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Density and Quality of Spaces in Relation to Built-Forms

(Case Study: Commercially Active Centers In Addis Ababa (Pedestrian Density And Pedestrian Priority))

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ABSTRACT: A vibrant and commercially active center is often the result of interesting, diverse building styles and or built-forms, pedestrian density along with variety of quality public places where people feel comfortable, spending time and shopping items for domestic and commercial functions in cities like Addis Ababa. The scale and design of buildings, pedestrian density, and other physical characteristics will determine the quality of built form and public spaces and how well they create an attractive and pedestrian friendly and welcoming environment in relation to built-up and pedestrian density.On the other hand, not many studies have been undertaken in relation to the concept and theory of "Pedestrian Density and Quality of Spaces". This research is aimed to analyze and explore the relationship among urban space quality, pedestrian density and built-form of the city in commercially active centers so as to contribute to a better understanding of the correlation among pedestrian density, built-form and quality of urban space. Hence, the study employed multiple data sources through quantitative and qualitative approaches (Triangulation). Finally, the research ended with arriving at answers for research questions through both statistical and non statistical techniques. The research result has highly addressed and concluded that Pedestrian friendly Streets with pedestrian density thresholds in commercially active built-environments are places that people like walking and want to stay in, with real character and sense of place. It concludes with an overview of emerging thinking/implications where further efforts are required in the future.

Keywords: Commercially-Active, Pedestrian-Density, Quality-Spaces, Built-form, pedestrian-priority.

INTRODUCTION

A vibrant and commercially active center is often the result of interesting, diverse building styles and or built-forms, pedestrian density along with variety of quality public places where people feel comfortable, spending time and shopping items for domestic and commercial functions. The Built-Form addresses ways in which private redevelopment and public improvements can contribute to Addis Ababa's downtown and commercially active areas with poor and jam pedestrian density, which leads to uncomfortable built-environment. The scale and design of buildings and other physical characteristics will determine the quality of built form and public spaces and how well they create an attractive and pedestrian friendly, safe and welcoming environment in relation to built-up (FAR and BAR) and pedestrian density. It is strongly believed that commercially active areas in Addis Ababa are composed of substandard & jam pedestrian density and built up density with high coverage built-forms. It is also strongly believed that the higher built-up density in terms of FAR, the higher Pedestrian density, which leads to consider pedestrian priority streets in commercial city centers, however the current situation indicates very serious problems associated with pedestrian movements in inner, intermediate and suburb commercial activity areas as the planning and design problems are being illustrated.

It is also very important to note that commercially active areas usually have very small resident populations. On the

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other hand, different sources indicate that there is evidently no consensus on the question of quality urban spaces and built-forms. Therefore, at certain built-up and pedestrian densities (thresholds), the number of people in commercially active centers within a given area is sufficient to generate the interactions needed to make certain activities, urban functions and amenities viable including pedestrian circulation spaces, outdoor spaces, green and open spaces, safety and security etc. Clearly, the greater the number and variety of urban activities, the richer the life of a consumers; thus, urbanity is based on density' (Lozano-Perez, 1990). There are very few efforts being applied by urban planning institutions or professionals and politicians to examine, evaluate and control densities, particularly pedestrian densities, built-up densities (BAR and FAR) and built-forms, and their impacts on the qualities of urban public spaces in commercially active built-environments. Designers, Planners and politicians over the world are aware of the urgent need for action plans to increase the quality urban spaces and sustainability in the large cities like Addis Ababa, Ethiopia. Therefore, the study focuses on the impact of pedestrian density and built-forms on the quality of spaces in commercially active centers.

Problem Statement

Addis Ababa is the capital city of Ethiopia with a population of 3.5 Million in 2016. As a chartered city, Addis Ababa has the status of both a city and a state. It is where the African Union and its predecessor the OAU are based. It also hosts the headquarters of the United Nations Economic Commission for Africa (UN-ECA) and numerous other continental and international organizations. Addis Ababa is therefore often referred to as "the political capital of Africa" due to its historical, diplomatic and political significance for the continent. It is also the primate city of the country.

Despite the fact that Addis Ababa is organically/biologically grown rather than technically grown that calls for proper urban design and planning interventions along the strong consideration of pedestrian density and built-up density (BAR & FAR) with proper pattern of built-forms in order to design quality spaces in commercially active built-environments. It is also important to note that the growth of Addis Ababa is without thorough planning intervention as the city centers composed of poor physical qualities including jam pedestrian densities and high percentage of ground coverage by dense commercial and mixed use built-forms. Built-up area ratio in the old and central part of the city may exceed 90%. Actually, more than 65% of the central part Addis Ababa is Slum neighborhoods (UN-Habitat, 2006).

Most of the commercial and mixed use built-environments in Addis Ababa are composed of single storied buildings and mostly dense due to the close distance among the business and commercial buildings with substandard and jam pedestrian density, high ground coverage of the building blocks expressed like low-rise built-forms with high ground coverage and absence of pedestrian priority being associated with street as primary urban and public spaces in commercially active built-environments. The usability of spaces inside the blocks of urban space is not efficient because most of the spaces inside the block are covered by building structures. In order to increase the efficiency of space, there is a need to analyze the pedestrian density in relation pedestrian priority and pedestrian friendly movements and built-up density, in terms of Floor Area Ratio (FAR) and percentage of land coverage by buildings (BAR) as well as built-forms in relation to quality of spaces. This study examines whether there are also economic benefits to businesses in walkable communities by determining pedestrian density as part of street density so as to detect quality of spaces in built-environment, which is one of the nervous challenges in Commercial active areas of Addis Ababa from centers to suburbs.

Therefore, this study aims to investigate the impact of pedestrian density and built forms on quality of urban spaces particularly commercially active built-environments to keep pace with the expanding horizon of knowledge that provides strong theoretical grounding looks for application of knowledge associated to pedestrian density and flow, pedestrian priority, built-forms & quality of urban spaces to develop solutions. It may also help the policy makers, managers, urban designers and planners, city officials to improve their understandings on the issues of quality and density in relation to built-forms. On the basis of the above stark realities, the following purpose/aim is stated below for investigation.

Aim of the Research

"It is with the above background of study and problem statement, the aim of the study is to analyze and explore the relationship among urban space quality, pedestrian and or built-up density and built-form of the city in commercially active city centers so as to contribute to a better understanding of the correlation between pedestrian density and quality of urban space. Therefore, the impact of pedestrian density and of built-forms on the quality of urban space in commercially active built-environments within different case areas were studied in Addis Ababa.

