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SUSTAINABLE OPERATION INDEX OF ARTERIALS IN CBD SECTOR AT HILLA CITY

Dr. Mohammad Ali Al-Anbari
Prof., Engineering College, University of Babylon, Babylon, Iraq.

Dr. Abdulhaq Hadi Abedali
Assist Prof., Highway and Transportation Engineering Department, Mustansiriayah University, Baghdad, Iraq.

Ali Abdul Ameer Alwash
Ph.D., Highway and Transportation Engineering Department, Mustansiriayah University, Baghdad, Iraq.

ABSTRACT

This research describes opportunities to incorporate environmental, economic, and social sustainability into- transportation decision-making throughout the use of performance measures. That allows to quickly observe all effects on operation of arterials in CBD sector at Hilla city. CBD sector (Sector 2) at Hilla city has arterials network with 26 links and 9 nodes.

For calculating I_{CST} (composite sustainability transport index), the data collected consists of delay, noise, and observed accidents for both links and adjacent main nodes within CBD and measuring all gases pollutants for main nodes only.

According to I_{CST} values within Hilla CBD arterial network, the overall evaluation of sustainability operation level is moderate for links and low for main adjacent nodes. That means needing for better organization of traffic operation for link and reorganization or implementation of new infrastructure projects for main nodes with support public transport.

Keyword: Sustainable operation, Arterials, CBD, Composite Index, links and nodes.

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1. INTRODUCTION

1.1. General

To provided good transport systems operation, it is importuning to transport goods safely, mobility and other environmental, economic and social objective, must be achieved to reduce the amount of emission from vehicles to decreased environmental impact the transportation sector

CO_2 is the primary greenhouse gas emitted by vehicles, accounting for 95 percent of transportation's impact on climate change. In gasoline-powered vehicles, CO_2 emissions are nearly directly proportional to the amount of fuel burned **[1]**.

There is some debate about how to account for lifecycle Green House Gas emissions of alternative fuels. Typically, only the CO_2 emitted from the tailpipes of conventional gasoline and diesel vehicles is counted in transportation-related carbon intensity metrics; however, the "upstream" production and distribution of gasoline and diesel also emit CO_2, which is typically accounted for under stationary source metrics. Alternative fuels change both upstream emissions and tailpipe emissions. For example, electric vehicles emit no tailpipe CO_2, but the production of the electricity used to power them typically creates CO_2 emissions **[1]**.

One-fifth of the carbon dioxide (CO_2), one third of chlorofluoro- carbons (CFCs), and half of nitrogen oxides (NO_x) in the atmosphere related to transport activities. Transportation has significant economic, social and environmental impacts and is an important factor in sustainability studies **[2]**. Gas emission depends on speed, acceleration and vehicle performance level (performance index for passenger car unit and trucks).

CO emission of the heavy vehicle, buses and trucks (diesel fuel) equal only 1/11 of that for small cars (benzene fuel) **[3]**.

Motor vehicles produce various harmful air emissions. Some impacts are localized, so where emissions occur affects their costs, while others are regional or global, and so location is less important. Emission control technologies have reduced emission rates of some but not all pollutants such as particulates **[4].**

Traffic noise (is considered an environmental pollution) depends on first engine noise, inlet and exhaust noise, cooling fan system transmission noise and road surface noise. Second traffic volume and travel speed, traffic compassion (the noise increase by increment of truck percentage), at intersection (the noise increased due to change in speed rate). Third, space dimension of road way. The noise increased by the decrement of width and increment of building height **[5]**. The heavy vehicle (like buses and trucks with diesel fuel) causes traffic noise equal to 115% of that for small cars (benzene fuel) **[3]**.

