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## **RELATING URBAN GRID AND PEDESTRIAN MOVEMENT THROUGH SPATIAL ANALYSIS: Using 'Old Dhaka', Bangladesh as a case study**

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### **Abstract.**

This paper investigates the relationships between the pedestrian movement pattern and the urban grid dynamics of Dhaka-one of the largest megacities of the world containing over 16 million people. In recent years, Dhaka city faces rapid and haphazard urbanization without proper planning process ignoring the inherent urban characteristics. Now it has become a congested city with numerous urban problems including severe traffic congestion. The older part of the city known as 'Old Dhaka' grows spontaneously over more than 400 years and still retains an organic urban pattern with mixture of varied land-uses. Though enhancing pedestrian movement in urban areas is a prime issue for a resilient urban development, pedestrian facilities are observed to be overlooked in different streets of Dhaka. In recent researches of 'Space Syntax' it is evident that the urban grid itself is the most influential shaper of urban movement patterns. This paper focuses on 'Old Dhaka' to reveal the correlation between urban grid configuration and pedestrian movement pattern. The study method is as follows: first, the present condition of the land was investigated: second, a spatial network was created using space syntax and pedestrian volume examined: and third, the correlation between pedestrian volume and spatial network data was analysed through regression analysis. Though according to Space Syntax Local and Global integration values has been proved to be the decisive factor accordingly for pedestrian movements and vehicular movements, however the result of this research indicates a strong correlation of pedestrian volume with global integration rather than local integration values in the context of 'Old Dhaka'.

**Keywords:** *Urban Grid; Pedestrian Movement; Space Syntax; Old Dhaka*

### **1. Introduction**

Now a day, Pedestrian movement is a crucial issue in modern urban design practices, nevertheless in many cases it is not reflected in the city planning due to the lack of proper awareness(Choi 2013, Shin et al. 2007). In western

countries, urban designers are continuously trying to encourage pedestrians in urban areas through different innovative urban design solutions, whereas in many Sub-Continental cities like Dhaka pedestrians are overlooked in the urban planning process. Many traditional and historical cities in the sub-continent have narrow and tortuous streets and alleys, where the full street is observed to be used by pedestrians. Unfortunately allowing automobiles into these types of streets create heavy traffic bottlenecks and make movement dreadful. Though a pedestrian friendly city is considered to be more sustainable and resilient in modern urban design arena, allowing automobiles into narrow pedestrian streets is a common phenomenon in many sub-continental cities.

Dhaka, the capital of Bangladesh, has grown from a small trading centre and has transformed to one of the megacities of the world. Through the process of urban growth and change, the city has expanded a lot but still the older part retains its significance. Even with the lack of authorized and political support, 'Old Dhaka' has constantly adjusted to its new role serving significant economic, cultural and communal functions not only for the whole city but for the hinterland as well. Rashid & Rashid (1985) observes that 'Old Dhaka' has a distinctive urban character and strength similar to that found by Fonseca in Old Delhi. The excitement and life found in the streets of Old Dhaka are to a great extent due to the cheerful chaos randomly built into it. The fact that old Dhaka still serves vital social and economic functions tells of the vitality and strength of the culture that produced it. Though Old Dhaka do not conform the western concepts of urban design and planning, are not aberrations. It is the circumstances, culture, society, politics and economy of their origin and growth that make them different. Such cities have to be understood and evaluated in terms of different form those used in other cultures. The dynamic elements of movement, activities, culture and life styles are as integral to the composition of the city as are the physical elements. Narrow streets of Old Dhaka that were designed for horse carriages elephants and foot traffic are now being used by the pushcarts, rickshaws, cars and trucks as well as pedestrians. Public transport is under-developed and mal-administrated. Traffic jams in old Dhaka are a way of life. The narrow tortuous roads and alleys are further constricted by public stand pipes, hawkers and spill-over of business onto the street where pavements are literally absent. The residential density of old Dhaka is more than 300 persons to an acre. If the number of people includes working in this area is included the gross density will be much higher. Most of the structures of Old Dhaka stand shoulder to shoulder without the minimum of open space necessary for light and air (Rashid & Rashid 1985).

