and commercial buildings. So, there is a high volume of traffic movement in this area but the road capacity is very low in comparison causing traffic congestion. A video-graphic survey was carried out for three weekdays to collect the traffic data. The traffic volume count was done through manual counting method and using the PCU values of NRS 2070. The peak hour traffic volume during the morning peak hours was much higher in compariso evening peak hours with motorcycles and scooters constituting 78% of the total traffic. SIDRA Intersection 8.0 software was used for the development of the simulation model of the intersection. The models were calibrated and validated for saturation flow rate and back of queue (BOQ). From the analysis of the study, the LOS of the intersection was found to be F which indicates breakdown of flow, extreme delays and long queue length. The existing traffic signals in the intersection were found to be not properly utilized. So, to tackle the problems of congestion, optimal signal timing was used. Although there was no improvement in the level of service (LOS) of the intersection, the use of optimum cycle length resulted in a decrease of average delay and queue length in the intersection.

***Keywords**: Back of Queue (BOQ), Capacity, Delay, Level of Service (LOS), Nepal Road Standard (NRS), SIDRA, Simulation Modelling*

## 1. Introduction

### 1.1 Background

Traffic congestion is a major problem in major cities around the world. It arises when the traffic demand exceeds the road capacity that results in slower vehicle speeds, increased travel times, and longer vehicle queues. Kathmandu is the most crowded city in Nepal with a very large population which makes transportation facilities difficult to manage. This difficulty leads to congestion at a number of intersections within the city. The increasing number of vehicles in the same road with no change in capacity is bound to create problems. The New Plaza Intersection experiences heavy traffic flow problems, especially in the peak hours. The vehicles travelling from offices and schools generally are within the same timeframe causing the traffic volume to be significantly higher during this timeframe, which is called the peak hour period.

The Level of Service (LOS) is a qualitative measure used to assess the quality of traffic flow and the operational conditions of roads, intersections, and transportation networks. It provides a standardized way to evaluate how well a roadway or intersection is functioning based on several key indicators. Signal optimization is a method of determining and using the ideal signal timings by utilizing the optimum cycle length to properly manage the road traffic. The optimum cycle length refers to the ideal duration of a complete cycle of signal phases at an intersection. It is a critical parameter in traffic signal timing, as it influences the efficiency of traffic flow, reduces delays, and maximizes the capacity of the intersection.

### 1.2 Research Objectives

The primary objective of this study is to identify the current level of service of the New Plaza Intersection, to calibrate and validate the simulation model and to compare the effects of optimizing the signal cycle length in reducing the average delay and queue length.

### 1.3 Literature Review

Surveys of intersection optimization have been conducted a number of times in Kathmandu. Simulation modeling with the use of software like VISSIM, CORSIM, Synchro, and SIDRA has increased in application in traffic modeling recently for even complex transportation cases due to their flexibility.

Dhakal et al. (2023) conducted an evaluation and performance enhancement of the four legged intersection of Satdobato using SIDRA Intersection 8 software where optimization of signal timing was performed to improve the level of service, delay time and the back of the queue of the intersection.

Maharjan et al. (2023) carried out performance evaluation and improvement of Thapathali intersection through SIDRA software to determine the initial LOS of the intersection to be E, which was improved to LOS C with the use of optimum cycle length.

Kafle et al. (2024) carried out the performance evaluation of Ekantakuna Intersection where different scenarios were used to improve the traffic flow. Among them, the restriction of vehicles from service lanes to main lanes was found to be the best scenario with the least delay and queue length.

Luitel et al. (2023) used SIDRA intersection software for the evaluation of operational performance and signal timing optimization of the Buspark intersection in Birgunj Metropolitan. It was concluded that the intersection was operated by an unsignalized intersection under manual control of the traffic police, with the Level of Service rated as E. The first proposed change consisted of the optimization of cycle length, while the second included left turns in addition to that. These two alternatives helped in significant delay and queue reductions at the intersection.

Acharya et al. (2024) modelled the unsignalized intersection at Kanchanbari in SIDRA and concluded that the intersection operated with a LOS of F. Optimizing the signal cycle length reduced the delay and queue length while controlling the left turn movements was found to be even more effective.

