ANALYSING CITY AGGLOMERATION IN TERMS OF LOCAL ECONOMIC DEVELOPMENT HIERARCHY WITH THE USE OF SPACE SYNTAX

SWAGOTA ROWNAK KHANDOKER[1] & FARIDA NILUFAR[2]
[1]Bangladesh University of Engineering & Technology (BUET), Dhaka, Bangladesh
swaro4705@gmail.com
[2]Bangladesh University of Engineering & Technology (BUET), Dhaka, Bangladesh
farida@arch.buet.ac.bd

Abstract
Pattern of urban growth is dictated by a complex interaction of place-specific factors in individual cities including geography, history, lifestyle, economies and administration. City's natural growth gradually defines its main economic centers and sub-centers according to spatial organization of its urban structure. In some cases of induced development planning, agglomeration of small towns forms a bigger city boundary for administrative operation. Narayanganj City Corporation of Bangladesh is similar to this case, which was formed by joining three municipalities in 2011. As commercial activities takes place in the most integrated part of a city, administrative agglomeration of small towns largely depends on their economic development cluster. Lack of proper agglomeration of economies among small towns may cause unplanned economic growth. Hence identifying local sub-centers can guide commercial development working as a whole. The spatial parameters of a city can evaluate functionality of economic activities within an urban structure, in accordance with hierarchical arrangement of local commercial centers. While analyzing city configuration with Space Syntax theory, movement & commercial growth within a given boundary can be predicted. This paper tries to analyze agglomeration of economic activities among three municipalities of Narayanganj working as a whole, with potential sub-centers as hierarchical city structure.

Keywords. *Agglomeration economies; hierarchical urban structure; spatial proximity; accessibility; spatial structure; space syntax theory; Narayanganj city corporation*

1. Introduction

Narayanganj City Corporation has joined three municipalities naming: Shiddhiganj, Kadam-rasul and Narayanganj sadar with a total of 72.43 square kilometre including Shitalakhya River. The Narayanganj Sadar has been core centre of growth since its origin in Mughal period in this region where rail, road and waterway communications with capital city Dhaka has given great importance in its growth as a town centre. In new city boundary, various development aspects are taken into account by govt. authority such as bridge proposals over Shitalakhya River for east-west city connection, khal (water links) development projects etc. which will lead to commercial boom in this region. Proper communication, connectivity & proximity among sub-centres depict agglomeration potentials to each other. Fast commercial growth is prone to unplanned economic agglomeration without considering inherent accessibility in city grid boundary. As city configuration defines major spatial character of a space in terms of connectivity & accessibility which accentuates commercial growth, this paper tries to presume potential sub-centres as local economic hub, proximate in distance, contributing holistic economic growth within three agglomerated municipalities of City Corporation boundary.

2. Agglomeration economy & concept of 'Sub-centre'- Theoretical perspective

City centre is formed where people are concentrated conveniently for functional specialties supported by the centre (Jacobs 1970). Centres can be considered as self-organizing system sustained by socio-economic process, which are affected by spatial accessibility within city network (Narvaez, Penn & Griffiths 2014). Polycentric urban growth consequently developed over time in many cities of UK, USA, Australia, Poland & others (Haughton & Hunter 2004; Narvaez, Penn & Griffiths 2014; Saeid 2010). In decentralized city concept, a number of territorial units known as 'Sub-centres' emerges when high land value, congestion and increased transportation cost disperse population and employment density from single centre to peripheral concentrations (Davoudi 2002; Donoghue 2014). 'Concentric zone model' of Burgess (1925), which depicts city as self-organizing network possessing a single centre, breaks down into "differences of spaces that allows different centres to be identified, firstly as specialised areas and later as self-organizing local economies" (Shane 2005). The local sub-centres not only attract people for special functions like shopping or work, but also as a meeting place with interaction flows (Donoghue 2014). If sub-centres maintain economic centrality or agglomeration with the city centre, according to Salazar & Sobrino (2010) the central city take a

polycentric hierarchical structure not with scattered sub-centres but rather a widened CBD. Here comes question for potential agglomeration.

