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BASIC CENTRALITY MEASURES ON URBAN TRANSPORT NETWORK NODES

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Abstract: Based on the degree of nodes of urban transport in Dispur town, thirty five bus stations are selected as nodes. From the speculation of complex network, the network model of Dispur urban transport is built. By analyzing the degree centrality index, betweenness centrality index and closeness centrality index of nodes within the network, the extent of centrality of every node within the network is studied. From a special purpose of read to work out the hub node of Dispur urban transport network, appreciate the city's key sites and major transfer sites. The dependableness of the network is decided by the soundness of some key nodes. The analysis of network node centralization will offer a theoretical basis for the rational allocation of urban transport network sites and conveyance system designing.

Keywords: degree centrality; betweenness centrality; closeness centrality; graph representation; urban transport.

2010 AMS Subject Classification: 05C07, 05C40, 05C62, 05C82.

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1. INTRODUCTION

Urban transport network may be a quite network that is established on the bus lines and stations of real society and its several characteristics that centrality measure in the real society. Road transport network is primarily designed to attach native resources and other people to distant, markets and population centers. Thus, it provides support to urban system development. Associate degree economical transport network is important for maintaining and rising the standard of life among cities and guaranteeing property development. Owing to the large biological process price of the road transport network, effective utilization is important, which may be earned only there's correct property and orientation. Hence, a good stress has to lean to layout and pattern of the urban road transport network. Urban road transport network analysis has less theoretical analysis, and relative project cases are not enough. Just some developed countries have meted out urban road network analysis and therefore it's nice potential for development and application prospects. Extraction of the fundamental property indices, which offer basic information to delineate a given network, character had been the main target of the many studies. Only a few studies targeting finding the abstraction pattern of the network and to grasp its structural attribute. Interaction between network property and also the structural attribute of the road network isn't clearly understood. To extend the understanding of this interaction we tend to explore the ideas of property and development. The most plan of this study is to work out if the road characteristic variables indicating property will justify important variance within the abstraction pattern of the network structure. Dispur region of Guwahati town has been chosen because the study space for getting ready the road network. Reception and abroad, some students abstracted the urban transport system into a posh network composed of bus lines and stops and created variety of potent works in enquiry. These researches have necessary reference price for revealing the topological characteristics of the urban transport network and understanding the operate and potency of the urban transport network. Wang Kui and Fu Xiufen mentioned the analysis on centrality of Urban Transport Network Nodes[1]. With the more study of urban transport system applying complicated network, invulnerability analysis

has necessary theoretical price and application significance within the transport network, and its central node plays a very necessary role. Particularly in recent years, subway bombings that occurred in Madrid and London, have created individuals begin to concentrate to the security and dependableness of the bus network [2]. In urban traffic networks, stations and lines are the basic elements, lines join the stations, forming pathways. So, within the traffic network, nodes represent traffic stations, edges represent the lines between stations. The network composed of the many edges and lots of nodes represent the fundamental framework of urban traffic network. Therefore, the urban traffic network is considered a posh network composed of lines and stations [5, 6]. Scheurer et al. [3] known and pictured the strengths and weaknesses of conveyance networks, in terms of geographical coverage, network property, competitive speed and repair levels, by victimization multiple centrality measures i.e. degree centrality index, betweenness centrality index and closeness centrality index in urban conveyance networks of Australian cities (Perth, Melbourne).

2. OBJECTIVES

The study has been conducted with a ready to meet the subsequent objectives:

- To drill the current situation of holdup at numerous traffic intersection points within the town of Dispur.
- To seek out all the attainable causes of traffic congestion in Dispur.
- To assess the standing of environmental pollution associated with conveyance pollution at numerous busy traffic points among the Dispur Boundary.
- To entails the all attainable solutions in terms of holdup within the town of Dispur.

The main objective of the study is to identification the particular cause behind the congestion and provided the sensible solutions for Dispur town to reduce congestion.

