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CEPT UNIVERSITY

Quantification of Urban Traffic Congestion : A Case Study of Ranchi Using K-Means Clustering

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OBJECTIVES

The following research objectives become evident in the context of traffic congestion in urban cities and mainly concerning India's emerging and smart cities :

- To observe commuters' Free Flow Time and Actual Travel Time while traversing different routes within the city.
- To determine the Level of Service (LOS) relying on the congestion index.

STUDY AREA & DATA COLLECTION

- Selected the travel routes that span approximately 15 to 20 kilometers within Ranchi City.
- The selected routes are prominent due to the consistent flow of commuters and include the residential areas, medical and educational establishments, and commercial centers of a city.
- The intersections that serve as the city's entry and exit points are also included in the designated routes.
- Two journeys have been selected with two different routes in each of them.

Table : Route description of Journey 1

Journey 1 - BIT More to Sujata Chowk	
Route 1 : Via Kokar Chowk (13.6 Km)	
Route Details	Distance (Km)
BIT More to Booty More	4.7
Booty More to Kokar Chowk	3.3
Kokar Chowk to Albert Ekka Chowk	3.7
Albert Ekka Chowk to Sujata Chowk	1.9
Route 2 : Via Karamtoli Chowk (14.9 Km)	
Route Details	Distance (Km)
BIT More to Booty More	4.7
Booty More to Karamtoli Chowk	6.1
Karamtoli Chowk to Albert Ekka	2.2
Albert Ekka Chowk to Sujata Chowk	1.9