Agglomeration in economies between sub-centres can be understood as a mechanism of sharing, matching and learning (Duranton & Puga 2004) where scope of common local linkages to get supply resources, population, local labour market, transport facilities and information flow is seen at ease. Spatial accessibility in terms of quantifiable distance of a space to another can modulate population movement, thus contribute to choice of functional use to that space (Narvaez, Penn & Griffiths 2014). Combining Alonso's trade-off model (1964) & Hillier's configuration theory (1999), Narvez, Penn & Griffiths found that trading between cost and access is a local process.
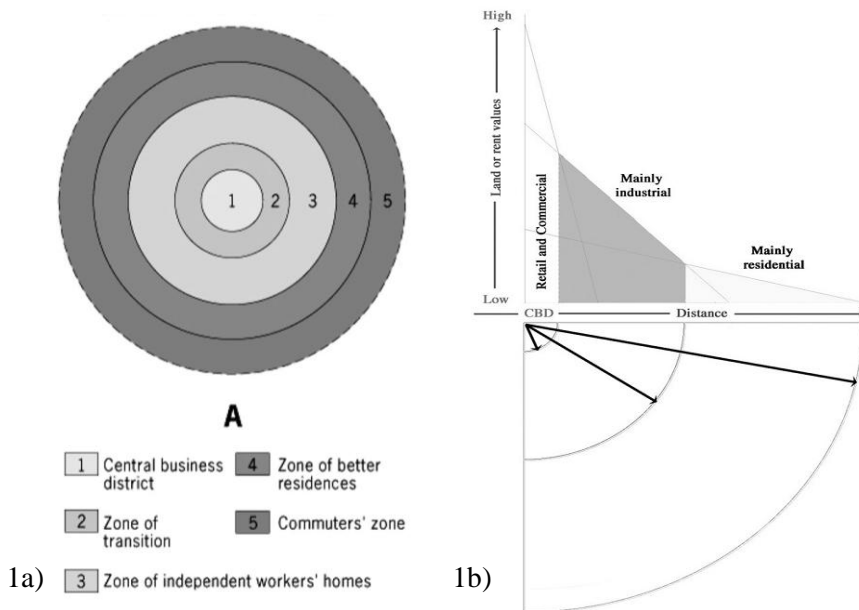

Figure 1a, Concentric Zone Model by Burgess; Figure 1b, Trade-off model by Alonso (Narvaez, Penn & Griffiths 2014)

In economic perspective, bottom-up flow of information & resources facilitates social cooperation and coordination in markets (Narvaez, Penn & Griffiths 2015). Proximity in distance among multiple local centres helps to agglomerate economic activities globally, which may form potential cluster of regional administrative boundary (Saeid 2010). Thinking reverse, within administrative boundary, efficient economy functioning depends on proximate local centres having inherent accessibility in an urban system. Proximate distance among local centres depicts global & local movement

easiness in a city configuration. The '400 meter rule' has been supported by extensive research in urban studies which assumes, a '5 minute walk' equals roughly 400 meters distance, to basic services and local transit facilities within a neighbourhood (Mehaffy, et al. 2010).