In recent years, researchers have drawn increased attention to the synergistic interactions between the urban spatial structure and pedestrian movement. Space Syntax, originally conceived by Bill Hillier, Julienne Hanson and colleagues at the Bartlett, University College London in the late 1970's to early

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1980's, an important theory and method to study the interplay between space and behaviour. Space Syntax method has been used for the assessment of spatial accessibility that analyses spaces by their configuration and calculates numerical values for all the accessible space in an urban area.

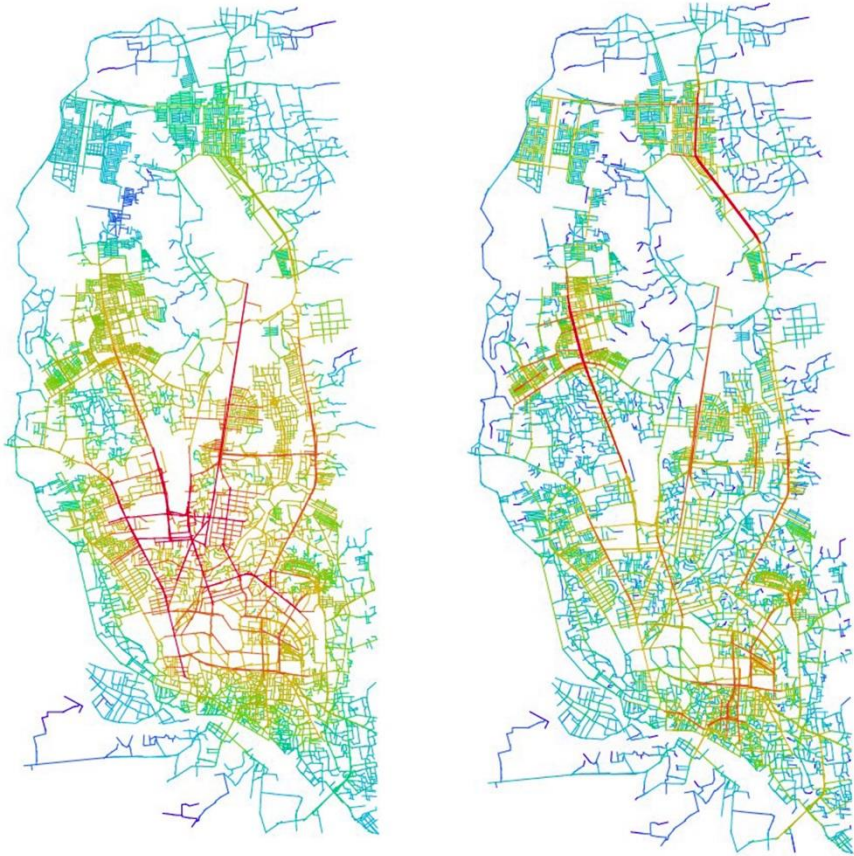
### **2. Literature review**

The literature review section investigates the basic theories of 'Space Syntax' regarding urban grid and movement pattern. It also focuses on the relevancy of enhancing pedestrian movement as well as different factors influencing pedestrian movement in urban areas from different literature.

#### **2.1. SPACE SYNTAX-GENERAL THEORY**

The ethos 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). Holanda (as cited in Pereira et al. 2012) states that Space Syntax theory aims to study the social implications of urban space.[...] in a few words, it aims to establish a relationship between the spatial structure of cities and buildings, the spatial dimension of social structures, and broader social variables. It seeks to reveal both the logic of urban space at any scale and the spatial logic of societies.