MATERIALS AND METHODS

To fulfill the objectives of this study, various methods have been applied. For the calculation of densities in terms of pedestrian density and (FAR & BAR) in relation to varying commercial and mixed use built-forms, the measurement of commercial plots, block area, ground coverage (BAR), total floor area ratio (FAR), building set-backs, pedestrian density together with pedestrian priority by taking cross sections, were calculated from the aerial photographs, on site counting of customers, Satellite image and line maps along with on-site Measurements from the case study built-environments of nodal and commercially active areas. In addition, survey corroborated with questionnaire and Interview has also been made to get in depth opinion. Observations (both overt and Covert), Video-graphic technique was also employed for collecting the pedestrian density data to reinforce the physical analysis with respect to pedestrian density, pedestrian flow and speed, pedestrian travel behavior and as well as built-up density in relation to built-forms. This research study has been engaged both qualitative and quantitative research approaches, which is called "triangulation".

"Therefore, the Research method aims to achieve maximum validity in order ensures the reliability of the research. Hence, the frame that has been chosen is wider as time series data has to be analyzed. For the maximum reliability, research methods selected cross checks and validate the analysis and inferences." The technique also used to analyze the interviews was based on Kvale's (1996) method of analysis. Out of the five possible approaches for analyzing interviews, recommended by Kvale, three were used: condensation– paraphrasing long interviews into succinct statements or shorter formulations; narrative– creating a coherent story out of the many happenings was reported in an interview; and interpretation– re-contextualizing of the statements within broader frames of reference. Applying condensation, the interviews from the fieldwork was first cleared from unnecessary and redundant information and abridged formulations was also made. These have then woven into the case study reports combined manner in such a way that they have been made coherent narrative. Finally, the narratives were made to correspond, as explained in the major strategy, to the predetermined research question-based topics. With regard to the questionnaire and measurements data, it was first entered in SPSS programme, version-22. In this regard, the SPSS analysis results would be focused on odds ratio used to examine the relationship between variables (response and Predictory variables) and Predictory variables level of significance for the model. In addition to the analysis of interviews and questionnaires; line maps, GIS, photographs, aerial photos and secondary written documents were interpreted in relation to the key issues of the research questions and were incorporated as part of the case reports all together.

Concepts and Theories

Concept of Quality Urban Space

Before discussing the concept of quality of urban spaces in commercial built environments in relation pedestrian density and built-forms, it is very important to realize that urban spaces should be clearly addressed. Thus, according to Krier (1979), urban spaces are defined as all types of spaces between buildings and geometrically bounded by elevations. Similarly Spreiregen (1965) defines urban spaces as formal spaces which are the products of cities and usually moulded by building facades and the city floor including pedestrian friendly market oriented built-environments. He also indicates that these spaces must be distinguished from other spaces by their predominant characteristics such as their quality of enclosure; the quality of their detailed treatment or outfitting; friendly pedestrian circulations and the activity that occur in them. He added that if anyone of these qualities is sufficiently strong, it alone may establish the sense of urban space and place in commercial oriented centres as well. In discussing urban space, Carmona also makes a useful distinction of urban spaces as: "hard space" principally bounded by Architectural walls, and the "soft space" or parks, pedestrian walkways, gardens and linear greenways which have less enclosure or defined boundary and are dominated by the natural environment (see Fig. 1). Paul Spreiregen also describes the size variation of urban spaces an: "Urban and architectural spaces from a hierarchy of spatial types, based on their size. In urban planning and design this hierarchy ranges from the scale of small intimate court spaces on to grand urban space and culminating in the vast space of nature in which the city is set" (Spreiregen, 1965, 126). In relation to urban spaces, many practitioners on the other hand have been attempted to investigate their qualities by defining urban space spatially to what extent they are serving the customers at large in built environments (Fig. 1). Accordingly, (M. Goethals, 2007, 4) defines quality of urban space as the extent to which that space satisfies the expectations of customers and beneficiaries particularly pedestrians. These expectations are determined by the values pursued by the customers in commercial areas for its development, more specifically its spatial development including pedestrian friendly commercial built-environments. They are expressed both in very general

Table 5: Test between issuance of the notice of completion and final inspection by the CGK (Source: Field survey data, 2018)

terms, the values pursued by the customers and in very specific configuration principles for that space in the process of making sure pedestrian friendly commercial areas.

Pedestrian Density and Flow Impacts on Quality of Urban Spaces

Different practitioners and researchers have also studied the pedestrian density and pedestrian flows in different countries under varying conditions ranging from indoor to outdoor walkway, sidewalks, movements in vibrant commercial and mixed use areas, movements under unidirectional or bidirectional pedestrian flows or under mixed traffic conditions. Pedestrian flow relationships have been developed by many researchers in the context of the study undertaken. Most of these models are based on a linear speed-density relation, except those given by Virkler & Elayadath (1994), Weidmann (1993) (as quoted in Daamen & Hoogendoorn, 2004) and Kotkar et al. (2010).

It is very important to note that the relation between pedestrian speed and pedestrian density becomes exponential under heavy pedestrian flow. Polus et al. (1983) developed single and three regime linear speed- density models for pedestrian flows on sidewalks in CBD of Haifa (Israel). They found that speeds are inversely proportional to pedestrian densities. In another similar study Al-Masaeid et al., (1993) found that the quadratic polynomial relation fits the speed-flow data the best. Tanaboriboon et al., (1986) developed flow relationships for sidewalks and walkways in Singapore and compared them with those obtained for the United States and the Britain. The relationship between speed and pedestrian density was found to be linear while flow-density and flow-speed relationships were quadratic. Seyfried et al., (2009) studied the unidirectional pedestrian flow using controlled experiments to measure the relation between density and speed of pedestrians. Contrary to the previous studies a linear relationship was found between the step length and speed even during low speeds of less than 0.5 m/s. It was also found that the space requirement of pedestrians moving at an average speed is less than the average space requirement.

The mean speeds in literature vary from 1.23 m/s to 1.50 m/s on sidewalks/walkways; the variation being from 1.23 m/s to 1.39 m/s in Asian countries (Hongfei et al., 2009; Kotkar et al., 2010); from 1.31 to 1.50 in European countries (Oeding, 1963; Older, 1968); and from 1.31 to 1.37 m/s in the US (Navin & Wheeler, 1969; Fruin, 1971). The average mean speed is lower in Asian countries and higher in European countries, which indicates towards the cultural effect on speed. Some researchers have calculated critical speed at maximum flow (capacity). This is found ranging from 0.61 m/s to 0.82 m/s on sidewalk or level walkways (Lam et al., 2003). Pedestrian walking speeds under mixed traffic are studied by Yu (1993, China), Gerilla (1995, Philippines) and Kotkar et al. (2010, India). The speed is found lower in China (1.26 m/s) and comparable in Philippines and India (1.38-1.39 m/s). Daamen & Hoogendoorn (2004) found the mean speed of non-constrained pedestrians as 1.406 m/s whereas, that of constrained pedestrians were 1.454 m/s. It is observed from studies that an average speed in European countries is 1.41 m/s, 1.35 m/s in the United States, 1.44 m/s in Australia, 1.02 m/s in Africa & 1.24 m/s in Asia. This indicates that pedestrians in African countries walk at slower speed as compared to those in European, US, and Asian cities.