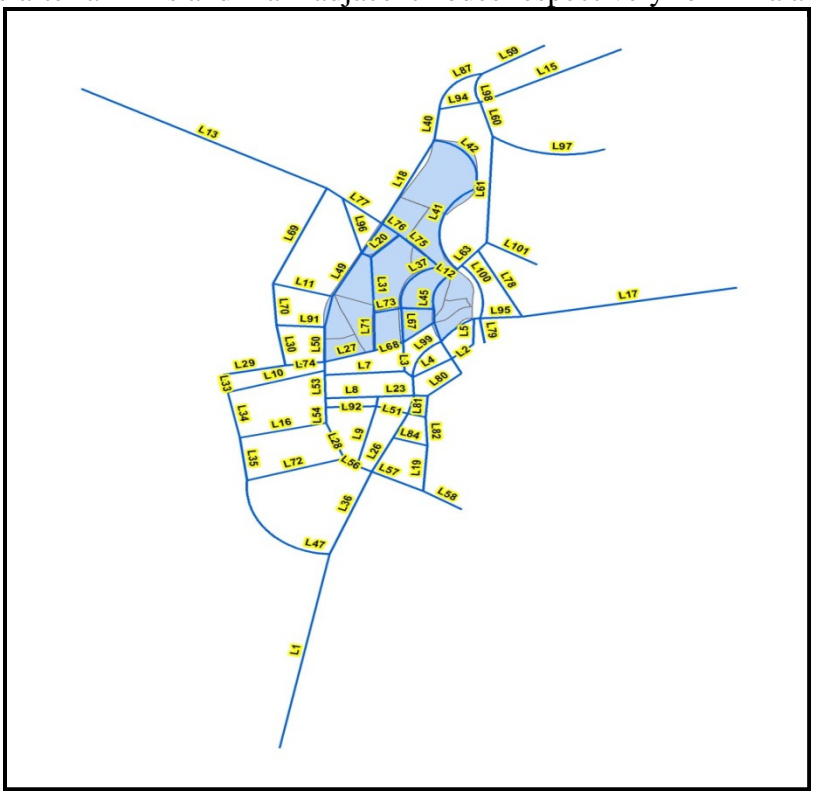
For most persons, the individual travel time is the most relevant criterion when planning and operation a route from a given origin to a given destination. Road managers and national economists are interested in the total travel time in a certain region over a certain time interval. Of particular interest is the total delay caused by congestion **[6]**.

"Accident" is the commonly accepted word for an occurrence involving one or more transportation vehicles in a collision that results in property damages, injury, or death. The term "accident" implies a random event that occurs for no apparent reason other than "it just happened". The causes of crashes are usually complex and involve several factors, they can be considered in four separate categories: actions by the driver or operator, mechanical condition of the vehicle, geometric characteristics of the roadway, and the physical or climatic environment in which the vehicle operates **[2]**.

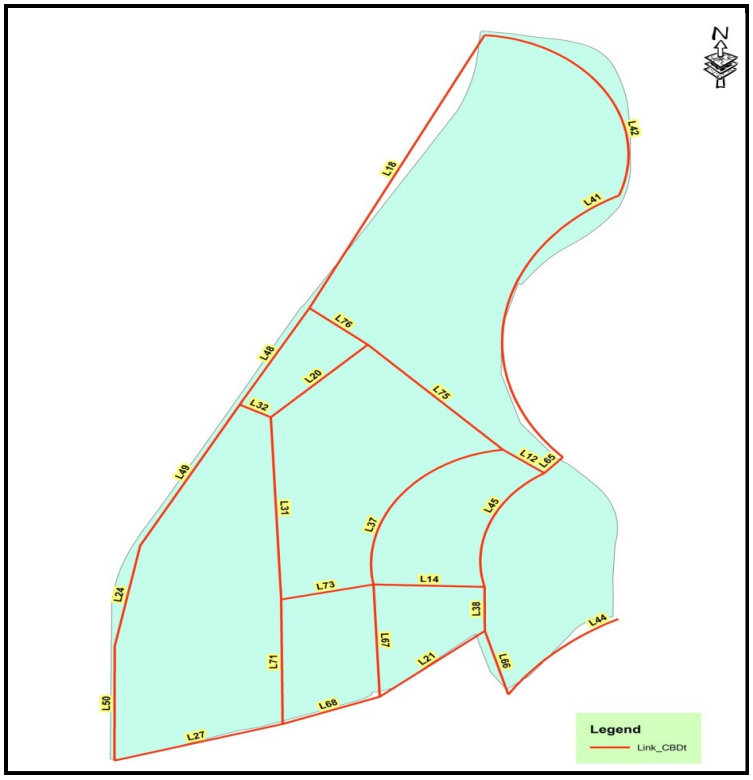
Economic, environmental and social dimensions are regarded as the triple-bottom-line principle of sustainability. The basic nature of transportation is to fulfill the mobility of passengers and goods, and the first primary factor of transportation is its capacity. Transport capacity firstly manifests as the amount of vehicles, the length of transport lines and so on. The second primary factor is service quality like connectivity, accessibility, as well as fare **[7]**.