Configuration modelling of urban networks has become a major focus of space syntax studies. Such type of models are constructed by breaking up the urban layout of a city or town into the fewest and longest lines of sight and access that pass through all possible routes of movement. The resulting axial map can then be analysed by using a number of statistical measures that describe the configurational properties of the urban network. A measure of how accessible each line segment is to neighbouring lines can be obtained by simply counting the number of connections per segment (Dawson 2003; Hillier 1993: 35). In addition to measuring the connectivity of a line segment, the relationship of each axial line to the whole urban system provides an important measure called 'integration'. The global and local integration measures the topological attributes of any street in respect to the whole urban system and to the nearby streets accordingly. Radius 3 of local integration means a value for integration among the spaces up to three steps away from the root. The most integrated lines in a network are those with the shortest average trip lengths to all other destinations within the grid. In contrast, the most segregated lines in which trip lengths vary to a much greater degree. In other words, integration measures the mean depth of every axial line in the grid relative to all other lines(Dawson 2003, Hillier et al. 1993: 35).



*Figure 1 & 2, Axial Map of Dhaka City (2009) with Global Integration ( $R=n$ ) and Local Integration ( $R=3$ )*

The software for Space Syntax analyses and calculates the spatial integration values by first selecting a line from the axial map and then calculating how many other lines are required for accessing each line in the whole axial map both for local and global level. The lines with higher integration values have higher accessibility than the other lines and marked through red lines in the analysed axial map. The integration cores of the system are suitable for central activity by the reason of having an integrated structure (Hillier & Hanson 1984; Ozer&Kubat 2007).

## 2.2. IMPORTANCE OF PEDESTRIAN MOVEMENT IN URBAN DESIGN

Middleton (as cited in Lindlow et al. 2014) states that walking can be seen as the most fundamental transport mode in accessible and sustainable cities and is

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practised by people of almost any age. Environments suitable for walking constitute a vital part of a successful public transport system as well as an attractive urban environment. Research on walking is often justified for instrumental reasons, with the ability to fulfil societal goal such as public health, modal shift, traffic safety, neighbourhood security or a more attractive urban environment.

Mangin & Panerai (as cited in Foltete & Piombini 2007) observe that it is important to encourage pedestrian movement for limiting the consequence of excessive automobile use in urban environment. In this respect, knowledge of pedestrian movement is a key issue for better urban planning and design. For several years, urban planners have been paying more attention to the expectations of the pedestrians who are more conscious of the urban environment. Choi (2013) states that the planning and design of pedestrian friendly urban environment is receiving more attention in recent years not only for urban planning issues rather for its various benefits related to public health, sustainability, economy and social life. Therefore, there is an increasing need for knowledge about the walkability of the urban built environment. Urban planning and transportation research have examined walking in the urban environment. There is also an emergent field often referred to as 'walkability' research which is a multidisciplinary form of research initiated from the preventive medicine field with the health beneficial aspect of walking as the most significant motivation

### 2.3. CORRELATIONS BETWEEN BUILT ENVIRONMENT AND PEDESTRIAN MOVEMENT

Dijst et al. (as cited in Lindlow et al. 2014) stated that walking is, as with any other transport mode, not only something happening in the context of the built environment, it is also a part of most people's everyday life. The choice to walk is influenced – either positively or negatively – by both the built environment and the demands of everyday activities of people. Pedestrian movement is a strong and resilient phenomenon that brings liveliness to the place. Walkability studies have provided evidence through statistical analysis between the time spent on walking and the factors of the built environment that individual walking behaviour is related to the condition of the urban form (Choi 2013). Ozer & Kubat (2013) argued that the movement potential generated by the urban grid has direct or indirect effects on many factors other than land uses. According to Helbing et al. (2001) patterns of movements of pedestrian crowds are predictable, although there are individual preferences, aims and destinations in effect. Walking behaviour of pedestrians is influenced by other pedestrians' movement and if their footprint were traced, it would be possible to see systems of these trails (Helbing et al. 2001, Ozer & Kubat 2013). Studies related to walkability that deal with the relation between urban built environment and

walking behaviour have been examining different properties of urban built environment that affect pedestrian movement pattern. In numerous studies correlation between pedestrian movement and built environment has been frequently found. The factors that have most consistently been proven for positively influencing pedestrian movement in urban areas include land-use mix, connectivity and density. Through various studies from transportation and urban planning research and the recent walkability studies, it has been suggested that neighbourhood with higher residential and employment densities, more connected street patterns, and a variety of destinations show higher rate of walking (Choi & Sayyar 2012). Theories and studies from Space Syntax field have also provided significant findings and discussions on the relation between movement and urban form (Choi & Koch 2015).