Pedestrian density is reported by various researchers either as jam density or as density at capacity to indicate quality of urban spaces as pedestrian friendly built-environment. Hongfei et al. (2009) found a very low jam density (1.65 p/m2) for a corridor in China, whereas, it was 4.83 p/m2 on a walkway in Singapore (Tanaboriboon et al., 1986). It is found varying between 3.6p/m2 and 5.10p/m2 under mixed traffic condition, the highest being observed in China and lowest in Philippines (Gerilla, 1995). Kotkar et al., 2010 reported pedestrian density of 4.17p/m2 for Indian cities. It is found ranging between 2.7p/m2 and 3.99p/m2 in Europe and the USA (Friun, 1971). Some researchers have also indicated a very high value (greater than 4.2p/m2) of jam density (Sarkar & Janardhan, 1997). The jam pedestrian density at capacity flow is reported by other researchers also. It is found low (1.3–1.9 p/m2) for the US and United Kingdom (Virkler & Elayadath, 1994) and high (2.1 p/m2) for India (Sarkar & Janardhan, 1997). Higher density observed in Asian cities and especially in India indicates accommodating nature of pedestrians who are willing to share the available space with other pedestrians more effectively in commercially active and mixed use built-environments.

Another important aspect related to pedestrian movements is the space occupied by a pedestrian and the minimum space required for comfortable walking in relation to commercial built-forms. The minimum area of an average pedestrian (without bulky clothes and baggage) is about 0.085 m2. As pedestrian body shape is taken as an ellipse, they cannot fill completely a specific area, which leads to a pedestrian area of 0.11 m2, and a maximum density of 9.09p/m2. In practice, a density between 2.0 and 2.9p/m2 is achieved for waiting pedestrians (Weidmann, 1993, as quoted in Daamen & Hoogendoorn, 2004). Pushkarev et al., (1975) noted that pedestrians prefer a body buffer zone space of 0.27-0.84 m2 including the space needed to make a step. Physical contacts may be avoided at densities of 3.0-3.5 p/m2 (Weidmann, 1993, as quoted in Daamen & Hoogendoorn, 2004). The data from South Africa clearly indicates that physical contact between pedestrians at higher density is not avoidable. Hall (1990) has examined the effect of culture on the distances maintained in human interactions and found that different cultures use spaces differently and this includes walking, sitting, standing, and talking as indicators of good urban design in the built-environments. The behavior of pedestrians at bottlenecks in Addis Ababa has not been studied so far.

Furthermore, this study examines the changes in the pedestrians' flow characteristics due to an increase in the width of the pedestrian facility, as well as, due to the bidirectional pedestrian flows on a facility and formation of bottlenecks due to encroachment of a facility by higher building coverage's or built-up density exceeding (BAR>65%) in terms of BAR. It also compares the results with those reported in literature to bring out with the differences in pedestrian behavior in relation jam pedestrian density or capacity. The findings of the study will be useful in the evaluation of the level of service on walking facilities in commercial and mixed use areas. These can also be used as important inputs for the development of dynamic continuum models to describe the pedestrian movements in the spatio-temporal domain associated with built-up and pedestrian density in relation to built-forms in commercially active & mixed use centers in Addis Ababa.

On the other hand, there is evidently no consensus on the question of urban quality, level of density particularly pedestrian and built-up densities in relation to commercial built forms. Steven also suggested that "Wisely used, density can be a valuable weapon in the planners' 'armoury', but indiscriminate use has revealed some limitations." Hence, at certain pedestrian and built-up densities (thresholds) with proper application & use, the number of people or customers within a given area is sufficient to generate the interactions needed to make certain urban functions or activities viable for better quality of spaces. Clearly, the greater the number and variety of urban activities, the richer the life of beneficiaries; thus, urbanity is based on 'density' (Lozano-Perez, 1990). Variations of the built from throughout the city will help to achieve a distinct 'sense of place' for each market oriented neighborhood and define activity levels to make pedestrian friendly commercial and mixed use built-environment by developing optimum pedestrian density. It is explicitly addressed in the analysis part below.

RESULTS AND DISCUSSIONS

Four case study commercially active centers in Addis Ababa, two in inner part of the city, one from Heyahulet Mazoria and one from Ayat suburb area were selected for the collection of pedestrian density flow data as well as Built-up Density in mixed condition to analyze the pedestrian density and built-forms in commercially active and mixed use built-environments. Out of these, Piazza and National Theatre areas are located the main city centers.

The commercially active city centers selected have cultural, commercial, historical and retailing backgrounds; represent different customer groups and supports substantial pedestrian density activity and built-up density in relation to built-forms. Therefore, these 4 study locations were selected within Addis Ababa for on-site data collection. To understand the general behavior of the pedestrians while walking, the locations were selected such that they represent varied land use around the facility, change in facility by width, and the effective width of the facility available for pedestrians to walk on in building pedestrian friendly commercial environment. Some locations have uni-/bi-directional pedestrian flows and some are constrained in width available to the pedestrians. These allow studying and examining the pedestrian behavior under varying flow conditions on facilities in each commercial built-form as being illustrated in Figure 2. The classification of selected locations based on the above criteria is given in Table 1. The sample locations are shown in table 1 and Figure 2.

On the other hand, (Built-up Density (FAR) Brings Pedestrian Friendly Environment), there is now clear evidence from the analysis below and review above that increasing built-up density in terms of floor area ratio/FAR/ reduces the need to travel great distances for local needs and reduces the reliance on cars for transport in business oriented areas. However, higher built-up density development or higher lot coverage is more compact and may affect the pedestrian movements and causes crowded pedestrian friendly environment. In former way, built-up density influences proximity, decreasing the distances between destinations and so making them more walkable. Built-up Density as being explained above, High Floor area ratio/FAR<2.0/ with low building converge (BAR>65%) also brings people closer together, which results in 'more eyes on the street' and contributes to the perceived and actual safety required to encourage physical activity, and more specifically walking in commercially active built-environments by making pedestrian friendly environment. It is also important to note that increasing built-up density (FAR) can result in a clustering of destinations, making it convenient for customers to access a variety of needs such as buildings, shops, malls, libraries, cafes, medical centers and so on, within one location in relation to built-forms. This clustering is associated with shorter travel distances and increased pedestrians for transport. People in high built-up density (FAR vs. low BAR) urban areas may achieve the recommended 30 minutes a day simply by walking to and from public transport and shops or commercial centers. It takes a certain number of people to support social infrastructure, such as schools and public transport, as well as a range of shops, services, local businesses and other amenities. Sufficient population density ensures that these local, walkable destinations have a customer base with pedestrian friendly built-environments with pedestrian facilities.

