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REVIVING THE INLAND WATERWAYS OF DHAKA:

A morphological approach towards an integrated transportation system

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Abstract

The rapid population growth along with increased and versatile urban land use patterns has generated substantial travel demand as well as numerous transport problems in Dhaka city. Inadequate urban transport planning and management has resulted in deterioration in accessibility, operational efficiency and urban environment. To solve this hazardous travel environment in metropolitan area, the Strategic Transport Plan has launched with the aim to sidetrack city's lone dependency on surface transportation system to monorail, metro rail, elevated expressways and inland waterways. Ironically, majority of these solutions could not utilize the cities inherent possibilities; rather they picked up hired solutions. Dhaka city, like many other cities in the world, was crisscrossed by canals and surrounded by rivers. The city itself developed on the bank of river Buriganga and was dependent on water based transportations as an access route to the historic city. But in developing city's infrastructure, the city authority never followed its integral natural features. Even these canals never played any role by the users to reduce city's traffic load on surface, so the problem persists.

This paper focuses on the possibilities of recent government intervention of Circular Waterways which covers the peripheral water routes of Dhaka city. It also explores the inherent morphological characteristics of the city through reviving present and historic canal networks to serve as an alternative and supplementary transportation system. Finally, the impact on the projected movement pattern of city traffic with an integration of water ways and the land routes has been syntactically analyzed. At present, the city grid with peripheral waterways, encircling the city shows trivial changes in the global movement pattern. The proposed Circular Waterway remains totally segregated from the global integration core due to its physical location and weaker connections with the city grid. However, it is understood that the impact of Circular Waterways in case of Dhaka is much of a 'by-pass' route and it will be feasible as a route for commuters without conflicting the city traffic. It is also imperative to incorporate the internal waterways with the street network of the city considering their network connectivity and geographical position. The syntactic analysis reveals that the internal waterways, if revived, have greater influence on the local movement. While being integrated with street network, they will release traffic load from the highly integrated global routes to the less integrated local routes. Based on findings, this paper proposes a revised spatial structure for Dhaka city incorporating the river and canal systems in order to utilize the potential of its natural features towards a sustainable urban transport system. In doing so, Space Syntax methodology has been adopted for analyzing the spatial structure of Dhaka city in present context along with simulated situation through reviving its historic canal systems.

Keywords: *Urban core, Dhaka City, Space Syntax, Integrated transportation system, Inland water transportation, Traffic congestion.*

Theme: *Urban Space and Social, Economic and Cultural Phenomena*

1. Introduction

Dhaka is one of the fastest growing cities in the world; in 2006 it ranked 11th among the world's megacities with an estimated population of 12.4 million (UN, 2006) and an area of 276 sqkm (DCC, 2004). While slowing, the urbanization rate in Dhaka is still over 2.5% (BBS, 2003), leading to expectation that its population would reach 16 million by 2015 (DMDP, 1997) and forecast to increase to 36 million by 2024 (STP, 2005). In fact, nearly 80,000 people live per square kilometre of land in Dhaka. The city is situated at the centre of the country and is surrounded by a river system comprising Buriganga, Balu, Turag, and Shitalakhya. Thus expansion of the city is limited by physical constraints. The urban core is almost already built-up; even so, the city authority has not been able to develop any network of public transport systems both for commuters and for people living within the city (Islam and Hadi, 2003; Quazi, 2003). Thus, the traffic congestion of the capital Dhaka stands as a major problem. A study conducted by the Metropolitan Chamber of Commerce and Industry in collaboration with Chartered Institute of Logistics and Transport states that 200 billion BDT is lost every year because of staying longer time, 8.15 million working hours, on the streets because of traffic jams every year (The financialexpress-bd.com). Besides, this massive traffic congestion is taking its toll on human health through massive air pollution. It is estimated that the transport sector is responsible for 70% of the national CO2 emissions of which 20–30% come from Dhaka (Alam and Rabbani, 2007).

Recently steps have been taken by the government through implementation of Strategic Transport Plan (STP) in 2008 to grab the traffic congestion bull by its horns. Under the plan, the government will construct and reconstruct 330 kilometers of roads and highways including 50 new roads, flyovers, elevated expressways, metro (underground railway), circular waterways, bus rapid transit, rapid mass transit, and will ensure bus-route rationalization, traffic system development and safe environment. But after four years, it is still in its initial stage of implementation as these ideas seem to be unrealistic in context of Dhaka due to its very high capital and operating cost system. In the context of a low income and developing country, mass transit through bus ways and inland waterways seem to be realistic solutions of urban transportation problem of metropolitan Dhaka (ADB, 2001). A circular water way round the capital city was partly implemented by BIWTA in 2001, which covers the western side of Dhaka city (Shadarghat to Ashulia). However, the plan did not provide much of a long-term solution to the problem due to lack of proper implementation and less integration with the city core. To address this issue, this research aims to identify a more integrated multi-modal public transport system. In order to do so, this paper will identify the impact of implemented government actions on existing urban core of the city through using Space Syntax. For future action plans, this paper will investigate whether existing lakes and canals (khals) will act as integrated part of city's transpiration network and how these inland waterways will impact locally on the surrounding road network.