## 2. Methodology

### 2.1 Study Area

The New Plaza intersection (27°42'03"N/ 85°19'19"E) lies in the heart of Kathmandu city. It is a major traffic hub connecting various important areas like Singhadurbar, Anamnagar and Putalisadak. The intersection is located on the Ram Shah Path roadway. Due to the small road width as compared to the high traffic volume, there is always traffic congestion at this intersection.

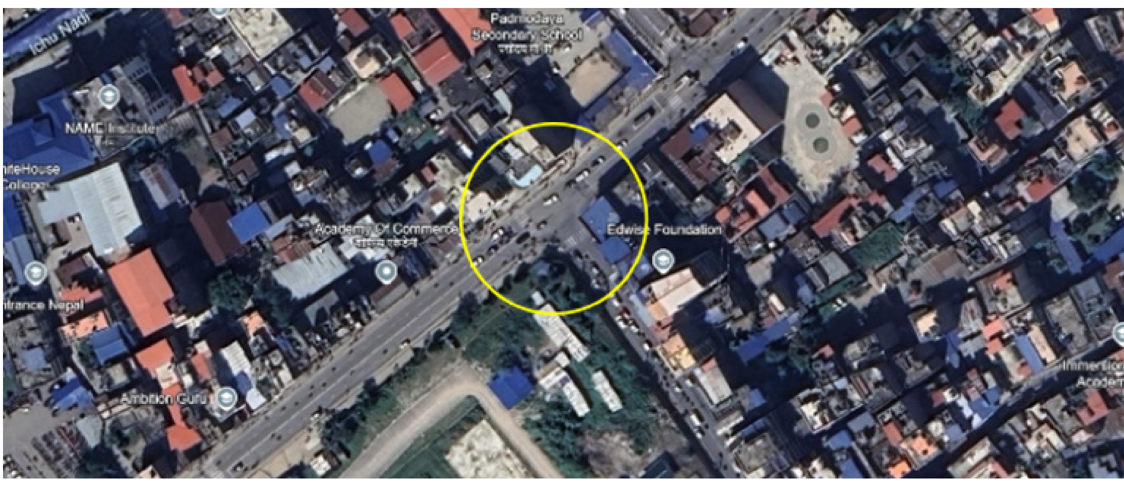


*Figure 1: Study Area*

### 2.2. Data collection through video-graphic survey

Data on geometric characteristics, traffic characteristics and signal control characteristics were collected through a field survey and video-graphic survey. The video-graphic survey was conducted by placing video cameras in suitable locations that oversee the study area. Video footage of three weekdays was used to carry out classified vehicle count and pedestrian volume count in the peak hours i.e. in the morning 9-11 am and in the evening 4-6 pm.  The NRS 2070 values were used to calculate the passenger car unit.

***Table 1 Passenger car unit for signalized intersection as per NRS 2070***

| Vehicle Type | Equivalency Factor |
|---|---|
| Bicycle, Motorcycle | 0.5 |
| Car, Auto, Rickshaw, SUV, Light Van, Pick Up | 1.0 |
| Light (Mini) Truck, Tractor, Rickshaw | 1.5 |
| Truck, Bus, Minibus, Tractor with trailer | 3.0 |
| Non-motorized carts | 6 |

*[Source : Nepal Road Standard 2070]*

### 2.3 Data collection through field survey

The field survey included the measurement of cruise speed, road geometry and queue length. The cruise speed of the vehicles was measured with the use of a radar gun on all approaches of the intersection. The 85th percentile of the cruise speed was used to input the data. The lane width, approach width, and approach distance were measured using a measuring tape and laser, along with the use of Google Earth. A number of samples of the queue length of all the approaches were taken during the peak hours and the average queue length at each approach was used as input.

### 2.4 Intersection Modelling

With the help of the data that was collected, combined and averaged, the simulation model of the intersection was constructed using the SIDRA intersection 8 software. The traffic volume, geometric data, vehicle movement data and signal phasing and timing were used as input for modelling the intersection model.

### 2.5 Calibration

Saturation flow rate and back of queue length were used as the calibration parameters due to its significant impact on traffic flow and intersection performance. As saturation flow rate measures the number of vehicles passing through an intersection during a green light cycle, which directly affects capacity and delays whereas back of queue reflects the traffic congestion. Hence these parameters are sensitive to local conditions, making them essential for accurately modelling the real-world traffic behaviors. The GEH value of the field measured saturation flow rate and the model saturation flow rate should be less than 5 as recommended by FDOT (2014). The difference between the model output and field-measured BOQ should be less than 20% as recommended by FDOT (2014).

