SPATIAL ANALYSIS OF THE INTEGRATION CORE OF COMILLA CITY CORPORATION AREA AND THE IMPACT OF THE BY-PASS ROAD - A SPACE SYNTAX ANALYSIS

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ABSTRACT

Urban area changes according to different uses of space and movement with the passage of time, as seen in land use, road network etc. Urban morphological transformation constantly remains under succession. The urbanization process substantially increases the demand for urban services such as transport, on whose efficiency and availability, the successful and continued existence of urban society depends. Transportation has a strong influence on the spatial structure at the local, regional and global levels. Historically, both social and economic growth within civilizations, have been structured by routes of travel. Thus, it is not surprising that a city's circulation system has become an important facet in today's communication-oriented urban life. Adequate transportation facilities are vital to promote growth, manage the effects of development and protect and improve city's quality of life. The paper is intended to analyze the present land uses of Comilla city (area under the newly formed City Corporation) by drawing axial lines over the collected base map and identify the integration core of the city, in relation to the introduction of the Dhaka – Chittagong by-pass road. The town though facing tremendous pressure of haphazard development, has the scope for suggested and designed development through rigorous surveys and analytical methods using space syntax analysis. This study helps to assess the spatial impact of introducing a by-pass road on the existing physical city in relation to its functional organization.

Key words: Comilla City, Integration core, Impact, By-pass road, Space syntax.

1.0 INTRODUCTION

1.1 Introduction
The trend of urbanization is very high in all the cities of the world. With the accumulation of variety of activities in a city, the issue of land use gets significant in terms of efficient use of the spaces and activity. Along with this issue, another unavoidable issue for proper urban development is accessibility or street network. In any area, whenever movement initiates, that is, spatial accessibility is provided, different land use generates. Different type of agglomeration generates different types of movement, for which a city has different types of land use and zoning. The basic relationship of spatial configuration – an output of street network and land use generation, helps to understand a city and guide its land use planning.

Transport system provides one of the basic infrastructures and acts as a prerequisite for socio-economic development of a country. The history of transport development all over the world is a process of gradual evolution. Bangladesh is not an exception in this regard. Over centuries a varied and complex transport system has developed in this country on account of its various geographical features and historical facts. Transportation has always played an important role in influencing the formation of urban societies. The initial settlements were relatively small developments but with due course of time, they grew in population and developed into big cities and major trade centers.

1.2 Objectives
This paper aims to investigate the morphological structure of Comilla City in order to use the knowledge as a basis of future development plan of the newly formed City Corporation of Comilla.

Brief narrations of the objectives are as follows:

■ Integration core in relation to land use of Comilla city.
■ Assessing the impact of Dhaka-Chitagong by-pass on land use of the city in the context of present spatial organization.

1.3 Methodology
The study is conducted in three phases. Firstly, available literatures are reviewed to understand and explain the generation and growth of Comilla city with the passage of time. Secondly, existing land use pattern is analyzed using the map collected from Comilla City Corporation and physical survey; reviewing different published literatures on Comilla district and the city; and finally data collected from visual survey and interviews with concerned personnel of Comilla City Corporation. The base map is collected from Comilla City Corporation office, previously known as Comilla Municipality. Finally syntactic analysis of the city using Space Syntax (Depth map1) is done to get the existing spatial integration pattern of the whole city. Then combining the syntactic measures a conclusive analysis is drawn to understand the relation between the changes in land use pattern and the change in the integration pattern with the introduction of the Dhaka – Chittagong by-pass road.

1.4 Limitations
Since Comilla Municipality has recently been converted to a City Corporation, enough primary data, like different base maps, area development plan, etc. were not available, which could have increased the depth and diversity of the study.

2.0 OVERVIEW OF THE STUDY AREA

2.1 Background of the City
Comilla District (Chittagong division) with an area of 3085.17 sq km, is bounded by Brahmanbaria and Narayanganj districts on the north, Noakhali and Feni districts on the south, Tripura (state of India) on the east, Munshiganj and Chandpur districts on the west. It lies between 23°02' and 23°48' north latitudes and between 90°38' and 91°22' east longitudes. The total area of the district is 3146.30 sq. km. (1214.79 sq. miles) including 6.79 sq. km. forest area.

Comilla District was established as Tripura in 1790. It was renamed Comilla in 1960. The district consists of 16 upazilas, 181 unions, 2473 mauzas, 3532 villages, 10 paurashavas, 99 wards and 296 mahallas. The upazilas are Comilla Adarsha Sadar, Barura, Chandina, Daudkandi, Laksham, Brahmanpara, Burichang, Chauddagram, Debidwar, Homna, Muradnagar, Titas, Comilla Sadar Dakshin, Monogarganj, Meghna and Nangalkot.

Comilla town is the administrative center of the Comilla District, under Chittagong division of Bangladesh and stands on the bank of river Gomuti. Comilla City Corporation is a self-governed municipal administration in Bangladesh that administers and oversees development and maintenance works in the city of Comilla. The corporation covers an area of over 33 square kilometer where over five million people live as permanent residents.

Comilla is a city in eastern Bangladesh, located along the Dhaka-Chittagong Highway at 23.4615392N and 91.1811161E. It is the administrative center of the Comilla District, part of the Chittagong Division. Comilla City Corporation (Fig. 01) stands on the bank of the Gumti River. Previously Comilla town was under Comilla municipality till the body was declared as Comilla City Corporation by a ministry of local government on 10 July 2011. It has an area of 53.04 sq km, which consists of 27 wards, with a population of 337,516 in 68181 households and 82 surrounding mouzas with a population of 187,634 in 41,320 households (BBS 2011). According to the government gazette, the new City Corporation consists of areas in the Comilla Municipality and Comilla Sadar (South) Municipality.

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[1]Depthmap is a single software platform under the umbrella term 'Space Syntax'. It is used to perform a set of spatial network analyses designed to understand social processes wit hin the built environment. It works at a variety of scales from building through small urban to whole cities or states. At each scale, the aim of the software is to produce a map of open space elements, connect them via some relationship (for example, inter-visibility or overlap) and then perform graph analysis of the resulting network. The objective of the analysis is to derive variables which may have social or experiential significance.

## 2.3 Land Use Pattern of the City

Comilla town has experienced substantial physical growth during last thirty years due to rapid population growth and rapid urbanization. At present the existing city portrays an organic morphological pattern which has been developing without any planning proposal. Comparing previous and present land use map (Fig. 01) it can be concluded that areas to the west, south-west and east, in particular the municipality, have been transformed into urban and semi-urban environments from their rural settings. The existing city area has obviously been unable to accommodate all the inevitable urban physical growth. Infrastructure and civic amenities are moderately well in the area.

The land use pattern of the city is quite diverse in nature. Predominantly residential areas cover 54.44 % of the total area of the city, commercial land use cover 6%, whereas educational facilities, government offices, industrial buildings, mixed use and non-government offices accounts for 1.73%, 1.61%, 1.23%, 0.04%, 0.04% respectively. Transportation and communication facilities accounts for 0.18% of the total land use cover. Agricultural and water body use are also influential which are 11.85 % and 9.2 % respectively (IDP 2017-2018, CoCC).

