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Performance Evaluation and Improvement of Intersection using Sidra Intersection 8 Software: A Case Study of New Baneshwor Intersection.

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Abstract

Located at the heart of Kathmandu Valley, New Baneshwor is the busiest intersection, often faces severe congestion during peak hours as it connects four major routes: Tinkune, Maitighar, Old Baneshwor, and Sankhamul. Due to heavy traffic flow, detailed analysis of the current operational performance of the signalized intersection is mandatory and new solution should be explored. A 3-day videographic survey was carried out to count the vehicular traffic flow during peak hour from 8:30 to 11:30 and 4:00 to 7:00 in morning and evening, respectively. Additionally, pedestrian traffic was counted manually during peak hours over two days from 8:00 to 10:00 in morning and 4:00 to 6:00 in evening. Calibration and Validation were done by using 'SIDRA Intersection 8.0' based on average 3-day traffic volume during peak hour i.e., 9:00 to 10:00 am. The analysis depicts average delay of 338.7 seconds with LOS F, and maximum BOQ 1567.7 meters. Three alternatives including optimization of cycle length (Alternative I), combined adjustment of signal phase configuration and cycle length optimization (Alternative II), and geometric enhancement with cycle length optimization (Alternative III), were developed to improve the performance of intersection. Among them alternative III is best to optimize the performance of intersection as it improves LOS from F to D, and alleviate average delay from 338.7 to 38.8 seconds and maximum BOQ from 1567.7 to 253.9 meters.

Keywords: Average delay, Back of Queue (BOQ), Level of Service (LOS), SIDRA Intersection 8.0, Signalized intersection

1. Introduction

An intersection is a critical component of road network where two or more roads converge, diverge or cross at same level to facilitate vehicular and pedestrian movement. A book by (Kadiyali, n.d.) describe an intersection involves conflicts between traffic in different directions and causes delay, its scientific design can control accidents and delay and can lead to orderly movement of traffic . A poorly designed intersection leads to congestion and escalate road fatalities. (Das et al., 2021) collect five year (2014-2018) of fatal crash data and find out that intersection is a critical point where one-fourth of these crashes happened. Congestion is one of the major problems at intersection which leads to increase travel time. Congestion leads to frustration due to delay, noise pollution due to overcrowding of vehicle and air pollution due to over fuel consumption. A journal by (Kumarage, 2004) explain that traffic congestion has adverse effect on economic growth, quality of life, environmental quality and anti-social behavior. New Baneshwor is one of the busiest signalized intersections in Kathmandu Valley, which serve to largest residential area of the valley, leads to highest congestion at this intersection. Rapid urbanization, increase transportation demands, and lack of available land for expansion are other factors contribute to this scenario. SIDRA Intersection 8 software is a specialized software used to evaluate and optimize the performance of intersections and road networks by simulating traffic flow and performance criteria. This software is mainly used for analysis and optimization of signalized and unsignalized intersection, and roundabout.

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2. Research Objective

The main objective of this research is to evaluate the existing performance of New Baneshwor intersection and also suggest the appropriate solution and alternative to improve the existing condition of intersection by using SIDRA intersection 8.0 software.

3. Literature Review

(Al-Dabbagh et al., 2019) simulate three real maps based on road intersection and results indicate that there was a significant impact of road topology on traffic congestion in terms of the increase of delay time. Inefficient signal timing is another factor which leads to congestion at intersection. (Yue et al., 2022) suggest that on many occasion traffic congestion is not only due to road infrastructure but signal control strategies are the major contributor to it, and develops a method for identifying the root cause of congestion. (Retallack & Ostendorf, 2019) suggest that level of accident increases with increase in congestion. Vulnerable Road User (VRU) such as pedestrian, bicyclist, and motorcyclist, are at high risk at intersection. (Mukherjee & Mitra, 2022) explain that VRU account more than half of total road traffic fatalities and develop a systematic approach to elevate VRU safety at the urban intersection of developing country. To alleviate congestion and to make intersection safer, movement at intersection should be free and this can be achieved by simulating and optimizing traffic flow at intersection.

For performance evaluation, manual method is used previously in various research. (Bhatta et al., 2025) & (Paudel et al., 2024) use manual method for performance evaluation of different Intersections of Nepal. But, for performance evaluation and optimization of Intersection, SIDRA software is widely used. In 2023, (Luitel, 2023) prepare existing model using 72 hours data and geometrical characteristics using SIDRA software and improve traffic flow at Birgunj intersection by providing two alternatives, which leads to reduction in average delay from 38.8% to 34.7% and Back of Queue (BOQ) alleviate from 40% to 34.7%. In another research, (Tiwari et al., 2023) analyze two intersection of Nepal- Kanti Children's Hospital and Shital Niwas. Model was prepared using SIDRA software and validated based on observed and modelled queue lengths for each approach, and the existing performance of intersection was evaluated. Various alternatives were developed to improve the performance. Result show that coordinating the signal systems significantly reduced the average delay time and maximum queue length from 106 to 26.5 seconds per vehicle and 744.7 to 122 meters respectively at Shital Nivas. Similarly, for Kanti Children's Hospital average delay time and maximum queue length decrease from 43.1 to 21.7 seconds per vehicle and 456.2 to 147.7 meters respectively. (Tariq et al., 2021) evaluate the traffic condition of Gujranwala City, Pakistan by using SIDRA considering Delay and Volume/Capacity ratio and find out Level of Service (LOS) is very poor at these intersections. Based on its various alternatives like additional lanes, signals and increasing lane width are recommended for improving LOS of intersection. In the same way, (Maharjan & Marsani, n.d.) perform another research in Thapathali intersection where 70.58% of motorcycle dominate the traffic. The simulation model of intersection was developed on SIDRA for both weekdays and weekends. After the model were calibrated and validated using the 95th percentile back of queue (BoQ). The analysis revealed that the LOS is F and D during weekdays and weekends respectively. Different alternatives model was proposed and LC3-2 model and LC6-2 model were the best option for weekdays and weekends respectively. The paper also recommends for upgradation of geometry of the intersection after 2032 with addition of lanes and reconfiguration phase timing to run intersection at LOS C and B for weekdays and weekends respectively.

VISSIM is another widely used microscopic, time-step-based, behavior driven software that modeled the movement of individual vehicle and pedestrian in traffic network. (Shrestha & Marsani, 2017) found LOS was F during peak hours at New Baneshwor Intersection and provide four alternatives: Three phased signal planning by providing U-Turn, Flyover with existing scenario, four phased signal planning with flyover, three phased signal planning with flyover by providing U-Turn verifying queue pocket area for U-Turn. After comparative modeling three phased signal planning with flyover by providing U-Turn is considered best approach to improve LOS.

(Tianzi et al., 2013) perform a comparative study of VISSIM and SIDRA software for signalized intersection and the features and evaluation results were analyzed from the viewpoint of operational simplicity and the output error. Result depict that the SIDRA operation is easier while VISSIM's output is more accurate and suggested to use SIDRA for simpler operation and easier construction.