### 2.6 Validation

The average back of queue length was used as the validation parameter. Validation is used so that the simulation model accurately displays the real-life traffic condition. The output of the simulation is compared with the Day 3 BOQ to validate. The difference should be within 20% as recommended by FDOT (2014).

## 3. Data analysis and Results

### 3.1 Traffic Volume

Figure 2 shows the traffic volume at each approach of the intersection during the peak hour which was found to be during the morning period.

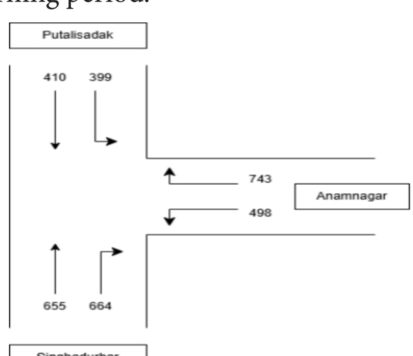


*Figure 2: Traffic volume during peak hour*

### 3.2 Existing Phase Timing and Pattern

The existing cycle length during the morning peak hour is 102 seconds that was obtained by taking the average of 12 manual observations of the total cycle length of the intersection. The phase timing and phase pattern are shown in the table and figure below.

*Table 2 Phase Timing*

| Phase | A | B | C |
|---|---|---|---|
| Phase Change Time | 0 | 28 | 74 |
| Green Time (sec) | 22 | 40 | 70 |
| Phase Time (sec) | 28 | 46 | 76 |
| Phase Split | 19% | 31% | 51% |

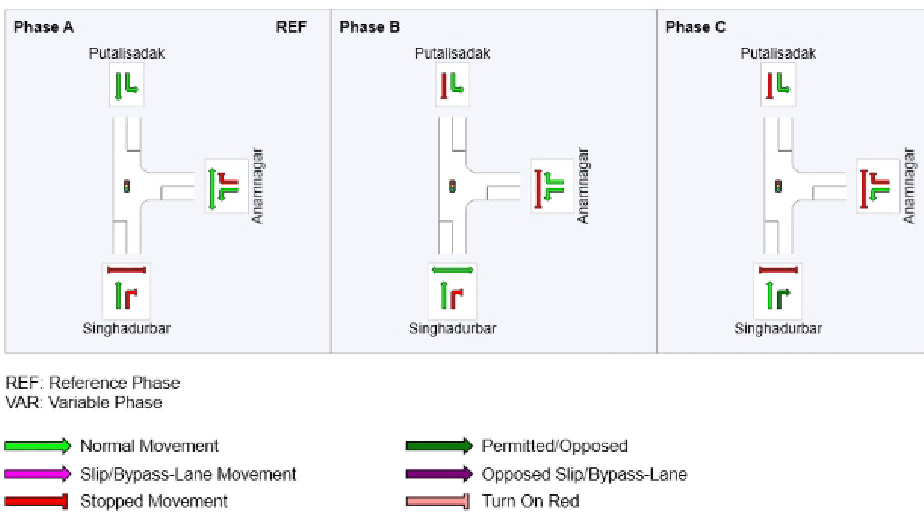


*Figure 3: Phase Sequence*

### 3.3 Existing Performance Evaluation

The existing performance indicates that the current level of service of New Plaza Chowk is F. The average delay is 301.9 sec and the average queue length is 191.6 m. The detailed result is given below:

*Table 3 Existing average delay and queue*

| Approach | Demand (veh/hour) | Average Delay (sec) | Average Back of Queue Distance (m) | LOS |
|---|---|---|---|---|
| Putalisadak | 832 | 275.6 | 104.1 | F |
| Anamnagar | 1314 | 325.8 | 133.6 | F |
| Singhadurbar | 1371 | 295.0 | 191.6 | F |

### 3.4 Calibration of Saturation Flow Rate

The saturation flow rate of the field was calculated for a certain time interval and compared with the model estimated saturation flow rate through GEH statistics formula to get the GEH value.