The city, under the city corporation authority, comprises of 27 wards, which includes former Comilla Sadar and South Municipality. The main activity hub, lies within wards no. 2, 5, 6, 10, 11 and 12, which portrays as the main town center (IDP 2017-2018, CoCC) (Fig. 01 & 02). The land use map of Comilla City (Fig. 01 & 02) shows that business areas in the Comilla City has been developed through one direction. Lots of shops, banks, insurance, restaurant and markets have developed near A K fazlul Haque road. The progression started from the "Kandir par mor" (node). This commercial development (Fig. 02) continues to Chowk Bazaar Bus Stand. In the northern side of Comilla City there is another bus stand named "Sasongacha". There is also some development between the "Kandir par Mor" and the Sasongacha bus stand.
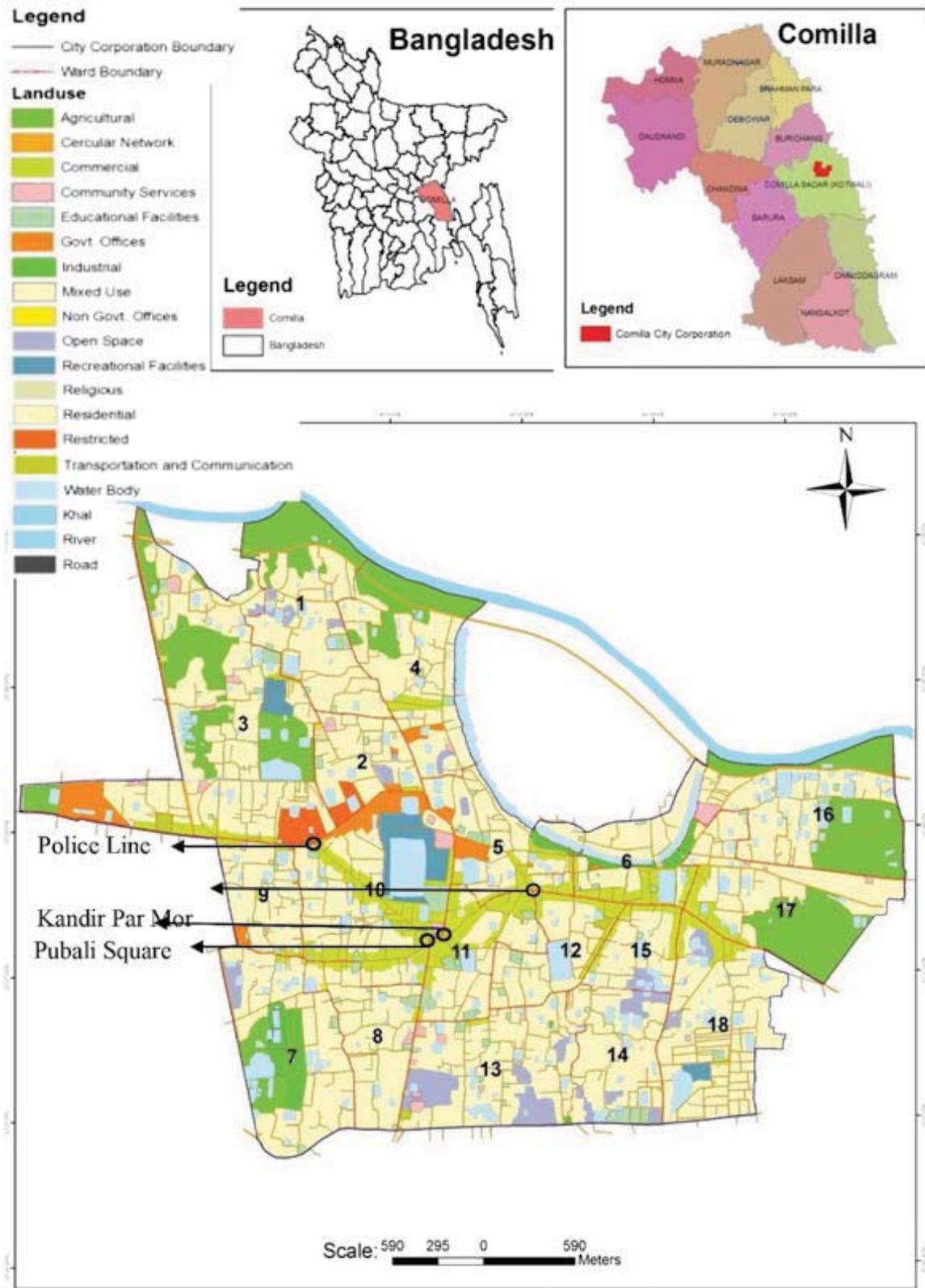
Fig 01. Land Use Map with the Four Important Nodes of Comilla City
Source: Local Government Engineering Department (LGED)
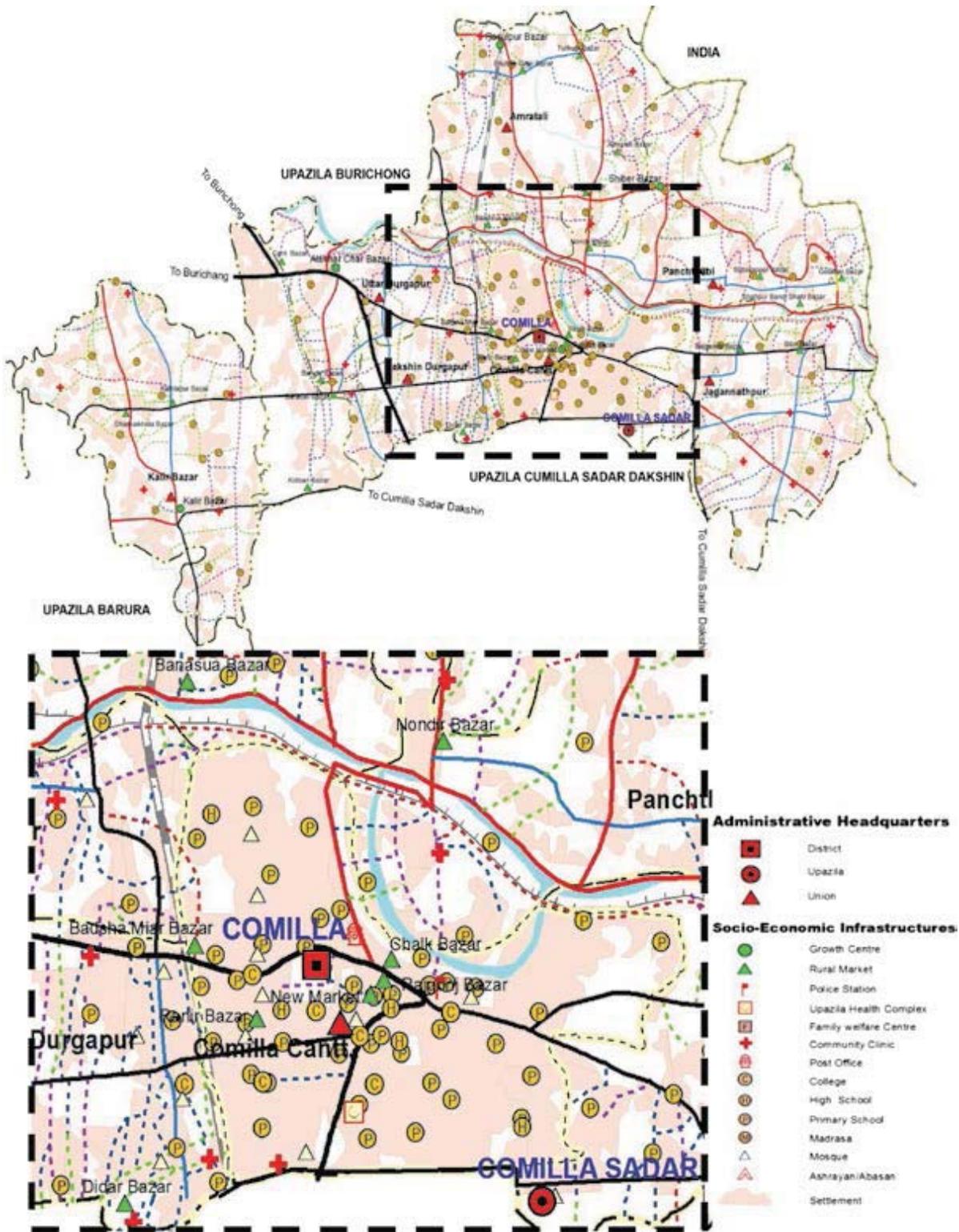
Fig 02. Map showing Important Infrastructures along the Four Nodes
**Source:** Local Government Engineering Department (LGED)

2.4 Road Network

Comilla is known as the hub of road communication for the eastern part of Bangladesh. It is the transit point between Dhaka-Chittagong routes. The communication system is very much sound throughout the region, particularly internal road communication systems of the eastern part has enormously developed in last decade. One of the

oldest highways of the Indian Sub-continent, 'The Grand Trunk Road', passes through the city. Historical Grand Trunk Road is used to communicate with the port facilities of Chittagong. Comilla's Court Road is an extension of historical Grand Trunk Road. At present, the most important Dhaka-Chittagong highway bypasses the city from the Comilla Cantonment to Poduar Bazar. Center point of Comilla is located 97 kilometers away from the capital city, Dhaka, which can be traveled by road or railway. Comilla also has a domestic airport situated in the Comilla Shadar Dakshin. Comilla has a total of 1219 km asphalted or paved road, 587 km of mud road and 108 km of railways. Rickshaw pulled by rickshaw pullers and CNG's are widely used. In recent years the battery-driven auto rickshaw has become very popular, mostly because of its convenience in short distance commutation throughout the main town. There are no parking facilities available for Auto Rickshaw, CNG, Rickshaw, and Trucks within the City Corporation area. There are three bus terminals located in the city corporation area: Jangalia bus terminal, Chakbazar bus terminal and Sasongacha bus terminal, but no designated intercity bus service exists there.