3. METHODOLOGY

3.1 Degree centrality: A large volume of analysis on networks has been dedicated to the

construct of position. This analysis addresses the question, "Which are the foremost necessary or central vertices during a network?"There centrality measure in fact several attainable definitions of importance, and correspondingly several position measures for networks. The only position live during a network is simply the degree of a vertex, the quantity of edges connected to that. Degree is typically known as degree centrality DC(v) within the social networks literature, to stress its use as a position live. In a social network, for instance, it seems reasonable to suppose that individuals who have connections to many others might have more influence, more access to information, or more prestige than those who have fewer connections. During a non directed graph, degree of a node is outlined because the range of direct connections with different nodes. Mathematically,

$$DC(v) = d(v)$$

3.2 Betweenness centrality: The Betweenness centrality (BC) for a node v is defines and measures the importance of a node during a network based mostly upon what percentage times it happens within the shortest path between all pairs of nodes during a graph. The larger of the index, the more number of the shortest path between any two nodes passing through this node in the network, the more important nodes in the network [4]. Mathematically,

$$BC(v) = \sum_{s \neq v \neq t \epsilon v} \frac{g_{st}(v)}{g_{st}}$$

Here, g_{st} is the number of shortest paths from node s to t and $g_{st}(v)$ the number of shortest paths from s to t that pass through the node v.

3.3 Closeness centrality: If we tend to denote the shortest path distance between two nodes i and j by d(i,j),then the closeness centrality(CC) of a node i is outlined as

$$CC(i) = \frac{1}{d(i)} \text{ where } d(i) = \sum_{j \in V, j \neq i} d(i,j)$$

4. A SMALL SYNTHETIC NETWORK EXAMPLE

Let us consider an undirected small network of 13 nodes having 17 edges with an unweighted graph.

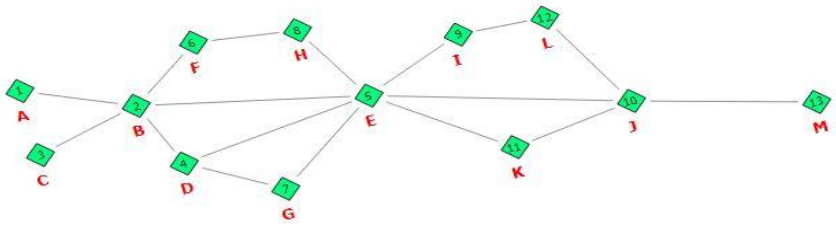

Figure 1: A small synthetic network.

Different centrality measures of 13 nodes are shown below

Table 1

Node	Label	DC	BC	CC
1	A	1	0	0.031
2	B	5	0.389	0.048
3	C	1	0	0.031
4	D	3	0.028	0.043
5	E	7	0.646	0.059
6	F	2	0.023	0.033
7	G	2	0	0.037
8	H	2	0.051	0.038
9	I	2	0.061	0.038
10	J	4	0.242	0.043
11	K	2	0	0.04
12	L	2	0.015	0.031
13	M	1	0	0.029

Degree centrality defines importance of a node in an exceedingly graph as being measured supported its degree, i.e. the higher the degree of a node, the lot of necessary it's in an exceedingly graph. The node E of centrality is seven, node B has five, node J has four and node M has one. At node E and B have a high degree centrality and can be ideal candidates if we would like to propagate any data to an outsized a part of the network quickly as compared to node M that solely contains a degree centrality of one. This data is extremely helpful for making selling or associate in nursing influencing strategy if a replacement product or plan has got to be introduced within the network. Marketers will target nodes like B, E etc. with high degree centrality to promote their product or concepts within the network to make sure higher reach ability among nodes.

The second flavor of spatial relation is thought as Betweenness centrality. This metric defines and measures the importance of a node in an exceedingly network primarily based upon what number times it happens within the shortest path between all pairs of nodes in an exceedingly graph. From the figure 1, Betweenness centrality BC(v) of node E, we are able to observe that it lies on the shortest path between the subsequent combine of nodes : (K, H), (K, D), (B, I),(B, J), (B, L), (B, K), (H, K), (H, I) etc. and so has the very best BC among all different nodes within the graph. We are able to conjointly observe that each node B and J even have high Betweenness centralities (BCs) as compared to different nodes (except E) within the graph. As mentioned, if we glance at our friends graph on top of (Figure 1), node E contains a terribly high BC. If we tend to where to get rid of it, it would lead to huge disruption in the network as there would be no way for nodes {A,B,C,D,F,G,H} to communicate with nodes {I,J,K,L,M} and vice versa and we would end up with two isolated sub graphs. This understanding marks the importance of nodes with high BCs. A sample application of BC is to search out bridge nodes in graphs. Nodes having high BC area unit the nodes that area unit on the shortest methods between an outsized variety of combine of nodes and thus area unit crucial to the communication in an exceedingly graph as they connect a high variety of nodes with one another. Removing these nodes from the network would lead to huge disruption in the linkage or communication of the network. A real life use

case of the above application is in analyzing global terrorism networks. For example, if we've got a network of terrorists or terrorist teams and different connected people pictured as nodes of a graph, we are able to calculate BC for every node and establish nodes with high BCs. These nodes (or terrorists during this case) are going to be bridge nodes within the network. This data is extremely helpful for defense agencies as they will be extremely effective in disrupting the full coercion network. Another use-case of this metric is to discover and monitor potential bottlenecks or hot-spots in laptop networks or flow networks.