2. Overview of transportation sector in Dhaka

The transport sector in Dhaka is comprised of many different modes of travel both motorized and non-motorized. These diverse modes of transportation systems are predominantly road based and non-motorized transportation. Among them rickshaws (tri-wheelers) have a substantial share. The road network of Dhaka city is nearly 3000 kms (of which 200 km primary, 110 km secondary, 50 km feeder and 2640 km narrow roads) with few alternative connector roads. The total number of motorised vehicles in the city now stands at a staggering 1.05 million which are crammed into some 220-kilometre road creating one of the highest traffic densities in the world (BRTA, 2007).Besides, absence of any type of mass transit system is resulting high

level of operational disorder (BRTA, 2007). This lack of discipline significantly diminishes the efficiency and effectiveness of the existing transport system and mostly responsible for city's congestion. The deteriorating traffic conditions are causing increasing delays and worsening air pollution, and seriously compromise the ability of the transport sector to serve and sustain economic growth and provide an acceptable quality of life.

2.1. Transport modal spilt

According to STP (2005), the buses comprise a small proportion of vehicle (8%) but carry about 60% of people; rickshaws are seen to carry about 40% of persons in the city areas; whereas the autos serve a low proportion of movements comprising less than 10% of travel. According to Roads and Highways (RHD, 2009), light to medium vehicles occupy 65 per cent of the road followed by buses and trucks with 20 per cent. Only 15 per cent road capacity was used by CNG auto-rickshaw (The financialexpress-bd.com). In every month, around 3,000 new vehicles hit the road contributing to increasing air pollution and severe traffic congestion which is also badly hampering the average speed of the vehicles (Roy, P. 2008). Volume and vehicle classification count data collected in the STP surveys indicates that bus passengers represent 58% of all people crossing the three screen lines. In terms of vehicles, buses accounted for 10% of all vehicles, 16% of all motorized vehicles and 25% of all 4-wheeled motorized vehicles (STP, 2005).

2.2. Government interventions

Dhaka's unplanned growth; a Dhaka-centric development of the country; the lack of east-west connecting roads; unplanned construction inside the city; increased number of private transports; and the lack of mass transit are some of the contributory factors to traffic congestion. Even the existing mass transport facilities are not sufficient to keep pace with growing population. The Strategic Transport Plan (STP, 2005) aimed at establishing an integrated environment-friendly traffic management system in greater Dhaka to relieve people of the nagging traffic congestion. The Bus Rapid Transport (BRT) system is the important component of the STP. Another component of the plan includes a proposal to develop some 60 kilometres of three-lane Mass Rapid Transport (MRT) system, combination of above-ground and underground grade separated MRT

According to experts, setting up Bus Rapid Transit is more viable than Mass Rapid Transit (http://www.newagebd.com/2010/may/14/may14/xtra_inner2.html, May 14-20, 2010). According to them, even STP has encouraged the use of private cars over mass-transport; besides the flyovers will not be successful in reducing traffic. Though STP claims that a waterway would be an environmentally friendly way to solve the transportation problem in Dhaka, but the proposed budgetary expenditure is only 1.11 per cent of the aggregate demand for building such a waterway and there are no holistic planning guidelines to incorporate these BRT and circular waterways (The financialexpress-bd.com).