1.2. CBD Sector

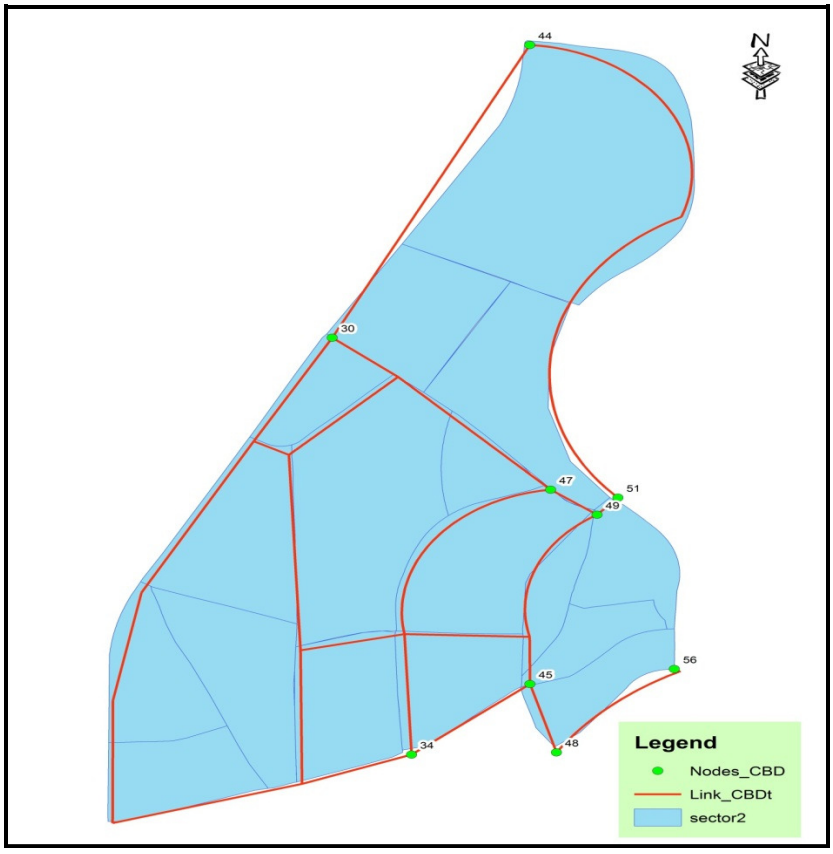
The central business district (CBD) is the high focus area in the city. It is the commercial, office and cultural city center, which related to center of urban arterials network. Usually, lack of clarity boundary to the CBD. But, it contains high density traffic, large number of transport nodes and a lot of activities during the day time. CBD is a fixed location where selling and commerce took place and it is typically near a main transport route and a side of river. However, it is an area meets the following criteria as high pedestrian level and parking lack, highest lane values, connected by public transport. **[8]** Therefore, through site views of the study area for a very long time CBD is represented by sector No. 2 at Hilla city. Map 1, Map 2 and Map 3 show CBD sector, the arterial links and main adjacent nodes respectively for Hilla arterial Network.