The third flavor we tend to area unit reaching to discuss is Closeness centrality. To grasp identical, initial we've got to grasp the thought of Geodesic distance between two nodes in an exceedingly graph. The geodesic distance d between two nodes i and j is outlined because the variety of edges between these two nodes on the shortest path of minimum variety of edges between them. From the figure 1, we are able to see that the geodesic link of node E is 17 whereas that of node M is 34. Suppose that within the friend's graph, every edge had a weight of one minute related to it i.e. it would take one minute to transmit data from a node to its neighboring node like E to K or K to J. now let's suppose we would like to send a bit of specific data (information are going to be completely different for every node) to every node of the graph and that we have to be compelled to choose a node within the graph which will transmit it quickly to all or any the nodes within the network. To resolve the on top of downside, we are able to calculate the Closeness centrality live for all the nodes within the network. As we tend to already calculated on top of for node E, if we tend to choose node E, the data will reach all the nodes by traversing seventeen edges as compared to node L, wherever it would take thirty-four minutes to transmit the data to all or any nodes. Clearly we are able to see the distinction in importance of each the nodes E and M in terms of Closeness centrality live.

5. STUDY AREA

In this study, we've got hand-picked a tiny low space around Dispur town set within the Guwahati of Assam, India that contains important traffic congestion throughout faculty and

workplace hours. All route and different sub ways, centrality measure thought of to construct a road network. Dispur is that the largest town in state and one in all the quickest developing cities in Republic of India. With the ascent of population within the town, the road traffic issues also are increasing at associate sinister rate. The event of a town or city ends up in the expansion of variety the amount the quantity of vehicles that is directly connected to multiplied holdup and a growing number of accidents and fatalities. Road traffic issues like congestion, unpredictable travel-time delays and road accidents, centrality measure taking a significant form within the town. The most objective of this study is to research the potential of bridging position on transportation network, viz. Dispur town map. It's a tactically town and capital of state. We tend to take thirty five major bus stoppages of this Dispur space to research the bridging nodes .Our study is concentrated on purposeless graph network, wherever every node represents associate intersection, junction, or a special place and every edge represent a road section between those intersections. The essential centralities for all nodes during this road network were computed. All simulations are carried out using software.