The main city center is termed as "Kandirpar Mor" (Fig. 03 & 04). The busiest AK Fazlul Haque Road (Fig. 03 & 04) starts from here. The main business district of the town is developed towards east moving with the AK Fazlul Haque Road. The road continues to Chawk Bazaar and after being intersected by "Thana road" and "Bazrapur road" at another nodal point is created, termed as "Razgang Chattar". The AK Fazlul Haque Road on the west and the Chawk Bazar Road in the east actually lies within the "Comilla- Chittagong By-pass Road" (Fig. 03). The "Kandirpar Mor" connects towards west with the second essential node named "Police Line Mor". This node has a major influence on morphological characteristics of Comilla City as it is being intersected by the new "Dhaka-Comilla-Chittagong Bypass Road". Before the establishment of this road, Comilla City was connected with Dhaka-Chittagong Highway through "Abdul Malek Road" (Barura Road). Another road named "Dr. Akhter Hamid Khan" act as a boundary line for the city as it has subtracted the EPZ and industrial zone from the city.
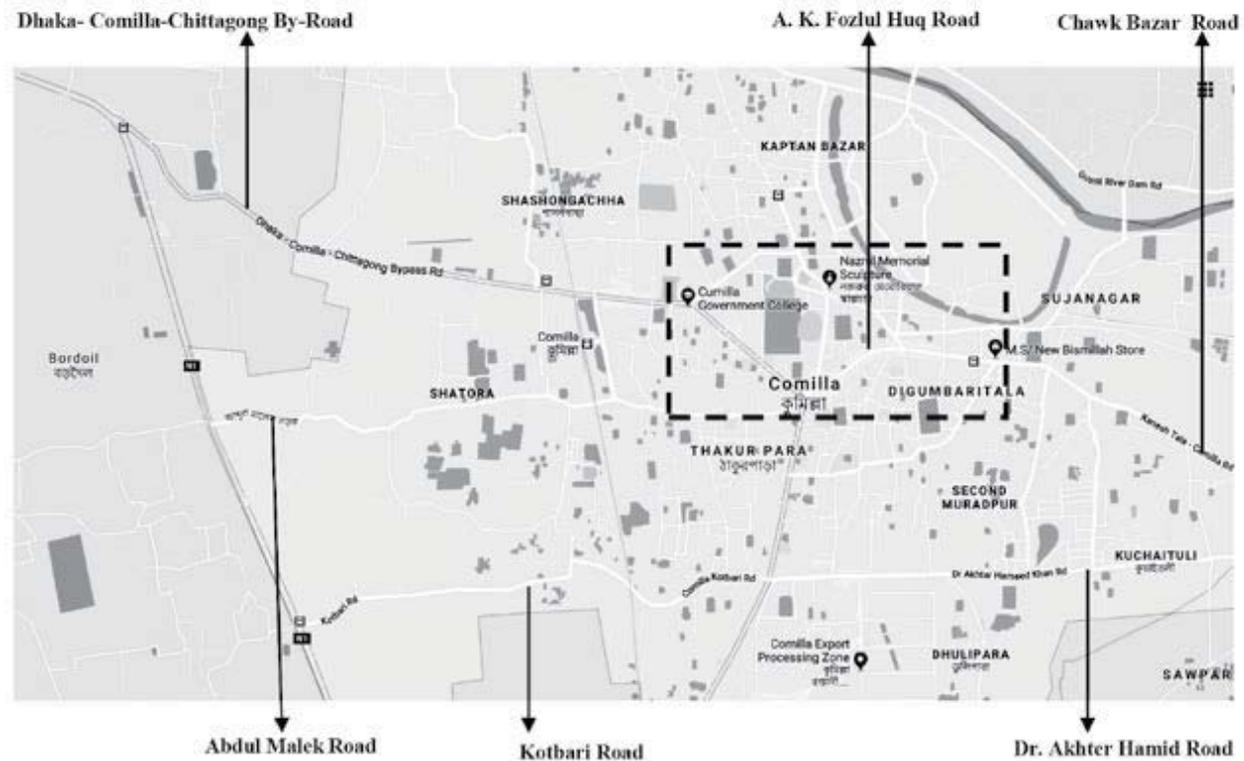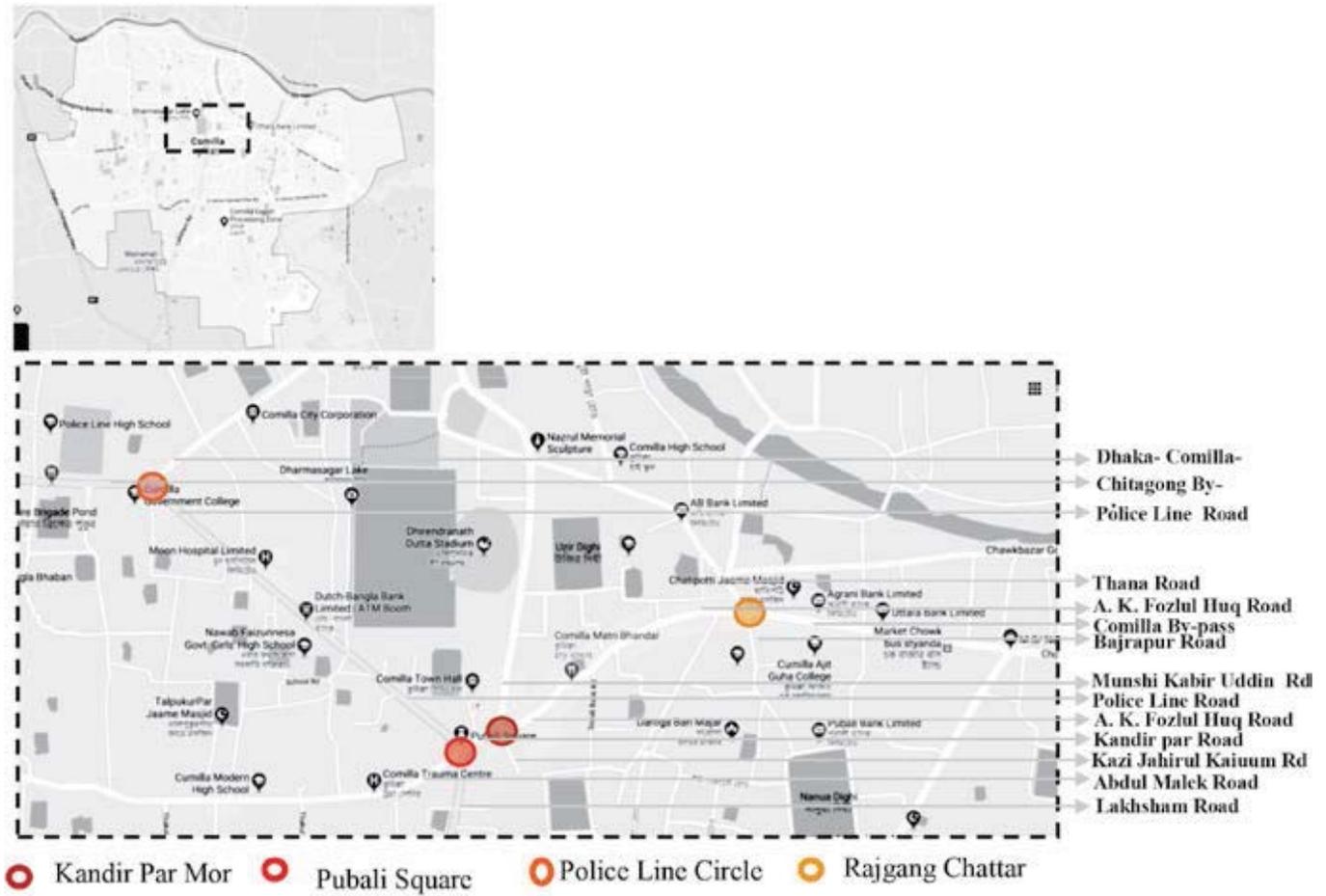
Fig 03: Map showing Important Roads and Connectivity of the Four Important Nodes
**Source:** Google Earth

**Fig 04.** The Four Important Nodes of Comilla City

3.0 ANALYSIS

3.1 Spatial Analysis of Comilla City using Base Map and Visual Survey

Physically the city center of Comilla is located mainly comprising Ward no. 10 and partially ward no. 2, 5, 6, 11 and 12 (IDP 2017-2018, CoCC) (Fig. 01 & 02). The Kandirpar Pubali Square (Fig 1 & 5b), near Dharma Sagar, located within the city center, is perhaps the busiest node of the city, consisting of four roads: Shahid Nizamuddin Road (also known as Police Line Road), Kandirpara Road from the west, Lakhsham Road from the south and AbdulMalek