*Table 4 Calibration for saturation flow rate*

| Approach | Lane | Field Measured Saturation Flow Rate (veh/hour) | Model Estimated Saturation Flow Rate (veh/hour) | GEH Value | Adjusted Basic Saturation Flow (PCU/hour) |
|---|---|---|---|---|---|
| Putalisadak | 1 | 1520 | 1605 | 2.15 | 1890 |
| | 2 | 1733 | 1632 | 2.462 | 1890 |
| Anamnagar | 1 | 1486 | 1425 | 1.599 | 1536 |
| | 2 | 1479 | 1384 | 2.511 | 1536 |
| Singhadurbar | 1 | 1792 | 1852 | 1.406 | 1890 |
| | 2 | 1735 | 1641 | 2.288 | 1890 |

### 3.5 Calibration for Back of Queue

The difference between the model estimated BOQ length and the field measured BOQ length was calculated to give the results as shown in the table below.

*Table 5 Calibration of SIDRA model for BOQ*

| Approach | Average BoQ (m) | | |
|---|---|---|---|
| | Model Estimated | Field Measured | Difference (%) |
| Putalisadak | 104.1 | 95.66 | 8.11 |
| Anamnagar | 133.6 | 117.73 | 11.88 |
| Singhadurbar | 191.6 | 156.55 | 18.29 |

### 3.6 Validation

The output of the model was tested against the third day traffic data to validate the model. The difference between the model's estimated average BoQ and the observed average BoQ of Day 3 must be within the acceptable limit of 20% as per FDOT (2014).

*Table 6 Validation of SIDRA model*

| Approach | Average BoQ (m) | | |
|---|---|---|---|
| | Model Estimated | Field Measured | Difference (%) |
| Putalisadak | 110.23 | 89.75 | 18.58 |
| Anamnagar | 118.52 | 102.75 | 13.31 |
| Singhadurbar | 124.2 | 146.52 | 17.97 |

### 3.7 Performance evaluation after signal optimization

*Table 7 Average delay and queue in optimum cycle length*

| Approach | Demand (veh/h) | Average Delay (sec) | Average Back of Queue Distance (m) | LOS |
|---|---|---|---|---|
| Putalisadak | 832 | 213.1 | 99.1 | F |
| Anamnagar | 1314 | 281.8 | 121.7 | F |
| Singhadurbar | 1371 | 257.4 | 134.2 | F |

The optimum cycle length of the intersection is 140 seconds. Although there is no change in the overall LOS of the intersection, the average delay decreased to 266.4 sec and the average queue length is reduced to 134.2 m. Here in SIDRA, signal optimization is done by adjusting cycle time and green splits to minimize delays, queue and degree of saturation using lane- based traffic flow models.

### 3.8 Comparison of the alternatives

The results obtained from analyzing SIDRA are compared for the intersection.

***Table 8 Comparison of BOQ***

| 1 | Scenario | BOQ (m) | Average Delay (sec) |
|---|---|---|---|
| A | Existing | 191.6 | 251 |
| B | Optimized | 134.2 | 242.9 |

With the use of optimum cycle length, the average BOQ length of the intersection reduced from 191.6 m to 134.2 m whereas the average delay reduced from 251 seconds to 242.9 seconds.

## 4. Conclusions

The New Plaza intersection was found to have high queue lengths and delays in the existing condition with LOS F. This condition is due to the insufficient capacity of the roads with high traffic volume that exceeds it. The LOS F indicates the worst traffic condition with frequent disturbances in the traffic flow. In the existing conditions, the average queue length of the intersection was found to be 191.6 m and the average delay was found to be 251 seconds.

In order to improve the performance of intersection signal optimization was done through the use of optimum cycle length. While using the optimum cycle length, the LOS of the intersection remained F, but there were noticeable reductions in the queue length and slight reduction in average delay. The average queue length of the intersection decreased from 191.6 m to 134.2 m, while the average delay decreased from 251 sec to 242.9 sec. Thus even after signal optimization there were no changes in the LOS which is due to the traffic demand exceeding the intersection capacity. Signal optimization can only improve the efficiency to a certain extent when the road infrastructure itself is insufficient to accommodate the traffic. To further improve the performance of the intersection, the signal timing of the intersection can be coordinated with the neighboring intersections.