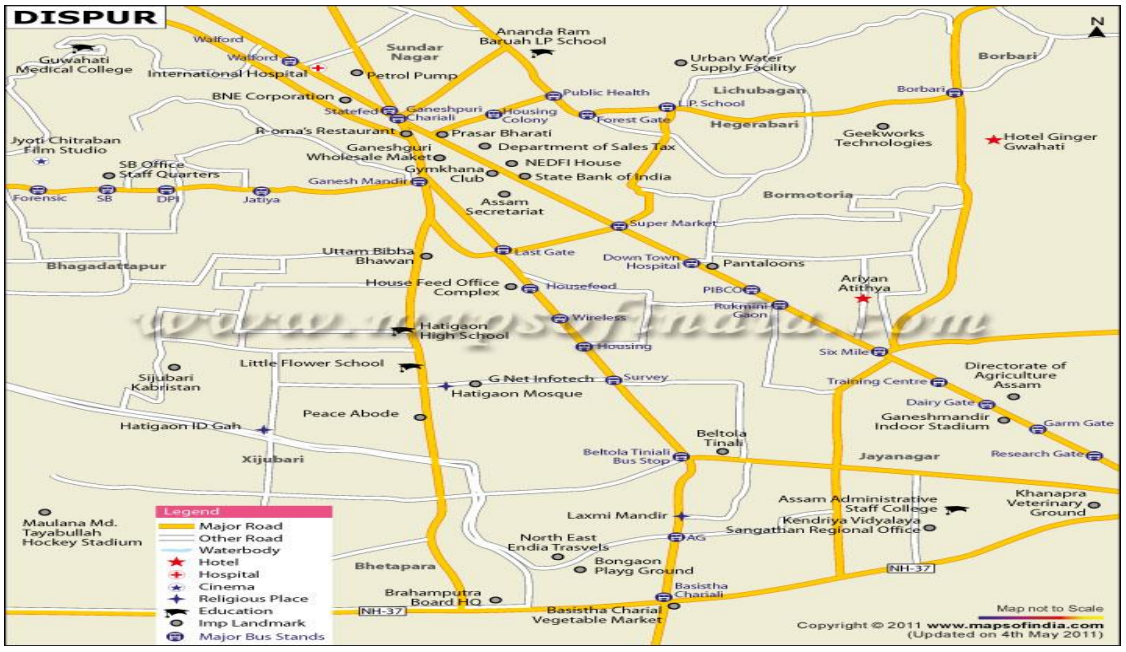

Figure 2: Map of Dispur City

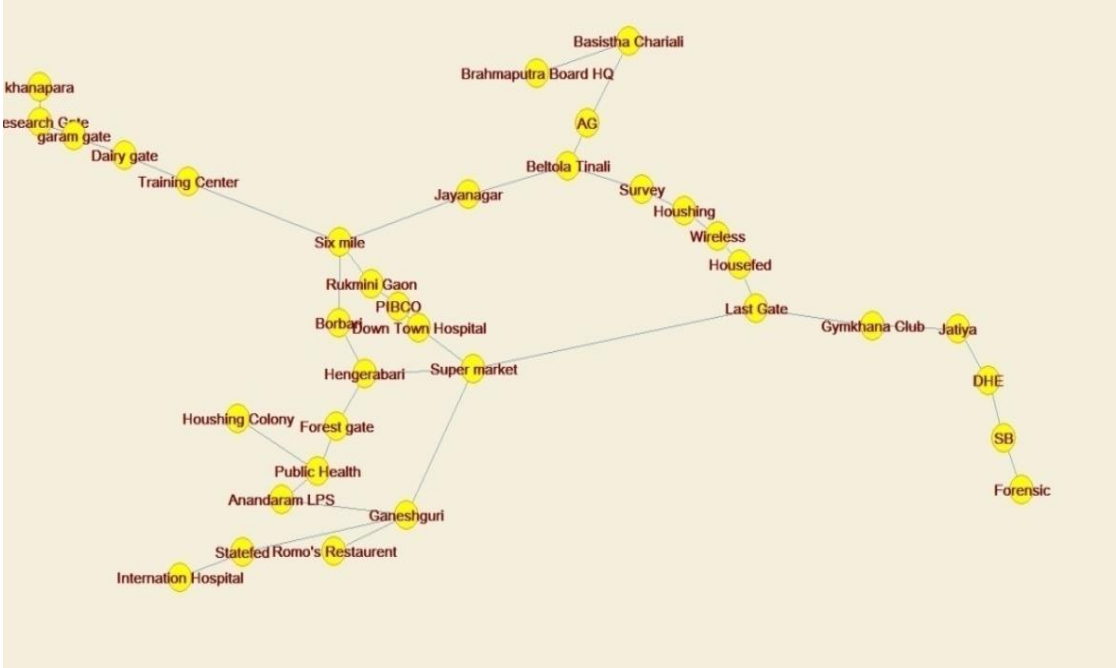

Figure 3: Graph Network of Dispur City

Different centrality measures of different nodes are shown below

Table 2.

Node	Label	Degree(d)	DC'=d/34	BC	CC
1	Khanapara	1	0.029	0	0.121
2	Research	2	0.059	0.059	0.138
3	Garam gate	2	0.059	0.114	0.157
4	Dairy gate	2	0.059	0.166	0.182
5	Training center	2	0.059	0.214	0.213
6	Six mile	4	0.118	0.423	0.252
7	Rukmini gaon	2	0.059	0.045	0.225
8	Borbari	2	0.059	0.296	0.258
9	Jayanagar	2	0.059	0.193	0.222
10	PIBCO	2	0.059	0.046	0.227
11	Down Town hospital	2	0.059	0.057	0.236