Road from the west. The Kandirpar Mor, located very near to the Pubali Square, seems to be the second busiest node. It is formed by the Kandir par Road, Shahid Kabiruddin Road (Zila School Raod), A. K. Fozlul Haque Road and Kazi Johurul Kaiuum Road (also known as Ranibazar Road), the road leading to the famous Victoria College (one of the landmark of Comilla City) (Fig. 01, 02 & 5a,b). Many important developments, particularly commercial and administrative developments, are noted beside these five roads, especially beside the Laksham Road, Shahid Nizamuddin Road and Shahid Kabiruddin Road (Fig. 03). Most of the public
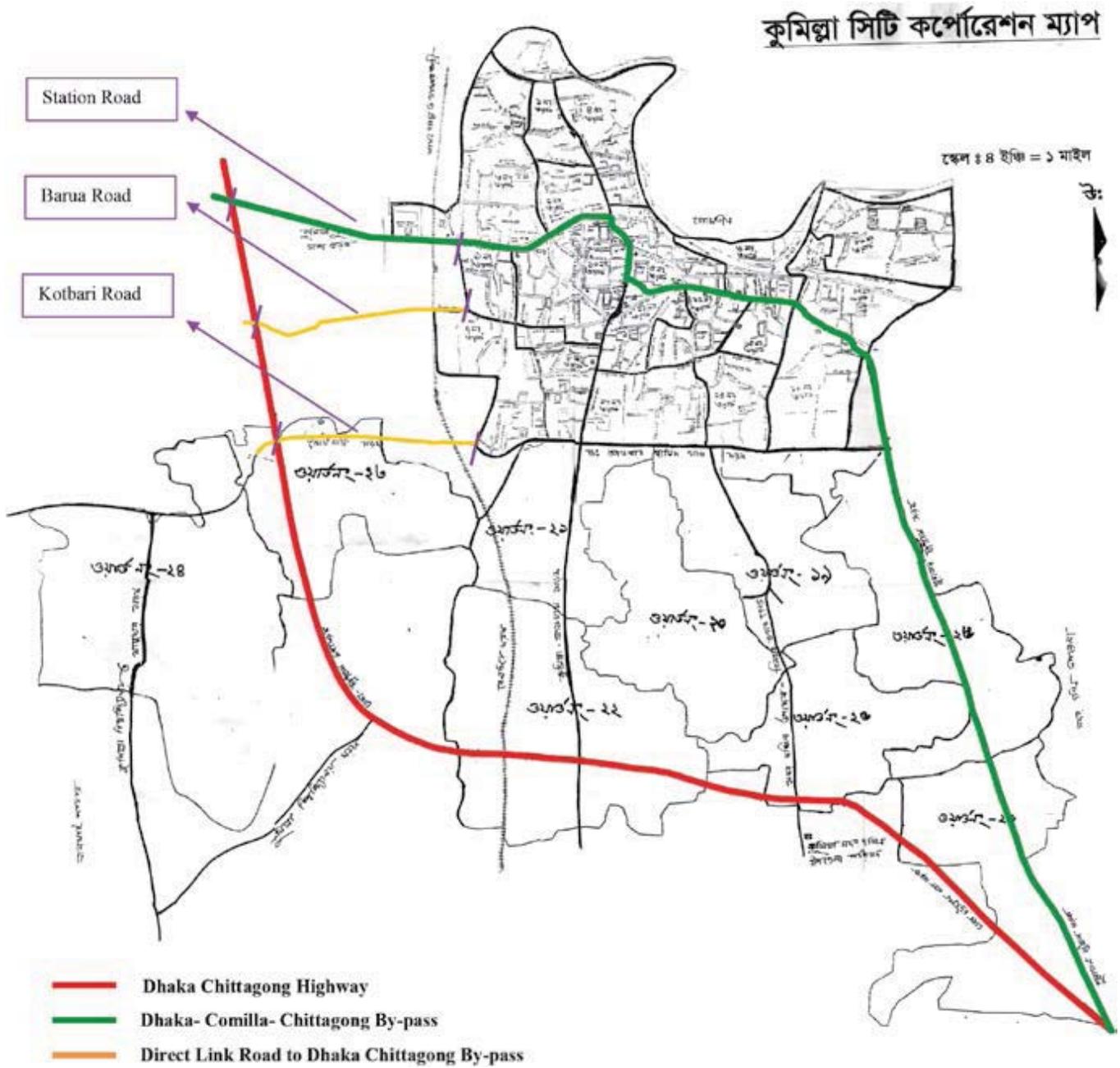
Fig 05a. Base Map (used for syntactic analysis) showing areas under Comilla City Corporation, Old Trunk Road, Dhaka Chittagong By-pass and its direct link roads to City
Source: Comilla City Corporation
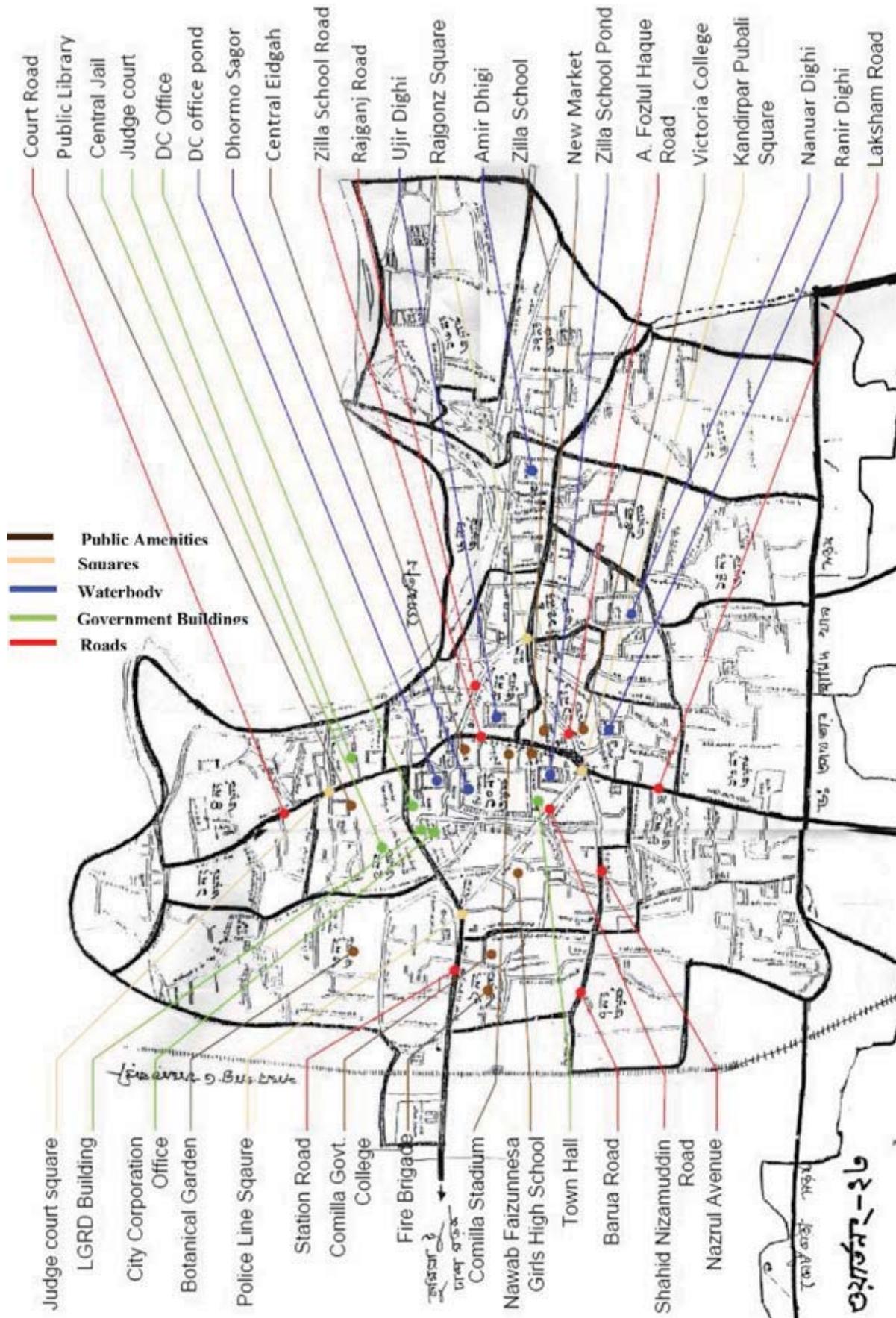
Fig 05b. Land Use Map showing areas under Comilla City Corporation
Source: Comilla City Corporation Map edited with Names

administrative buildings, like the City Corporation Office, LGRD Building, DC Office are situated in ward no. 10, surrounding the famous Dharma Sagar (Fig. 03). Many other civic amenities like Pouroshova Park, Central EidGah, Town Hall, Comilla Stadium, Zilla School, Comilla Hospital, and New Market are also located within this ward. Another important node is the Police Line Sqaure, perhaps the second busy node of the city. It is formed by the intersection of Shahid Nizamuddin Road, and Burichong Road (Station Road) (Fig. 01, 02 & 5a,b). Structures like Comilla Governtment Colege, Nawab Faizunnesa Girls High School, Central Jail, Fire Brigade, etc are located besides these roads. There is another square on the east known as the Rajgonz Square. It constitutes the Comilla Bypass Road from the east, the Bajrapur Road from the south, the Thana Road and the A. K. Fazlul Haque Road from the west (Fig. 01, 02 & 5a,b). The Abdul Malek Road, bearing the name of Barua Roadon the east and the Station Road on the west ultimately meet the Dhaka Chitagong Highway. Comilla-Chittagong railway, near ward no. 7, runs through the western part of the town. Considering goods transportation and physical accessibility both by the road and railway the west and south-west part has major urban development prospects. The city is connected directly to the Dhaka - Chittagong Highway by two link roads: the Abdul Malek Road and Kotbari Road on the west. Sation Road on the south meets the Dhaka - Chittagong By-pass, at a point close to the Dhaka - Chittagong Highway and the Dhaka - Chittagong By-pass. Dr. Hamid Khan Road connects with the Dhaka - Chittagong By-pass from the east (Fig 03 & 05a,b).