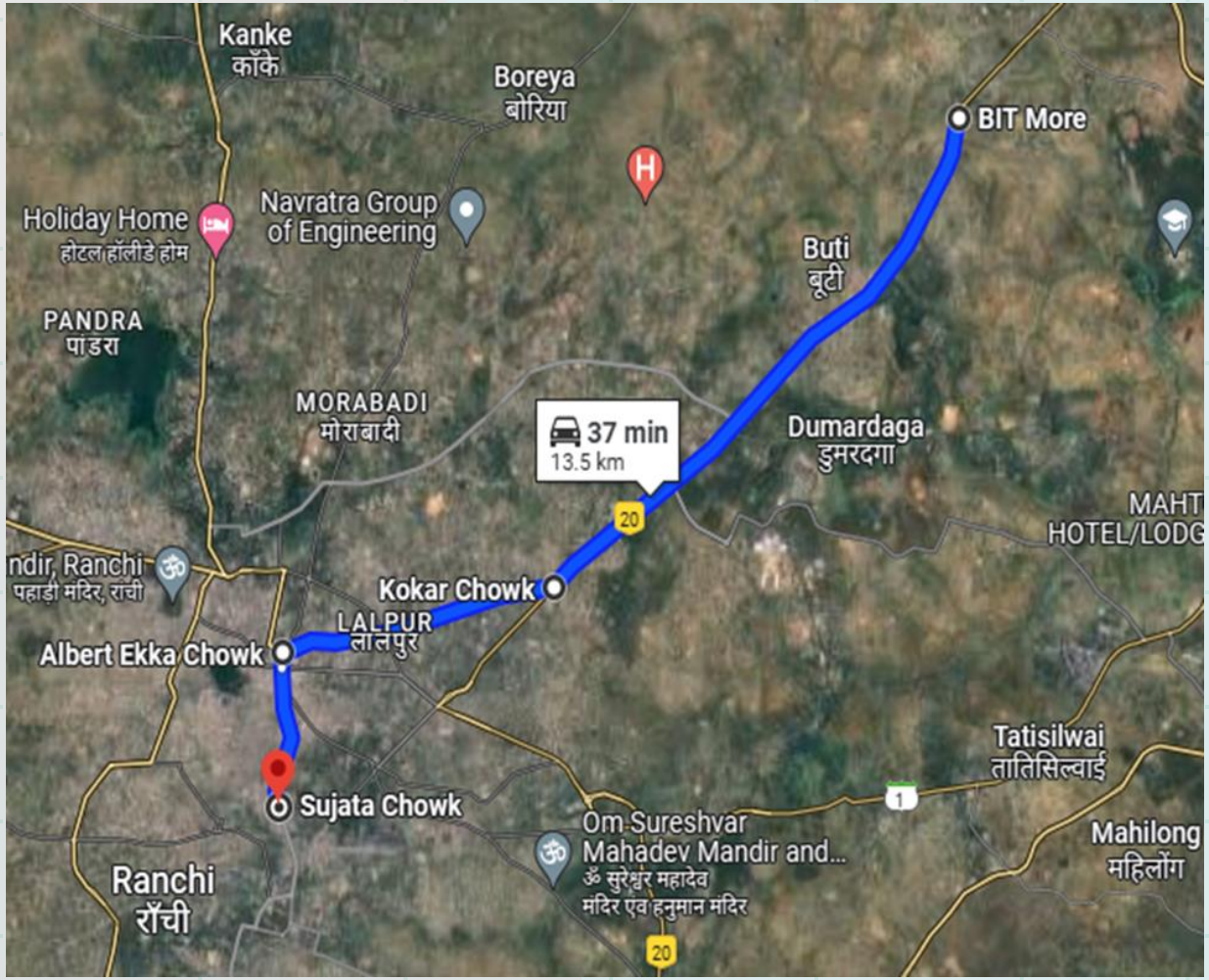

Figure : Route 1 of Journey 1

Table : Route description of Journey 2

Journey 2 - BIT More to Birsa Chowk	
Route 3 : Via Kantatoli Chowk (17.4 Km)	
Route Details	Distance (Km)
BIT More to Booty More	4.7
Booty More to Kantatoli Chowk	5.4
Kantatoli Chowk to Sujata Chowk	2.6
Sujata Chowk to Birsa Chowk	4.7

Route 4 : Via Argora Chowk (20.9 Km)	
Route Details	Distance (Km)
BIT More to Booty More	4.7
Booty More to Karamtoli Chowk	6.1
Karamtoli Chowk to Argora Chowk	6.5
Argora Chowk to Birsa Chowk	3.6