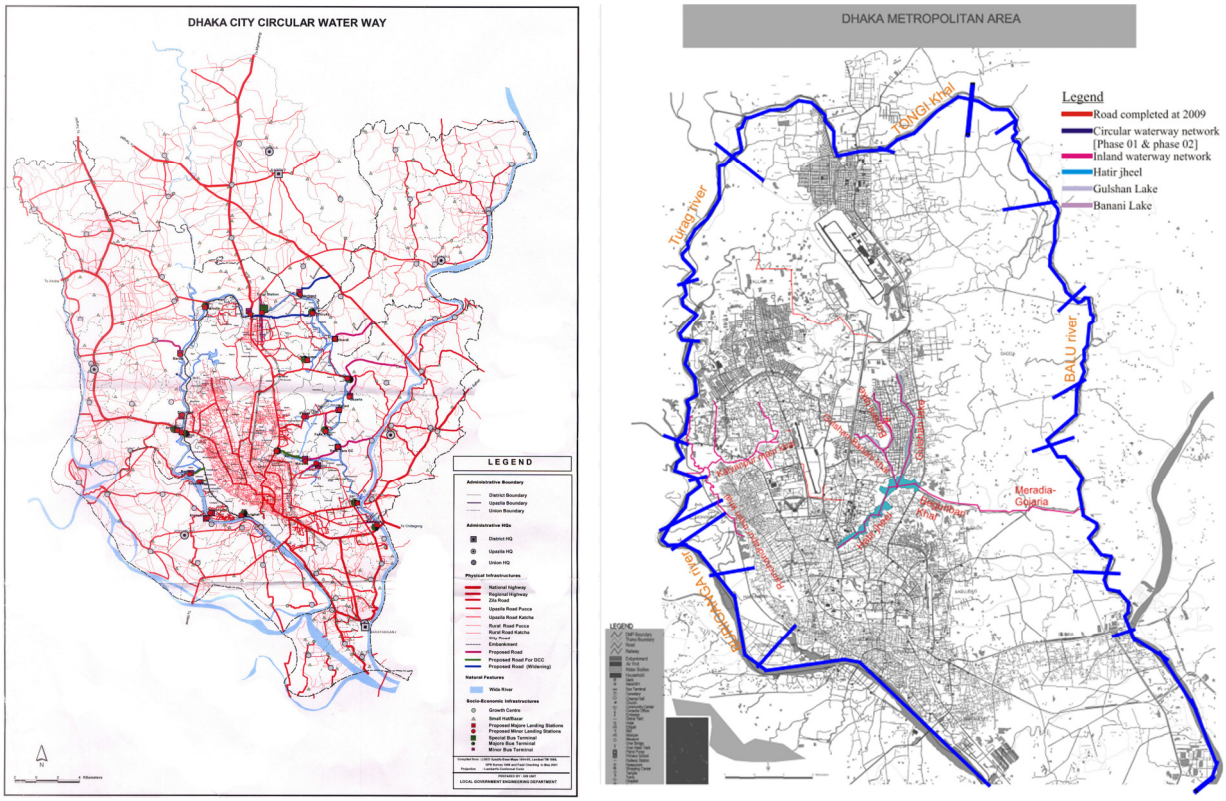


Figure 1 Left: Circular waterways route in and around the Dhaka city (STP, 2005). Right: Road network completed after 2009 (after Khan.Nayma, 2008)

The Bangladesh Inland Waterways Transport Authority (BIWTA) is already proceeding with the development of a circular waterways system around Dhaka, for the transport of people and goods (Figure 1). The main objective of the BIWTA implemented project is decreasing traffic jam in Dhaka, reviving the rivers in and around the capital to integrate the waterways with the land transport systems (DTCB), improving Tourist value and environmental Development. In 2001, BIWTA implemented a project introducing waterways on the western side of Dhaka city from Shadarghat to Ashulia (29.50 km), which was completed in March, 2005. Besides, in 2004, BIWTA had undertaken a project for the development of waterways on the eastern side of Dhaka city from Ashulia Bridge to Kachpur via Tongi as phase two of the circular waterways (40.50 km) around Dhaka city (Development Project Proposal, BIWTA, 2007). Under this project BIWTA has constructed ten landing stations at first phase at Swarighat, Kholamura, Basilla, Rayer bazaar, Nawab bag, Shinnirtek, Berulia, Amin bazaar, Mirpur, Ashulia (Figure: 1). The proposed landing stations for the eastern parts are Tongi, Herbaid, Trimukh, Khardi, Ishapura, Baraid, Kayetpara, Demra, Kanchpur.

3. Literature review

3.1. Transportation system

The term ‘transport system’ refers to socio-technological systems for transport of people and goods which consist of vehicles-energy infrastructure-organizations-people embedded in an urban, social, cultural and geographical context (Volvo Research and Educational Foundations, 2004). As a result activity generation and concentration is managed through transport system. (Dimitriou, 1992; Banister, 1995) Transportation demand influences transport system in its

function (Benson et al., 1994). Transportation demand is also influenced by the modal choice of the users (public or private carriage). Such modal split of passenger carriage is also affected by availability of alternatives, comfort, dependability and safety (Lieb, 1985).
The efficiency of urban transport system is greatly affected by the management, capacity, and conditions of the transport system under which the system operates (Dimitriou, 1992). It can be brought through effective decision making process including plan preparation, technology adoption, assessment of demand and supply of transport facility, modal allowance, signage, traffic control and management etc. (Camagni, et al., 2005).

3.2. Inland water transportation systems and experience

Inland waterway transportation is one of the oldest economically and environmentally sustainable modes of transportation for passengers and cargo. It has been found out that the environmental impacts of water transportation are environmentally compatible, provides a means to sustainable development, and that the use of this environmentally-friendly mode should be encouraged. (Butts and Dana, 1992) IWTS is the cheapest and least costly in terms of land acquisition, energy, labor, resources and most beneficial form of all. (Doerflinger, Frederic. 1975) Thus promoting the development of IWT is beneficial to global economy, society and well being (APEC, 2007).

Inland water transportation (IWT) across the world is varied and offers interesting and alternative transportation solutions. In Italian city of Venice, Thailand ubiquitous water buses provide the principal means of transport. In Thailand IWT is next to road in share of freight carried (about 20 million tons) (ADB, 2007). Bangkok as the “Venice of the East” with its serpentine river and network of canals, the unfortunate reality is that it is fast becoming the Los Angeles of the East. However, Bangkok’s tightly-woven urban fabric which, like many other Asian cities, has not been built for the automobile. Non-motorized modes, especially waterway transport, were the basis of Bangkok’s early development, followed by trams and buses. It is only since about 1980 that vehicle ownership, and thus congestion, has gone out of control (Poboon et al., 1994). Water transport is an attractive, fast way to travel in Bangkok. It provides passengers with relief from the hot climate and separation from the fumes and noise of the roads. However, many canals have been filled in for roads, and even the river is the focus of an attempt to build a floating freeway. According to Federal Transport Infrastructure Plan of 2003 (BVWP 2003), inland waterways of Kochi, India have significant reserve capacities in all major corridors which applies not only for the current situation, but also for 2015, with due consideration of expected increases in traffic volumes.