3. Case Study- Narayanganj City

Narayanganj district is just beside south-east corner of capital city Dhaka. Geographic position of Narayanaganj and the Dhaleshwary River bent made the Shitalakhya River more feasible water rout to enter Dhaka from south.
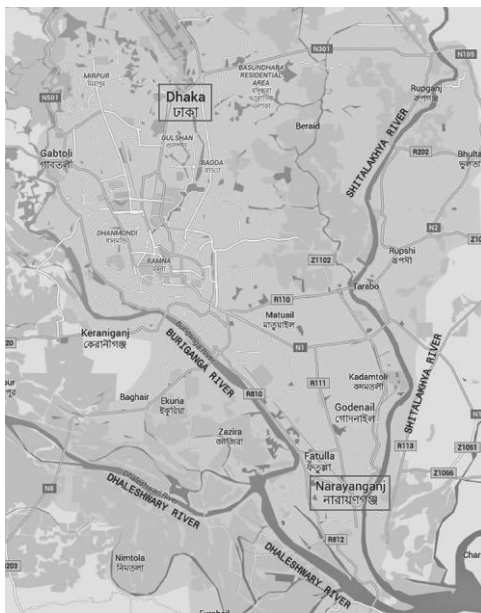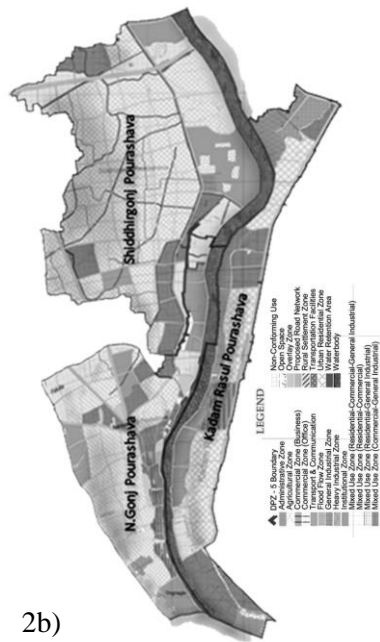
2a)   2b)

Figure 2a, Location of Narayanganj from Dhaka (Google map 2015); Figure 2b, Narayanganj City Corporation Map showing 3 municipalities (Narayanganj City Corporation 2012)

   In Mughal period, road connection to Dhaka was established and Sonakanda & Hajiganj forts were built in southern part near port to protest Magh pirates enter Dhaka through Shitalakhya River (Allen 1912). Kadam rasul dargah- a religious centre was built in eastern bank of Shitalakhya River by Mughals around which human settlements evolved. Import-exporting variety of goods like, raw foods, timber, cotton, ivory, gold, silver, wrought iron & other finished product in Narayanganj port established the region as an important commercial hub for retail market and warehouse

shops. Railway connection from Narayanganj to Dhaka, established during British reign forming strong global connection. The developments took place in Narayaganj Sadar municipality, forming city's main artery- Bangabandhu (B.B) Road parallel to river. In Pakistan period, Narayaganj emerged as industrial city while Adamjee Jute Mill was established in Shiddhiganj municipality at north of Sadar. Afterwards cotton mills, garments industries became prominent at the fringe of Narayaganj Sadar municipality.
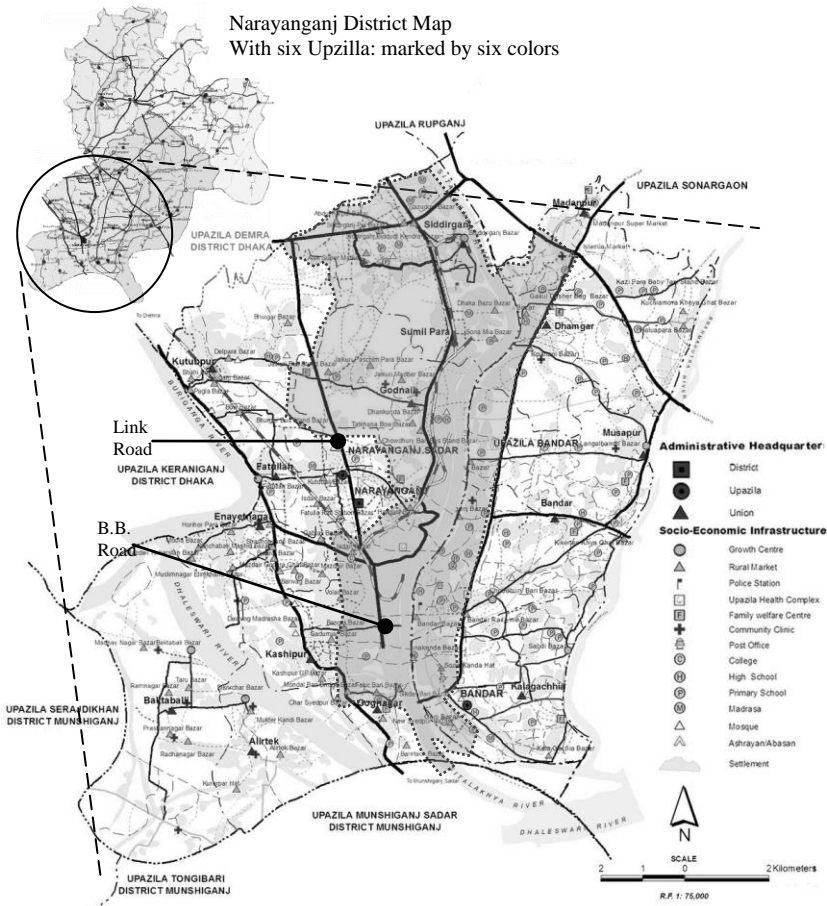