#### 2.4. URBAN GRID AND PEDESTRIAN MOVEMENT

Space Syntax is always claimed that the geometrical and topological structure of the street network is the most influential shaper of the movement patterns in urban areas (Hillier et al. 1993). According to Hillier et al. (1993), the spatial configuration plays a primitive or principal role for the pedestrian mobility. The urban grid or spatial configuration affects the pedestrians when they have to take the decision about what route they want to select for their trips. So the urban grid could encourage or discourage the selection of a route about which pedestrian can to arrive to the opportunities, even more if the street has different design properties (Era 2012).

The discovery of significant correlations between the integration value of an axial line and the amount of pedestrian and vehicular traffic that flows along it suggests that the spatial configuration of an urban network exerts a strong effect on human movement. What is especially interesting about this relationship is that it contradicts the idea that movement density is determined primarily by patterns of land use. Early examinations of pedestrian movement tended to apply a point to point approach in which the presence or absence of attractors such as retail shops and other service providers along a route of movement determined how 'busy' or 'quite' it would be. But Hillier (as cited in Dawson 2003) conclude that attractors tend to serve as multipliers on a basic pattern of movement and that movement densities are therefore more an outcome of the position occupied by a route of movement in the urban grid.

A number of researches conducted by Space Syntax have proved that pedestrian movement in urban areas is significantly influenced by spatial configuration (Hillier et al. 1987, Song et al. 2013). Integration value, that are used to describe its mean depth from other lines within a certain radius is closely related to the urban movement (Hillier 1996, Song et al. 2013) especially reflected in two dimensional level. The 'radius 3 integration' was

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proved to be the most powerful determinant of pedestrian movement in urban areas (Penn et al. 1998). This effect of spatial configuration on pedestrian mobility has created a new concept in planning studies, the concept of “Natural Movement” (Hillier et al 1993; Era 2012) This ‘Natural movement’ concept serves as a solid foundation for the later concepts such as ‘Movement Economy’ and Centrality process etc. and it has been verified in many cities of the world after the first case studies in London. In a research conducted in London it is found that 60% of pedestrian movement flows are due to the pattern of street network itself. (Hillier & Lida 2005; Hillier 2005; Penn et al 1998, Dai & Yu 2013)

### 3. Research Methodology

Literature, space syntax data, photographs, maps, pedestrian counts – calculated several times in weekdays by the author and personal impressions of the research area are the materials of the research. Steps of the research are; Literature research, Space Syntax Analysis, Pedestrian counts, Land uses patterns, comparison and conclusion. Space Syntax data and the analysis belonging to the research area was performed by the software Depthmap developed by Alasdair Turner. Local and global integration, connectivity are some of the most interesting measures of Space Syntax analysis that is used to analyse the urban grid pattern of Dhaka. The data of pedestrian movement were collected by using the ‘Gate Count’ method developed by Space Syntax research. The aim is to investigate the pedestrian distribution on different street segments within the study area.

Measurement of connectivity and integration were taken from the axial maps constructed for Dhaka. Integration is measured at both the local (Radius 3) and global (radius n) scales for study area. Fieldwork was then undertaken in Chawk Bazaar and surrounding areas of Old Dhaka during the month of June 2016 to collect observational data on rates of pedestrian movement along various road segments. Observations were taken at 26 gate positions covering a range of heavily used, moderately used and poorly used streets. Each route was observed for 2.5 minutes in morning and afternoon interval and a sunny and moderate weather in several workdays. The pedestrian data was converted to pedestrian count per hour for analysis.