3.2 Space Syntax Analysis (Depth Map)
3.2.1 Space Syntax
Space syntax, from its origin in urban research, proposes a language of space that could be of interest for many research and application areas involved in the description and analysis of spatial patterns. Space syntax provides a method for partitioning a spatial system into relatively independent but connected subspaces so that the importance of these subspaces can be measured in terms of their relative nearness or accessibility (Hillier and Hanson, 1984).

The techniques – and the theories – of space syntax are based on two key propositions. The first is that space is not a background to human activity, but intrinsic to it, that is each kind of human activity has its own natural geometry (Hillier, 2014). The second proposition is that space is first and foremost configurational, that is space has simultaneously existing relations (Hillier, 2014).

The space, in configuration analysis, starts with the representational techniques. In this technique 'convex spaces', defined by polygons where no line drawn between any two points in the space goes outside it; 'axial lines', defined as the longest and fewest straight lines of visibility and permeability that cover all the convex spaces, represent the one dimensional organization of the spatial layout (Hillier & Hanson, 1984).

In the context of a city, urban blocks or plots are considered as closed spaces, while streets and squares as parts of the open space. Open space provides a unique vision in understanding the configuration of an urban system. 'Syntax maps', based on the open spaces, provide a precise skeleton representation of an urban configuration and a reference for analytical measures. (Jiang & Claramunt, 1999). The maps are, namely, axial maps, convex maps, isovist maps etc. In axial analysis for cities, space syntax models work by taking the pattern of full street network and analyzing it with mathematical tools.

Based on the syntactic maps, a series of measures of the properties of the configuration of the street grid are derived. The four first order measures are Integration, Connectivity, Control and Choice among which the first one is the most important of all. The 'integration' of a space is a function of the mean number of lines and changes of direction that need to be taken to go to all other space in the system. Integration is therefore about syntactic, not about metric accessibility and the word depth rather than distance is used to interpret how far a space lies. The integration value of a line is a mathematical way of expressing the depth of that line from all other line in the system (Hillier & Hanson, 1984). The spaces of a system can be ranked from the most integrated to the most segregated.

Global Integration provides a global index of relative integration and segregation for that line relative to all others. Values well below 1 — of the order of 0.4 to 0.6, indicate more segregation and; while the value ending to and above 1 show strong integration. Warmer color axial line has, high global or local integration value, vice versa (most integrated roads

in red and least integrated roads in blue). Local integration relate to the spatial properties of space up to three steps (R=3) away from the root. It is conjectured that part of the urban grid are differentially connected within and between themselves, which should be revealed by the rank order of the local integration value. Integration core is the set of the most integrating spaces of a system (Nilufer, 1997). The configuration of that core can be fully connected or split, which is an important property of layouts.

It is also possible to develop second order measures by correlating these four first order measures. Intelligibility, for example, is the correlation between connectivity and integration and describes how far the depth of a space from the layout as a whole can be inferred from the number of its direct connections, i.e. what can be understood of the global relation of a space from what can be observed within that space.

3.2.2 Syntactic Analysis of Comilla City

In this section, syntactic analysis of Comilla City is carried out to assess the global integration core and the existing center of the city and to understand accessibility and connectivity issues of the global integration core with and without the Dhaka - Chittagong bypass. Based on the existing map of Comilla City Corporation (4" = 1 mile) an axial map for the city has been produced and analyzed using depth map to reveal the spatial attribute of the city. As mentioned before, Comilla is an organic city and it has a lattice or mesh like road network. All the arterial, sub-arterial and most of the collector roads are considered here. Because of the curvilinear nature of the roads, axial lines could not be continued very long. Most of the portion of the axial map is fragmented in character.

3.2.3.1 Analysis without considering the by-pass road

Syntactic analysis of Comilla city with radius 'n' is given in 'figure 7'. It is a derivation of the process in which each line is picked up in turn and the complexity distance or depth is calculated to all other lines in the system. For this study 5% integration core is considered. Here the range of global integration (Rn) value of the system is from (Rn= 1.07) to (Rn= 0.88). The map shows a color variation from red to blue. In this analysis of Comilla city, the shallowest lines, which means the lines with the lowest total of depth and highest integration value, coincides with

the previously mentioned city center (Kandirpar Pubali Square), running through the city from the south towards north up to Ward no. 2 and to Ward no. 5, 11, 12 and 6 in the west.

5% integration core (5% of 980) = 49 lines (Range: 1.07254 to 0.87941)

In this part the direct connections with the Dhaka – Chittagong by-pass (using Sation road and Barua Road) are omitted to assess the state of integration core with respect to only the internal movement within the city. The red colored lines, around the Kandirpar Pubali Square, is the highest integrated core of the city for radius-n (Rn). It is more or less in the visual center of the city area (Section 3.1, Fig. 02 & 03). A blown up drawing of the core is given in Figure 7. From the axial map analysis of Comilla city, without considering the by-pass road, it is found that the most integrated roads of the city are A.K. Fazlul Haq road, Shahid Nizamuddin road, Shahid Kabir Uddin road, Laksham road, Station Road, Burichong Road, Dr. Akhter Hamid Khan Road, etc. Collectively these roads can be terned as the global "Integration core" (Fig.7). Integrated roads attract more traffic movement that means more accessibility can be ensured in these roads. Total numbers of line is 14756 and summarized values of some measures of those lines are given below in Table 1.

Table 1. Attribute Summary

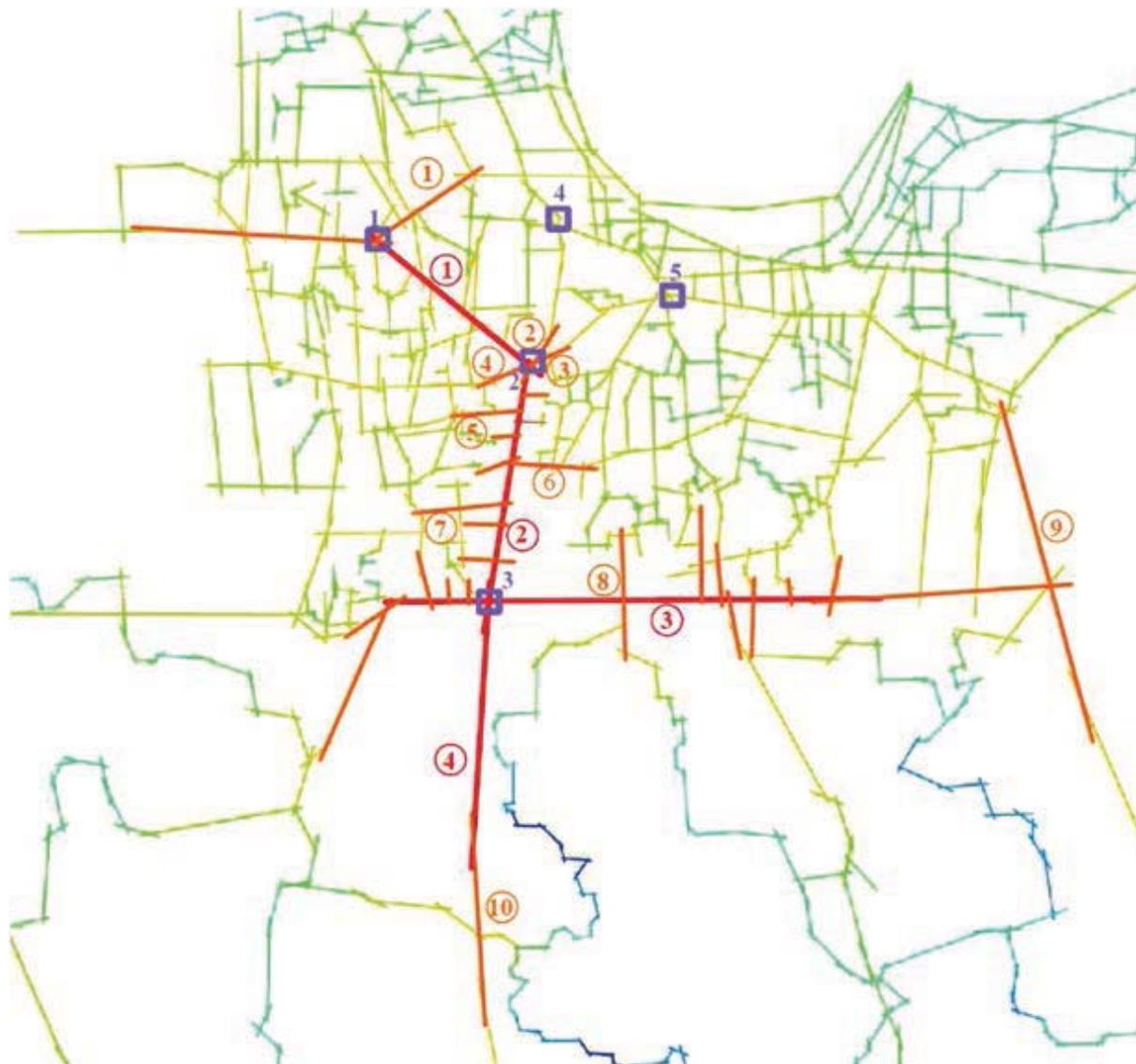| Attribute	Minimum	Average	Maximum
Integration	0.276708	0.631118	1.07254
Connectivity	1	2.85918	15
Mean Depth	7.86517	13.5122	27.6098
Node Count	980	980	980

From the syntactic analysis without considering the by-pass road and the existing spatial formation of road network, it can be established that the roads with high integration value are functionally very important for the city and have better accessibility, so used intensively by the city dwellers. It is also found that different administrative, cultural, educational buildings and many other civic amenities are located besides these roads, which are easily accessible and recognizable. The range of global integration (R=n) value of the system ranges from 1.07254 to 0.87941, which is more than the mean value of 0.631118. The table below demonstrates the syntactic data along with the important structures beside the most integrated roads.