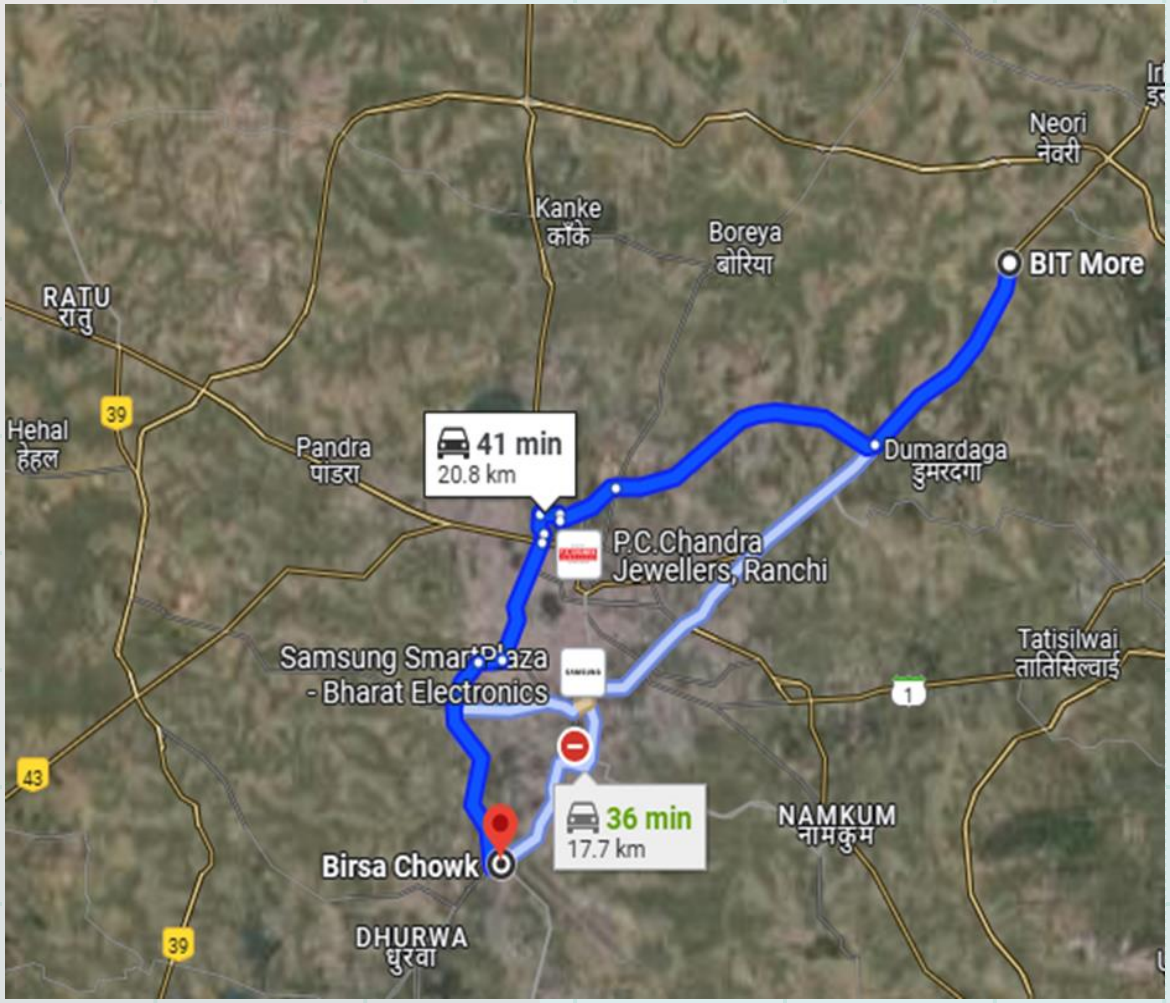

Figure : Route 4 of Journey 2

Questionnaire Survey

Gender:	☐ Male	☐ Female	
Occupation :			
Trip Purpose:	☐ Work	☐ Education	☐ Discretionary
Journey Covered:	☐ Journey 1	BIT More to Sujata Chowk	
	☐ Journey 2	BIT More to Birsa Chowk	
Route followed :	☐ Journey 1 -	Route 1 Via Kokar Chowk	
	☐ Journey 1 -	Route 2 Via Karamtoli Chowk	
	☐ Journey 2 -	Route 3 Via Kantatoli Chowk	
	☐ Journey 2 -	Route 4 Via Argora Chowk	
Frequency of Travel:	☐ Regular	☐ Occasional	
Time of Travel:	☐ 8 AM- 10 AM	☐ 12 PM-2 PM	
	☐ 4 PM 6 PM	☐ 9 PM -11 PM	
Vehicle Used:	☐ Two-wheeler (2W)		
	☐ Four-wheeler (4W)		
	☐ Three-wheeler (3W)		
Actual Travel Time (in minutes) :			
What about Traffic? :	☐ No Traffic	☐ Less	☐ Moderate ☐ Heavy

Figure: Queries covered in survey

METHODOLOGY

Analytical Approach

- To obtain Congestion Index (CI), the questionnaire survey offers an adequate quantity of data sets.

- It is apparent that nighttime travel is largely convenient and efficient in terms of travel time on the defined routes of the study area, thus these time is considered as Free Flow Time (FFT).

- The different set of travel times on various routes and in diverse time spans considered in the study is referred to as Actual Travel Time (ATT).

$$CI\ (in\ \%) = \frac{ATT - FFT}{FFT} \times 100 \qquad (1)$$

K-means Clustering Technique

It is an unsupervised machine learning algorithm that is utilized to organize a dataset into ‘k’ distinct, non-overlapping clusters. Here each cluster is represented by its centroid ‘μ’ which is the mean of all data points assigned together.

It’s advantages:

- ✓ It is straightforward to perform, employing simple mathematical procedures that make it suitable for a wide range of applications.
- ✓ The algorithms have excellent scalability and can efficiently process a significant number of datasets. Its computational complexity is linear, and it works with a variety of data sets, including mixed-type, categorical, and numerical data.
- ✓ Its iterative nature allows it to rapidly converge and create a more compact and tightly packed cluster.