#### 3.1 DESCRIPTION OF THE STUDY AREA

Chawk Bazaar and surrounding areas BoroKatra, ChotoKatra and nearby streets Champatoli lane, Buckland Road, SwariGhat road and Devi Das Ghat lane are the subject area of this research. Basically these areas are famous for business areas of Dhaka. Some zones are used for retail goods, whereas some are for wholesale markets and some areas are for store houses of the wholesale shops. Chawk Bazaar was one of the most famous business and social meeting

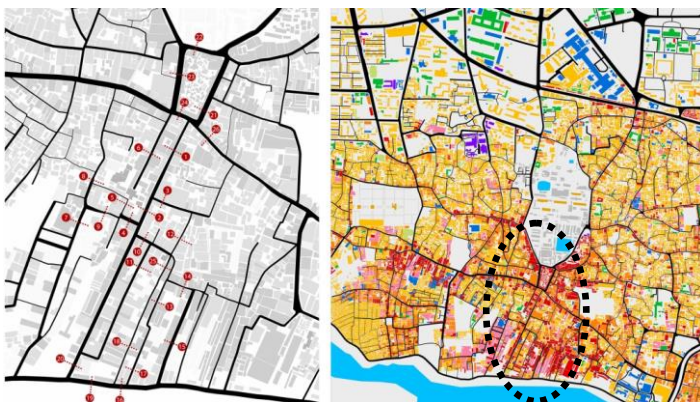
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centres of Dhaka in the Mughal Period. Even after 400 years it is still famous as before though Dhaka extends a lot. It is one of the Dhaka's old markets and it formed in the place where old markets once were. In the 18<sup>th</sup> century, Chawk Bazaar was a famous social and business centre. Along with the historical significance, the geological settlement of this zone also contributed to its massive activities, expansion, population increase and popularity. The Great



*Figure 3, 4, 5&6 (Clockwise) Different street activities in the study area (Source: Author)*

Buriganga River was just at the south of Chawk Bazaar, which contributed easy water transport and thus made trade more frequent and efficient. Chawk bazaar was located in such a way that 10 different other places were connected with straight roads. Chowk bazaar is famous for its special food items for iftar. During the month of Ramadan one part of the street of Chawk Circular Road (in front of the famous mosque) is fully occupied by the street food shop from afternoon till iftar time and all kind of vehicle even rickshaws are prohibited in that street. This bazaar attracts a huge number of people not only from old Dhaka but from different parts of Dhaka (Wikipedia).



*Figure 7&8, Different gate points of pedestrian count and existing land use pattern in the study area.*



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#### 4. Findings and Analysis

The analysis and findings of the research are discussed in the following sections.

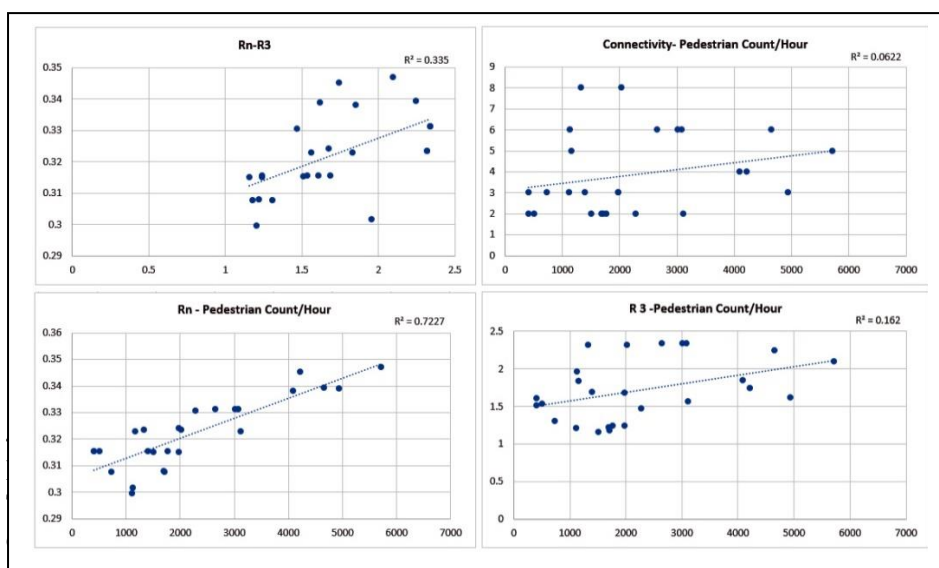
##### 4.1. ANALYSIS OF THE CORRELATION BETWEEN PEDESTRIAN VOLUME AND CONNECTIVITY

