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DEPARTMENT OF CIVIL AND CONSTRUCTION ENGINEERING

Pedestrian Travel Speed: Case Study of Tom Mboya Street in Nairobi Kenya

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Degree of Master of science in Civil Engineering (Transportation Engineering)

F16/80906/2015

A thesis submitted in partial fulfilment for the award of the Degree of Master of Science in Civil Engineering (Transportation Engineering Option) of the

University of Nairobi.

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DECLARATION AND APPROVAL

This thesis is my original work. I also affirm that to the best of my knowledge; this has not been presented for a degree in any other university.

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ABSTRACT

The study examines NMT operations along Tom Mboya Street. Tom Mboya Street is an access road, with vehicle operation speed at this section of the road is 40 Km/hr. Pedestrian activities dominate the street operation. The area is also immersed by; wailing horns, hawking, pulsing calls, visual impairing advertisement, and musical noise. Tom Mboya street offers access and a crucial connection links to most Nairobi metropolitan regions and estates. The study aims to identify individuals' pedestrian speed and additional absolute walking aspects to fulfil the gap of understanding speed needs. The study adopts regression analysis to weigh, examine pedestrian speed and the outcome presented in graphical form. Mitullah and Makajuma (2011) observed that the walking speed range for pedestrian crossing is from 1.2 to 1.3 meters/second for mixed pedestrian age groups. Walking speed varies from 1.07 to 1.37 meters/second depending on the heat level, gathering size, surface texture, and path density (Traffic Engineering Handbook, 2007). Although Chapter 403 of the Traffic Act emphasizes pedestrian safety, such as Non-Motorized Transport (NMT), the Act has no reference to jaywalking. A desk analysis and a field study were employed to assess pedestrian velocity in this study.

The findings established an average crosswalk speed of 1.14 metes/second, and discrete gender suggests that virile pedestrians cross at 1.17 meters/second while feminine utilizes 1.10 metes/second. The study street's maximum pedestrian at-grade speed ranged from 1.17 to 1.26 meters/second, an average of 0.87 to 0.93 meters/second for road users of different ages. Since no literature on at-grade pedestrian speed, design values, the findings were unique for that walkway. The study found that hostile street environments, negative social attitudes toward NMT (NMT mode use reflect the pedestrian's social status in Nairobi), and inappropriate NMT regulation are the main barriers to NMT usage. The walkway operates at

Level of Service LOS D, instead of the suggested boost to LOS C or higher grounded on maximum pedestrian volume. An approximate pedestrian space of 1.60 square meters/pedestrian, with a current flow of 49 - 75 Ped/min/m and 1.95 m effective walk width, was established. Pedestrians interviewed proposed NMT policy review in Nairobi. To handle NMT physical limitation logical approach was suggested. It means effective restrictions, scheduling, urban design, performance, and sustainability factors are necessary for sustainable urban mobility. There is a need for policy improvement in the following areas; jaywalking, outdoor advertisement, noise, health, and safety policy.

ACKNOWLEDGEMENT

I truly appreciated my supervisors, Dr. Solano Simpson Nyambane and Professor Sixtus Kinyua Mwea. For their continual backing and supervision, they offered towards the conceptualization and writing of this thesis. I certainly value their involvement to the prosperous thesis completion.

Lastly, my heartfelt gratitude goes to my family and friends. God bless you all plentifully.

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ABBREVIATIONS

ADA	-	American with Disability Act
CDB	-	Central Business District
HCM	-	Highway Capacity Manual
JICA	-	Japan International Cooperation in Africa
LOS	-	Level of Services
m/sec	-	Meters per second
m^2/ped	-	meters square per pedestrians
MT	-	Motorized Transport
NMT	-	Non-Motorized Transport
PSV	-	Public Service Vehicle
PWD	-	People with Disability

Chapter One

1. INTRODUCTION

1.1 Background of the Study

Speed and space are essential for urban mobility. They are pointers for urban overcrowding and are used to evaluate travel time. Walkway pattern knowledge is a requirement for traffic engineers. Walkway Level of Service (LSO) provides an adequate descriptor of walkway performance level. The LOS is a measure of traffic flow utilizing the aspect of speed and space management (HCM 2010). Walking speed depicts walkway LOS, supportive in street design features aimed to optimize conflict point managements, perception and quantified based on speed, flow, density, space, and density.

The variable speed describes all transport mode performance. Displacement at a distance of one meter in a unit time of one second (m/sec) defines the pedestrian speed (HCM 2010). Speed is essential in urban planning to determine the mode frequency and operational timing of transportation systems. However, variable walking speed is often not used in infrastructure planning. Comparison of the results with other study results helps in the evaluation of the existing correlations. In public transportation, speed and space are vital in gauging facility performance levels (Fruin 1971). Zoning pedestrian source and concentration areas enable movement characteristics extraction to determine design flow characteristics such as; pedestrian speed, space, flow, and density. These characteristics are vital in the design of urban mobility systems. Fundamental movement features in urban mobility are speed and pedestrian space. They are indicators for urban congestion essential for evaluating travel time.