Figure 3, Narayanganj Sadar & Bandar Upazilla together high-lightened with city corporation boundary- showing Global street network and local retail markets. (LGED 2015)

In 1984 Narayanganj was upgraded to district with 6 Upazillas naming: Sadar, Bandar, Sonargaon, Araihazar & Rupganj. The Sadar and Shiddhirganj municipality belongs to Sadar Upzilla and Kadam-Rasul

municipality belongs to Bandar Upazilla, which have made up Narayaganj City Corporation later (figure 3). In 2000, Dhaka-Narayanganj link road was established contributing more population movement to the town centre, making B.B. road as prominent global core in this region (figure 3). After upgrading the town to City Corporation in 2011, two bridges are proposed which will connect west to east over Shitalakhya River with Sadar & Kadam-rasul municipality on the southern part of city (Narayanganj City Corporation 2015).

4. Methodology-Space Syntax

Space syntax theory has two key propositions: the first is configuration of space is a primary determinant of probable pedestrian and vehicle movement behaviour within urban system, which is known as 'Theory of Natural movement' (Hillier et al., 1993). The second is about economic distribution which is generated as a consequence of their dependency on population movement in urban grid (Hillier 1996).

Space syntax analysis is taken as methods for measuring parameters of segment's choice and segment's metric distance to identify potential accessible local economic centres in terms of connectivity of city grid configuration within city boundary. Other broader issues in this regard i.e. land value, land use transformation, retail geography, historical or ecological effect need further research to modify the approach. This paper tries to presume hierarchical arrangement of local economic concentration which portray city's economic agglomeration in accessibility issue.

4.1. VARIABLE OF CHOICE FOR LOCAL ECONOMIC CENTRE-SEGMENT ANGULAR ANALYSIS

In segment angular analysis of road configuration, each road is considered as segment lines that create city map, where 'Segment Angular Choice' measures how many least angular paths lay between every pair of segments within a given distance (UCL Space Syntax 2015). The urban structure is considered as a system of streets, individual spaces that are visible from one end to the other without obstruction (Narvaez, Penn & Griffiths 2012). Those individual axial spaces (Penn 2001) are straight lines that represent a possible path of movement over a map of an urban settlement. The "angular segment analysis algorithm produces better correlation with observed vehicular flow than both standard axial analysis and block-distance measure" (Turner, 2007).

In socio-economic process, urban form can be understood by 'background' and 'foreground' network of urban configuration (Hillier et al., 2007). Pattern of local economic distribution can be seen by 'foreground network properties' of a city's street configuration. The street configuration

is represented as a choice measure, which shows how the main arteries relate to the interconnected accessibility within the urban system. It establishes that in the highest accessible spaces, commercial and retail activities cluster more than in other areas (Hillier 1999; Narvaez, Penn & Griffiths 2012).

This foreground study of street map with segment angular analysis was executed in case of Narayanganj City Corporation to find potential areas for local economic sub-centres within the system.