As being stated above, Video-graphic technique was employed for collecting the pedestrian density data as shown in fig 2 and 3 A trap of known length was marked on the pedestrian facility using a self-adhesive white tape for measuring the pedestrian speed and flow. The video camera was kept at an elevated point so as to cover the pedestrian movement on the entire trap. The movements of pedestrians were recorded during the morning and evening peak periods (7.00 – 9.30 A.M, and 5.00 – 6.30 P.M) on a working day at each of the study locations. The required pedestrian density data were later extracted from the recorded videos. Looking at the continuous flow of pedestrians entering the trap the flow data was extracted on one minute basis though under fluctuating flows lower value of time interval would be more appropriate. The time taken by each pedestrian to cross the trap length was noted to an accuracy of 0.01s to determine pedestrian speed. Based on the pedestrian flow, pedestrian density per square meter is calculated. The inverse of pedestrian density yielded the area module. These were found for the entire study duration. It is important to note that the higher the built-up density in terms floor area ratio has direct influence on the pedestrian movements in the commercial built-environments as the higher the floor area ratio the higher

Fig. 2: Conditions observed under study from all four case study areas in Addis Ababa, 2016

Table 1: Details of study locations from all case study areas

By width of the facility			By effective width of the facility	
Classification	Number of locations	Width of facility, m	Facility width, m	Effective Width, %
Sidewalk	12	1.7 – 4.2	7.5	45
Wide sidewalk	6	> 4.1, ≤ 9.2	6.3	50
Commercial blocks	4	> 9.2		
Carriageway	3	5.4*		

* Used by pedestrians, total width of the street is 11 m per direction separated by a median, 2016

pedestrian movements in the study areas.

Pedestrian Density & Pedestrian Flow Relations and Characteristics

Before estimating various flow characteristics for pedestrians at different selected locations, the locations which are found similar (based on pedestrian flow conditions and width of the facility) have been clubbed together. In this regard, a sidewalk study location in Ayat area is excluded from the analysis. This is the only location which has divided sidewalk with bi/unidirectional flow. Bottleneck conditions prevailing on two of the wide-sidewalks are also excluded. Data from rest of the locations are combined under the heads sidewalk, wide-sidewalk, Commercial areas and carriageway and the flow characteristics like pedestrian flow, speed, density and area module are estimated. A single-regime approach is used to ascertain the relationship between pedestrian speed and density due to constraints of the data points. Various distributions like linear, logarithmic, power, polynomial, exponential, etc. are considered to arrive at the best fit distribution. Once this is ascertained, the mutual relationships between flow, density and speed are derived theoretically and their goodness of fit is examined based on data plot and statistical parameters like R2, standard error and Chi-squared test. The goodness-of-fit statistics are calculated for the observed range of the data. In the case of sidewalks, wide-sidewalks and commercial precincts, a negative exponential relationship is found fitting pedestrian speed and density data the best.

The theoretical relationship between pedestrian flow and density, as well as, pedestrian flow and area module is exponential; and is logarithmic between pedestrian flow and speed. The developed relationships are given in table 2. In general, the goodness-of-fit defined by various statistics is found between satisfactory and good (based on R2 value, >0.70), leaving speed-density relationship for wide-sidewalks for which it is quite low (<0.50), and is fair (>0.50 and <0.70) for flow-speed relationship of sidewalks and speed-density relationship of commercial areas. The data points are found to be highly scattered around the best fit curve in these cases. The flow relationships developed in the present study are similar to those reported for other world class cities for heavy density pedestrian back flow.

The relationships developed for different types of pedestrian facilities are shown in Figure 3.

These relationships clearly indicate the difference in the three types of sidewalk facilities as classified in the present work. Based on the relationship between pedestrian flow characteristics and characteristics parameter values, the behavior of the pedestrians on sidewalks and wide-sidewalks is found to be more similar than that on commercial precinct in relation to the quality of pedestrian friendly spaces. This indicates that as the width of the pedestrian facility increases above 9.0 m a distinct change in the pedestrian behavior is noticeable as indicator of quality of urban spaces. The mean free speed of pedestrians decreased from 1.576m/s on a conventional sidewalk (≤ 4.0 m) to 1.492m/s on a wide-sidewalk (5.33% reduction) and to 1.339m/s on a commercial precinct (15.04% reduction). These speeds are in the higher range of 1.23m/s to 1.50m/s given in the literature. The average speed of pedestrians is found to be 1.165m/s (Maximum 1.67m/s, Minimum 0.72m/s). The speed at capacity is 0.578m/s on sidewalks, 0.548m/s on wide-sidewalks and 0.493 m/s on commercial and mixed use built-environments. These speeds are lower than the range (0.61 m/s to 0.82m/s) reported in literature for sidewalks and level walkways as good quality of pedestrian spaces in building pedestrian friendly commercial built-forms.

As being explained in the literature that pedestrians in Addis Ababa walk at lower speed during side frictions on the facility due to congestion or jam pedestrian density. Similar behavior is observed in the present study also. At low densities (< 0.18p/m2) and low flow values of up to 20p/ms the behavior of pedestrians on the three facilities is more or less similar. As the flow increases above 20p/ms, a higher reduction is observed in the pedestrian speed on commercial built-environments as is evident from the steepness of the speed-flow curve (Figure 3). The flow at capacity is found to be 1.757p/ms on sidewalks, 1.568 p/ms on wide-sidewalks (10.75% low), and 1.263p/ms on commercial areas (28.11% low). The study locations of sidewalks are mostly in commercial or mixed activity areas and this may be the reason for higher flows that might reduce the quality of pedestrian spaces (Fig.3).

As it has been observed that higher flow values in commercial areas as trip characteristics are mainly business oriented. The pedestrian density at capacity is found to be 3.3p/m2 on sidewalks, 2.86p/m2 on wide-sidewalks (5.6% reduction) and 2.56p/m2 on commercial precincts (15.51% reduction). This is almost similar to the trend observed for speed. The values observed are higher than those reported for USA and UK (1.3 – 1.9 p/m2). The jam pedestrian density is expected to be higher than 4.5p/m2. This is higher than that reported for Europe and USA, but lower than the one reported from China as being addressed in the literature. This is supported by the pedestrian space available on a facility. The pedestrian buffer space (space occupied by a pedestrian along with half of the surrounding

Table 2: Relationships between pedestrian flow characteristics from all four case study areas

Facility	*Relation*	*Model equation*	*R^2 value*	*SE*	*Chi test**
Sidewalks	Speed-Density	$v = 1.576 \times e^{-k/3.03}$	0.817	13.50	9.25
	Flow-density	$q = 1.576 \times k\, e^{-k/3.03}$	0.726	23.63	10.68
	Flow-speed	$q = -3.03 \times v \times \ln(v/1.576)$	0.641	12.05	13.53
	Flow-space	$q = (1.576/M) \times e^{-1/3.03M}$	0.857	5.17	8.94
Wide-sidewalks	Speed-Density	$v = 1.492 \times e^{-k/2.857}$	0.364	41.25	19.21
	Flow-density	$q = 1.492 \times k\, e^{-k/2.857}$	0.911	37.19	6.17
	Flow-speed	$q = -2.86 \times v \times \ln(v/2.857)$	0.791	16.48	11.23
	Flow-space	$q = (2.857/M) \times e^{-1/2.857M}$	0.842	32.42	9.14
Precincts	Speed-Density	$v = 1.340 \times e^{-k/2.564}$	0.566	17.28	15.66
	Flow-density	$q = 1.340 \times k\, e^{-k/2.564}$	0.939	25.89	4.93
	Flow-speed	$q = -2.56 \times v \times \ln(v/1.340)$	0.861	4.79	8.78
	Flow-space	$q = (1.340/M) \times e^{-1/2.564M}$	0.959	21.09	5.71