4. Methodology and Study Area

4.1 Study area

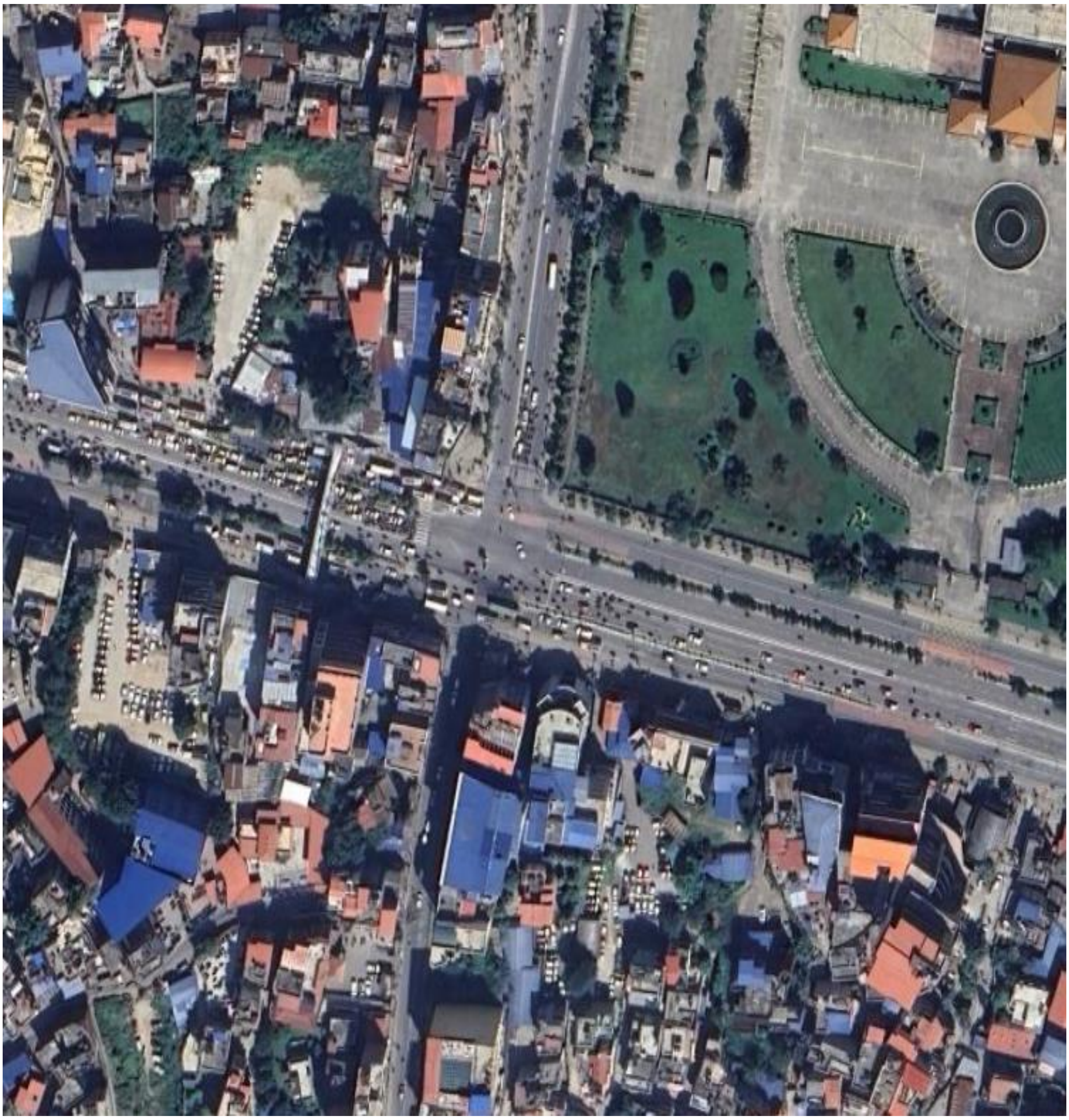

Figure 1. Google map image of New Baneshwor Intersection.

New Baneshwor intersection is considered as one of the congested intersections of Nepal due to extremely high traffic volumes, particularly during peak hours. New Baneshwor as shown in Figure 1 connects Tinkune, Maitighar, Old Baneshwor, and Sankhamul, which are major location inside the valley and also a major part of Araniko Highway. The coordinates of intersection is 27.71453°N/85.31991°E.

The 3-days traffic count is done and video data for that time is extracted. Peak hour traffic count is done to determine peak flow and peak hour factor for all 4-legs. Through this design hourly volume is calculated. Traffic distribution of each direction and left turn and right turn proportion is counted manually from video footage and calculated. For the standardization of the flow of vehicle standard Passenger car unit (PCU) is introduced. The count was carried out for; day 1 (June 20, 2023) from 8:30 AM to 11:00AM and 3:30PM to 5:45 PM, day 2 (June 21,2023) from 8:15 AM to 10:45PM and 3:15 PM to 5:45 PM, day 3 (June 22, 2023) from 8:15 AM to 10:45 AM and 3:30 PM to 5:45 PM.

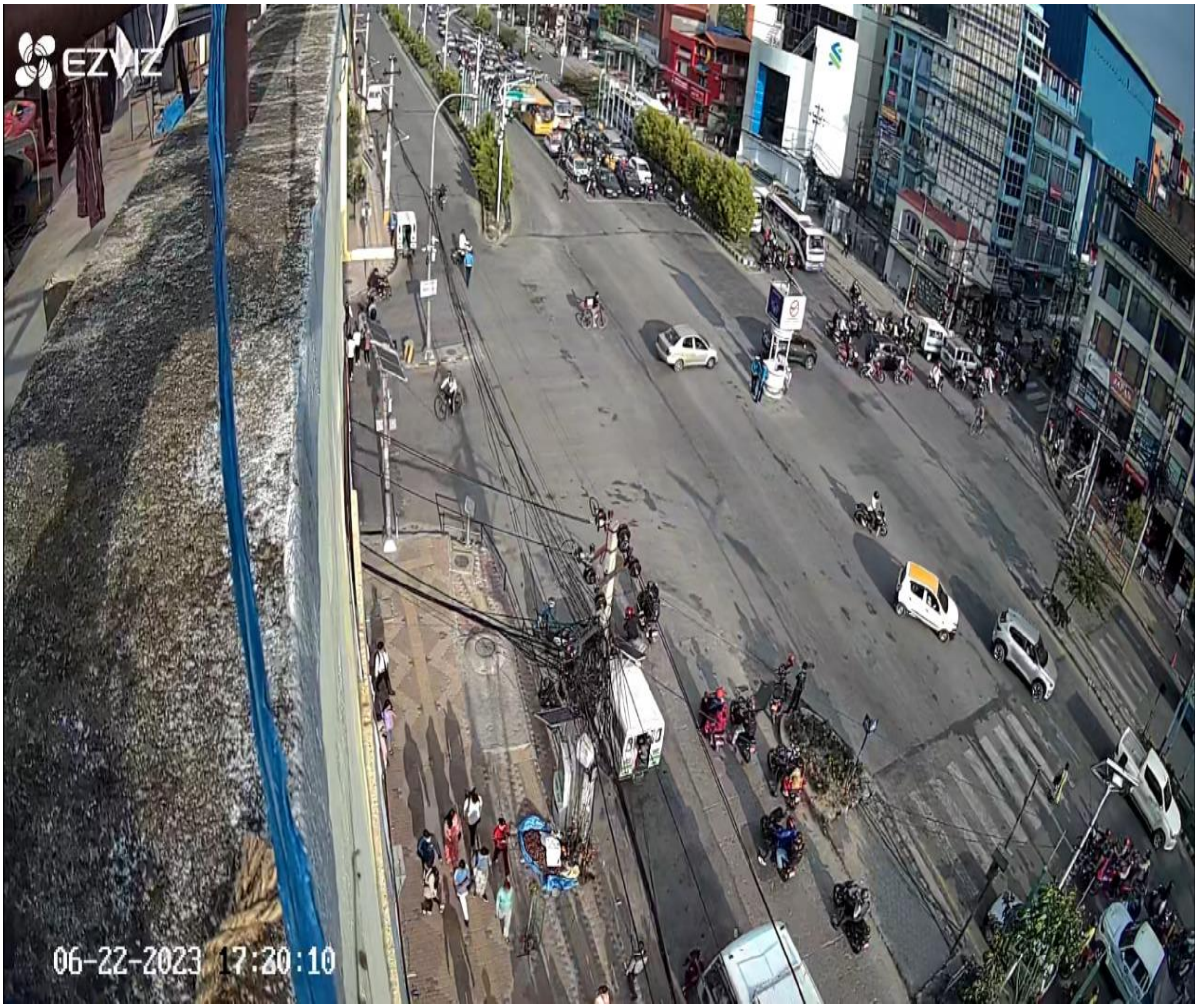

Figure 2 Aerial snapshot from videographic survey conducted at New Baneshwor Intersection

New Baneshwor is most developed place in Nepal as it is the central hub of many businesses and opportunities and is among one of the congested residential areas in Kathmandu. Due to lack of land for addition of road network, achieving of fast and safe movement of vehicles, various alternatives must be developed and analyzed.