4.2. VARIABLE OF METRIC DISTANCE FOR HIERARCHICAL PATTERN OF SUBCENTRES- STEP DEPTH ANALYSIS

Step depth is calculated to measure the physical distance of sub-centre potential roads from the city street origin which has highest movement concentration, namely the new core in agglomerated boundary. According to Narvaez, Penn & Griffiths (2014) distances are not only a measurement but also relatedness to urban architecture, resulting in a relation of space & economy that, economy requires proximity and proximity requires opportunity for economic activity. Metric distance captures the local patchwork properties of the network mostly with spatial differentiation (Hillier et al. 2007). In this paper, metric distances from city centre are compared among sub-centres to visualize a hierarchical accumulation in terms of movement within city corporation boundary.

5. Analysis & Discussion

5.1. PRESUME SUBCENTRE LOCATIONS

Analysing Narayaganj City Corporation street configuration into segment map, angular choice values for R=400, 500, 800, 1000, 2000 & 5000 was taken into account. From foreground & background pattern, micro-economic qualities of each municipality were clearly distinguished in the form of sub centre at a radius of 500 meters, demarked as A, B, C etc. (figure 4a). It depicts, local non-motorized transport means are more active which develop local economy in this city boundary at small radius choice.

In case of global links among the centres, it is found while R=5000 meter, the sub-centres tend to connect together regionally (figure 4b). This depicts, although single sub-centres are formed by supporting local movement, their connectivity with each other is at far. The core line of some sub-centres diminishes in global value (< top 10% of total value) starting from radius 2000m. It means urban structure of these sub-centres is clustered as 'distant agglomeration', functioning singular but not as a whole. Whereas in organic growth, integrated routes are originated from the core of sub-centres that connect with other sub-centres globally in whole urban structure

(Narvaez, Penn & Griffiths 2014). Hence in this case of induced town agglomeration, economic agglomeration has to develop more in terms of accessibility. It is seen that, administrative boundary agglomeration forms new urban structure that emerges new local commercial centres where global transportation and connectivity development among them may pull more budgetary concentration in planning issue.
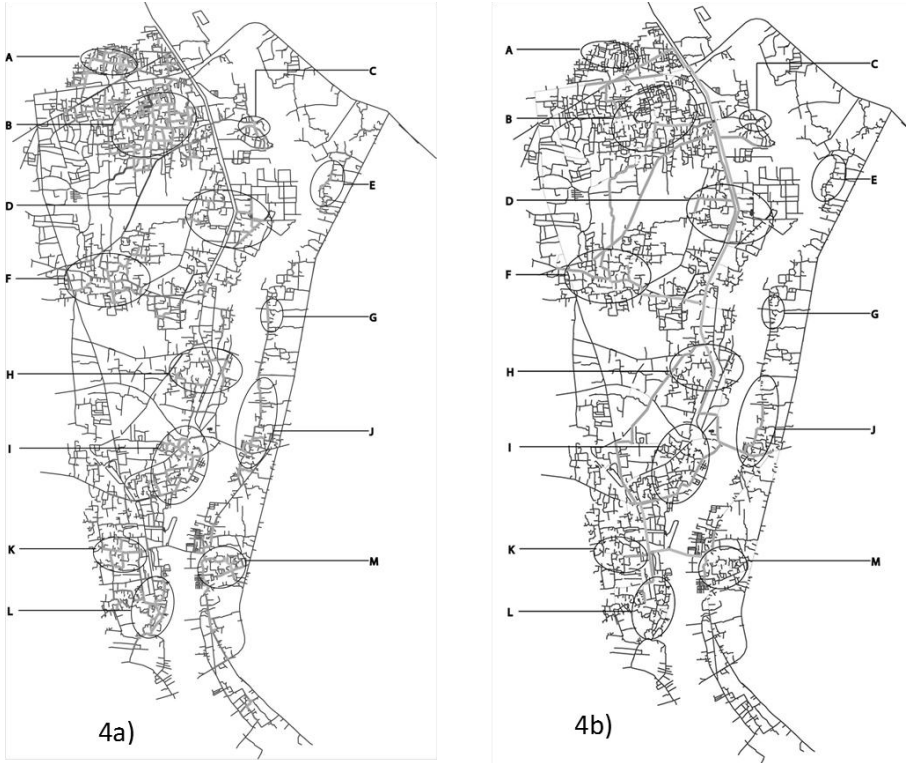