12	**Super market**	**4**	**0.118**	**0.449**	**0.27**
13	Hengerabar	3	0.088	0.351	0.268
14	Ganeshguri	4	0.118	0.227	0.231
15	Last gate	3	0.088	0.35	0.248
16	Statefed	2	0.059	0.059	0.191
17	Romo's restaurent	1	0.029	0	0.189
18	Anandaram LPS	2	0.059	0.039	0.195
19	Internatio hospital	1	0.029	0	0.161
20	Houshing	1	0.029	0	0.163
21	Public health	3	0.088	0.076	0.194
22	Forest gate	2	0.059	0.086	0.221
23	Gymkhana Club	2	0.059	0.214	0.21
24	Jatiya	2	0.059	0.166	0.18
25	DHE	2	0.059	0.114	0.156
26	SB	2	0.059	0.059	0.137
27	Forensic	1	0.029	0	0.121
28	Housefed	2	0.059	0.131	0.219
29	Wireless	2	0.059	0.109	0.202
30	Houshing	2	0.059	0.098	0.195
31	Survey	2	0.059	0.096	0.194
32	Beltola Tinali	3	0.088	0.224	0.205
33	AG	2	0.059	0.114	0.174
34	Basistha Chariali	2	0.059	0.059	0.15
35	Brahmaputr Board HQ	1	0.029	0	0.131