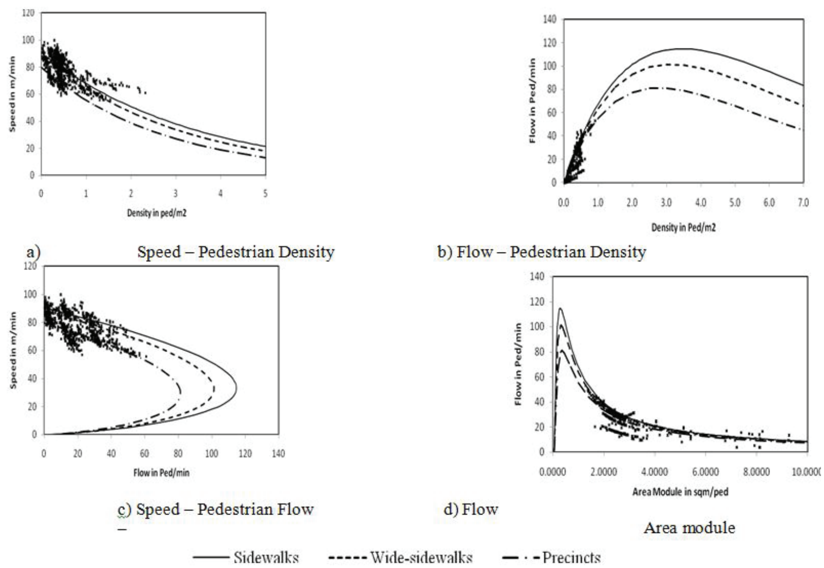

Fig. 3: Pedestrian Flow relationships developed for different pedestrian facilities in four case areas

clearances between pedestrians) at capacity flow is found to be 0.33 m2/p on sidewalks, 0.35 m2/p on wide-sidewalks and 0.39 m2/p on Commercial and mixed use built-environments. The increased space and freedom from boundary restrictions resulted in higher leisure walking behavior of pedestrians on wider facilities to check the quality of spaces. In all the four cases the physical contact between the pedestrians at capacity flow is avoided as suggested by the author. Various flow characteristics as estimated from figure 4 and 5 for different pedestrian facilities are given in table 3.

Built-up Density and Pedestrian Circulation Spaces

As already being explained in the review and analysis, "The size of commercial plot, the amount of plot which can be built up and the height of the building give the dimensions of the most visible aspect of built-up density: the amount of space which is built". Built-up density includes built-up area ratio (BAR) and floor-area ratio (FAR). In the procedure of actual calculations of built-up density including BAR & FAR, actual site, line and Nortek maps have been used. For all sites, coverage of the area are measured and called "ground coverage". These are measurements for the "site" which is the actual area of the commercial and mixed us plots in which a business or commercial complex is built on, and block level calculations in all cases included the addition of half of the width of the surrounding streets. In some cases the presence of public facilities such as small day care centers, or large areas with undetermined uses attached to them have been included, if these have been considered as variables that constitute as being a part of the type under analysis. The calculation comprises: total floor area ratio/FAR/: ratio of total built commercial and business area to area of land, building height: number of stories and built-up area ratio (BAR): built up area divided by the size of the commercial plot.

However, a naked eye observation on the case study areas morphology suffices to retrace the minimal role of planning intervention in `urban space consumption` over time in relation pedestrian movements. This predominance of haphazard development poses a substantial need for re-planning. The high building coverage's of commercial plot and block contributes for the absence of open and green spaces, circulations & mobility particularly impedes pedestrian flows, possibility to use recreational and commercial outdoor spaces as being illustrated on figure 6. Therefore, the analysis results unveil that less attention has been given for developing appropriate patterns of built form & morphology with proper density thresholds as prescriptions and norms to control pedestrian quality urban spaces in commercial and mixed use built-environment. As a result, planning controls were not developed as per prescribed maximum allowable densities (BAR<65% and FAR ›2.0). Many municipalities and design experts have been less strived to determine the minimum and maximum built-up density as 'norms and prescriptions' to plan and design quality commercial built environment in building better quality and pedestrian friendly urban spaces.

The figure 6 also illustrates that the built up area ratio/BAR/ is exceeding 85% or approximately close to 90% that there is no space for pedestrian circulation and mobility, greenery, open spaces, contributes for the incidence of crime in the market oriented neighborhood and the surrounding urban environments. The figure 6 also depicts that the ground coverage in business plots are almost the same in all case study areas, which close to 1 or 100%. Hence, this built environment is highly occupied by building structures fail to accommodate the adequate quality elements as being stated above. Therefore, it clearly shows that built-up density would affect the urban built form and quality of commercial neighborhoods in terms of poor pedestrian friendly built environment.

Impediments to Walking in relation to Pedestrians

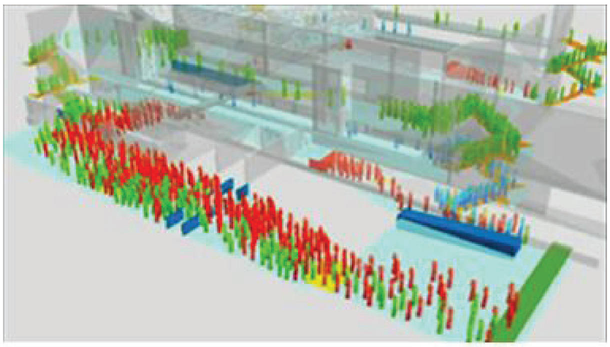

Fig 4. Good quality of pedestrian space in building pedestrian friendly commercial built-forms

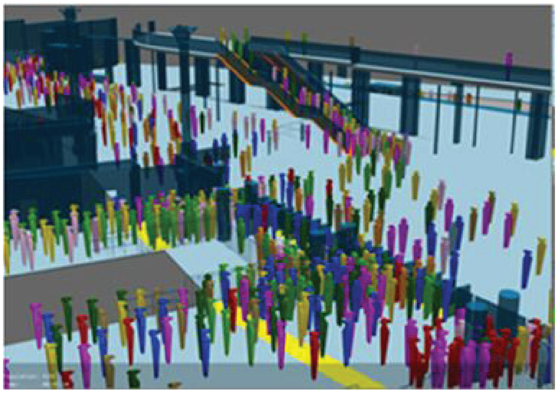

Fig 5. poor quality of pedestrian space in building pedestrian friendly commercial built-forms with jam pedestrian density