Figure 4a, segment angular choice map at R=500 m, identifying local centres within city corporation boundary; Figure 4b, segment angular choice map at R=5000 global connection of sub-centres

From the table 1, 2 & 3 below, it is seen that the sub-centres of Kadam-rasul municipality are globally less connected than others. Sub-centres of Sadar municipality show fewer global integration within city boundary whereas this region used to be the main town centre in former period. This analysis indicates to new city core formation within City Corporation boundary. The sub-centres of Shiddhirganj have better choice range and

integration (within top 10% value of city structure) which means new core will be more connected to this municipality.

Table 1: Sub-centre potentials in Shiddhiganj Municipality

Sub centre	Ref. no of main road	Segment Angular choice value				Segment Angular Integration value			
		R (400)	R (500)	R (1000)	R (5000)	R (400)	R (500)	R (1000)	R (5000)
		Top 10% range of Choice				*Top 10% range of Integration*			
		1273-6898	*2305-12246*	*14663-88422*	*620441-9446302*	*58.93-204.8*	*70.14-173.62*	*132.98-290.15*	*696.19-1078.74*
A	*16453*	2711	6233	65634	1332510	98.51	125.34	266.54	722.46
B	*11347*	2783	7154	71849	815150	87.60	114.63	165.16	613.35
C	*2275*	3320	6838	28913	623141	56.54	67.82	77.07	477.30
D	*16784*	5673	11723	39442	522751	66.54	68.57	131.18	734.63
F	*9446*	1324	3453	47444	1229630	51.52	68.06	137.21	535.56

Table 2: Sub-centre potentials in Kadam-Rasul Municipality

Sub centre	Ref. no of main road	Segment Angular choice value				Segment Angular Integration value			
		R (400)	R (500)	R (1000)	R (5000)	R (400)	R (500)	R (1000)	R (5000)
		Top 10% range of Choice				*Top 10% range of Integration*			
		1273-6898	*2305-12246*	*14663-88422*	*620441-9446302*	*58.93-204.8*	*70.14-173.62*	*132.98-290.15*	*696.19-1078.74*
E	*8489*	2441	3505	13843	70497	35.31	36.39	51.20	180
G	*15516*	1313	3047	13250	355105	75.18	77.60	82.08	239.56
J	*15848*	2462	4365	25755	3111750	64.57	70.94	94.94	563.42
M	*15932*	3305	6840	37840	1309750	70.86	82.15	97.41	511.29

Increasing movement by 'area development' in sub-centres may increase global connectivity among them. Further development of east-west connection at the north part of city may increase connectivity to Kadam-rasul municipality with Shiddhirganj municipality. Budgetary concentration in these planning aspects may have potential scope to focus on global accumulation of sub-centre economy in future.

SWAGOTA ROWNAK KHANDOKER & FARIDA NILUFAR

Table 3: Sub-centre potentials in Narayanganj Sadar Municipality

Sub centre	Ref. no of main road	Segment Angular choice value				Segment Angular Integration value			
		R (400)	R (500)	R (1000)	R (5000)	R (400)	R (500)	R (1000)	R (5000)
		Top 10% range of Choice				*Top 10% range of Integration*			
		1273-6898	*2305-12246*	*14663-88422*	*620441-9446302*	*58.93-204.8*	*70.14-173.62*	*132.98-290.15*	*696.19-1078.74*
H	*15600*	1575	3357	30886	1213560	80.42	94.47	173.72	738.07
I	*8742*	3096	6130	35114	237301	60.20	67.20	92.16	566.82
K	*13913*	3252	6181	34185	1529820	74.54	85.50	147.40	661
L	*10580*	2609	5037	33248	114493	44.85	63.96	112.90	493.05