Table 2. Syntactic Data without considering the by-pass road

Name of the access road	Segment (access rd	Connectivity	Mean Depth	R=n (golbal integ. rad.)	Structures beside the road
Laksham road (wrd no. 8 & 13)	23	14	147.96	1.05712	Comilla Education board, Comilla Residential School
Laksham road (ward no. 21)	144	3	8.1951	1.02336	Comilla EPZ, Shaktola High School
Laksham road (ward no. 22)	159	4	8.77528	1.02336	Paduar Bazar Bishaw Road Jamae Mosque
Police Line Rd(Shahid Nizamuddin Rd)	180	15	8.400	0.994965	Nawab Fayzunnesa govt. High School, fire Brigade, Rotary Club
Dr. Hamid Khan Road	7	15	7.8652	1.07254	Comilla EPZ
Dhaka Chitagong Trunk Road (Station road)	2	11	8.978	0.922868	Comilla Central Jail, DC Office, LGED Office, Comilla City Corporation, Comilla
Station road (Dhaka Chitagong Trunk Road)	1	12	8.996	0.920864	Argrculture Department Office, Regional Passport Office
Zila School road(Shahid Kabiruddin Road)	25	4	8.606	0.967977	Comilla Central shahid minar, Town Hall, Zilla School, Comilla Stadium
Nazrul Avenue	181	7	8.444	0.989095	Pubali Bank and Comilla kagoj
Roy Bari road	24	6	8.908	0.931093	Central medical College Hospital
Comilla Court road	29	4	10.412	0.78226	Government Public Library, Judge Court
A. K. Fozlul Haque Road	182	3	9.0633	0.920864	Kotwali Thana, Ajit guha Degree College
Shadar Hospital Road	32	7	9.7906	0.945132	Comilla Shadar hospital
Abdur Rahman Khandakar Rd	416	4	8.7681	0.947866	Comilla Govt. Women College
Thakur Para Road	183	4	8.7314	0.952375	Comilla Education Board
Chawk Bazar Rd	148	5	8.9836	0.922278	Bakrabad Primary and High School, Agrani Bank. Uttara Bank
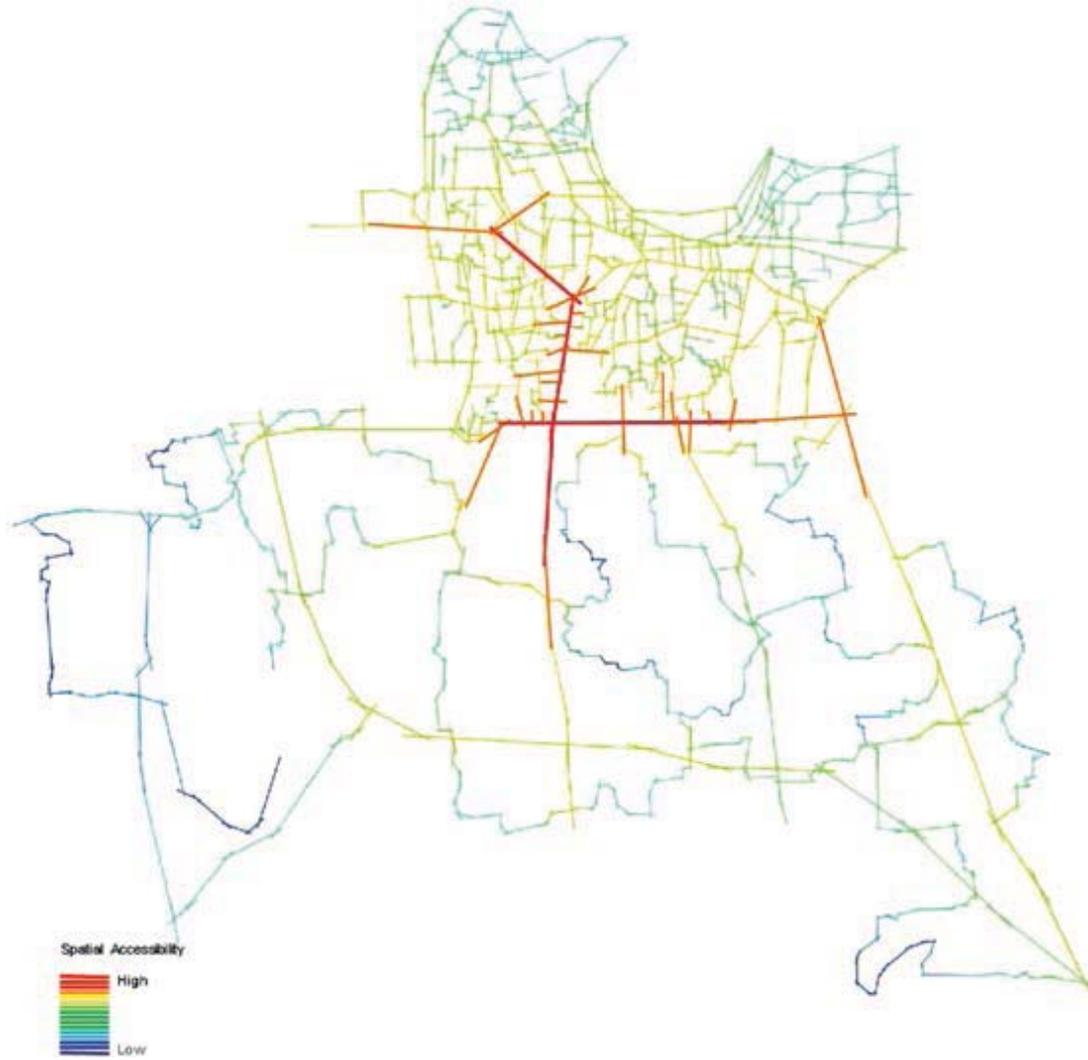
Fig 06: Syntactic Analysis of Comilla City without considering the By-Pass Road (R=n)

LEGENDS

Most integrated roads			Second most integrated roads			Squares formed by highly integrated roads	
	Name	R = n		Name	R = n		Name
1	Shahid Nizamuddin Road	0.99496	1	Station Road	0.92086	1	Kandirpar Pubali Square
2	Laksham rd (wrd no. 8 & 13)	1.05712	2	Shahid Kabir Uddin Road	0.96798	2	Police Line Square
3	Dr. Hamid Khan Road		3	A. K. Fozlul Haque Road	0.92087	3	Laksham Node
4	Laksham road (ward no. 21)	1.02336	4	Nazrul Avenew	0.98909	4	Court Road Node
			5	Roy Bari Road	0.93109	5	Rajgong square
			6	Shadar Hospital Road	0.94514		
			7	Thakur Para Road	0.95238		
			8	Abdur Rahman Khandakar Rd	0.94786		
			9	Chawk Bazar Rd	0.92228		
			10	Laksham road (ward no. 22)	1.02336		

Fig 7. Blow-up of Integration core of Comilla city without considering Dhaka - Chittagong Bypass road (R = n)
Source: Produced by Depth Map

3.2.3.2 Analysis considering the By-pass Road

In this part, the syntactic analysis is done considering the impact of the Dhaka – Chittagong bypass road on the global integration core of the city. The axial map for this part is prepared by superimposing the axial map of the area under the Comilla city corporation and the sub-district map of Comilla (Comilla Sadar and Comilla Sadar Dakshin) collected from LGED website. Here the range of global integration value (Rn) of the system from (Rn=0.869) to (Rn= 0.730) is considered using again a 5% core. Total number of lines is 14756, whose attribute summary is given below in table 3.