FINDINGS

Validation of Cluster Index

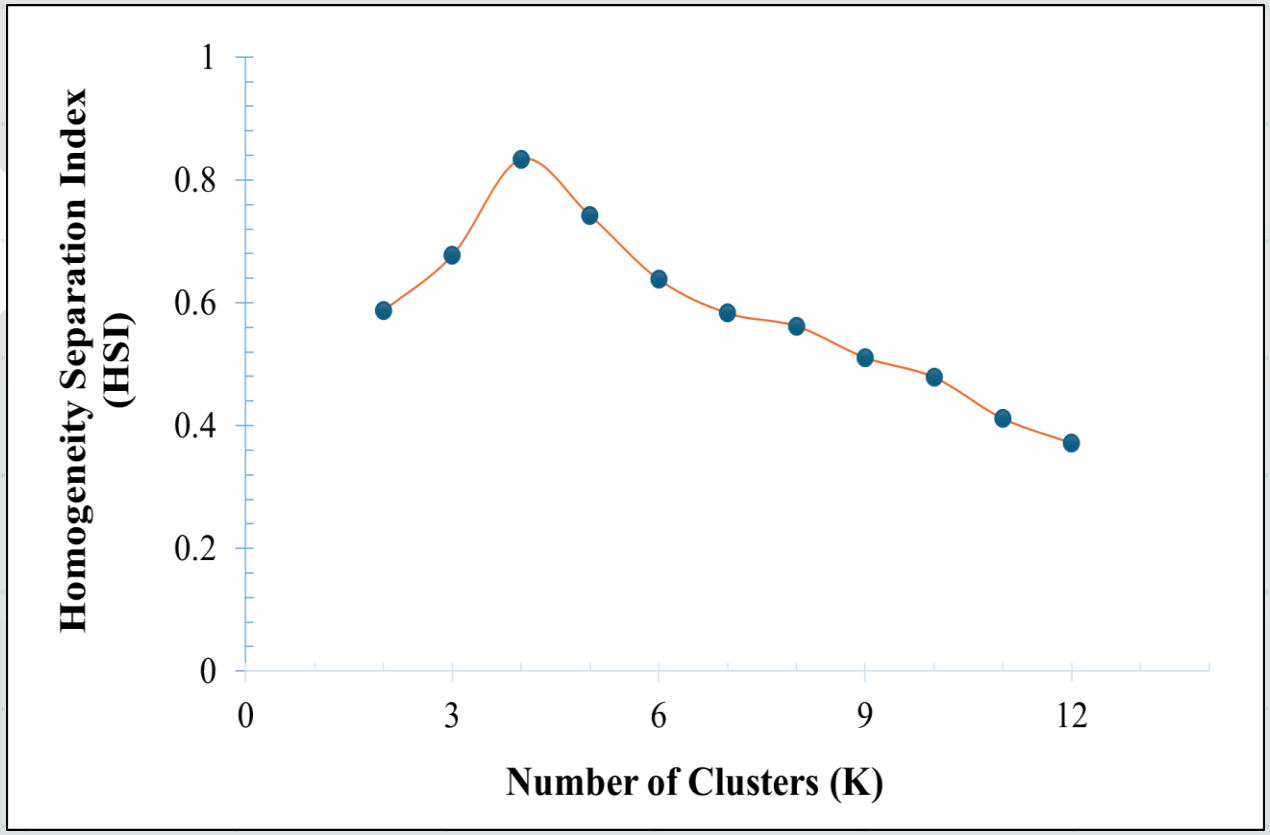

Figure: HSI versus K

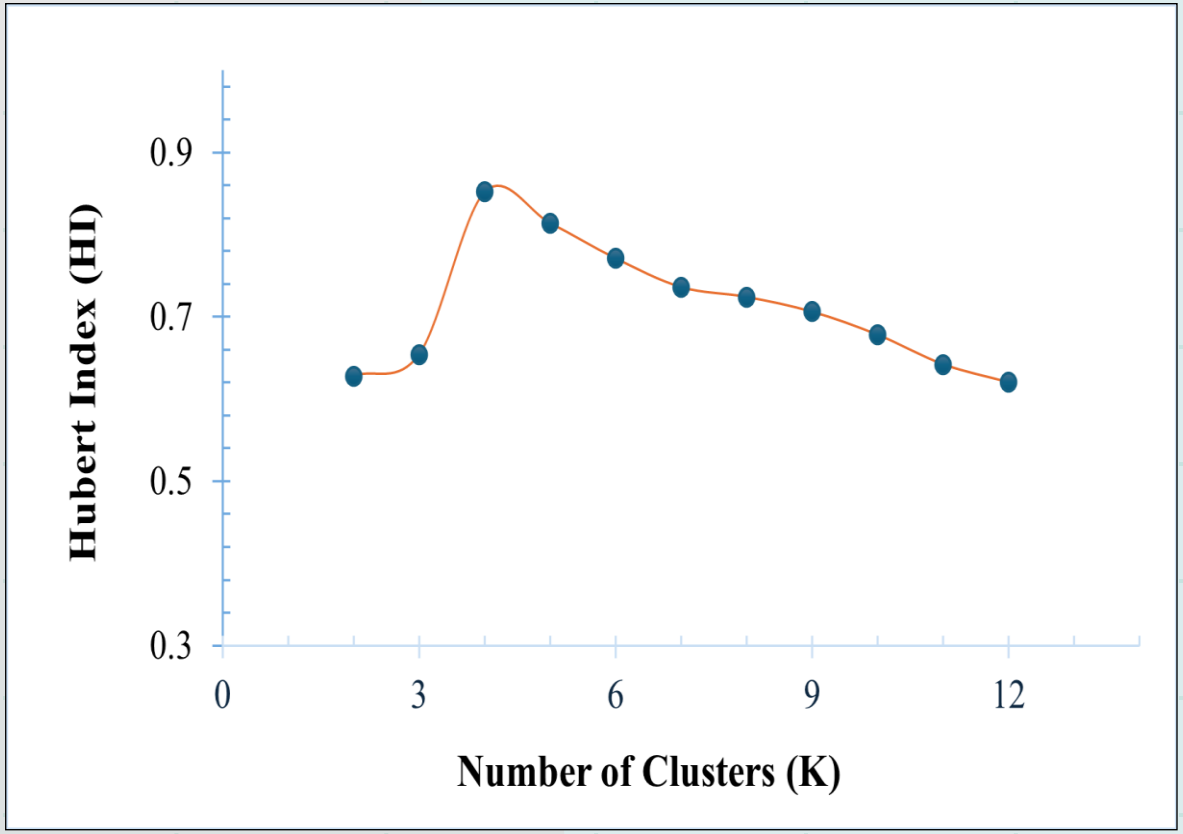

Figure: RI versus K

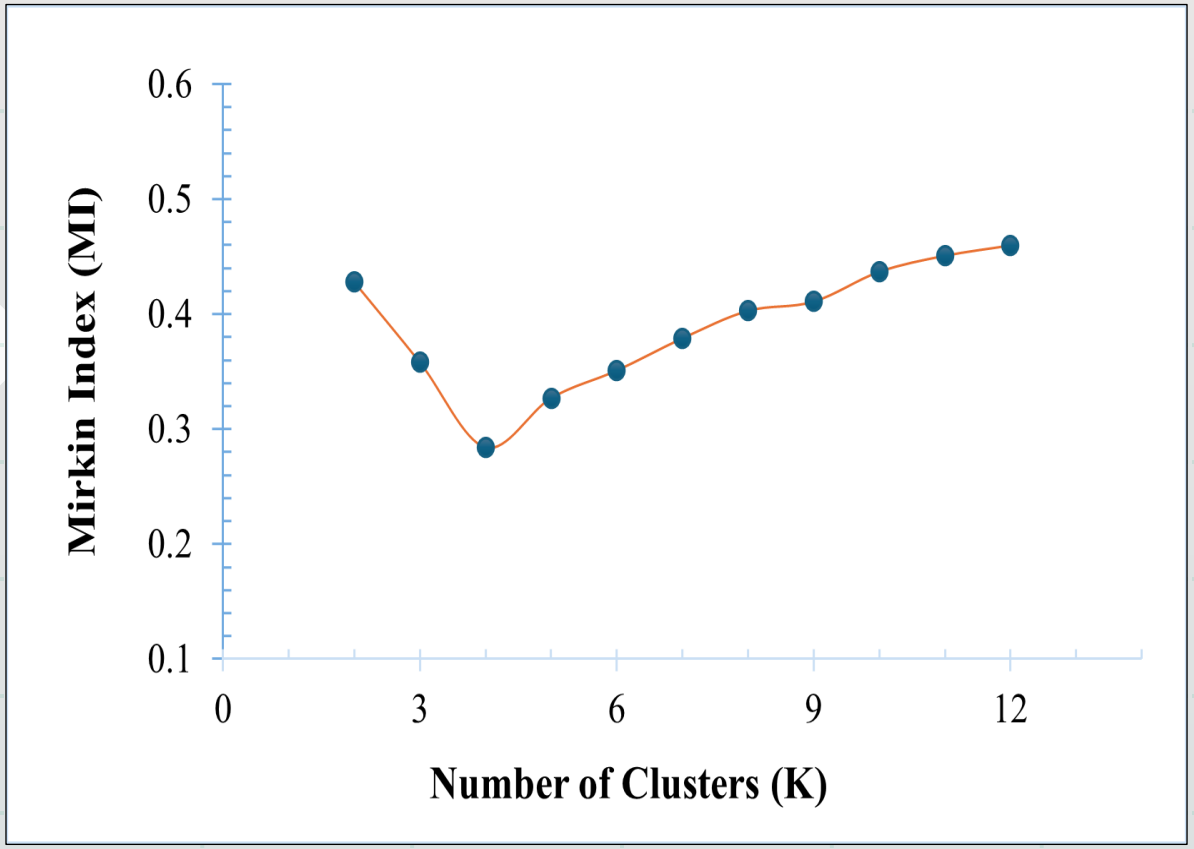

Figure: MI versus K

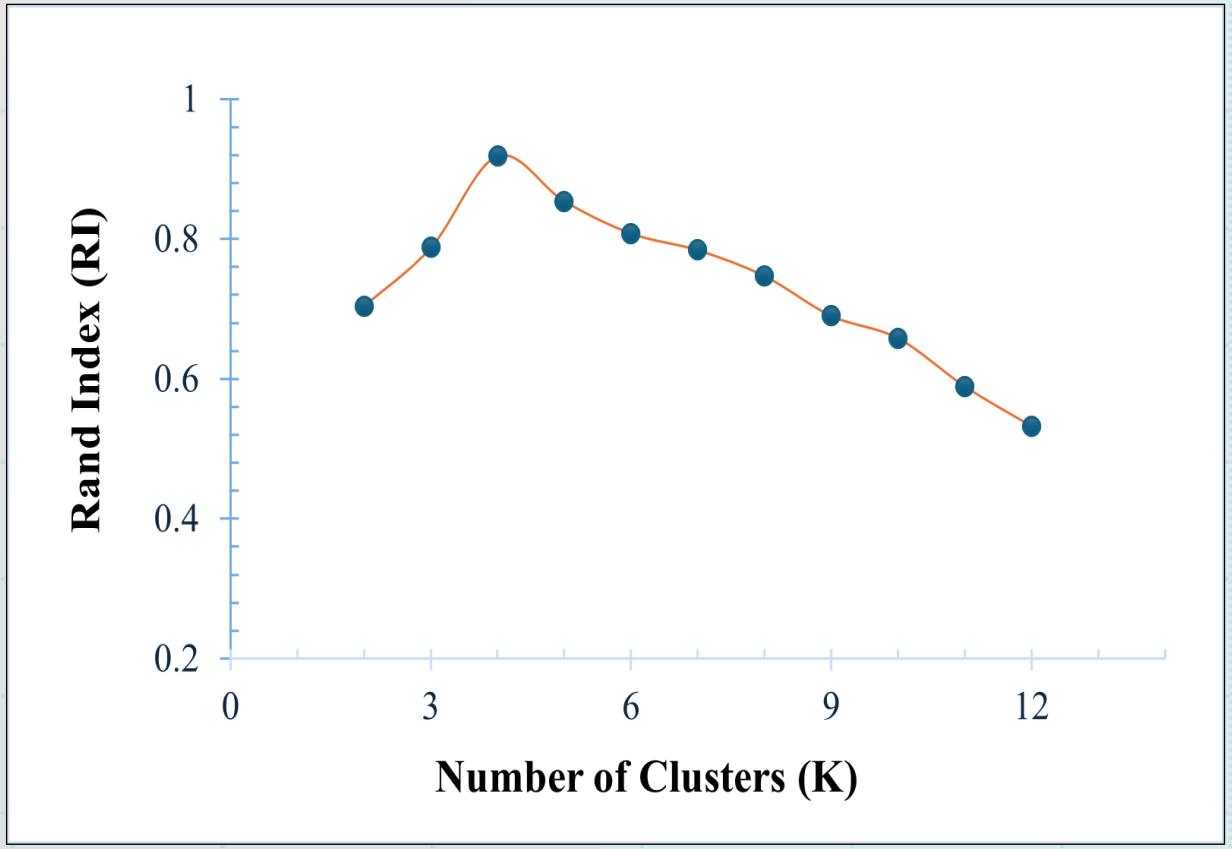

Figure: RI versus K

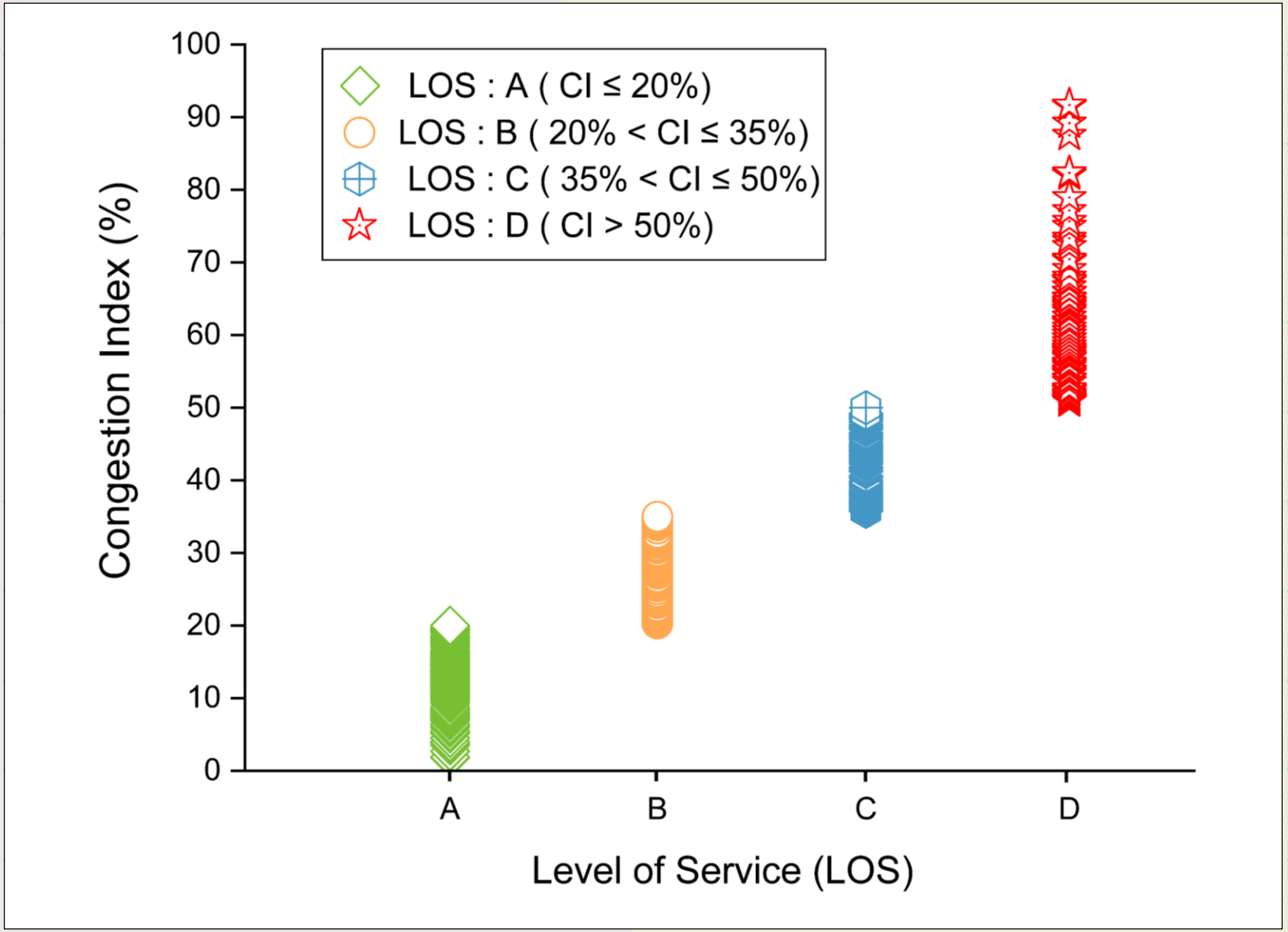

Figure: K-means clustering of different LOS based on CI

CONCLUSION

- Travel time is considered for determining the traffic congestion values, rather than delay time or free flow speed.
- The heterogeneity in signalization pattern in each of the routes renders to opt for Actual Travel Time while taking a journey.
- The congestion period is mostly found during the evening hours, afternoon hours, and morning hours in order.
- The different validation indices for clarifying the number of clusters i.e. to be 4 are Rand Index, Homogeneity separation Index, Hubert Index, and Mirkin Index having values of about 0.91, 0.83, 0.85, and 0.28 respectively.
- 16% of commuters felt severe traffic congestion compared to about 27% in the low congestion scenario, which brings out that more than 50% of commuters are in the zone of moderate and heavy traffic congestion.

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SUGGESTIONS & DISCUSSION

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