5.2. HIERARCHICAL DISTANCE FROM NEW CITY CORE

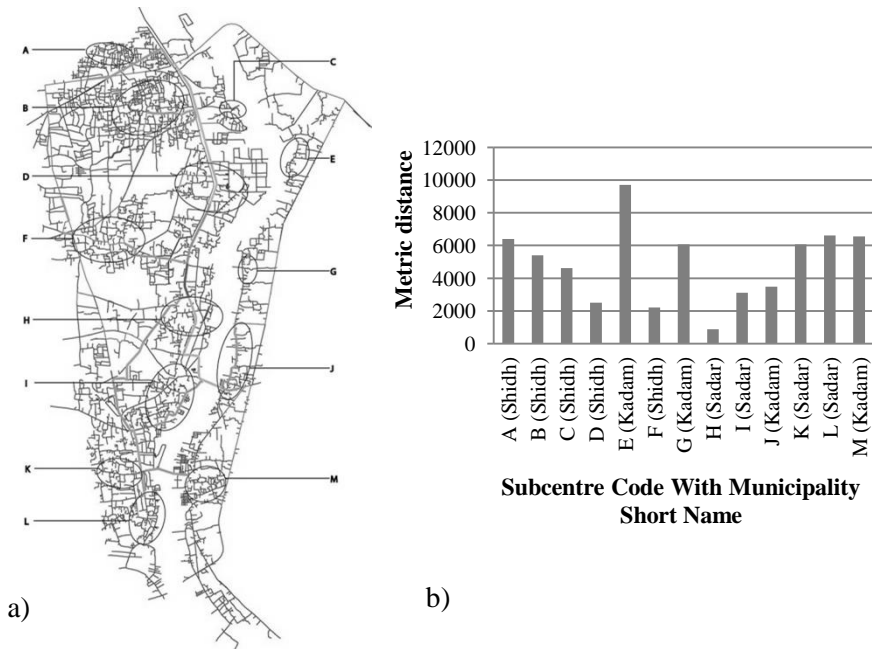
a)   b)

Figure 5a: Segment angular choice map at R=n, showing choice core with red line; Figure 5b: Comparative step depth distance (metric) from probable city core to sub-centres.

The probable new city core is assumed where highest value of both choice and integration core are available, theoretically this core will attract

more movement and potential for central commercial growth. Hence, proximate distance from city core to sub-centres shows a hierarchical pattern for agglomeration economies in terms of accessibility.

The sub-centres which are at close proximate, located at <4000 meters to the core may agglomerate economic activities by means of local non-motorized transport system, but to agglomerate sub-centres located at >4000 meters, motorized transportation or connectivity development may be needed, which can be monitored by considering further in-depth place-specific analysis of each sub-centres.

6. Conclusion

The process of finding sub-centre locations by analysing movement within city grid configuration will help to reduce trial & error development works and utilise resources. Further research may contribute to analyse bid-rent hierarchy for detail land use pattern for each sub-centres under three municipalities to monitor overall development in newly formed Narayanganj City Corporation. Scope for using waterways as a connector within city boundary may also seek concentration for improving economic agglomeration.

As commercial strength of a city is its driving power to move on, hence other development planning should revolve around giving prime importance to it. Ease of accessibility develops communication as well as contributes to accumulate local economic forces, thereby inherent overall development. To monitor induced development, foremost scope for concentration should be local economic sector to wheel up overall growth under proper management authority, thus supervise other planning aspect in city growth.

Acknowledgement

References

Allen, B.C., 1912, *Dacca-Eastern Bengal district Gadget*, Allahabad, India

Davoudi, S., 2002, *Polycentric-Modelling or Determining Reality*, Town and Centre Planning, 7(4), p. 114-117

Donoghue, D.P. (ed.) 2014, *Urban Transformation: Centres, Peripheries and Systems.* Ashgate Publishing, Ltd.