River training and use of rivers and canals for a variety of purposes has been common for various countries for a number of years. IWT is seen as a complementary mode of transport and offers an alternative for environmental concerns. Adjustable subsidies on movements by IWT would be a better way to build traffic than enforcing percentages of movement by a particular mode. The current challenges are safety and the development of integrated systems to harmonize traffic in urban areas.

3.3. Space syntax and analyzing city’s spatial structure

Space syntax is computer-based analysis technique to describe the spatial pattern of urban space. Space syntax theory was developed in the 1970s by a group led by Bill Hillier and Julienne Hanson and the philosophy of Space syntax is based on how built space configuration affects the way the city works, influencing urban dynamics (Hillier et al 1993; Hillier, 1996). It studies the relationship between urban configuration and spatial mobility of pedestrians has focused their analyses on axial maps, which include a simplified representation of the street grid and its

integration values resulting from barriers and permeability.

Space syntax measures geographic accessibility with axial lines. Axial lines are lines of unobstructed movement used in computing accessibility. And the first representation, a so called axial map, is defined as the least number of longest straight lines. According to how each line intersects every other line, a connectivity graph, taking axial lines as nodes and line intersections as links, can be derived. Axial maps are fundamentally based on a relational approach of the set of streets making up the road system of a city. This approach allows considerations on the topological attributes that each street establishes with its nearby streets (local connections) or with the whole system to which it pertains (global connections). The studies of Hillier et al. (1993) and Hillier (1996) suggest that the amount of movement which occurs on each street is substantially influenced by its configuration. In this respect, the topological characteristics of a road system might be conceived as a system of possible routes and it embed a kind of probability field in which it becomes possible to identify routes that are potentially more likely to be travelled.

4. Water bodies and wetlands in and around the Dhaka City

The Dhaka metropolis is surrounded by the distributaries of the two major rivers i.e. the Brahmaputra and the Meghna. The surrounding rivers are Buriganga in the south, Turag in the west, Tongi khal in the north, and Balu in the east (Figure 1). Canals of Dhaka used to be connecting channels of rivers surrounded by the greater Dhaka district. Even now whatever is left of the canals is used as the primary drainage system for Dhaka. But most of these canals have vanished due to a variety of reasons: unplanned urbanization, encroachment, dumping of solid wastes, lack of co-ordination between the government agencies and lack of maintenance to the system. The few canals which are left are on the verge of extinction as they have lost their flow, blocked by either roads or unauthorized structures. As a result, each year, the city dwellers face acute water logging during the rainy season.

Although over 50 affluent canals once used to flow through the capital and added to its lifeline, most of the water channels have been fully or partially choked, while the rest are under serious threat. Historical references (Figure 2) indicate that Dhaka was crisscrossed by 3 main rivers (Mamun, M. 1993). Among canals in Dhaka the Dulai, which once used to be the artery of an important navigational route for country boats to and from destinations within the metropolis, has almost disappeared due to four decades of incorrect policies of the city administration to construct roads by closing the canal. It was the most important river channel most probably tributary of Balu river, taking off from a little above Demra and flowing south-west through the city to join the Buriganga River (Rizvi, 1975). The present abandoned channels along Segunbagicha-Ramna park-DMC were part of the Dulai river. Carevan (Karwan) river in its previous alignment might be along Begunbari Khal-Green Road-Kalabagan-Dhanmondi lake to Turag River. The third one is Pandu River which was most flowed along the Kalyanpur-Agargaon-Mohakhali area. All three rivers were well connected and jointly responsible for the present topography and natural drainage system of the city (Islam, 2009). At the center there was the mighty Hatirjheel. The Gulshan lake system directly drained south-west into Hatirjheel and into east through the Rampura Khal to the Balu River. The Gulshan lake system was connected to Dhanmondi lake system via the Begunbari khal which then drained through the Katasur Khal into Turag. In the west the Katasur canal also drained Rayerbazar and Mohammadpur areas. Panthapath landfill destroyed the whole eastern portion of the Begunbari Khal connecting Hatirjheel to Dhanmondi lake system. Several studies have documented to determine the loss of wetland in Dhaka over the period 1989-1999 and 1999-2003 (Figure 2). The annual rate of loss of wetland in Dhaka during the period 1989-1999

was 1.23%; where as the annual rate of loss was 5.67% over the period 1999-2003. Rajdhani Unnayan Katripakkha (RAJUK) has a list of 20 lost canals that once flowed through Segunbaghia, Basabo, Begunbari, Mohakhali, Katasur, Ibrahimpur, Digun, Ramchandrapur, Baunia, Abdullahpur, Diabari, Kallyan, Dholaikhal and Jiranikhal. Study showed that Dhaka is still left with 19.3% of wetland (The Daily Star web edition, 2006). Thus recently government has taken specific projects for different Zones in Dhaka regarding lake developments and navigability.