4.2 Methodology

The following steps shown in Figure 3 below are followed to complete this research:

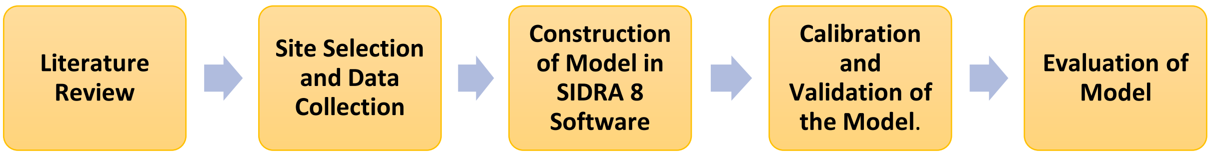

Figure 3. Flow Chart

The following steps are followed to complete this research:

1. Literature Review

Various journals, books and research paper related to signalized intersection were reviewed and ideas were collected.

2. Site Selection and Data Collection

The site is selected due to its important contribution in economic growth of Kathmandu valley as it is the major location for different businesses and opportunities and being one of the most congested intersections of Nepal. Traffic volume during peak hour was counted using 3-days videographic survey, 8:30 to 11:30 and 4:00 to 7:00 in morning and evening, respectively. The pedestrian volume was conducted manually using tally counter during peak hour over two days from 8 to 10 in morning and 4 to 6 in evening. However, for calibration the SIDRA intersection software was used and average 3-day data during peak hour i.e. 9:00 to 10:00 am were taken because of heavy traffic flow during this time. Geometric property and phase timing of lane were collected from the field.

3. Construction of Model in SIDRA 8 Software.

The classified directional traffic volume data, geometry data and signal timing were obtained from the videographic survey and field. Based on the data a model for New Baneshwor intersection was developed by using SIDRA intersection 8 software. The parameters such as delay, Back of Queue, and Level of service were assessed to measure the performance of intersection. The existing layout as per the geometric data generated by SIDRA software is shown in Figure 4.

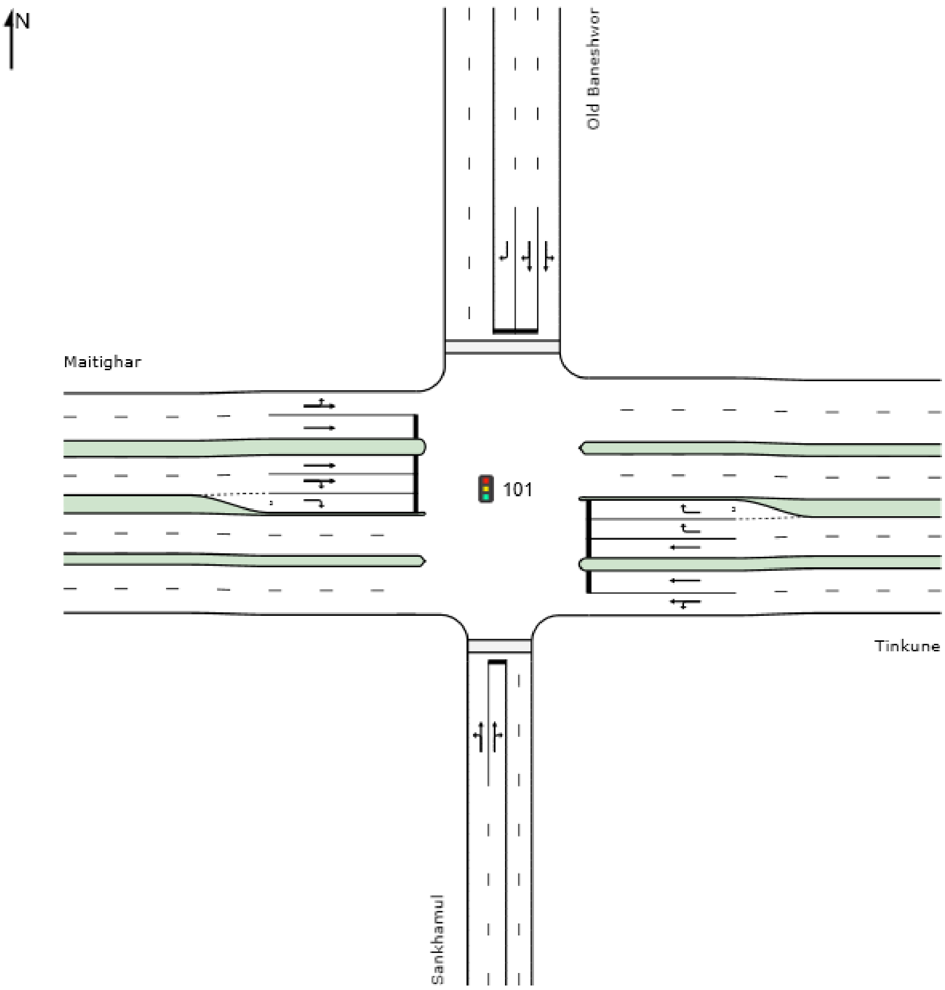

Figure 4. Existing layout of New Baneshwor Intersection

4. Calibration and Validation of the Model.

   On the basis of existing geometric data and traffic volume, SIDRA software model was developed. The model was then calibrated using phase sequence, cycle time, base saturation flow, equivalency factor and other parameters as shown in the Table 1. For validation, 95% of the BOQ obtained from model is compared with field BOQ. Table 2 demonstrates that there is a below 20% difference between the field and SIDRA-generated BOQ.

Table 1: Sidra calibration input

Parameters	Value	Remarks
Base Saturation Flow	1950	On-site Measurement
Lane utilization Ratio	Program	Program calculated
Saturation Speed		Program calculated
Capacity Adjustment	0%	No capacity adjustments
Buses stopping	0 veh/hr	No bus bays within 75 m
Parking Maneuvers	0 veh/hr	No parking Lane

Table 2: Observed Vs model generated back of queue

Approach	Model	Observed	Difference (%)
South: Sankhamul	1181.3	1017	16
East: Tinkune	1567.7	1323	18
North: Old Baneshwor	85.2	74	15
West: Maitighar	231.8	206	12

5. Evaluation of Model

   Based on average delay and back of queue length, the calibrated and validated model was used to find out the current performance of intersection. For escalating the performance of intersection, three alternatives were developed. These alternatives include optimization of cycle time (Alternative I), adjustment of phase configuration along with cycle time optimization (Alternative of II) and geometric enhancement along with cycle time optimization (Alternative III).