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## Reference

CSIR. (2017). Indian Highway Capacity Manual (Indo-HCM). New Delhi: CSIR..

HCM. (2000). Highway Capacity Manual. Washington D.C: Transportation Research Board.

DOR. (2013). Nepal Road Standard. Government of Nepal, Ministry of Physical Infrastructure and Transport, Department of Roads, Planning and Design Branch Road and Traffic Unit.

JICA, S. (2012). Data collection survey on traffic improvement in Kathmandu valley, Technical report, JAPAN INTERNATIONAL COOPERATION AGENCY (JICA).

FDOT (2014). Traffic Analysis Handbook: A Reference for Planning and Operation, Florida Department of Transport. Systems Planning Office.

Maharjan, L. (2023). Performance Evaluation and improvement of an Intersection: Case study of Thapathali Intersection. Lalitpur: Transportation Engineering Program.

Kafle, S.R., Shrestha, P.K (2024). Performance Evaluation of Ekantakuna Intersection. KEC Conference.

Paudel, J., Joshi, M. R., Bhatt, K. C., Giri, K., Bist, M., Luitel, S., Tiwari, H. (2024). Comparative Analysis of Intersection Performance Using PCU Values from NRS and Indo HCM: A Case Study of New Baneshwor Intersection. Journal of Transportation Systems.

Dhakal, K., Tiwari, H., Luitel, S. (2023). Evaluation and Performance Enhancement of four Legged Intersection: Satdobato, Nepal. Journal of Advanced Research in Construction and Urban Architecture.

Luitel, S., Pokhrel, A., Tiwari, H., Dhakal, A. (2023). Evaluation of Operational Performance of Intersection and Optimizing Signal Timing: A Case Study of the Buspark Intersection in Birgunj Metropolitan. Journal of Advanced Research in Civil and Environmental Engineering.

Khyaju, S. (2021). Traffic Flow Analysis of Uncontrolled Intersection: A Case Study of Keshar Mahal Intersection, Kathmandu, Nepal. Journal of Transportation Engineering and Traffic Management.

Kunwar, K. B., Marsani, A. (2019). The Effect of Countdown Timer Signal on the Performance of Signalized Intersection- A case study at New Baneshwor and Narayan Gopal Intersection. IOE Graduate Conference.

Tiwari, H., Luitel, S., Pokhrel, A. (2023). Optimizing Performance at Signalized Intersections through Signal Coordination in Two Intersections of Nepal. Journal of Transportation Systems.

Acharya, S., Dhakal, R., Pokhrel, A., Ojha, K. N. (2024). Intersection Efficiency Improvement through Signal Optimization- A Case Study in Kanchanbari, Biratnagar. Journal of Transportation Systems.

Shrestha, R. A., Marsani, A. (2023). Modeling Pedestrian Level of Service for Crosswalks at Signalized Intersection in Kathmandu Valley. 14th IOE Graduate Conference.

CSIR. (2017). Indian Highway Capacity Manual (Indo-HCM). New Delhi: CSIR..HCM. (2000). Highway Capacity Manual. Washington D.C: Transportation Board.OR. (2013). Nepal

Road Standard. Government of Nepal, Ministry of Physical Infrastructure and Transport, Department of Roads, Planning and Design Branch Road and Traffic Unit.

JICA, S. (2012). Data collection survey on traffic improvement in Kathmandu valley, Technical report, JAPAN INTERNATIONAL COOPERATION AGENCY (JICA).

FDOT (2014). Traffic Analysis Handbook: A Reference for Planning and Operation, Florida Department of Transport. Systems Planning Office.

Maharjan, L. (2023). Performance Evaluation and improvement of an Intersection: Case study of Thapathali Intersection. Lalitpur: Transportation Engineering Program.

Kafle, S.R., Shrestha, P.K (2024). Performance Evaluation of Ekantakuna Intersection. KEC Conference.

Paudel, J., Joshi, M. R., Bhatt, K. C., Giri, K., Bist, M., Luitel, S., Tiwari, H. (2024). Comparative Analysis of Intersection Performance Using PCU Values from NRS and Indo HCM: A Case Study of New Baneshwor Intersection. Journal of Transportation Systems.