Map 1 CBD (Color part) within Hilla City (Sector No.2).



Map 2 Hilla arterials links within (Sector No.2).



Map 3 Hilla arterials main nodes within CBD (sector No.2).

2. DATA COLLECTION FOR SUSTAINABILITY EVALUATION

Traffic operation data for CBD arterial network is predicted according to related equations in HCM 2010 and by Sidra software while the environmental data and gas emission like CO_2 and other air pollutants like (lead, SO_2, CO, NOx) are measured by cooperation with environmental office in Hilla city as well as the traffic noise values. Also, the data of observed accidents is collected by cooperation with traffic police office in Hilla city [9].

Table 1 shows the filed data for arterial links within the CBD networks and Table 2 shows the filed data for arterial nodes at CBD network.

The suggested air quality specification for EPA (2009) Environmental Ministry as

Noise L_{eq} (Iraqi limit = 55 dB).

Lead (Iraqi suggested limit = 2 microgram/m^3).

SO_2 (Iraqi suggested limit = 40 ppb).

CO (Iraqi suggested limit = 35 ppm).

NO_x (Iraqi suggested limit = 5 ppb).

CO_2 (Iraqi suggested limit =300 ppm).

The above air quality specification obtained from environmental office at Hilla city. Noise as environmental indicators show higher values above adopted limit along all arterials (especially at signalized nodes).

Table 1 Field Data Measurements for Arterials Links at Hilla CBD.

Link_No	Noise (dB)	Accident (No)	Delay (sec) *
12	**75.1**	**12**	**29.80**
14	**71.5**	**2**	**0.40**
18	**77.9**	**5**	**21.50**
20	**68.9**	**1**	**1.20**
21	**72.1**	**3**	**31.10**
24	**72.1**	**3**	**11.00**
27	**75.9**	**3**	**61.30**
31	**70.0**	**1**	**43.30**
32	**70.0**	**1**	**0.10**
37	**73.4**	**3**	**17.50**
38	**77.6**	**3**	**0.10**
41	**65.0**	**2**	**2.50**
42	**65.7**	**3**	**4.00**
44	**75.2**	**5**	**16.60**
45	**69.5**	**1**	**4.10**
48	**72.0**	**3**	**3.40**
49	**71.0**	**2**	**3.40**
50	**74.5**	**2**	**4.10**
65	**75.1**	**12**	**16.20**
66	**73.3**	**3**	**0.40**
67	**71.5**	**5**	**12.70**
68	**74.9**	**2**	**22.70**
71	**71.1**	**1**	**0.20**
73	**71.7**	**4**	**0.20**
75	**73.0**	**5**	**18.40**
76	**73.3**	**3**	**7.20**

*Delay = $T_{congested} - T_{free\ flow}$ **[10]**

Table 2 Field Data Measurement for Arterials Nodes at Hilla CBD.

Node No.	*Noise (dB)	Accident (No.)	Lead ($\mu g/m^3$)	ppb(So_2)	ppm(Co)	ppb(Nox)	ppm(Co_2)	Delay (sec)
30	**79.1**	**23**	**2.07**	**46.5**	**31.1**	**33.5**	**378**	**43**
44	**80.9**	**6**	**2.01**	**40.1**	**37**	**44**	**305**	**1000**
34	**72.2**	**3**	**1.7**	**60**	**40**	**43.4**	**270**	**101**
47	**75.3**	**12**	**1.5**	**55**	**38**	**67.2**	**376**	**286**
51	**74.8**	**5**	**1.8**	**40.5**	**37**	**49**	**320**	**255**
45	**75.2**	**3**	**1.9**	**39**	**31.5**	**48.1**	**290**	**152**
49	**73.9**	**5**	**1.53**	**29.2**	**27**	**45**	**295**	**300**
48	**72**	**4**	**2.05**	**33.2**	**30**	**40.9**	**271**	**256**
56	**75.2**	**15**	**2.1**	**38.1**	**30.9**	**50.5**	**293**	**210**

*by device: Svam 955

Observed accidents as social (safety) indicator show higher values than these predicted (calculated) especially at intersections. While the other environmental indicators like CO_2 and other pollutant are almost above the acceptable control limits, especially intersections, significantly at signalized ones, due to traffic concentration at the AM peak period (rather than round about ones).