5. Results

Existing Phasing Overview

The overall intersection operates at Level of Service (LOS) F, with an average delay of 959.9 seconds and maximum BOQ of 2892.2 meters indicating severe congestion and inefficient traffic flow. The degree of saturation for the entire intersection is 3.528, suggesting that the intersection is operating well beyond its capacity, leading to excessive queuing and delays.

The intersection is a signalized intersection operating as an isolated junction with an existing signal phasing system. The intersection follows a five-phase cycle with a total cycle time of 172 seconds. The existing phasing summary and phase sequence is shown in the table 3 and Figure 5.

Table 3: Existing Phase timing summary

Phase	1	2	3	4	5
Phase Change Time (sec)	0	14	61	90	133
Green Time (sec)	7	40	22	36	32
Phase Time (sec)	14	47	29	43	39
Phase Split	8%	27%	17%	25%	23%

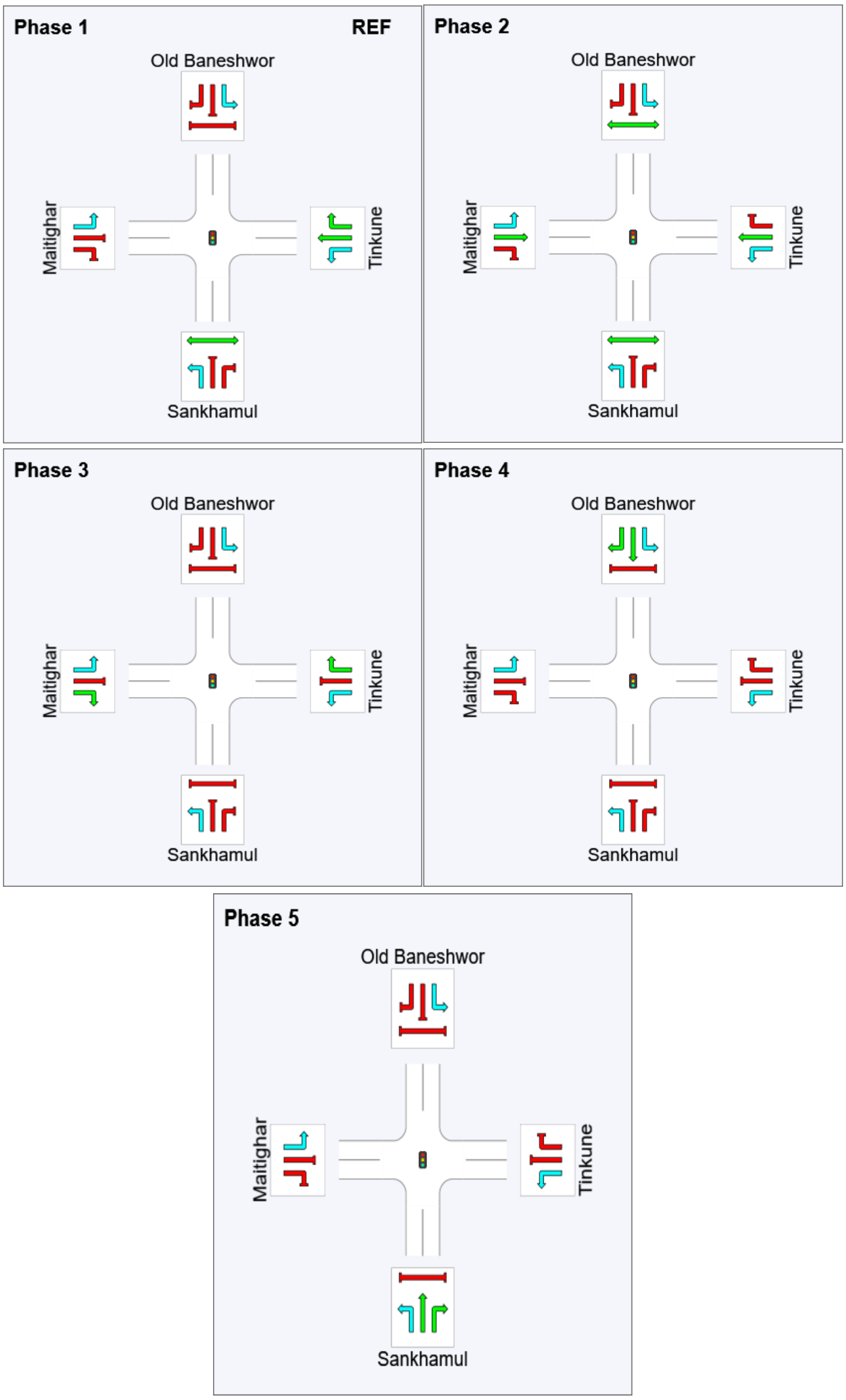

Figure 5: Existing phase sequence of New Baneshwor intersection

Table 4: Lane use and Performance of intersection

Approach	Demand Flows Total (veh/hr)	Average Delay (sc)	Level of Service (LOS)	95% Back of Queue **Distance (m)**
		South: Sankhamul		
Lane 1	2791	1.4	LOS A	0.0
Lane 2	1046	4360.1	LOS F	2531.3

Approach	Demand Flows Total (veh/hr)	Average Delay (sc)	Level of Service (LOS)	95% Back of Queue **Distance (m)**
Approach	3837	1189.6	LOS F	2531.3
		East: Tinkune		
Lane 1	4433	225.1	LOS F	0.0
Lane 2	145	541.5	LOS F	166.7
Lane 3	1368	502.0	LOS F	1495.3
Lane 4	1156	4595.3	LOS F	2892.2
Lane 5	1075	4596.0	LOS F	2688.6
Approach	8176	1469.6	LOS F	2892.2
		North: Old Baneshwor		
Lane 1	2983	2.0	LOS A	0.0
Lane 2	656	1818.1	LOS F	1344.7
Lane 3	656	1818.1	LOS F	1344.7
Approach	4295	556.7	LOS F	1344.7
		West: Maitighar		
Lane 1	2841	1.1	LOS A	0.0
Lane 2	138	65.0	LOS E	44.8
Lane 3	627	66.1	LOS E	218.0
Lane 4	346	1103.2	LOS F	552.3
Lane 5	279	1104.5	LOS F	446.9
Approach	4231	175.7	LOS F	552.3
Intersection	20539	959.9	LOS F	2892.2

Alternative I: Optimizing the cycle time

For minimizing delay, the program generated optimum signal time was implemented to replace the current practical signal time. The results indicate that the new cycle time significantly reduces delays, particularly for longer cycle times, enhancing overall traffic flow efficiency. The relationship between delay, cycle time and degree of saturation is shown in Figure 6. The phase time summary listed in Table 5 was implemented for this alternative.