Table 3. Attribute Summary

Attribute	Minimum	Average	Maximum
Integration	0.191847	0.536308	0.869076
Connectivity	1	2.74686	14
Mean Depth	9.68374	16.0442	40.3378
Node Count	1114	1114	1114

With the introduction of the Dhaka – Chittagong bypass road, it is found that the integration core has slightly shifted towards the south (Fig. 08& 09). The higher integration value still coincides with the previously mentioned city center, Kandirpar Pubali Square (Section 3.1), running through the city from the south towards north up to Ward no. 2 and to Ward no. 5, 11, 12 and 6 in the west, except the newer addition of the segment of Laksham road passing through Ward no. 22 in the extreme south. Considering 5% integration core value of Rn ranges from 1.07254 to 0.87941.

5% integration core (5% of 1114) = 56 lines (Range: 1.07254 to 0.87941)

The integration core considering the bypass road more or less coincides with the previous integration core (Table 5), though with a variation in the extreme south of the city. From the axial map analysis of Comilla city with and without the bypass road, it is noted that exclusion of the By-pass road, and considering the Dhaka Chittagong as the only thoroughfare from Dhaka to Chittagong, has comparatively minor effect on the location of integration core of the city.

Table 4. Syntactic Data considering the By-pass Road

Name of the access road	Segment used as an access road	Connectivity	Mean Depth	R = n (global inte-gration radius)	Structures beside the road
Laksham road (betwn. ward no. 8 & 13)	44	11	9.75651	0.861853	Comilla Residential School, Thompson Bridge Bus station, Ishwar Pathshala High School
Laksham road (ward no. 21)	175	3	9.68374	0.869076	Comilla EPZ, Shaktola High School
Laksham road (ward no. 22)	190	4	10.1905	0.821158	Paduar Bazar Bishaw Road Jamae Mosque
Police Line Road (Sha-hid Nizamuddin Road)	205	13	10.406	0.802333	Nawab Fayzunnesa govt. High School, Fire Brigade, Rotary Club
Dr. Hamid Khan Road (Chowk Bazar Road)	178	14	9.805	0.857104	Comilla EPZ, Comilla Housing State Area
Dr. Akhter Hamid Khan Road (Chowk Bazar Road)	182	6	11.066	0.749699	Comilla Medical college
Station road (Dhaka Chittagong Trunk Road)	24	11	10.9461	0.758774	Comilla Central Jail, DC Office, LGED Office, Comilla City Cor-poration, Comilla Govt. Public Library
Zila School Road (Sha-hid Kabiruddin Road)	47	3	10.6792	0.779692	Comilla Central shahid minar, Town Hall, Zilla School, Comilla Stadium

Nazrul Avenue	206	6	10.394	0.802333	Pubali Bank and Comilla Kagoj
A. K. Fozlul Haque Road	201	3	10.945	0.758842	Kotwali Thana, Ajit guha Degree College
Shadar Hospital Road	53	6	10.5472	0.790478	Comilla Shadar Hospital
Abdur Rahman Khan-dakar Road	695	5	10.6801	0.77962	Comilla Govt. Women College
Roy Bari Road	45	6	10.6164	0.784791	Ramghat Mosque
Thakur Para Road	208	4	10.4825	0.795871	Comilla Education Board
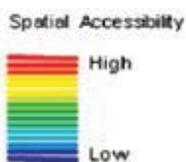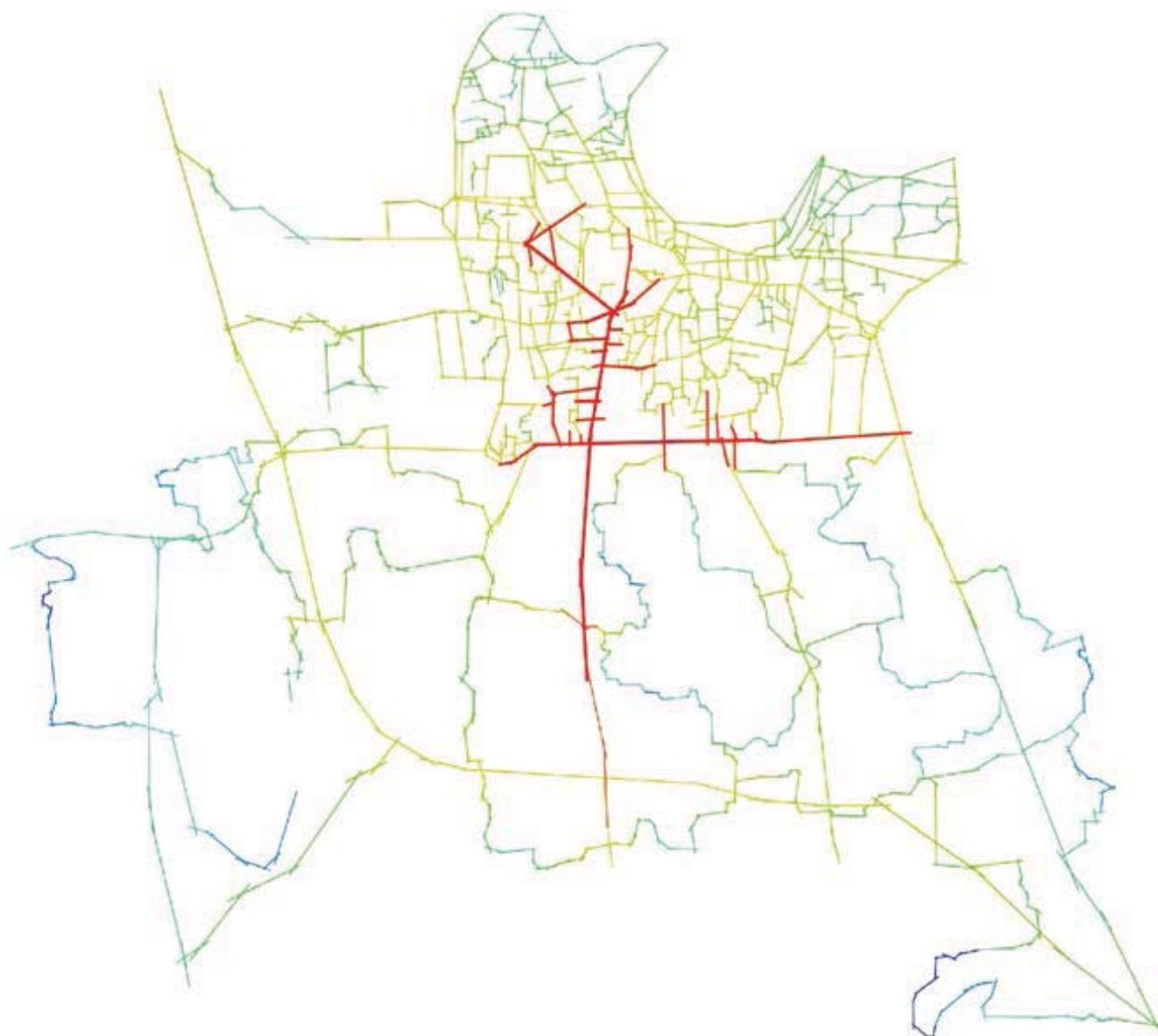
Fig 08. Syntactic Analysis of Comilla City considering Dhaka - Chittagong Bypass road (R = n)
Source: Produced by Depth Map

LEGENDS

Most integrated roads			Second most integrated roads			Squares formed by highly integrated roads	
	Name	R = n		Name	R = n		Name
1	Shahid Nizamuddin Road	0.802333	1	Station Road	0.758774	1	Kandirpar Pubali Square
2	Laksham rd (wrd no. 8 & 13)	0.802333	2	Shahid Kabir Uddin Road	0.779692	2	Police Line Square
3	Dr. Hamid Khan Road	0.861853	3	A. K. Fozlul Haque Road	0.758842	3	Laksham Node
4	Laksham road (ward no. 21)	0.857104	4	Roy Bari Road	0.784791		
5	Laksham road (ward no. 21)	0.869076	5	Shadar Hospital Road	0.790478		
6	Laksham road (ward no. 22)	0.821158	6	Thakur Para Road	0.795871		
			7	Abdur Rahman Khandakar Rd	0.77962		

Fig 09. Blow-up of Integration Core of Comilla City considering Dhaka - Chittagong Bypass road (R = n)
Source: Produced by Depth Map

3.2.4 Comparison

From the above analysis it is found that the integration core changes, though slightly, with the introduction of the by-pass road. A comparison of the highly integrated roads common in both the cases, with and without the by-pass road is summarized below.

Table 5: Comparison of Rn considering and without considering the by-pass

Name of the Access Road	Without Considering the By-Pass Road (R = n)	Considering By-pass Road (R = n)
Laksham Road	1.05712	0.861853
Police Line Road	0.994965	0.802333
Dr. Hamid Rhan Road	1.02336	0.857104
Dhaka Chitagong By-pass Road	0.922868	0.7588
Zila School Road	0.967977	0.779692
Nazrul Avenue	0.989095	0.802333
A. K. Fozlul Haque Road	0.814707	0.758842
Shadar Hospital road	0.945132	0.790478

From this table, it can be noticed that, the integration value of these eight roads varies slightly with the introduction the by-pass road in context of the whole city. Thus, it can be assumed that the flow of internal traffic is higher within the city center than compared to the traffic flow from the by-pass road (Fig. 06, 07, 08 & 09).