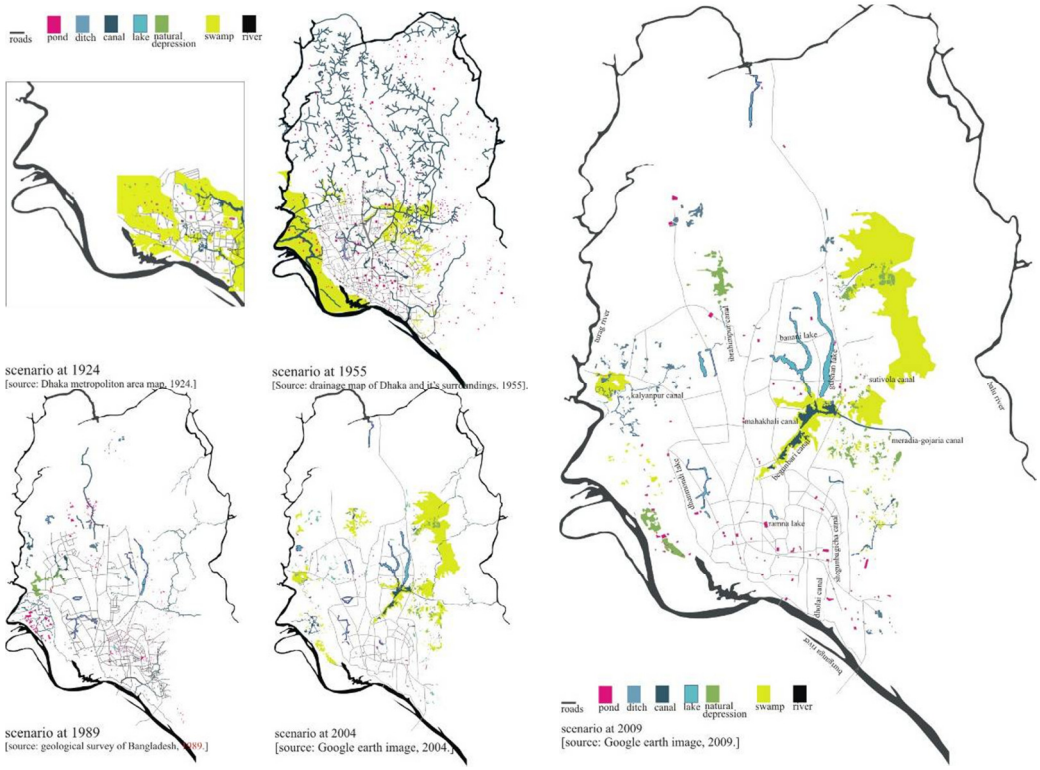


Figure 2 Chronological overview.

Source: Workshop on 'Integrating the Urban Water Bodies in Dhaka's Fabric: An Imperative Issue of Sustainable City; Organized by the Department of Architecture, BUET, 2009.

5. Analysis and Findings

In this research, 'axial map analysis' by Space Syntax is used. These have the values of integration which is an indicator which enables the reading of the relations of the urban form, from the degree of accessibility through the permeability of the elements that compose the urban system. Such integration values have been presented in a chromatic scale, in a way that the most integrated axis, the more accessible ones, are assigned a color in the scale of yellow, orange and red; while the more segregated axis are represented in a scale of green, light blue and dark blue.

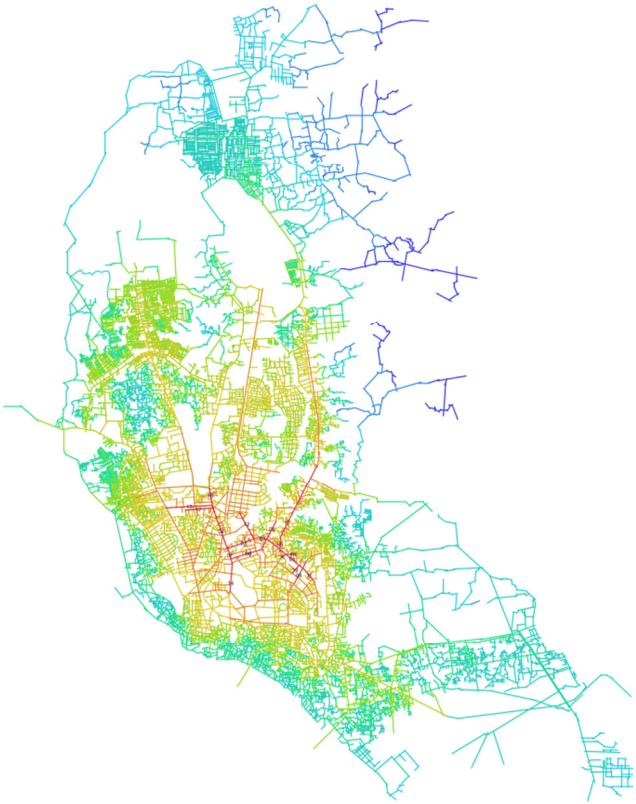
5.1. Comparing Global Integration Cores of Dhaka city with Space Syntax: An evaluation of Circular Waterways

Integration is a static global measure. It describes the average depth of a space to all other spaces in the system. 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. These values of well below 01 of the order of 0.4

to 0.6 indicate more segregation and; while the value ending to and above 01 show strong integration. Local integration relate to the spatial properties of space up to three steps (R=4) 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. 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.