3. SUSTAINABLE INDICATORS OF CBD ARTERIAL NETWORK

Transport indicators contains different type of information (environmental, social, and economic) therefore before indicators aggregation it is necessary to transform them to number without any dimension (Dimensional analysis). Indicators (as selected in the research) whose increasing values have negative impact on sustainability where normalized using equation below **[11]**:

$$Ii = \frac{I\max - I}{I\max - I\,min} \quad (1)$$

Where:

I_i = any calculated normalized indicators.

All normalized data indicators: I_{delay}, $I_{accident}$, I_{noise}, for CBD arterial links and I_{delay}, $I_{accident}$, I_{noise}, I_{lead}, I_{CO}, I_{CO2}, I_{SO2}, and I_{NOx} for CBD atrial nodes are shown in Table 3 and 4 respectively.

Table 3 Normalized data indicators for CBD arterials links.

Link_No	I_Noise	I_Accident	I_Delay	Link_No	I_Noise	I_Accident	I_Delay
12	0.22	0.56	0.83	44	0.21	0.84	0.91
14	0.50	0.96	1.00	45	0.65	1.00	0.98
18	0.00	0.84	0.88	48	0.46	0.92	0.98
20	0.70	1.00	0.99	49	0.53	0.96	0.98
21	0.45	0.92	0.83	50	0.26	0.96	0.98
24	0.45	0.92	0.94	65	0.22	0.56	0.91
27	0.16	0.92	0.66	66	0.36	0.92	1.00
31	0.61	1.00	0.76	67	0.50	0.84	0.93
32	0.61	1.00	1.00	68	0.23	0.96	0.87
37	0.35	0.92	0.90	71	0.53	1.00	1.00
38	0.02	0.92	1.00	73	0.48	0.88	1.00
41	1.00	0.96	0.99	75	0.38	0.84	0.90
42	0.95	0.92	0.98	76	0.36	0.92	0.96

Table 4 Normalized data indicators for CBD arterials main nodes.

Node_No	I_Noise	I_Accident	I_Delay	I_Lead	I_So2	I_Co	I_Nox	I_C02	ICST
30	0.05	0.00	0.97	0.03	0.39	0.49	0.93	0.24	0.46
44	0.00	0.81	0.00	0.10	0.57	0.17	0.83	0.67	0.35
34	0.24	0.95	0.91	0.43	0.00	0.00	0.78	0.88	0.78
47	0.17	0.52	0.72	0.68	0.14	0.11	0.81	0.25	0.55
51	0.18	0.86	0.75	0.34	0.56	0.17	0.83	0.58	0.69
45	0.17	0.95	0.86	0.23	0.61	0.47	0.92	0.76	0.78
49	0.21	0.86	0.71	0.65	0.89	0.72	0.99	0.73	0.72
48	0.26	0.90	0.75	0.06	0.77	0.56	0.94	0.88	0.74
56	0.17	0.38	0.80	0.00	0.63	0.51	0.93	0.74	0.55

4. SUSTAINABILITY INDEX OF CBD ARTERIALS NETWORK

This research is on attempt to measure CBD Hilla arterials sustainability which prepares data for current (study year 2018). The values of Icst (composit sistanblity transport index) are between zero (worst condition) and one (best condition) for comparion of each situation to other. The value of I_{cst} could be high in each arterials link, if the sub-medics is high. Finally this analysis is expected to help reduces society costs, enhance human heath and prawned access for persons.