Table 1b shows the regression analysis between the amounts of pedestrian traffic in the case study area with the street connectivity. The coefficient of determinant (R Square Value) is .0622 between the two factors. It means there is almost no relation between these two. So, in this area pedestrian movement pattern is not related with connectivity of street segments.

##### 4.2. ANALYSIS OF THE CORRELATION BETWEEN PEDESTRIAN VOLUME AND LOCAL AND GLOBAL INTEGRATION

Table 1c & 1d shows the regression analysis between the amount of pedestrian traffic in the case study area with local (Radius 3) and global (radius n) integration values accordingly. The coefficient of determinant (R Square Value) is .162 for the relationship between pedestrian volume and local integration which means that local integration (R3) values is not working as a guiding factor in the study area. In Table 1d, it shows that the global integration value works a guiding factor for the pedestrian movement where the coefficient of determinant (R Square Value) is .7227 that means a very strong correlation between these two determinants.

Table 1 (a,b,c,d-clockwise) Correlation between a. Rn & R3, b. Connectivity & Pedestrian count, c. Local integration (R3) & Ped. count. d. Global integration (Rn) & Ped. Count.



of retail shops for toys and cosmetics item. It is also famous for different types of foods especially during the months of Ramadan. There is also a very old and large mosque in this zone. The pedestrian movement volume is observed the highest in this zone.

In BoroKatra lane and the SwariGhatLane there are retail shops as well as some store houses. Here the pedestrian count is also higher. Champatoli lane is mostly used for wholesale goods especially for spices. Here the observed pedestrian movement is lower than the SwariGhat lane and BoroKatraLane. In some part of Champatoli lane where the store houses are situated, the pedestrian volume is observed very low with respect to the other zones nearby.

#### 4.4. FINDINGS

Though, in many western countries positive correlations between connectivity and pedestrian movement was found but in the study area where the street grid is deformed and the culture is different, connectivity is not found as a influencing factor for pedestrians. Even according to Space Syntax the radius 3 integration has been proved to be a guiding factor for pedestrians, but here very poor correlations were found. Whereas Global Integration Value that has been proved to a decisive factor for vehicular movements in many western cities, here it is found to be a decisive factor for pedestrian movement pattern.

#### 5. Conclusion and future directions

In this study, the correlation between spatial network by Space Syntax analysis and the observed pedestrian volume was analysed. The study result shows that the pedestrian movement pattern in a traditional city like 'Old Dhaka' acts differently than the western countries. Though, a strong relationship is found between global integration values and pedestrian volume. In a city like old Dhaka, where the street are very narrow and tortuous in pattern local (radius 3) integration is found inappropriate for determining pedestrian volume.

Another interesting finding of this research is that though the full study area is served as a business area, there is a huge difference in pedestrian count according to wholesale, retail and storehouse areas. This proves that there are different pedestrian characteristics according to different types of business zones.

In order to acquire better understanding of how urban form affects pedestrian movement in such type of traditional cities like Old Dhaka, it is important to acknowledge both in the way built environment factors affect movement and also the differences of land uses as well. This study, although limited in the amount of data and statistical testing, was an attempt to investigate these

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differences. Further investigation may be done by testing the detail data on different land use zones in the greater parts of 'Old Dhaka'.

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