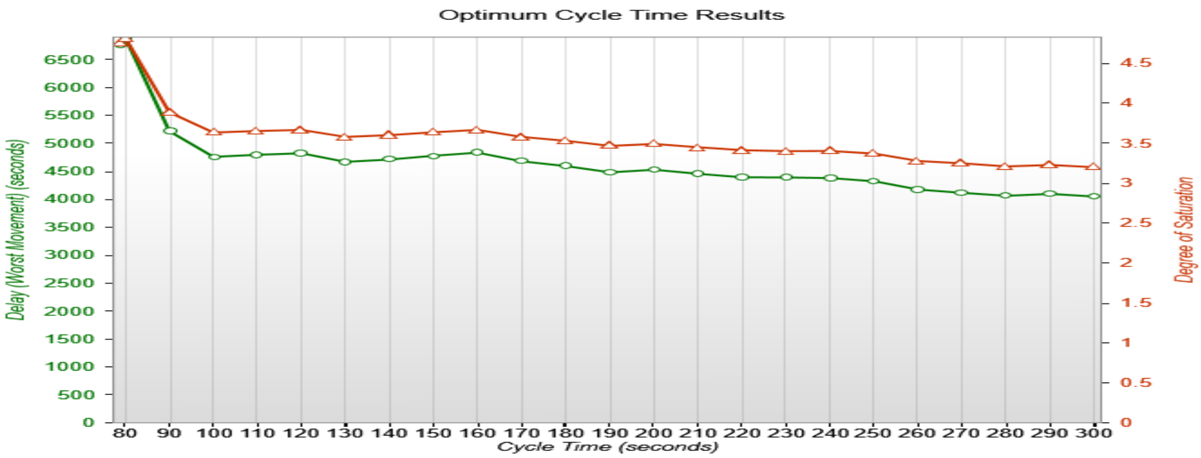

Figure 6: Optimum cycle time results

Table 5: Phase timing summary after alternative- I

Phase	**1**	**2**	**3**	**4**	**5**
Phase Change Time (sec)	0	18	84	141	213
Green Time (sec)	11	59	50	65	60

Phase	1	2	3	4	5
Phase Time (sec)	18	66	57	72	67
Phase Split	6%	24%	20%	26%	24%

Table 6: Lane use and Performance of intersection after alternative- I

Approach	Demand Flows Total (veh/hr)	Average Delay (sec)	Level of Service (LOS)	95% Back of Queue Distance (m)
		South: Sankhamul		
Lane 1	2791	1.4	LOS A	0.0
Lane 2	1046	4053.4	LOS F	2688.9
Approach	3837	1106.0	LOS F	2688.9
		East: Tinkune		
Lane 1	4649	277.5	LOS F	0.0
Lane 2	44	713.4	LOS F	68.0
Lane 3	1252	636.1	LOS F	1802.4
Lane 4	1128	3973.8	LOS F	2862.9
Lane 5	1103	3974.1	LOS F	2801.6
Approach	8176	1343.4	LOS F	2862.9
		North: Old Baneshwor		
Lane 1	2983	2.0	LOS A	0.0
Lane 2	656	1705.7	LOS F	1448.4
Lane 3	656	1705.7	LOS F	1448.4
Approach	4295	522.4	LOS F	1448.4
		West: Maitighar		
Lane 1	2950	1.1	LOS A	0.0
Lane 2	68	114.7	LOS F	37.2
Lane 3	588	110.8	LOS F	334.1
Lane 4	329	525.3	LOS F	404.2
Lane 5	296	527.0	LOS F	363.6
Approach	4231	95.7	LOS F	404.2
Intersection	20539	870.4	LOS F	2862.9

Alternative II: Adjustment of signal phase configuration along with optimizing cycle time

Following the adjustment of the signal phase configuration from five to seven phases and the implementation optimum cycle length, the overall intersection continues to operate at Level of Service (LOS F). However, specific lanes particularly in the Sankhamul and Tinkune approaches demonstrate improved traffic flow. Optimum Cycle time results graph in Figure 7 indicates that as cycle time increases, both delay and the degree of saturation rises significantly. Table 7 presents the phase summary for the intersection, while Figure 8 illustrates the corresponding phase sequence, providing a comprehensive overview of the signal operation.

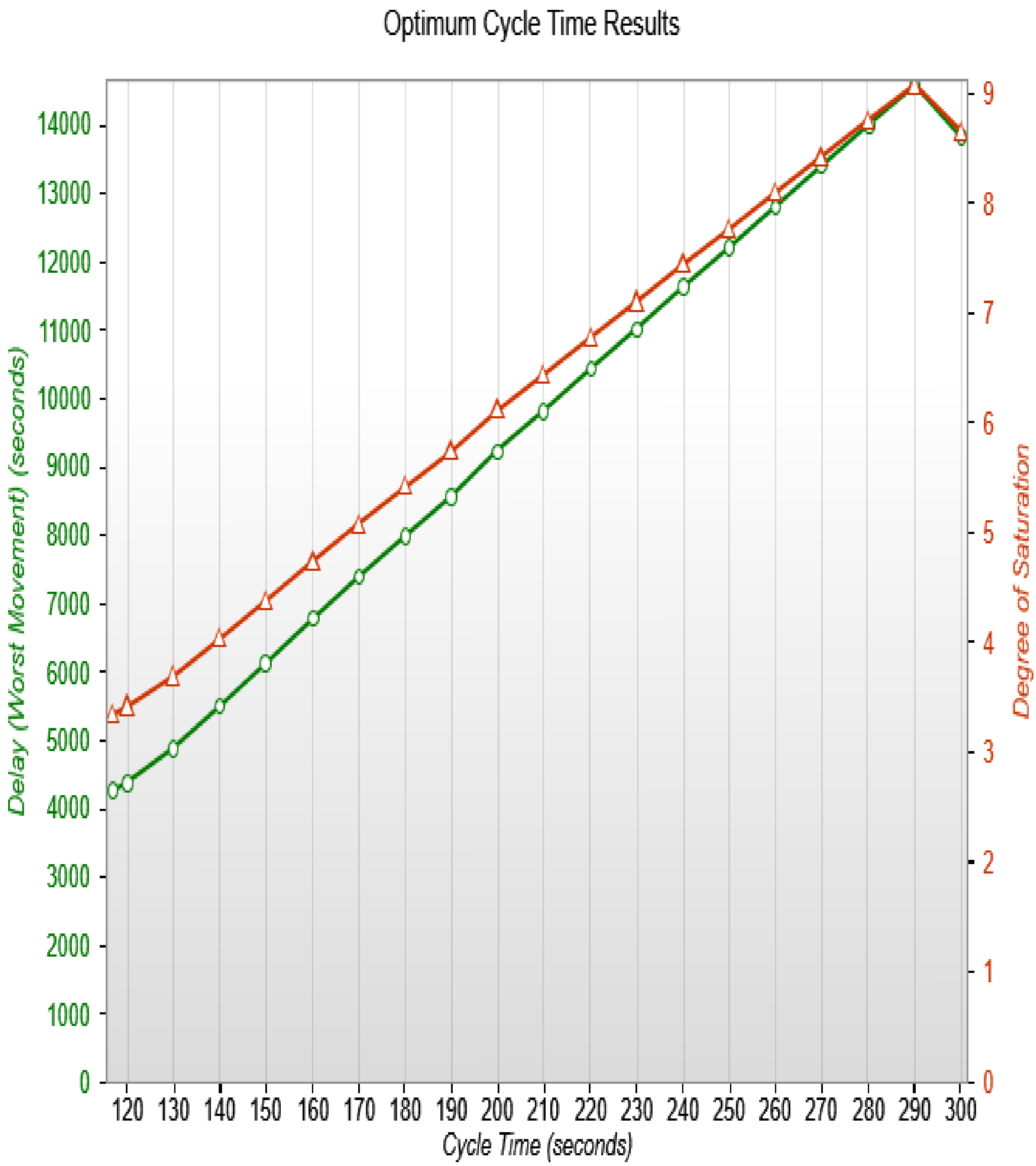

Figure 7: Optimum cycle time results

Table 7: Phase timing summary after alternative- II

Phase	1	2	3	4	5	6	7
Phase Change Time (sec)	0	12	39	52	66	81	108
Green Time (sec)	6	20	6	7	8	20	6
Phase Time (sec)	13	27	13	14	15	26	12
Phase Split	11%	23%	11%	12%	13%	22%	10%