The purpose of criterion weighting is to identify the significant of each criterion relative to other. Many weighting methods corresponds with judgments of decant makers have been used for this purpose. These methods include ranking, rating and trade off analysis, which are different in accruing, use easiness degree and understanding on the part of design makers. Trade off analysis method is more suitable when concerns with accruing and tertian foundation. However, the weigh can be defined as an assessment value and the large are means more important in the overall utility. The weights are usually normalized to sum of I and the set of weight is defined as following: $W= (w_1, w_2, w_3, \ldots\ldots w_n)$ and $\sum w_i= 1$.

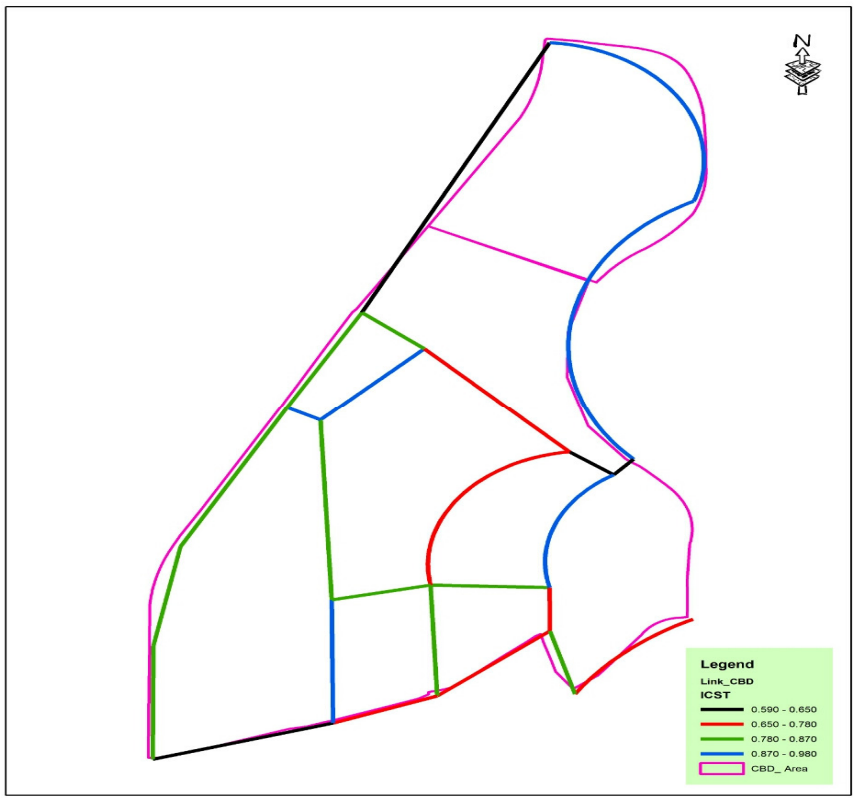
The trade-off analysis method makes use of direct assessments of trade-offs that the decision maker is willing to make between alternatives. It is suggested that the almost trade-off procedures should be used only with objectively quantified evaluation criteria. The procedure is more difficult to use when the criteria are subjective ratings. One weakness is that the decision maker is presumed to obey the axioms and can make fine-grained indifference judgments [12].

For calculating composite sustainability transport index I_{CST}, depending on adopted weights and normalized indicators, utilizing the following equations for all CBD arterials network (links and adjacent nodes) respectively