Walkway pattern knowledge is a requirement for traffic engineers. The LOS utilizes the aspect of speed and space management (HCM 2010). Walking speed depicts walkway LOS, supportive in street design features aimed to optimize conflict point managements, perception and quantified based on speed, flow, density, space, and density. The variable pedestrian speed describes all transport performance. Displacement at a distance of one meter in a unit time of one second (m/sec) defines the pedestrian speed (HCM 2010). Speed is essential in urban planning to determine the mode frequency and operational timing of transportation systems. However, variable walking speed is often not used in infrastructure planning. Most finding and studies exist on cross points speed, with limited research in at-grade pedestrian speed in the area of high concentration informing the study need. Comparison of the results with other study results helps in the evaluation of the existing correlations. In public transportation, speed and space are vital in gauging facility performance levels (Fruin 1971). Zoning pedestrian source and concentration areas enable movement characteristics extraction to determine design flow characteristics such as; pedestrian speed, space, flow, and density. These characteristics are vital in the design of all urban mobility systems. This study focuses on the analysis of pedestrian speed and space characteristics.

1.2 Study Zone

Paratransit dominates public transportation in the Nairobi (Kenya) Central Business District (CBD). Consequently, uncontrolled urban sprawl leads to the strain of a few transport corridors in Nairobi. In the last four decades, the Nairobi population growth rate has increased by 0.01 percent. By the year 2020, the figure has reached 4.7 percent. Previous findings acknowledge walking dominancy in Nairobi; home trips contribute 34.8 percent, although school base trips are on the surge of 46.7 percent (Japan International Cooperation Agency 2014). The study examines Non-motorized transport (NMT) operations along Tom Mboya Street. Tom Mboya Street is an access road, with vehicle operation speed at this section of the road is 40 Km/hr. Pedestrian activities dominate the street operation. The area is also immersed by; wailing horns, hawking, pulsing calls, visual impairing advertisement, and musical noise. The street offers access and a crucial connection links to most Nairobi metropolitan regions and estates.

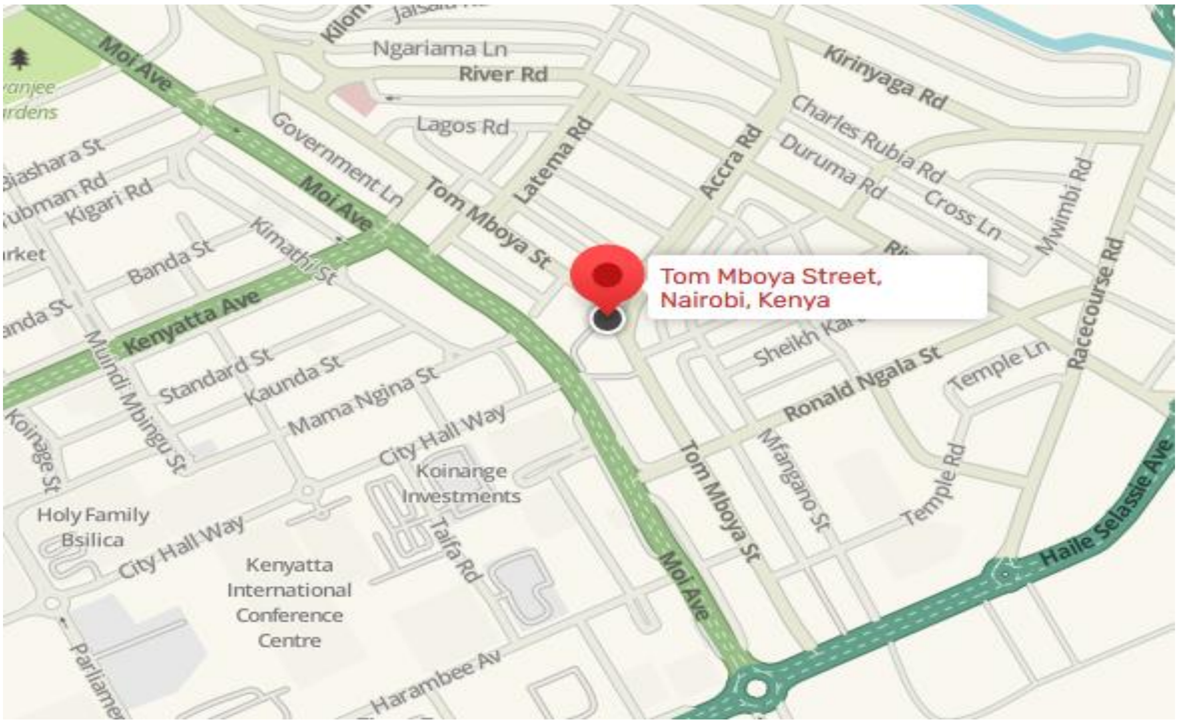


Figure 1. 1: Satellite Image showing the Tom Mboya Streets in Nairobi CBD

Source: https://www.waze.com/live-map/directions/kenya/nairobi-county/nairobi/tom-mboya-street (2021)