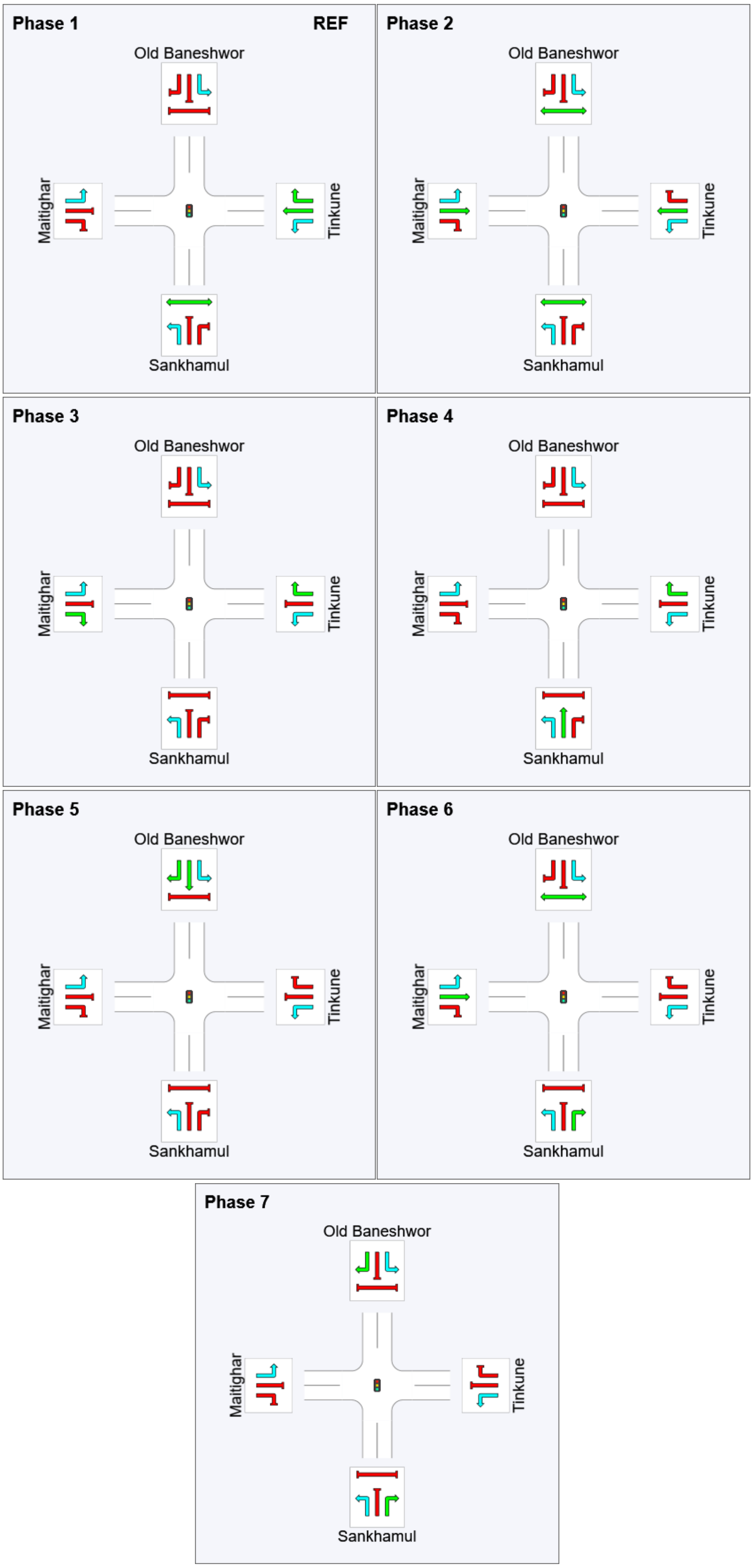

Figure 8: Phase sequence after alternative- II

Table 8: Lane use and performance of intersection after alternative- II

Approach	Demand Flows Total (veh/hr)	Average Delay (sec)	Level of Service (LOS)	95% Back of Queue Distance (m)
		South: Sankhamul		
Lane 1	2791	1.4	LOS A	0.0
Lane 2	1046	2505.1	LOS F	2040.8
Approach	3837	683.9	LOS F	2040.8
		East: Tinkune		
Lane 1	4542	263.8	LOS F	0.0
Lane 2	165	582.6	LOS F	181.5
Lane 3	1238	559.5	LOS F	1322.5
Lane 4	1165	3043.4	LOS F	2505.5
Lane 5	1066	3044.0	LOS F	2294.6
Approach	8176	1073.6	LOS F	2505.5
		North: Old Baneshwor		
Lane 1	2983	2.0	LOS A	0.0
Lane 2	656	2332.8	LOS F	1364.5
Lane 3	656	2332.8	LOS F	1364.5
Approach	4295	714.0	LOS F	1364.5
		West: Maitighar		
Lane 1	2345	1.2	LOS A	0.0
Lane 2	537	18.3	LOS B	67.9
Lane 3	725	19.7	LOS B	99.2
Lane 4	456	4361.1	LOS F	1195.6
Lane 5	169	4363.8	LOS F	443.8
Approach	4231	650.7	LOS F	1195.6
Intersection	20539	838.5	LOS F	2505.5

Alternative III: Geometric enhancement along with optimizing signal timing.

The combined implementation of a bypass, short lane and optimized signal timing significantly improved level of service and reduced delays at intersection. Degree of saturation was lowered in certain lanes indicating use of bypass and short lane significantly balance the demand and capacity ratio. Figure 9 indicates the graph shows as cycle time increases, delay initially fluctuates but stabilizes at a lower level, while the degree of saturation remains relatively constant after an initial drop. The updated intersection layout after adding bypass and a short lane to the existing design is shown in Figure 10. Phase summary is illustrated below in Table 9.