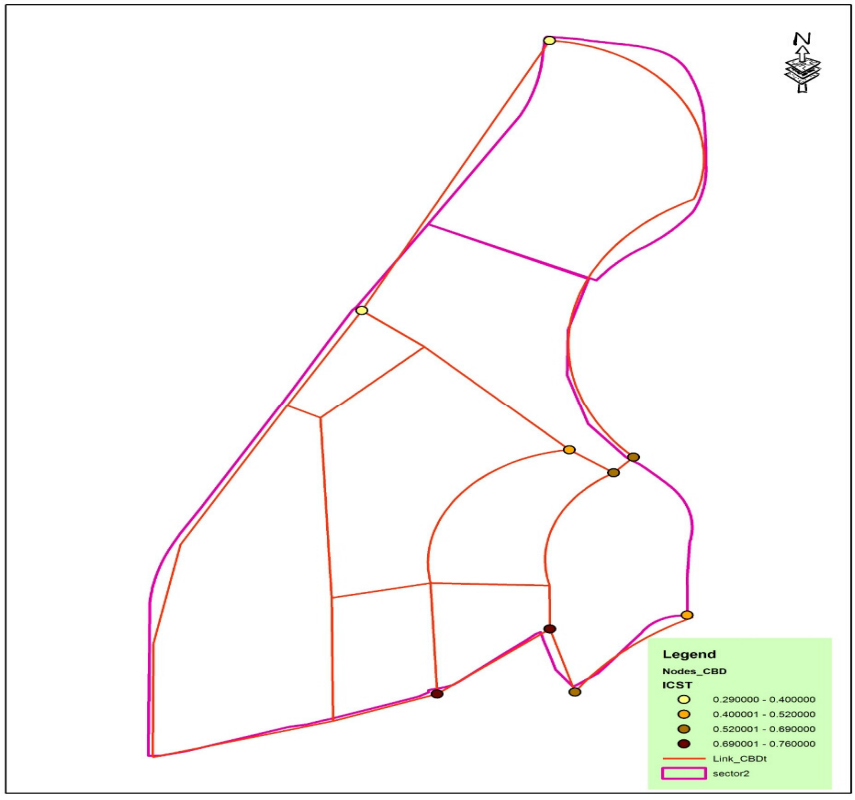
$$I_{CST\ links} = 0.402\ I_{delay} + 0.357\ I_{accident} + 0.241\ I_{noise} \quad (2)$$

$$I_{CST\ nodes} = 0.402\ I_{delay} + 0.357\ I_{accident} + 0.087\ I_{noise} + 0.03\ I_{CO} + 0.03\ I_{CO2} + 0.03\ I_{SO2} + 0.03\ I_{NOx} + 0.034\ I_{lead} \quad (3)$$

The results of I_{CST} are represented by Map 4 and Map 5 for CBD atrial network links and adjacent nodes.



Map 4 I_{cst} of arterial links within Hilla CBD (Sector – 2) at (2018).



Map 5 I_{cst} of arterial main nodes within Hilla CBD (Sector – 2) at (2018).

Map shows the varince of arterial links Icst. The black color represents very low level of sistainabilty operation, red color represents low level while green color represents modrate level and blue color for high level.

While Map5 shows the varinve of arterial main nodes Icst. The yellew color represents very low level of sustanability operation, orang color represents low level while red color represents modrate level and black color for high level.

From Map 4 for measured data of delay, noise, and observed accidents in the calculation of I_{CST} for CBD arterials links at research year (2018), the overall evaluation is moderate level of sustainability operation (congested traffic operation but high walking mode), that means needing better organization for traffic operation (like adopting one way roadway system) or reduction of asses points alonge the links with smooth riding to enhace sustanabilty operation for links with very low and low level.

From Map 5 for measured data of delay, noise, all pollutants, and observed accidents for CBD arterials' main nodes. The overall evaluation is low level of sustainability operation (very congested traffic operation with high pollutants, gasses and noise). That need improvements by bridges and overpasses implementations. For nods with very low level sustanablity operation and reorganization for nods with low and moderate sustanablity operation level.

5. CONCLUSION

The conclusion that have been summarised with the limits of collected data:

1. CBD is represented by Sector No.2 at Hilla city because this area meets all operation and land use criteria,
2. CBD sector at Hilla city has arterial network with 26 links and 9 main nodes, For arterials links within CBD, the measured data conclude delay, noise, and observed accidents while for arterial main nodes within CBD too, the measured data consist of all gasses pollutants rather than delay, noise, and observed accidents.
3. The overall evaluation of sustainability operation level of arterial link within CBD is moderate by reference to I_{CST} value.
4. The overall evaluation of sustainability operation level of arterial main node within CBD is low according to I_{CST} value.

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