(Road label with the red line is Tom Mboya Street linking between Khoja roundabout, Luthuli Avenue, Latema road, Ronald Ngala road, and Haile Selassie Avenue)

1.3 Problem Statement

Urban sustainability measures pedestrian access usage; sustainability achieves a specific performance rate or level, focusing on the present and future use. The walkway should be uniformly leveled, fit with resting area, all-weather surface, usable by all pedestrian groups, and operate at appropriate LOS. In this area, walking dominates all modes, and pedestrian density is consistent throughout the day leading to reduced speed and sporadic congestion. Planning information, maintenance schedules, and poor organization of paratransit unit limitations contribute to pedestrian challenge consistency (See Appendix 6). The street is full of automobile activities, alongside poor pedestrian infrastructure, demonstrated by the abundance of parking slots, hawking, obstruction, dirty narrow sidewalks, and encroachment impacting walking speed and space management. The advertisement signage height potentially destructs pedestrians and inflicts injuries on road users. The walkway infrastructure lacks user guide systems. However, walkway surfaces are deformed (See Appendix 7: Plate 1 and Plate 2). Currently, the Nairobi Metropolitan service is investing much in pedestrian facilities. However, Non-motorized transport (NMT) facilities remain challenged, marginalizing vulnerable units in the society relying on those facilities and limited opportunities for alternate mobility means. With limited resources, the agencies are grappling to provide. There is a need to understand the street activity's contribution to pedestrian mobility and its influence on pedestrian speed and flow.

1.4 Research Hypothesis Statements

The demerits of NMT usage along Tom Mboya street outlined in the problem statements necessitate review and identifying necessary solutions to promote walking and uplifting NMT sustainable development. It compels the researcher to test the following hypothesis statements: -

1. Singularity in the use of transport infrastructure enhance speed and flow
2. The pedestrian activities and attraction are impactful in LOS management
3. Perceptions enhance walkway usage

1.5 Research Questions

The null hypothesis above relieves subject matters addressed to satisfy hypothesis statements, achieved by asking the following research questions: -

1. Are the urban walkway mobility and congestions a factor of pedestrian speed?
2. What is the contribution of space and street utilizing activities impact flow?
3. Do walkway attractiveness and perceptions impact mobility?

1.6 Research Objectives

The objectives specifically include to: -

1. Examine and determine the average speed, and flow frequency of pedestrians.
2. Evaluate the pedestrian walkway LOS along the study area.
3. Quantifying the pedestrian perception needs to enhance walkway use and development.

1.7 Research Scope

The study examines and establishes at-grade pedestrian variable speed, flow, and space. Already existing models are used, with limited or no alteration of existing variables. And the results were adopted to stimulate NMT use and values adopted for design.

1.8 Research Limitations

The study is limited to at-grade pedestrian characteristic evaluation. Testing parameters speed, space management of pedestrians walking within the effective walk width. Single cross point also examined. Although, the influence of other modes and activities is assumed negligible. And the effect of pedestrians moving in the opposite direction is insignificant.

1.9 Justification of the Study

The uncontrolled urban sprawl necessitates transportation planning needs to promote public transportation. Fruin (1971) pioneered the analysis of pedestrian facilities and information needs. The design variables such as speed and space are essential to design and operations parameters. Often designers use design values adopted from various literature. At-grade pedestrian characteristic values will influence reconsideration of the existing empirical design values.

Chapter Two

2. LITERATURE REVIEW

2.1 Overview

The reviews outline existing background knowledge on the study area by other researchers, drawing study gaps locally, worldwide, identifying variables statements, models to understand pedestrian mode, and focusing on objective statements. To conceptualize speeds and space evaluation to outline and generate inferences affecting walking.

2.2 Studies on Travel Speed in Kenya

2.2.1 At – Grade Walking Speed

Pedestrians within the Nairobi Komarock area registered at an at-grade speed of 1.41 m/sec although, the findings lacked a model validation framework. However, Non-Motorized transport (NMT) facilities exist pedestrians often cross the road at undesignated areas (Orege M. 2018). The results exceed the 1.40 m/sec proposed at-grade speed (HCM 2010). Although more researchers established factors influencing walking speed. Footbridge usage is gaining popularity along major crossing corridors. Pedestrians use 1.56-minute walking at 0.74 meters/second mean speed to cross the entire Uthiru footbridge. With average ascending and descending speed of 0.58 m/sec (utilizing 0.69 minutes) and 0.76 m/sec (0.45- minutes) respectively. Although the facility lacked People with disability (PWD) structures (Majanja 2011). Limited studies in Kenya focus on grade pedestrian speed, majorly examining cross points.