Duranton, G. and Puga, D., 2004, *Micro-foundations of urban agglomeration economies*, Handbook of Regional and Urban Economics, (4), p.2063-2117

Haughton, G. and Hunter, C., 2004, *Sustainable Cities,* Routledge

Hillier, B., Penn, A., Hanson, J.,Grajewski, T. and Xu, J., 1993, *Natural movement or configuration and attraction in urban pedestrian movement,* Environment & Planning B:Planning and Design, (20), p.29-66

Hillier, B., 1996, *Cities as movement economies*, Urban Design International (1), p.49-60

Hillier, B., 1999, *Centrality as a Process: Accounting for attraction inequalities in grids,* Urban Design International, 4(3-4), p.107-127

Hillier, B., Turner, A., Yang, T. and Park, H., 2007, *Metric and Topological Properties of Urban Street Networks: Some convergences, divergences and new results*, Proceedings of 6th International Space Syntax Symposium, Istanbul Technical University, Cenkler, Istanbul, p.001.01-22

Jacobs, J., 1970. *The Economy of Cities*, Vintage Books, A Division of Random House, New York.

Jenks, M., Kozak, D. and Takkanon, P. 2013, *World cities and Urban Form: Fragmented, Polycentric, Sustainable?. Routledge*

Local Government Engineering Department, 2012, [Online] Available from: http://www.lged.gov.bd/ViewMap.aspx [Accessed: 1st October 2015]

Mehaffy, M., Porta, S., Yodan, R. and Salingaros, N., 2010, *Urban Nuclei and the Geometry of Streets: The "emergent neighbourhoods' model"*, Urban Design International, (15), p.22-46

Narayaganj City Corporation, 2012, [Online] Available from: http://www.ncc.org.bd [Accessed: 1st October 2015]

Narvaez, L., Penn, A. and Griffiths, S. 2012, *Creating Urban Place: Rethinking the Value of Residential and Commercial use in Urban City Networks,* Space and Flows: An International Journal of Urban and Extra-Urban Studies, Common Ground Publishing LLC, Illinois, USA, p.149-168

Narvaez, L., Penn, A. and Griffiths, S. 2014, *The Spatial Dimensions of Trade: From the geography of uses to the architecture of local economies,* ITU Journal of the Faculty of Architecture, 11(2), p.209-230

Narvaez, L., Penn, A. and Griffiths, S. 2015, *The Architectural adaptation in Urban economic Life: Location, use and form of the commercial-residential building in Cardiff,* ed. K. Karimi et al., Proceedings of the 10th International Space Syntax Symposium, Space Syntax Laboratory, The Bartlett School of Architecture, UCL, UK

Penn, A., 2001, *Space Syntax and Spatial Cognition or Why the Axial Line?,* Environment and Behaviour, 35(1), p.30-65

Saeid, A., 2010, *The Spatial Parameters of Agglomeration Economies within Urban Structure of Wroclaw,* Proceedings of the 1st International Conference on Cities and their growth: Sustainability and Factuality, Institute of Socio-Economic Geography & Spatial Management, Adam Mickiewicz University, Poland

Salazar, C. E. and Sobrino, J., 2010, La ciudad central de la Ciudad de Mexico, Estudios Demograficos y Urbanos, 25(3), p.589-623

Shane Grahame, D., 2005, *Recombinant Urbanism: Conceptual Modelling in Architecture and City Theory*, Wiley and Sons Ltd. Hoboken, NJ and Chichester, England

Turner, A., 2007, *From Axial to Road-centre Lines: A new representation for Space Syntax and A New Model of Route Choice for Transport Network Analysis,* Environment and Planning B: Planning and Design, 34(3), p.539-555

UCL Space Syntax Glossary, 2015, [Online] Available from: http://otp.spacesyntax.net/term/segmental-choice/ [Accessed: 1st October 2015]