6. EXPERIMENTAL ANALYSIS

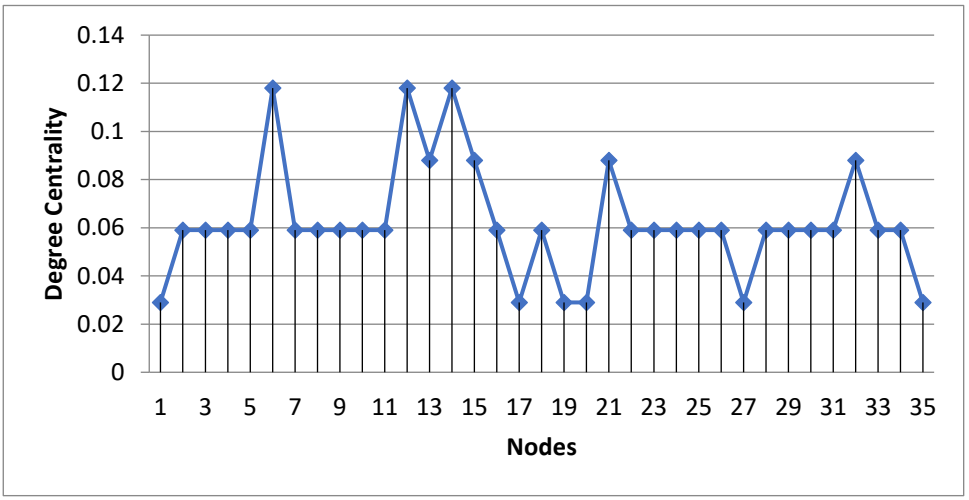

Figure 4: Degree Centrality of Dispur Network

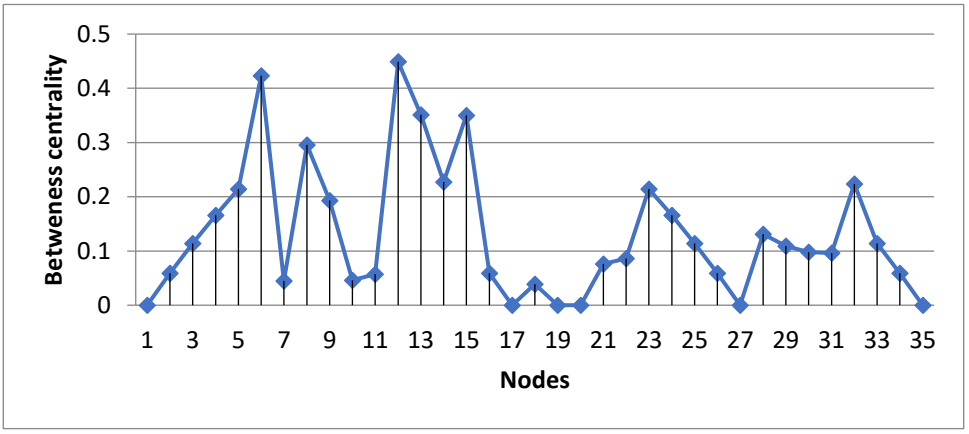

Figure 5: Betweenness Centrality of Dispur Network

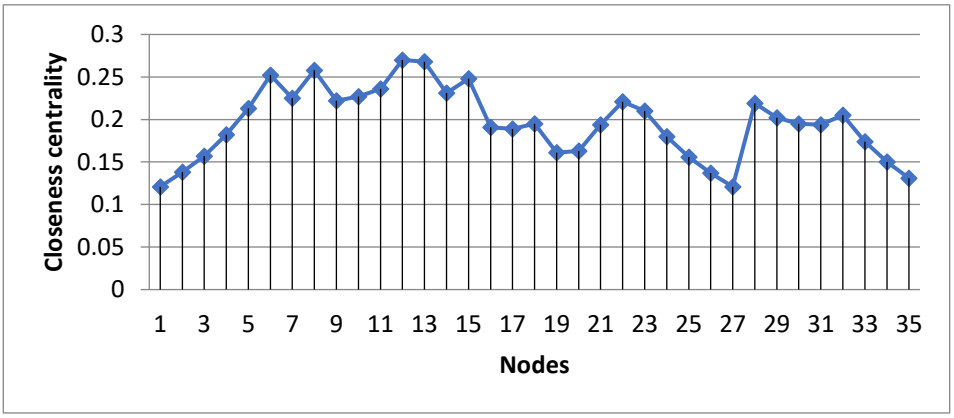

Figure 6: Closeness Centrality of Dispur Network

The on top of 3 central indexes will be wont to mirror the necessary degree of nodes within the network; however their focus is completely different. From Figure 4 the Degree centrality index depicts the amount of edges connected to the node, reflective the direct impact of a node to different nodes within the network. From Figure 5 Betweenness centrality contains the shortest path of this node, reflective the load capability of this node. From figure 6 Closeness centrality characterizes the degree of problem of a node to different nodes, that reflects the power of the node to exert influence on different nodes over the network. Though a number of the site's degree worth is low, however as a result of the shortest ways through this website centrality measure additional, centralization degree of those sites continues to be high. These sites centrality measure situated within the city's necessary transfer location, bus routes centrality measure additional, traveler flow volume is larger, once congestion happens, and causes palsy of the complete bus network, that plays a vital role within the property of the entire network. Passengers will avoid these crowded places whereas traveling. Meanwhile, Betweenness centrality relation and Closeness centrality each take into consideration the shortest path; so, with the rise of closeness centrality worth, Betweeness centrality relation worth conjointly will increase. Per the two-dimensional distribution of 3 central indicators of every node within the network, some key nodes, whose 3 central indicators worth centrality measure all comparatively high, will be obtained. The govt. will improve the transport potency by gap the bus special line, reducing transfer times and different ways that, to make sure the property of the complete bus network, and enhance the transport capability of the network.

7. CONCLUSION

Based on the idea of advanced network, this paper constructs a model of Dispur public transportation network, and uses the tactic of chemical analysis to work out the necessary nodes within the network. Supported the excellent analysis of the Degree centrality, Betweenness centrality and Closeness centrality of network nodes, the importance of network nodes to different nodes is evaluated from completely different angles. These key nodes of networks have

a high degree of centralization, which corresponds to the hub sites or the most transfer points within the urban traffic system, and centrality measure situated within the center of the urban network. Therefore, in considering the optimization theme of the transit network, we must always begin from these hub nodes, improve the transport capability of those sites, disperse the flow of traffic, and enhance the convenience of bus travel. Meanwhile, individuals within the alternative of the transfer locations will be acceptable to avoid these sites, for his or her own trip select an additional convenient route.

At the end part of this chapter it can be concluded that if different measures are taken then the traffic speed would improve in future and in consequence the emission level in the city of Dispur would have been lowered. Some recommendations are to be reducing the traffic congestion in the city and likewise improvement in the city's air. These are enumerated below.

(i) Strict order and regulation ought to be maintained to ban the encroachment on the face of the road and optimization of traffic and improvement in traffic management should be followed to extend the speed of vehicles which might cut back conveyance emission.

(ii) Traffic management programs ought to be initiated as well as GPS navigation and traffic sign system.

(iii) Different measures ought to be taken to boost the ordinance of the vehicles and reducing emission level like,

(a) Social awareness campaign ought to be organized.

(b) Construction of additional range of flyovers.

(c) Implementation of strict traffic rules and increasing of pedestrian facilities.

(d) Separate lane ought to be create beside the main road for the movement of bi-cycle, hand pulled rickshaw, cycle rickshaw etc.

(e) Most use of road breadth and conjointly forbidding of unauthorized parking beside the most engorged intersection points.

CONFLICT OF INTERESTS

The author(s) declare that there is no conflict of interests.

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