2.2.2 Speed at Crossing Point

Mitullah and Makajuma (2011), Joogo road modelled as a mix-use facility, with existing walking and cycling lanes. Pedestrians cross two-lane carriage of 7 meters at an average speed of 1.20 to 1.30 meters/second, waiting time of 16 seconds for an adequate crossing gap to exist. The findings rely on observational techniques marred with inadequate sampling information and model validation. Mbache and Otieno (2001) postulate pedestrian intersecting speeds of 1.20 - 1.13 meters/second for Kenyatta avenue and University way road, exceeding 1.02 meters/second, endorsed by Fruin (1970). The pedestrian areas are affected by signal timing durations, generating pedestrian areas of 0.72 m^2 and 3.5 m^2 tentatively along Kenyatta avenue and the University way, exceeding the Fruin (1971) values of 0.6 m^2 – 3.5 m^2 pedestrian areas.

2.3 Travel Speed in Other Zones

2.3.1 At – Grade Walking Speed

Young pedestrians with less than two decades walk at a mean speed of 1.24 meters/second faster than elderly pedestrians above five decades. Pedestrian of age between 20 years to 50 years walks at an average of 1.20 meters/second, suggesting reduced walking speed with the increase in age (Satish et al. 2014). Azmi et al. (2012) evaluated characteristics of rural and urban pedestrians. A maximum speed of 1.45 meters/second represents the speed of male pedestrians in rural areas, walking faster than rural females. In urban areas, young female pedestrians below 12 years achieve a maximum speed of 1.46 meters/second. Although, the speed values lack a validation framework. The remaining groups are slow. Walking speed is affected by land use, age, and sidewalk availability (Azmi et al. 2012)

2.3.2 Speed at Crossing Point

Boon Hoe et al. (2012) at signalized crossing speeds of 85^{th} and 15^{th} percentile range from 1.31, 1.53, and 1.09 meters/second. While non-signalized cross point similar percentiles are 1.39, 1.63, and 1.15 meters/second in turn, with rampant age influence on speed and higher speed achieved at signalized points. At the crosswalk, young pedestrians are faster than old pedestrians in the USA - Portland - Oregon, attaining mean pedestrian haste of 1.51 meters/second, despite the 15^{th} percentile speed of 1.24 - 1.07 meters/second for young and old pedestrians (Carey 2005). Walking is affected by the proportion of elderly proportion on the walkway (Knoblauch et al. 1996). Rahman et al. (2012) identified the following impediment; age, gender, walkway infrastructure, and environment. The infrastructure outline walkway values such as location, terrain, and platform. In walkway design, user age proportions are significant. A speed of 1.2 meters/second is adopted when elderly users exceed 20 percent (Pushkarev (1978) and Fruin (1971)).

2.4 Level of Service (LOS)

LOS describes the traffic flow and operation quality of the walkway. The LOS descriptive parameters are pedestrian speed, space, flow, and density concentration. Sidewalks performance measured based on circulation area capacity (individual utilized area) and fluctuation on flow leading to platooning effect. LOS is a walkway appraisal tool for pedestrian capacity, comfort, and space. LOS is categorized in LOS A to LOS F. At LOS A, the desired speed is achievable, illustrating optimal operation conditions. While at LOS F, the pedestrian speeds are low, with inadequate freedom to choose the pacing distance (shown in figure 2.1). Khisty (1994) and Sarkar 1993 acknowledge the effect of environment, safety, security, and comfort on LOS. These were similar to (Fruin 1990) findings in queuing areas. Equation 2.1 evaluates pedestrian space in circulation areas.

$M = T_{Sc}/4V_{tot}$ Equation 2.1

Where: M – Pedestrian movement area (m^2/ped), T_{Sc} – Whole walking space available, and V_{tot} –Aggregate pedestrian walking in a complete series.