Figure 3 Spatial structure with Circular Water Way at 2009-Global integration core [HH]

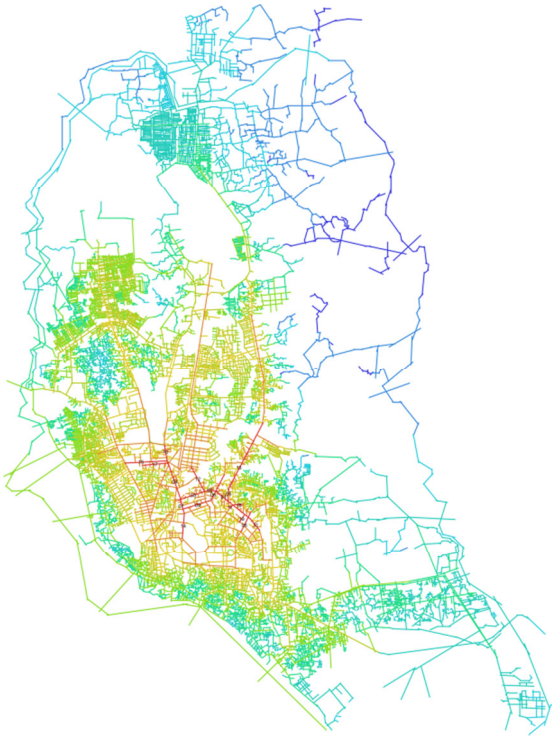
Existing city frame of Dhaka (2009) has been compared with the current city grid integrated along with circular waterway system. Axial lines of circular waterway networks of both phases (completed and proposed) have incorporated with the axial map of Dhaka city (2009) (Figure 3). It appears that the impact of this circular waterway on the spatial network of Dhaka is very weak, particularly on the integration core. It can be easily understood that the impact of this circular waterway of very indirect being located far away from the city and because of it's distant and irregular connections with the urban grid of Dhaka.



Blow up: 0.15 % Global Integration core (2009)

Figure 4 Spatial structure at 2009-Global integration core [HH]

For comparing through using Space syntax, 0.15% global integration core has been analyzed (Figure 4). It is marked from spatial analysis that inland waterway networks are almost segregated from the existing (2009) city model (Figure 4-b).Even these networks haven't made any changes in the global integration core (Table: 1). Except the south-west part of water ways along the Burigonga river rest of the parts are within the range of cooler colors which depicts its segregation. The reason behind this nature is mainly due to its location and inappropriate connections with the existing road networks. As this is around the periphery of Dhaka city thus these water ways are far away from the existing global integration core. There are very few road networks along the north-east and eastern part of the city. Thus circular water ways at phase-02 are least accessible from the city; though the prime objective of introducing circular waterway was to reduce the traffic congestions from the city grid. From this syntactic analysis, it is evident that this is completely an inappropriate intervention by the government.



Blow up: 0.15% Global Integration core (2009+C.W.W)

Figure 5 Spatial structure combining the existing city grid at 2009 with circular waterway networks

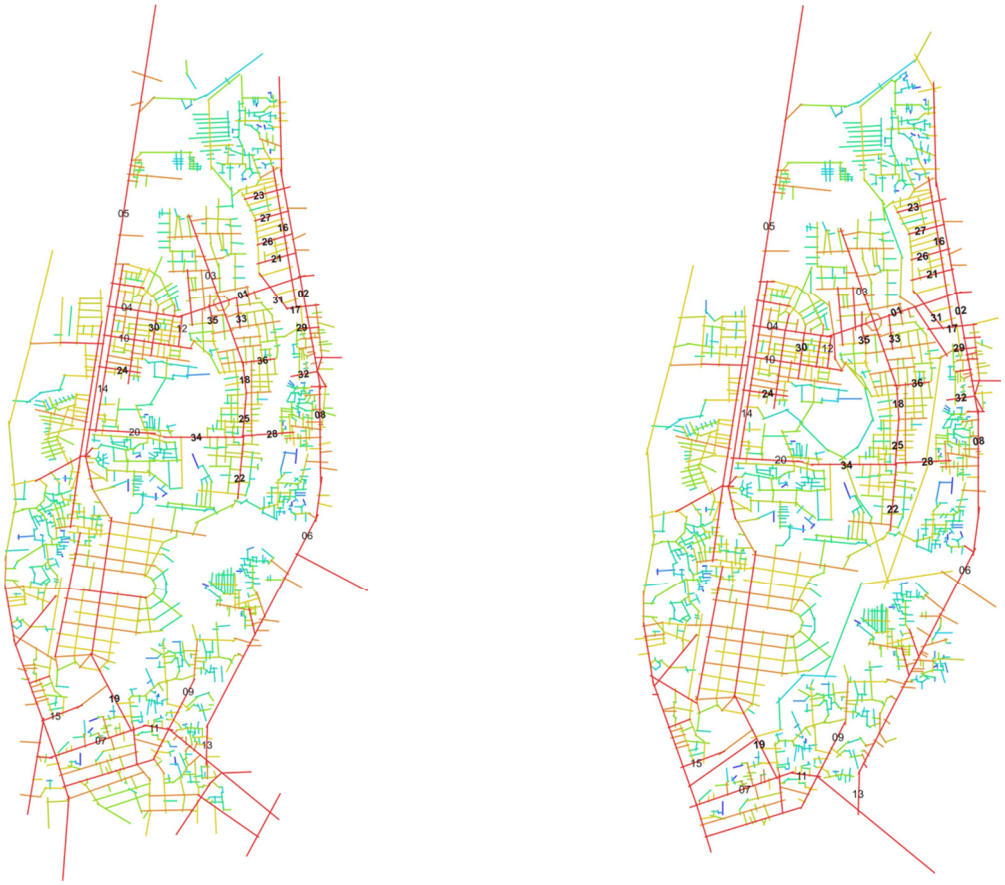
Table 1 Comparing the changes of global integration core at different scenario