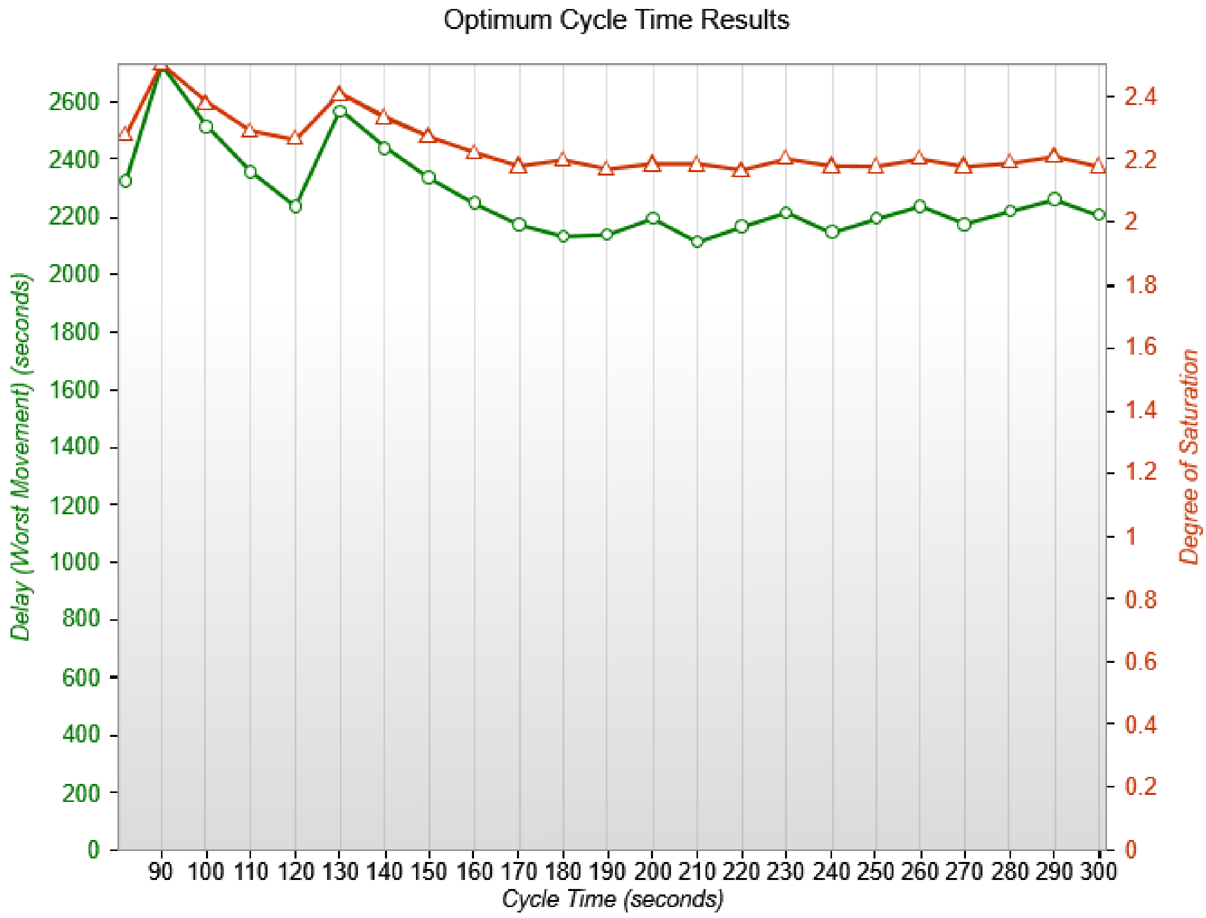

Figure 9: Optimum cycle time results

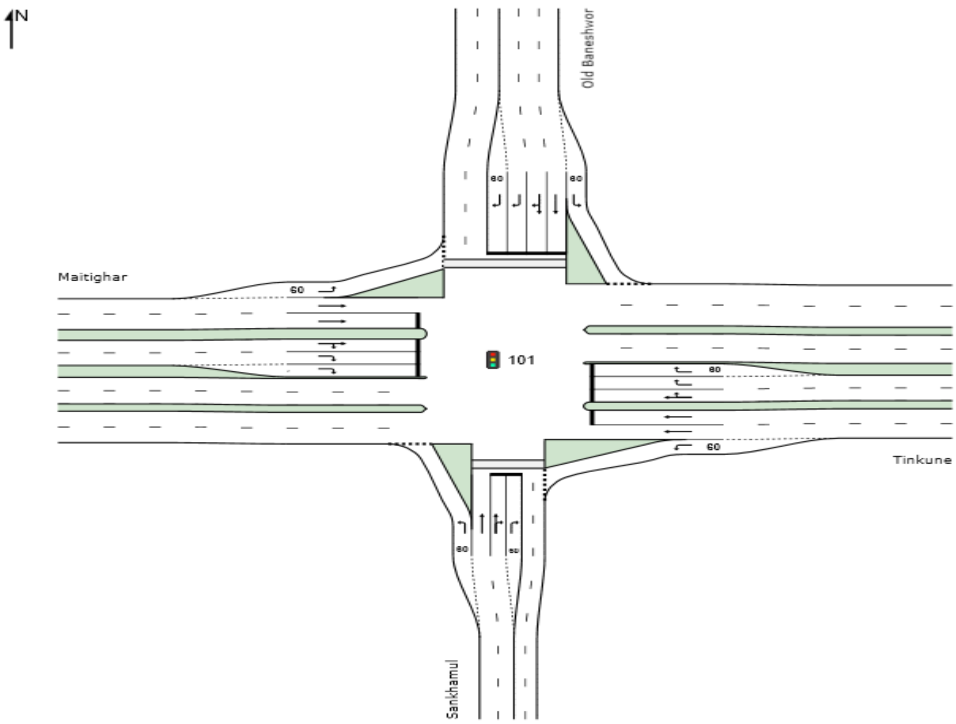

Figure 10 Intersection layout after alternative III

Table 9: Phase timing summary after alternative- III

Phase	1	2	3	4	5
Phase Change Time (sec)	0	13	43	56	69
Green Time (sec)	6	23	6	6	6
Phase Time (sec)	13	30	13	13	13
Phase Split	16%	37%	16%	16%	16%

Table 10: Lane use and Performance of intersection after alternative- III

Approach	Demand Flows Total (veh/hr)	Average Delay (sec)	Level of Service (LOS)	95% Back of Queue **Distance (m)**
		South: Sankhamul		
Lane 1	1279	155.0	LOS F	443.9
Lane 2	1512	0.1	LOS A	0.0
Lane 3	523	1415.6	LOS F	755.6
Lane 4	523	1415.6	LOS F	755.6
Approach	3837	437.6	LOS F	755.6
		East: Tinkune		
Lane 1	981	6.9	LOS A	56.5
Lane 2	3761	43.1	LOS D	0.0
Lane 3	1203	141.7	LOS F	509.7
Lane 4	211	19.9	LOS B	16.4
Lane 5	1010	1465.3	LOS F	1532.4
Lane 6	1010	1465.3	LOS F	1532.4
Approach	8176	404.0	LOS F	1532.4
		North: Old Baneshwor		
Lane 1	1695	284.1	LOS F	1000.6
Lane 2	728	2319.3	LOS F	1325.0
Lane 3	696	2319.9	LOS F	1300.1
Lane 4	588	2322.7	LOS F	1217.3
Lane 5	588	2322.7	LOS F	1217.3
Approach	4295	1517.1	LOS F	1325.0
		West: Maitighar		
Lane 1	748	6.0	LOS A	32.3
Lane 2	2268	0.3	LOS A	0.0
Lane 3	590	27.8	LOS C	91.1
Lane 4	13	46.0	LOS D	3.6
Lane 5	498	1615.4	LOS F	855.7
Lane 6	114	1618.6	LOS F	196.3
Approach	4231	239.0	LOS F	855.7
Intersection	20539	609.1	LOS F	1532.4

Comparison between existing and alternatives performance of intersection.

Comparison between existing and alternatives measures was done on the basis of Level of service, control delay and Back of Queue length. As the intersection's existing performance was assessed as 'F'. Though implementing alternative I, II and III reduces control delay and Back of Queue but still the level of service remains unchanged.

The bar graph in Figure 11 illustrates the average delay for existing scenarios and three proposed alternatives. With an average delay of 959.9 seconds, the current state shows the largest delay. Alternative I shows a modest decrease to 870.4 seconds, while Alternative II shows a bit improvement than Alternative I with 838.5 seconds. Interestingly, Alternative III performs noticeably better than the other alternatives, with an average delay of only 609.1 seconds.

The bar graph in Figure 12 illustrates the 95% back of queue (BOQ) length in meters across different scenarios. The queue length under the current scenario is 2892.2 meters. Although Alternative I `with minimal reduction of BOQ length to 2862.9 meters while a noticeable improvement is seen with Alternative II which brings BOQ length to 2505.5 meters. The greatest significant reduction is offered by alternative III, which reduces the queue length to just 1532.4 meters.