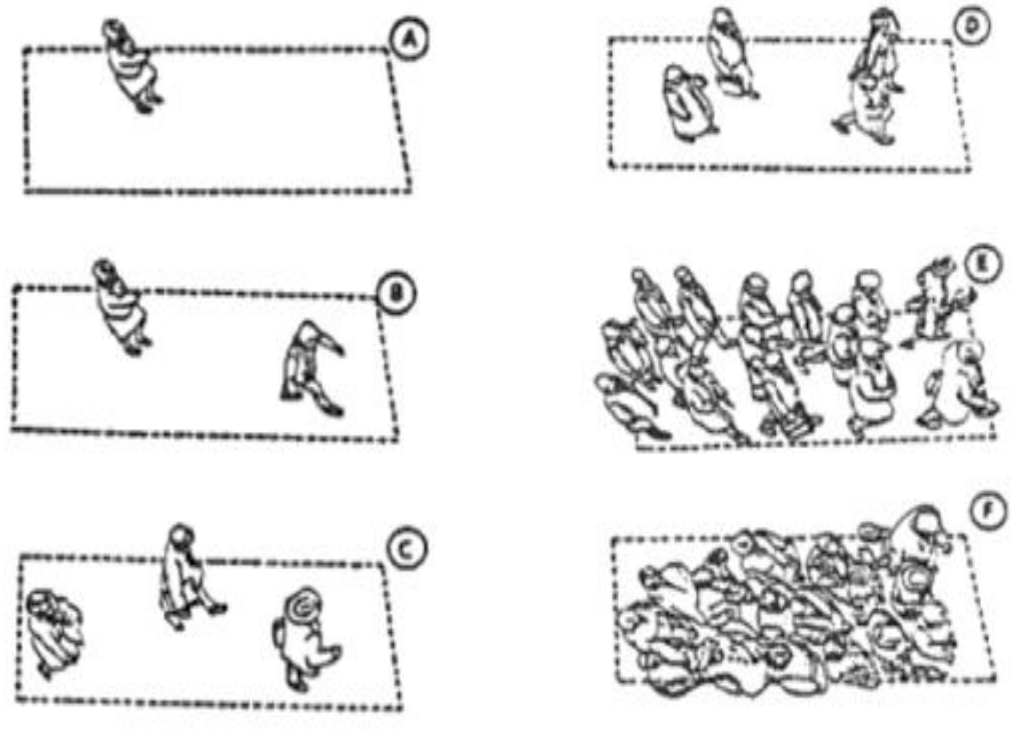


Figure 2. 1: Walkways Level of Services Illustration (As pedestrian density increases space (Sensory zone forward space-diminish and freedom walking speed is limited)

Source: HCM (2010)

2.4.1 LOS Studies in Kenya

Komarock zone, walkways function at the level of service F flow rate 94 ped/min/m (Orege M. Otieno 2018) as opposed to 79 ped/min/m attained in Nairobi CBD cross point influence by periodic variation (Mbeche and Otieno 2001). Majanja (2011) established LOS F as the operation capacity of Uthiru footbridge, recommending improvement to LOS C where streamflow controls are necessary.

2.4.2 Level of Service Studies in the Other Areas

Fugger et al. (2000) acknowledge factors such as corner space, crossing points, and NMT intersection yielding walkway environment development needs. Muraleetharan et al. (2005), in Sapporo - Singapore, pedestrians prefer routes with more rights of way. By adopting stepwise regression analysis, the findings purposed to identify factors affecting intersection, estimate pedestrian LOS at corner and cross points to improve NMT usage. Equation 2.2 was adopted to evaluate LOS, although the model variable needs through evaluations and validation.

$$\text{Pedestrian LOS at crosswalks} = 7.842 + \sum_{i=1}^{3}\sum_{j=1}^{3} \mathrm{Dij}\,\partial\mathrm{ij} - (0.037 * \mathrm{Pd}) - 0.0031\mathrm{Pb}$$

Equation 2.2

Where;

Dij – categorical scores linked to the j^{th} level of the i^{th} characteristic, ∂ij - 1 if the j^{th} level of the i^{th} characteristics exists, Pd – Pedestrian delays (seconds), and Pb – (number of pedestrians - bike relations).

Pushkarev et al. (1975) evaluated pedestrian LOS, 15 minutes count of pedestrians passing a specified point, reducing the figure to one minute afterward dividing with effective width. Table 2.1 shows the LOS value related to space, flow, and average speed. The LOS is a flexible method, focusing on factors appropriately addressed through planning and engineering.

Table 2. 1: Footpaths LOS

LOS	**Space (Square meters/pedestrian)**	**Flow frequency (pedestrian/minute/meter)**	**Mean Speed (meters/second)**	**Flow/Capacity V/C share**
A	≥5.6	<16	>1.3	≤0.21
B	3.7-5.6	16-23	1.27-1.30	>0.21-0.31
C	2.2-3.7	23-33	1.22-1.27	>0.31-0.44
D	1.4-2.2	33-49	1.14-1.22	>0.44-0.65
E	0.75-1.4	49-75	0.75-1.14	>0.65-1.00
F	Below 0.75	variable	Below 0.75	Variable

Source: HCM (2010)

Where; V/C is the ratio of the flow volume to the ideal capacity of the walkway. The capacity value is approximately 78 ped/min/m (HCM 2010).

2.5 Pedestrian Characteristic Curves

2.5.1 Correlation of Speed – Concentration (Density)

Available space impact mobility and speed for the students, commuters, and shoppers expressed in figure 2.2. The pedestrian density varies inversely proportional to speed.