3.3 Correlation of Syntactic Measure

The correlation between global integration and connectivity shows the intelligibility of the space. It also leads to a strong sense of readability of the system. In more intelligible system, the people occupancy along the axial line is predictable from the measure of integration. That means the most integrated lines are the most intensely used path by the people and in the non-intelligible system, people occupancy rate along axial lines tend to be more random (Khan, 2008). To measure the correlation of global integration (Rn) and connectivity (CN),

points are plotted according to its degree of global integration on the horizontal axis and connectivity on the vertical axis. Depending on how well a space is connected, the axial map is colored from red to blue, the connectivity or integration. Red lines represent very well connected/integrated space and blue lines are not well connected and the most segregated, using the spectrum (red to blue) to show something in between (Jacoby, 2006).

3.3.1 Correlation without considering the By-Pass Road.

To measure the intelligibility of the most integrated access road in city scale, at first the correlation value between the global integration and connectivity has been determined and then compared with the correlation value between global integration and connectivity of the particular segments used as the access roads comprising the core. Highly integrated lines are well connected.
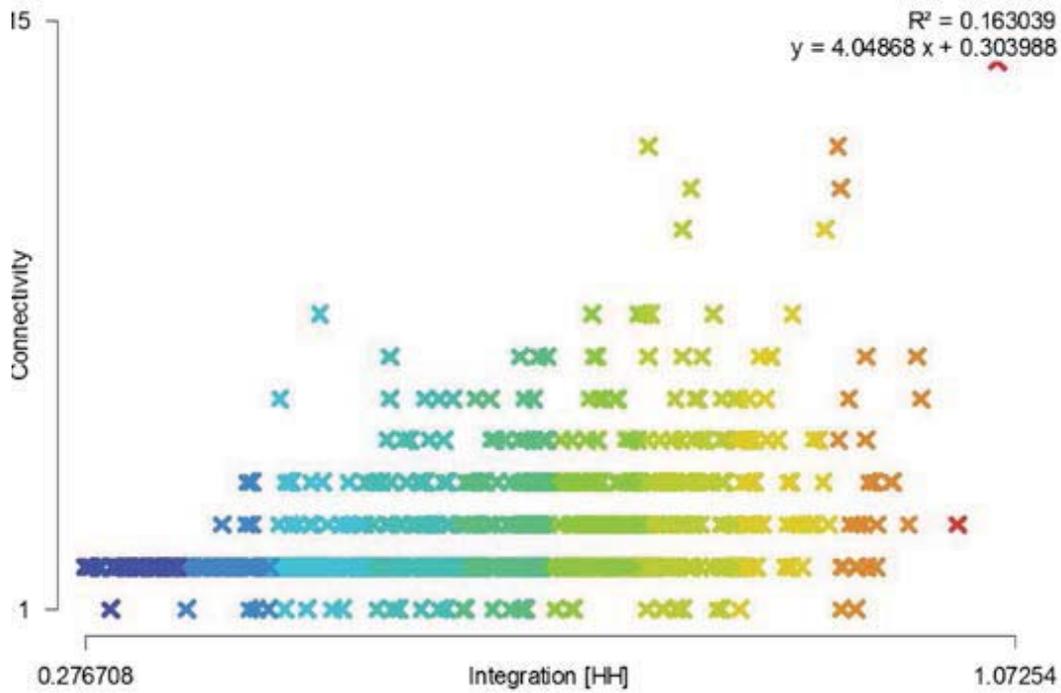
Fig 10. Correlation between global integration & connectivity of Comilla city without considering the By-Pass Road.

From the correlation (Fig. 10) it is found that the correlation value between connectivity and global integration of the total system is $R^2 = 0.163$, which is much less than the value 0.5, that indicates poor correlation and non-intelligible when the access roads are analyzed as part of the whole system.

3.3.2 Correlation considering the By-pass Road
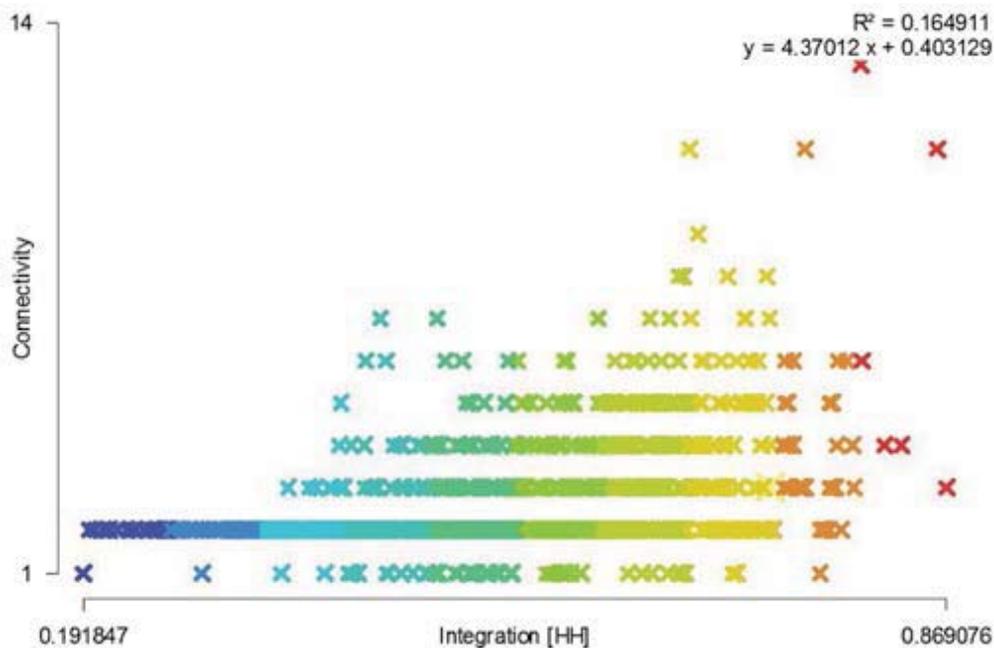
Fig 11. Correlation between global integration & connectivity of Comilla city considering the By-pass Road

From the correlation (Fig. 11) it is found that the correlation value between connectivity and global integration of the total system is $R^2 = 0.165$, which is much less than the value 0.5, that indicates poor correlation and non-intelligible when the access roads are analyzed as part of the whole system.

3.3.2 Comparison

From the above correlations it is seen in the correlation between global measure and connectivity that the value of $R^2 = 0.163$ (without the by-pass road) and $R^2 = 0.165$ (considering the by-pass road) are much less than 0.5, indicates poor correlation and non-intelligible as part of the whole system. Correlation is comparatively negligible when the by-pass is considered. But in both the situation, the value of R2 is less than 0.5. It indicates that the city is less intangible or readable in global scale.

4 CONCLUSION

4.1 Findings

From the syntactic analysis, it is found that most of the administrative buildings and civic amenities coincide with 5% integrated roads of the city. So it is evident from the analysis that the city center has better accessibility in the city scale as all the integrated values of the access roads of the buildings are higher than the mean integration value. Mostly commercial and administrative developments (public administration), are concentrated near the main integration core of Comilla city. The global integration value of the highly integrated roads slightly increases when the by-pass road is not considered. From this it can be assumed that, in context of the whole city, flow of internal traffic is higher within the city center than compared to the traffic flow from the by-pass road.

The correlation (between the global integration and connectivity) is poor in global condition both considering and without considering the inter-city traffic. That means the city is less intangible or readable in the global context. Though the integration value increases considering the inter-city traffic through the city, the intelligibility decreases in the local context.

4.2 Conclusion

In the conclusion it can be said that the internal movement within the city is not at all hampered by the introduction of the by-pass road. The city becomes slightly more intelligible (readable) with the introduction of by-pass road, which is though very negligible but can be important for small scale city like Comilla. As it is seen in this research that roads surrounding the Kandirpar Pubali square coincide with the present integration core and it is and will be attracting more activities, mostly commercial and similar other land uses, future planning decisions can be taken accordingly. The analysis shows that further commercial development will take place towards the Dhaka-Chittagong-Comilla bypass road. The result of the study will help to understand the future land use pattern and to make them compatible with the present as well as ever growing future demand of Comilla City.

The Comilla town though facing tremendous pressure of haphazard development, has still the scope for suggested and designed development through rigorous surveys, analytical methods and other virtual analysis like using space syntax for spatial network analyses to understand and predict social processes within the built environment. Both built and vacant areas along the integration core are still attracting new developments and redevelopments. In such a small urban state like Comilla, planning decisions have a lot of scope to explore a city in a properly thriving way. Syntactic analysis is a tool which can help the planners to see the unforeseen about a city.

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