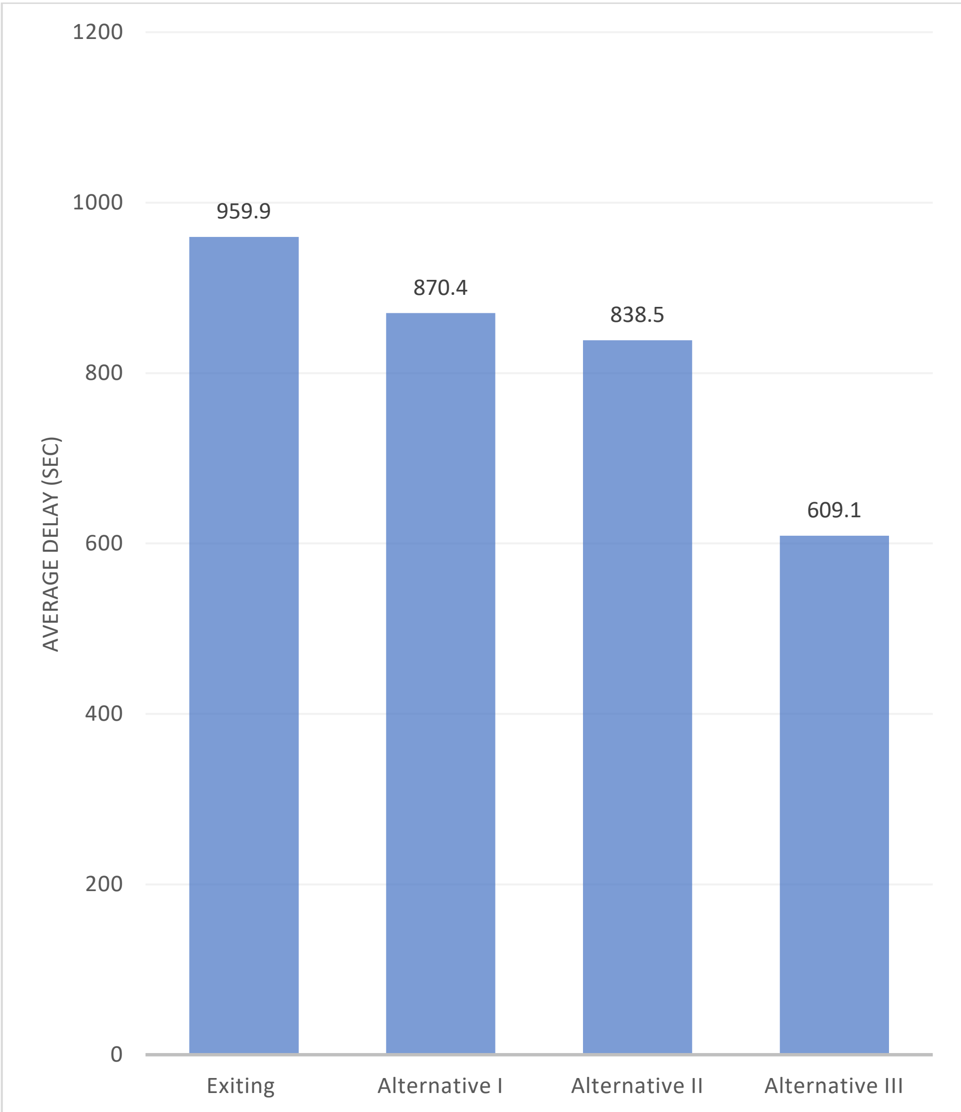

Figure 11: Average delay comparison chart

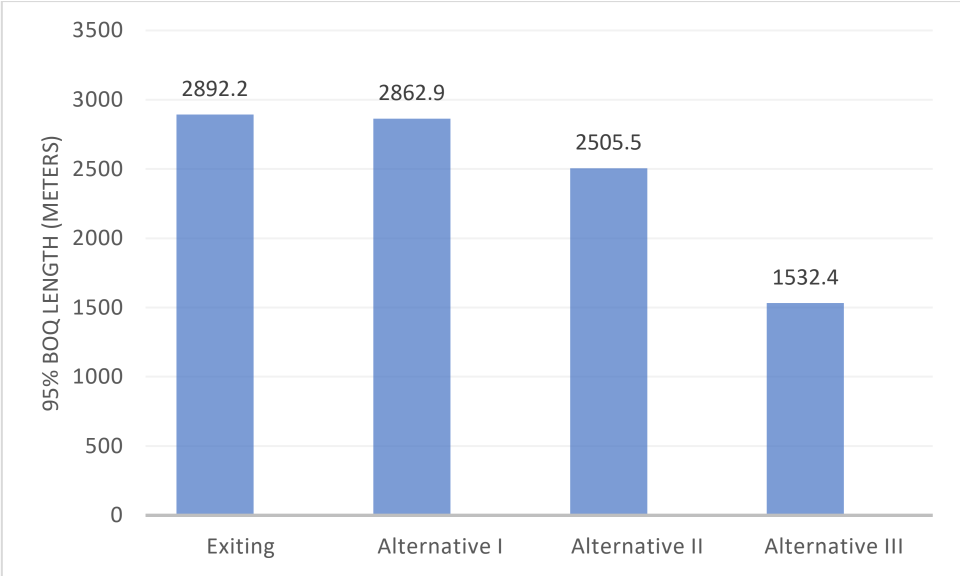

Figure 12: 95% BOQ length comparison chart

6. Discussion

The use of SIDRA software and intersection performance metrics (LOS, delay, BOQ) in this study aligns with approaches in recent Nepalese research. Luitel (2023) reported a 34.7% reduction in BOQ and improved signal timing at Birgunj's Buspark intersection. However, their model focused solely on phasing optimization, whereas this study's Alternative III added geometric redesign, producing more substantial improvements—LOS uplift from F to D, and delay cut by over 60%. Similarly, Tiwari et al. (2023) used SIDRA for two Kathmandu intersections and achieved delay reductions of up to 80% using signal coordination strategies. Yet, their interventions lacked geometric refinement, which, in our case, proved pivotal. Compared to Maharjan and Marsani's (n.d.) work at Thapathali, where LOS improved only after long-term geometry upgrades projected for post-2032, this study demonstrates short-term gains through compact modifications like bypass and short lanes.

The inclusion of geometric enhancements in Alternative III sets this study apart, yielding significantly better outcomes with improved LOS and reduced delays. Despite the limited right-of-way at New Baneshwor, the proposed modifications—like short lanes and bypasses—are relatively modest in scale and offer practical, high-impact benefits. These results demonstrate the feasibility of targeted geometric improvements, reinforcing their value in congested urban intersections where extensive expansion is not viable.

7. Conclusion and Recommendation:

Due to increase in population, vehicle flow is increasing tremendously in Kathmandu City as Kathmandu is Capital of Nepal, ultimately leads in congestion at major intersections of city. This paper addressed the problem of congestion at one of the most important intersections of Kathmandu, New Baneshwor Intersection and three alternatives including optimization of cycle length, combined adjustment of phase and cycle length optimization, and geometric enhancement along with cycle length optimization were developed to improve LOS, delay and maximum BOQ. All three alternative helps to reduce average delay and maximum BOQ. Among them, alternative III is the best option which improve LOS from F to D by alleviating average delay from 338.7 to 38.8 seconds and maximum BOQ from 1567.7 to 253.9 meters during peak hour. The implication of this alternative is profound and play a pivotal role in improving LOS, delay and maximum BOQ of the intersection. However, due to lack of availability of land it is difficult for addition of bypass and short lane in existing situation. Further research for feasibility of geometric enhancement at New Baneshwor intersection need to carried out based on both morning and evening peak hour flow separately considering contribution of nearby intersection.

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