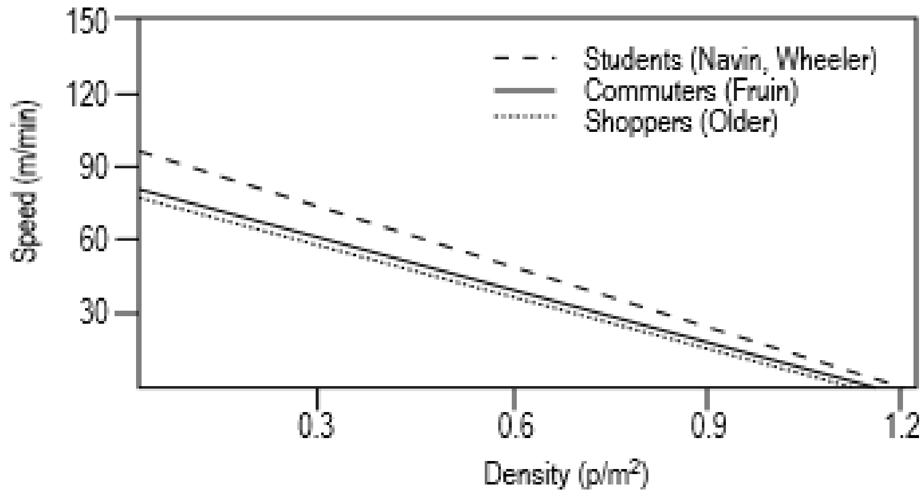


Figure 2. 2: Correlation of Speed - Density Curve

Source: Pushkarev and Zupan (1975)

2.5.2 Speed – Space Correlation

The speed and space criteria evaluate LOS (figure 2.3) (HCM 2000). Pushkarev et al. (1975) suggest that, as space increases, pedestrians achieve higher walking speed. And the pedestrian speed of 1.8 m/sec is attained at pedestrian space more than 4.0 m^2/p as space reduces to less than 3.5 m^2/p flow is compressed. Correspondingly, as space per person increases, the ability to choose pace increases afterward for the pedestrian to achieve maximum speeds.

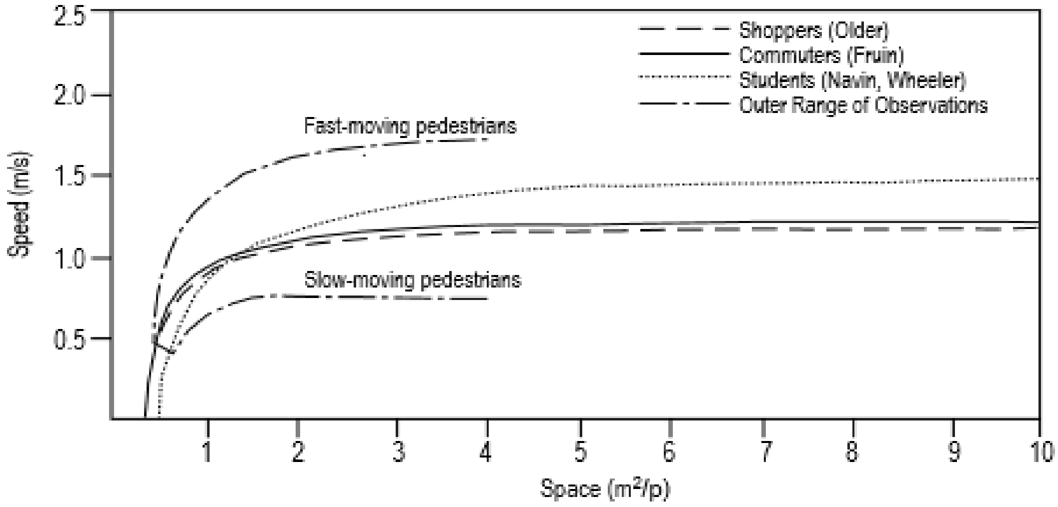


Figure 2. 3: Correlation of Speed - Space Curve

Source: Pushkarev and Zupan (1975)

2.5.3 Speed – Flow Correlation

As flow increases walking speed declines, crowding results in speed decline (Pushkarev et al. 1975).