NOTIFICATION.	Most Globally Integrated Road	2009 Integration[HH] Fig :3	Road completed 2009 and Circular Waterway Integration[HH] Fig :4
1	Outer circular Road	0.946176	0.937803
2	New Eskatan Road_a	0.938578	0.930098
3	New Eskatan Road_b	0.939263	0.930315
4	Airport Road_a	0.926055	0.917346
5	DIT Road_a	0.908703	0.901297
6	Wireless Road	0.907149	0.899346
7	Kazi Najrul Islam Avenue_a	0.908185	0.899702
8	DIT Extension Road	0.901894	0.894865
9	Old Elephant Road	0.901463	0.893554
10	Airport Road_b	0.901681	0.893448
11	Outer circular Road[Motijheel]	0.894648	0.887946
12	Shahid Tajuddin Road	0.888933	0.880981
13	DIT Road	0.881877	0.875209
14	Kazi Najrul Islam Avenue_b	0.882201	0.874611
15	Khamar Bari+Manik Mian Avenue	0.878476	0.870848
16	Kakrail Road	0.874306	0.867974
17	Farm Gate[Telegraph Bhaban]	0.87575	0.867207
18	shahid bag	0.873304	0.866232
19	Rajarbag	0.87304	0.865976

From above table it is clear that from 2009 to current situation, Outer Circular road is the highest integrated road. Even at both cases the global integration core didn't change its position.

5.2. Accessibility analysis of a sample area at local condition

For evaluating the prospects and possibilities of khals or lakes as a part of inland water transportation system, syntactic analysis has been conducted concerning local integration (R=04) value. Axial lines of these water bodies has been connected with the existing city frame (2009) to form an integrated transportation system. The inland waterway networks of inter-connected channels are Gulshan lake, Banani lake, Hatir jheel, and Meradia khal fall to Balu river. (Figure: 6)



a.Local integration [HH, R-4], Dhaka at 2009. **b**. Local integration [HH, R-4], after incorporating water transportation network of Gulshan-Banani lake and Hatir jhil with existing city grid.

Figure 6 Comparison among the roads [at 2009] and Inland water networks of Gulshan lake-Banani lake-Hatir jheel.

Table 2 The comparison between Local integration value [R=4], considering 4% Local Integration core.

	ROAD_2009		ROAD+C.W.W+LAKE_ FUTURE Prediction
sl. No.	Road Name	Integration [HH] **R4**	Integration [HH] **R4**
1	Madani Avenue	2.96492	3.01969
2	Pragati Sharani	2.88488	2.90778
3	Gulshan Avenue-a	2.79644	2.81722
4	Kemal Ataturk Ave	2.78598	2.81592
5	Dhaka-Mymensingh Hwy	2.78314	2.79335
6	Rampura DIT Road	2.75306	2.79991
7	New Eskatan Road_b	2.75241	2.76315
8	Pragati Sharani_b	2.72982	2.7375
9	DIT Road	2.61709	2.61399
10	Banani-Rd:11	2.59981	2.63759
11	New Eskatan Road_a	2.58043	2.58465
12	Gulshan-2,Rd-19/A	2.52632	2.56547
13	DIT Road_a	2.56986	2.59147
14	Banani-Rd:04	2.52273	2.55874
15	Pantha Path	2.50374	2.51173
16	Baridhara-Park road	2.48135	2.51874
17	Bash Tola Road	2.45984	2.49315
18	Gulshan Avenue-b	2.45084	2.47069
19	Shahed Tajuddin Road	2.4309	2.45924
20	Mohakhali	2.42769	2.43522
21	Baridhara-Road:03	2.36847	2.38408
22	Tejgaon-Gulshan Link Road	2.36757	2.44308
23	Baridhara-Road:11	2.36463	2.41491
24	Banani-Rd:01	2.36456	2.3773
25	Gulshan Avenue-c	2.3624	2.41491
26	Baridhara-Road:04	2.36081	2.3767
27	Baridhara-Road:08	2.35699	2.37302
28	Gulshan-Badda Link Rd	2.34594	2.43504
29	Bayzid Road	2.3336	2.36389
30	Gulshan-2,Rd:10	2.32831	2.35586
31	UN Road-Baridhara	2.31358	2.35272
32	Uttar badda	2.31232	2.32999
33	Gulshan-2, Rd:95	2.30238	2.3422
34	Gulshan-1, Mohakhali Rd	2.30005	2.37233
35	Gulshan-2, Rd:	2.29274	2.33642
36	Gulshan, Rd-113	2.19846	2.40689
37	Gulshan lake_segment.a	0	2.35865
38	Banani lake_segment.a	0	2.30643
39	Hatir jheel_segment.a	0	2.37005