Table 3: Pedestrian flow characteristics under different conditions all case study areas (Source: Survey Results, 2016, Pedestrian flow characteristics)

Facility / Condition	Free speed (μf), m/s	Flow at capacity p/ms	Area module (M) at capacity (m^2/p)	At capacity Speed m/s	Pedest. Density p/m^2/
Sidewalks	1.576	1.757	0.33	0.578	5.03
Wide-sidewalks	1.492	1.568	0.35	0.548	4.86
-Commercial Mixed use built	1.339	1.263	0.39	0.493	6.56
Unidirectional	1.595	1.333	0.44	0.588	4.27
Bi-directional	1.576	1.768	0.33	0.568	6.13
Unrestrained	1.492	1.568	0.35	0.548	4.86
Restrained	1.212	1.345	0.29	0.413	6.45
Carriageway	1.415	2.067	0.34	0.703	4.92
Exclusive facility	1.502	1.493	0.37	0.553	4.70

It is also important to note that respondents were also asked to indicate what personal/environmental as well as transportation system factors discourage them from walking more in commercially active built-environments. For each factor listed, respondents indicated the relative importance of that factor in their decision to walk (a ranking of 1 indicated "not a factor" while a ranking of 5 indicated "most important").

Personal and Environmental Factors

It has also been observed that examples of personal and environmental factors that would discourage walking in market oriented built-environments include weather, personal health/ fitness levels, terrain, and concerns about safety and crime. In general, these factors are less significant in discouraging customers from walking as explicitly analyzed.

Every one of the factors received more votes in categories 1 and 2 ("not a factor" and "less important") than in categories 4 and 5 ("very important" and "most important"). The two personal and environmental factors receiving the highest relative importance were inattentive or aggressive drivers (safety) with an average score of 2.87, and too dark (average score of 2.78). Particularly noteworthy is that concerns about inattentive and aggressive drivers received a higher score than any factor, both in the personal/environmental and transportation system categories indicating that a focus on pedestrian safety and traffic calming in those active market areas that will be an important component in the development of a complete pedestrian friendly network.

Particularly encouraging is the low average score of “don't enjoy,” which received an average score of 1.24, indicating that most respondents enjoy using their feet as a mode of transportation or pedestrians. Therefore, it is quite essential to plan and design pedestrian friendly commercial and mixed use environment in the city. The table 4 provides a comparison of the relative respondent rankings on the factors.

Transportation System Factors

The analysis results clearly shows examples of the transportation factors that potentially influence whether one might choose to walk include lack of sidewalks, crossing barriers (highway, streams), unsafe street crossings, incomplete sidewalk networks (stopping and starting), sidewalk too close to moving traffic, and poor maintenance of sidewalks lead to poor pedestrian friendly built-environment . The most important factors, with average score listed, include: No sidewalks (2.86), Inadequate lighting (2.75), not enough separation between sidewalk and vehicle lanes (2.71) and Sidewalk connectivity issues (2.62)

The least important factors include (with average score): Lack of useable wheelchair ramps (1.40) and Sidewalks/ pathways too difficult for wheelchairs (1.42). These low scores are particularly surprising given the fact that some mothers who regularly push their children in strollers indicated that wheelchair ramps are important to them for this reason. Table 5 provides a comparison of the relative respondent rankings on the factors associated with pedestrian movements and flow characteristics.

Findings of the Study

The analysis results have found that higher built-up densities along with commercial and mixed-uses are associated with walking for transport through pedestrian density at all ages and that people living in higher density commercial built-environments undertake more walking and physical activity than people living in low density commercial areas. On the other hand an international literature review and analysis results on pedestrians found that built-up density was associated with walking for travel or pedestrian density in most studies.

The finding made sure that the challenge in finding the link and relationship between built-up densities and walking has been explored by trying to separate out the role of density from other built environment features. One key study found that walking for transport was most strongly related to land use diversity, intersection density, pedestrian density and the number of destinations within walking distance. Despite measurement challenges, it has been shown that higher built-up density commercial built-forms generally have a number of negative key elements that work together to create environments that support might not pedestrians or walking in terms of pedestrian friendly commercial built-environments. Therefore, these findings clearly show that there is strong positive correlation in between pedestrian density and quality of spaces in commercially active centers in the built-environments in relation to built-forms and broadly affects the quality of spaces particularly pedestrian public spaces.

Similarly, this study on the other hand found that the impact of pedestrian and built up density as well as behavior of pedestrians walking on different type of facilities and under varying flow conditions. The pedestrians are studied on sidewalks categorized by the width of the facility, and under conditions like bidirectional or unidirectional flow, reduction in the effective width of the facility and the absence of an exclusive pedestrian facility at a location. The flow relationships are developed and characteristic values are found out. It is observed that the speed-density relationship follows exponential form on sidewalk of varying widths and linear form on a non-exclusive facility like side of a carriageway.

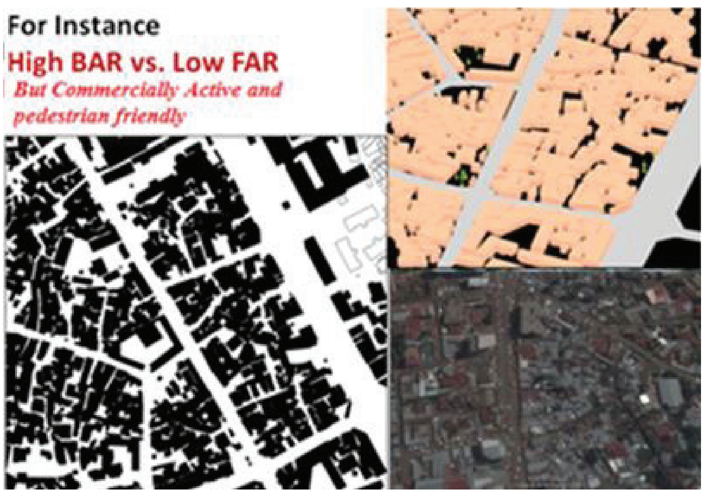

Fig 6. High ground coverage. Morphology and buildings situation in plaza area

Table 4: personal and environmental factors limiting walking in commercial environments from cases (Source: Questionnaire Survey, 2016)

What Personal and Environmental Factors Limit You From Walking More Often?				
			# of Responses by Priority Rating	
	# of Responses	Average Ranking Score*	StRONG (4&5)	LOW (1&2)
Physical (Pedestrian walkways)	813	1.38	43	770
Don't Enjoy	810	1.24	21	789
Personal Appearance	815	1.20	20	792
Aggressive Drivers (Safety)	820	2.87	310	510
Crime	828	2.30	162	666
Too Dark	822	2.78	241	581
Weather	821	2.64	189	632
Terrain	819	2.02	67	752
* Ratings scale from 1 (Not a Factor) to 5 (Most Important)				

Pedestrians behave similarly to each other within a close band of flow characteristics, up to a width of 9.0 m and beyond this the behavior changes drastically.