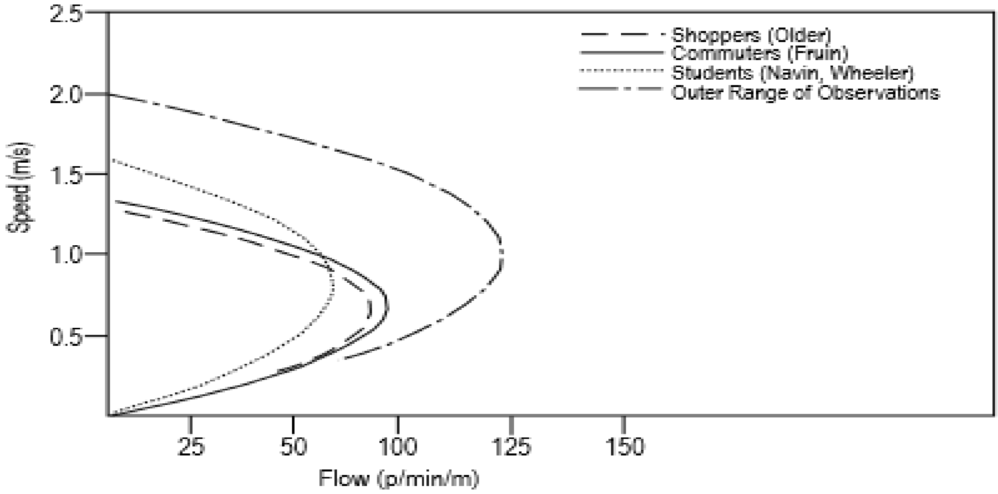


Figure 2. 4: Correlation of Speed - Flow Curve

Source: Pushkarev and Zupan (1975)

2.5.4 Flow – Concentration Correlation

HCM (2010) discloses the link between; density, speed, and flow stream equivalent illustrated by equation 2.3.

Unit flow $V_{pedestrian}$ (pedestrian/minutes/meters), = $S_{pedestrian\ speed}$ (meters/minute) * $D_{pedestrian\ density}$ (pedestrian/square meters) Equation 2.3

The most suitable expression for Pushkarev and Zupan (1975) uses mutually beneficial concentration or interplanetary as follows:

V_{ped} =$S_{pedestrian}$ / M (square meters/pedestrian Equation 2.4

Where: M – interplanetary of pedestrian (square meters/pedestrian)

HCM 2010 proposes an ultimate (peak) of 15 minutes of pedestrian count with certain variables of width to be used in determining the unit flow rate, as shown in equation 2.5.

$Vp = V_{15}/(15*W_E)$ Equation 2.5

Where: WE – Actual path breadth (m), V15 – Highest 15 min flow degrees, and Vp – Pedestrian unit flow degrees (p/min/m)

Once interplanetary falls beneath 0.4 m^2/p flow rate, all moves effectively end at the least allocation of space of 0.2 m^2/p expresses the technique of LOS evaluation (Figure 2.5).

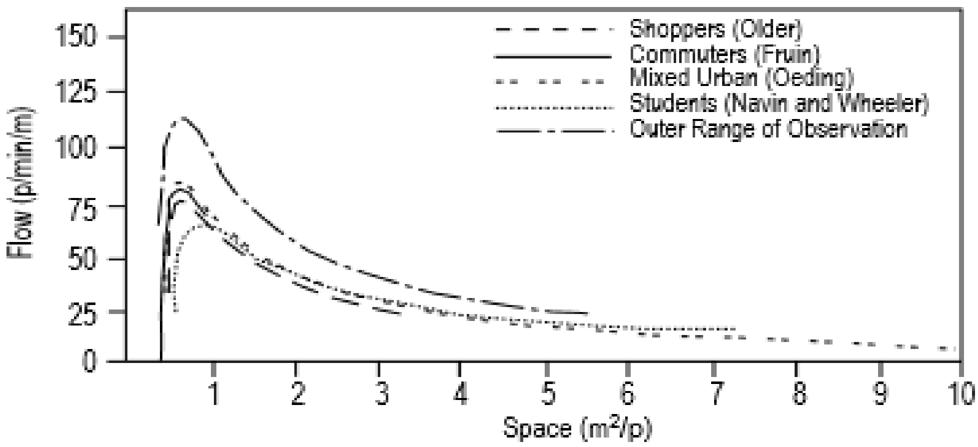


Figure 2. 5: Correlation Flow and Spaces Curve

Source: Pushkarev & Zupan (1975)

2.6 Body Ellipse besides Space

The space and width of the walkway should accommodate user body size. The body size defines by the body ellipse. It is the element about body width and breadth (shoulder span) of regular dimension pedestrian. Useful in space requirement assessment for walkway development. Significant in space requirement assessment for walkway development. Figure 2.6 demonstrates the simplified boy ellipse dimension of area 0.30 m^2 (Fruin 1990). To enhance walking pacing, zone and sensory zone are vital, shown in figure 2.7. The space requirement is firmly attached to speed and space relationships, useful to determine LOS (Fruin 1981).