From above chart it is evident that though inland waterways haven't made any drastic changes in local integration core [R=4]. The locally highest integrated roads at existing model like Madani Avenue, Pragati Sharani, Gulshan Avenue, Kemal Ataturk Ave etc. still remain in highest ranking roads at predicted city model. Along with these local integration core, few segments of water bodies have also became the part of local integration core [Figure: 5 (b)]. Like no. 37, 38, 39 on table-3. It is evident that these type interventions will be rather feasible in respect of reducing traffic congestion if waterways will be properly navigable and modern water vessels will be introduced to compete with road transportations.

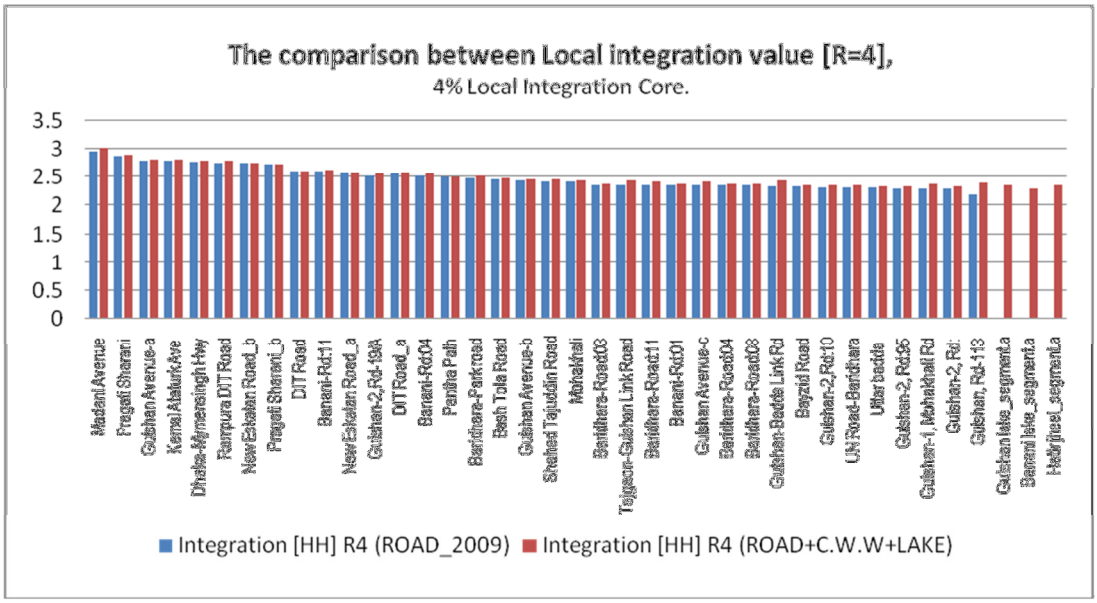


Figure 7 Bar Diagram showing comparison of Local Integration core between existing (2009) city model surrounding the Gulshan-Banani-Hatir jheel water networks and Predicted city model after incorporating Inland water ways.

From bar diagram (Figure 7), it is evident that the segment of inland waterways of three water bodies have not only become a part of local integration core [R=4] but also they have higher ranges of local integration values.

6. Recommendation and Conclusion

The role of efficient transport and communication system is extremely critical for the socio-economic progress of a country. As physical infrastructure is indispensable, a well-knit transport and communication network ensures a well balanced distribution system for the means of city's economical development. Sustainable transport and sustainable mobility is about finding ways for communication that reduce its impact on the environment, economy and society.

Dhaka is surrounded by rivers and interconnected with canals which have always formed a life-line for the city residents. Government has taken initiative to use these water routes to release the traffic load in Dhaka city. However, the impact of Circular water ways is very insignificant on the major circulation routes of the city. Besides, through syntactic analysis it has been recognized from this paper that by connecting some missing links of existing water channels and by proper positioning within the existing city grid, a sustainable and integrated multimodal transportation networks can be generated. It will be intensified by if government will take appropriate initiative to revive them and make them navigable.

Infrastructure has a long-term life span. We have to make strategic choices to be ready for the socio-demographic, technological, economic, environmental and political changes which are unfolding right now. To make inland water networks even more competitive, we need to make some futuristic decisions.

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