The study result also unveiled that the pedestrians behave similarly at very low density (or flow) irrespective of the type of a facility but behavior is different at higher built-up and pedestrian densities which are directly affecting the quality of urban spaces in the commercially active built-environments. The flow characteristics are found different from those observed in World class cities around the globe. The free speeds in Addis Ababa on sidewalks are found higher than that in most of the cities of African and Asian, though the average speeds are lower. This indicates that due to heavy pedestrian flows and limitation imposed by width of the facility pedestrians in Addis Ababa walk slower but given an ideal condition they may walk faster than their counterparts in other countries. "Therefore, the relationship between pedestrian density and quality of spaces in commercially active city centers in the built-environments in relation to built-forms is quite strong."

The Analysis result also indicates that the current situation of pedestrian density in almost all case study areas are exceeding 5.5p/m2 and is clear manifestations of jam pedestrian density as good indicator of poor quality spaces in commercially active centers in Addis Ababa. However, the literature review of best

Table 5: Transportation Factors Limiting Walking assessed from all four case study areas (Survey Results, 2016)

What Transportation System Factors Limit You From Walking More Often?				
	# of Responses	Average Ranking Score*	# of Responses by Priority Rating	
			StRONG (4&5)	LOW (1&2)
No Sidewalks	823	2.30	145	678
Crossing Barriers	823	2.15	165	658
Width of Streets	820	1.78	136	684
Not Enough Crossing Time	820	1.63	139	681
Paths Start and Stop	816	2.62	196	620
Not Enough Trails	816	2.66	189	627
Not Enough Separation	816	2.71	202	614
No Wheelchair Ramps	809	1.40	186	623
Sidewalks too Difficult for Wheelchairs	813	1.42	66	747
Distance/Time	816	2.56	151	665
Poor Maintenance	811	2.26	131	680
Poor Transit Stops	814	1.97	52	762
Inadequate Lighting	819	2.86	179	640
* Ratings scale from 1 (Not a Factor) to 5 (Most Important)				

practice and observation unveil that the pedestrian density at capacity is found to be 3.3p/m2 on sidewalks, 2.86p/m2 on wide-sidewalks and 2.56p/m2 on commercial precincts. This is almost similar to the trend observed for speed. The jam pedestrian density is expected to be higher than 4.5p/m2. The pedestrians are found to maintain higher buffer space on wider facilities resulting in relaxed walking. Even at very high density, the pedestrians adjust the space available without causing body-to-body contact as indicated by area module at capacity flow, which are clear manifestations of poor quality urban spaces like weak pedestrian friendly built environments. It infers that the width of a facility along with density governs the pedestrian behavior.

On the other hand, the study confirmed that pedestrian and Built-up density characteristics are the basic determinants of quality spaces in commercially active built environments and built forms. It is evident that the higher the ground coverage (>65%) the lower quality by occupying spaces with dense built-forms for the above stated quality elements as well as pedestrian density exceeding 3.3p/m2. The analysis results further underlines that Jam pedestrian density could be perceived when it exceed 4.5p/m2highly deteriorates pedestrian friendly market oriented built-environment. Therefore, the lower the pedestrian density the higher pedestrian friendly built-environment and the lower ground coverage within the density thresholds (BAR: <65% in commercial centers) is showing the increasing trend of better quality of urban spaces. These are clear manifestations of the direct relationships among pedestrian density, built-up density (high FAR) and quality of spaces as already being deeply analyzed in cross case analysis. Hence, total floor area ratio (FAR) as component of built-up density has direct relationship with higher pedestrian movement and quality of spaces, like increasing total floor area ratio means increasing the height of the commercial and mixed use buildings with many more flats so as to allow more people to work in business, and shopping in.

It is also worth mentioning that urban spaces design and planning should respect proper pedestrian circulation spaces with optimum pedestrian density (<3.3p/m2) along (Standard widths of street: 8m minimum, 12m, 15, 18, 25, 30, 40m etc) as well as proper dimensions of pedestrian walkways (3-5m) in the built-environment creating pedestrian friendly circulation spaces as basic determinants, vehicular spaces to install attracting sustainable built-environments. Street grids generally should allow better pedestrian circulation because they have more intersections and more connecting streets. Subdivision regulations could be revised to require a minimum number of connecting streets to existing roads and/or a limitation on the number of cul-de-sacs, or a similar regulation the encourages pedestrian-friendly street patterns in commercially active centers in order to declare pedestrian friendly built-environment.. Similarly, the analysis result also unveils that creating a strong street wall in relation to built-forms by locating building frontages is at the required setback or, where no setback requirement exists, at the front property line of the commercial buildings. Where additional setback is necessary or a prevailing setback exists, activate the area with a courtyard or "outdoor room" adjacent to the street by incorporating pedestrian amenities such as plazas with seating or water features, for example with average and optimum building coverage (BAR) and high Floor area ratio (FAR) as built-up density in relation to built-forms. Otherwise, the results clearly have shown the poor quality of spaces in commercially active built environments.

It is also quite worthy to provide direct paths of travel for pedestrian destinations within large developments. Especially near rapid bus transit lines, create primary entrances for pedestrians that are safe, easily accessible, and a short distance from transit stops in order to install pedestrian friendly commercial built environments. Therefore, optimum pedestrian density is very important to maintain existing alleys for access in relation to built-forms so as develop quality urban spaces. It is also used to avoid vacating alleys or streets to address location-specific design challenges. In dense commercial neighborhoods, it is also possible to incorporate passageways for pedestrians into mid-block develop¬ments, particularly on through blocks that facilitate pedestrian access to commercial amenities from adjacent mixed use areas to maintain easy access to commercial areas from adjacent mixed use neighborhoods so as to avoid unnecessary or circuitous travel. Hence, paths should never be blocked by a fence that impedes the pedestrian flow, a kind of poor quality urban spaces indicator.

The study also found that personal, environmental and transportation factors that would discourage walking in market oriented built-environments include weather, personal health/fitness levels, terrain, and concerns about safety and crime as some determinants of pedestrian flow. The two personal and environmental factors receiving the highest relative importance were inattentive or aggressive drivers (safety) with an average score of 2.87, and too dark (average score of 2.78). Particularly noteworthy is that concerns about inattentive and aggressive drivers received a higher score than any factor, both in the personal/environmental and transportation system categories indicating that a focus on pedestrian safety and traffic calming in those active commercial areas that will be an important component in the development of a complete pedestrian friendly network. It is also strongly believed that personal, environmental and transportation factors are also boldly affecting the pedestrian density to make sure quality urban spaces by planning and design of pedestrian friendly public spaces. Hence, transportation factors that potentially influence whether one might choose to walk include lack of sidewalks, crossing barriers (highway, streams), unsafe street crossings, incomplete sidewalk networks (stopping and starting), sidewalk too close to moving traffic, and poor maintenance of sidewalks lead to poor pedestrian friendly built-environment . Low scores are particularly surprising given the fact that some mothers who regularly push their children in strollers indicated that wheelchair ramps are important to them for this reason. Therefore, particularly encouraging is the low average score of "don't enjoy," which received an average score of 1.24, indicating that most respondents enjoy using their feet as a mode of transportation or pedestrians. Therefore, it is quite essential to plan and design pedestrian friendly commercial and mixed use environment in the city.