Dhakal, K., Tiwari, H., Luitel, S. (2023). Evaluation and Performance Enhancement of four Legged Intersection: Satdobato, Nepal. Journal of Advanced Research in Construction and Urban Architecture.

Luitel, S., Pokhrel, A., Tiwari, H., Dhakal, A. (2023). Evaluation of Operational Performance of Intersection and Optimizing Signal Timing: A Case Study of the Buspark Intersection in Birgunj Metropolitan. Journal of Advanced Research in Civil and Environmental Engineering.

Khyaju, S. (2021). Traffic Flow Analysis of Uncontrolled Intersection: A Case Study of Keshar Mahal Intersection, Kathmandu, Nepal. Journal of Transportation Engineering and Traffic Management.

Kunwar, K. B., Marsani, A. (2019). The Effect of Countdown Timer Signal on the Performance of Signalized Intersection- A case study at New Baneshwor and Narayan Gopal Intersection. IOE Graduate Conference.

Tiwari, H., Luitel, S., Pokhrel, A. (2023). Optimizing Performance at Signalized Intersections through Signal Coordination in Two Intersections of Nepal. Journal of Transportation Systems.

Acharya, S., Dhakal, R., Pokhrel, A., Ojha, K. N. (2024). Intersection Efficiency Improvement through Signal Optimization- A Case Study in Kanchanbari, Biratnagar. Journal of Transportation Systems.

Shrestha, R. A., Marsani, A. (2023). Modeling Pedestrian Level of Service for Crosswalks at Signalized Intersection in Kathmandu Valley. 14th IOE Graduate Conference.DOR. (2013). Nepal Road Standard. Government of Nepal, Ministry of Physical Infrastructure and Transport, Department of Roads, Planning and Design Branch Road and Traffic Unit.

JICA, S. (2012). Data collection survey on traffic improvement in Kathmandu valley, Technical report, JAPAN INTERNATIONAL COOPERATION AGENCY (JICA).

FDOT (2014). Traffic Analysis Handbook: A Reference for Planning and Operation, Florida Department of Transport. Systems Planning Office.

Maharjan, L. (2023). Performance Evaluation and improvement of an Intersection: Case study of Thapathali Intersection. Lalitpur: Transportation Engineering Program.

Kafle, S.R., Shrestha, P.K (2024). Performance Evaluation of Ekantakuna Intersection. KEC Conference.

Paudel, J., Joshi, M. R., Bhatt, K. C., Giri, K., Bist, M., Luitel, S., Tiwari, H. (2024). Comparative Analysis of Intersection Performance Using PCU Values from NRS and Indo HCM: A Case Study of New Baneshwor Intersection. Journal of Transportation Systems.

Dhakal, K., Tiwari, H., Luitel, S. (2023). Evaluation and Performance Enhancement of four Legged Intersection: Satdobato, Nepal. Journal of Advanced Research in Construction and Urban Architecture.

Luitel, S., Pokhrel, A., Tiwari, H., Dhakal, A. (2023). Evaluation of Operational Performance of Intersection and Optimizing Signal Timing: A Case Study of the Buspark Intersection in Birgunj Metropolitan. Journal of Advanced Research in Civil and Environmental Engineering.

Khyaju, S. (2021). Traffic Flow Analysis of Uncontrolled Intersection: A Case Study of Keshar Mahal Intersection, Kathmandu, Nepal. Journal of Transportation Engineering and Traffic Management.

Kunwar, K. B., Marsani, A. (2019). The Effect of Countdown Timer Signal on the Performance of Signalized Intersection- A case study at New Baneshwor and Narayan Gopal Intersection. IOE Graduate Conference.

Tiwari, H., Luitel, S., Pokhrel, A. (2023). Optimizing Performance at Signalized Intersections through Signal Coordination in Two Intersections of Nepal. Journal of Transportation Systems.

Acharya, S., Dhakal, R., Pokhrel, A., Ojha, K. N. (2024). Intersection Efficiency Improvement through Signal Optimization- A Case Study in Kanchanbari, Biratnagar. Journal of Transportation Systems.

Shrestha, R. A., Marsani, A. (2023). Modeling Pedestrian Level of Service for Crosswalks at Signalized Intersection in Kathmandu Valley. 14th IOE Graduate Conference.