Finally, as being analyzed and explicitly addressed in the analysis results and review, the pedestrian densities exceeding 4.5p/m2 would create jam and poor pedestrian commercial and mixed use built-environments as implication. Similarly, the analysis result unveils that commercially active areas with built-up density including BAR exceeding 65 % and floor area ratio (FAR) less than 2.0 may discourage pedestrian flow characteristics and leads to weak pedestrian friendly commercial corridors. Therefore, in this post modern era, urban centers must be highly dominated by pedestrian movements and enhancing mass transit system instead of individual automobiles in the built-environments. It is also recognized that sidewalks are desirable in other locations to make pedestrian friendly built-environment. For example, sidewalks are required both sides of collector streets and on at least one side of local streets for new commercial and mixed use developments. Finally, the index provides a strategy for the City Administration to complete the sidewalk network in commercially active areas in efficient way - that is, to build those sidewalks which are most critically needed first, and then systematically complete the entire sidewalk network in order of priority so as install pedestrian friendly built-environment through optimum or capacity pedestrian density. Therefore, the impact of density on quality of spaces in relation to built-forms is very significant according to the findings of the study.

CONCLUSION

This study concludes that built-up densities of commercial and mixed-uses, are associated with walking for transport through pedestrian density at all ages and that people living in higher density commercial built-environments undertake more walking and physical activity than people living in low density commercial areas. On the other hand an international literature review and analysis results on pedestrians found that density was associated with walking for travel in most studies. This study also made sure that the challenge in finding the link between built-up densities and walking has been explored by trying to separate out the role of density from other built environment features. One key study found that walking for transport was most strongly related to land use diversity, intersection density, pedestrian density and the number of destinations within walking distance.

The study on the other hand concludes that the impact of pedestrian and built up density as well as behavior of pedestrians walking on different type of facilities and under varying flow conditions. It is observed that the speed-density relationship follows exponential form on sidewalk of varying widths and linear form on a non-exclusive facility like side of a carriageway. Pedestrians behave similarly to each other within a close band of flow characteristics, up to a width of 9.0 m and beyond this the behavior changes drastically.

Similarly, it concludes that the pedestrian density at capacity is found to be 3.3p/m2 on sidewalks, 2.86p/m2 on wide-sidewalks and 2.56p/m2 on commercial precincts (15.51% reduction). This is almost similar to the trend observed for speed. The jam pedestrian density is expected to be higher than 4.5p/m2. The pedestrians are found to maintain higher buffer space on wider facilities resulting in relaxed walking. Even at very high density, the pedestrians adjust the space available without causing body-to-body contact as indicated by area module at capacity flow, which are clear manifestations of poor quality urban spaces like weak pedestrian friendly built environments. It infers that the width of a facility along with density governs the pedestrian behavior.

Recommendations

This study has been structured to underline recommendations about pedestrian travel, pedestrian friendly commercial built-environments, built-up density thresholds, provision of new pedestrian facilities, Repair and upgrade of existing facilities, Signalized pedestrian crossings, pedestrian density in relation to built-forms. The research result highly addresses, Pedestrian friendly Streets with pedestrian density thresholds in commercially active built-environments are places that people like walking and want to stay in, with real character and sense of place. It has to be recommended that all customers in this market oriented centers should have to have access to good quality spaces and connectivity to where they work, and live, possibility to use pedestrian spaces, safe and secured environment, accessibility for amenities, circulation and mobility.

Finally, the study underlines the following recommendations to be taken by the city administration and other concerning body so as to bring about good quality of urban spaces in the commercially active built-environments, in relation pedestrian density and built-forms:

The city administration should increase pedestrian travel, and the majority must have explicit goals or targets so as improve pedestrian friendly built-environment;

The policies, activities undertaken, and guidelines should be followed by each sub-city to provide pedestrian facilities together with optimum pedestrian density.

The City Administration must receive complaints and requests about specific issues, and pressure to improve the overall pedestrian network;

Pedestrian density and pedestrian flow characteristics should be used to plan pedestrian friendly commercial and mixed used use built-environments;

Pedestrian facilities are important components that should Incorporate features such as white markings, signage, and lighting so that pedestrian crossings are visible to moving vehicles during the day and at night so as to make sure pedestrian friendly commercial environment through optimum pedestrian density.

Optimum pedestrian density should be taken as very important component to maintain existing alleys for access in relation to built-forms so as develop quality urban spaces.

place public use areas such as restaurant seating, reception, lobbies, and retail, along street-facing walls where they should be visible to passersby as pedestrian friendly environment

The pedestrian buffer space (space occupied by a pedestrian along with half of the surrounding clearances between pedestrians) at capacity flow should be found to be 0.33 m2/p on sidewalks, 0.35 m2/p on wide-sidewalks and 0.39 m2/p on Commercial and mixed use built-environments.

Consistent architectural detail or good built-forms with optimum built-up density (<65%) and design elements must be well emphasized to provide cohesive urban spaces along proper pedestrian circulations (<3.3p/m2) as being addressed in the analysis.

The City Administration should plan and design pedestrian friendly commercial and mixed use environment in the city through Sidewalk Priority Index.

Pedestrian density at capacity should be found to be 3.3p/m2 on sidewalks, 2.86p/m2 on wide-sidewalks and 2.56p/m2 on commercial precincts. This is almost similar to the trend observed for speed. The jam pedestrian density is expected to be higher than 4.5p/m2.

Pedestrian and Built-up density characteristics should be the basic determinants of quality of commercially active built environments and built forms. It is evident that the higher the ground coverage (>60%) the lower quality by occupying spaces with dense commercial built-forms for quality elements as well as pedestrian density exceeding 3.3p/m2 for poor pedestrian friendly built-environment.

The city administration should be moving towards providing wider sidewalks on both sides of both collectors and arterial streets. The study areas currently requires sidewalks on both sides of arterials & collectors streets;

The city Administration and concerned body should have to address issues and policies regarding accessibility in terms of pedestrian priority and they do feel that the city administration guidelines from structural plan are robust or progressive enough.

The city administration should have policies on the placement of street furniture not only one had a system to zone the differing segments of sidewalks, as well as guidelines on where street furniture, such as public telephone, hydrants and parking meters, can be placed;

All pedestrian friendly built-environments should have GIS (Geographic Information Systems) that are supposed to be interested in introducing a system. The world cities are currently testing handheld computers with GIS maps for sidewalk inspections and so on;

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