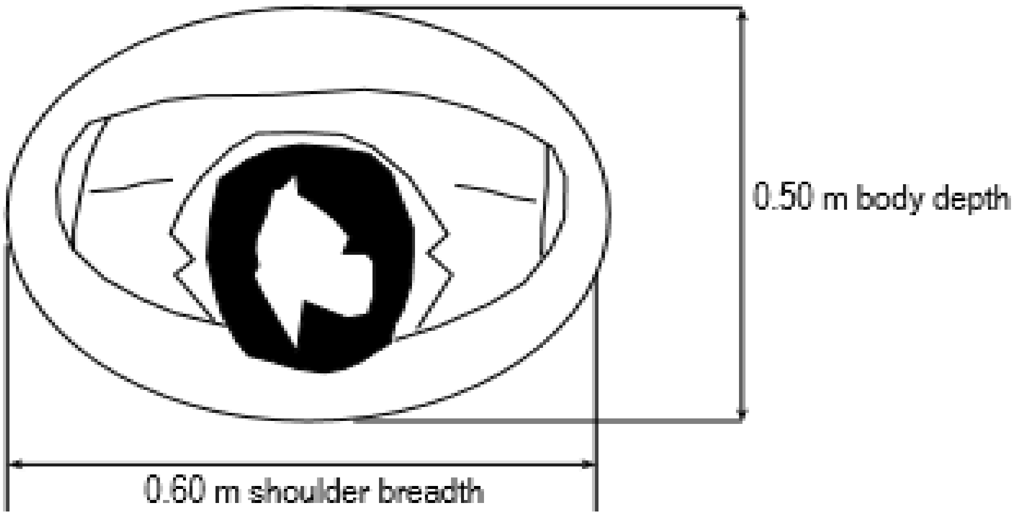


Figure 2. 6: Plan sight of the human physique

Source: Fruin (1990)

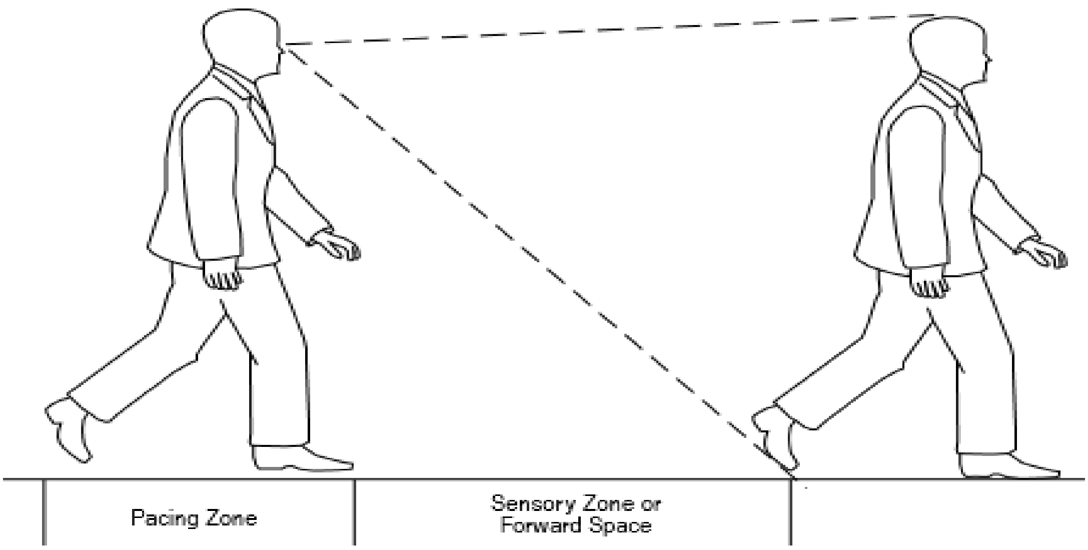


Figure 2. 7: Pedestrian Space.

Source: Fruin (1990)

(Pacing zone is the existing interplanetary to make a step, while the sensory area is the toe distance of succeeding pedestrian)

2.7 Definite Walkway Breadth

Actual walk width defines walkway proportion utilized by the pedestrian, often shy away from the obstruction. The effective walkway width is the overall walkway minus barriers along the width and walkway shy distance used to analyze flow. The lengths of 2.4 m and 1.5 m are preferably for commercial buildings and clear sidewalks (AASHTO 1991). Although lane conception stands not applicable on NMT evaluations effect of abreast pedestrians needs consideration. The pedestrians passing one another need more than 0.8 m widths. Although the pedestrian who knows one another uses space less than 0.7 m, the probability of body sway arises (Pushkarev et al. 1975), equation 2.6 appraises effective walkway width (HCM 2010).

$$W_E = W_T - W_o \qquad \text{Equation 2.6}$$

Where: W_E – Actual path breadth (m), W_T – Entire path breadth (m), and W_o – Wo – the summation of the breadth and path shy distance from obstructions.

2.8 Models Discussion

The microscopic, macroscopic, and mesoscopic models form pedestrian traffic research levels. In the description, the first model involves individual pedestrian evaluation and understanding of how they interact with the walking environment. And macroscopic level segregates pedestrian movement into flow density and speed. Pedestrian movement is quantified similarly to fluid flow with all its characteristics. The mesoscopic model defines each pedestrian individually, hence achieving individual properties such as evaluation of origin-destination. To answer the objectives, flows reviews are vital to investigate the speed parameters.

Therefore, the models reviewed as follows: -

1. Pedestrian speed (m/sec)

Model 2.7 help to determine speed, and the model variables, determined on-site. The street length, determined by monitoring the actual street length. Second, based on simplicity and the ability to eliminate significant impediments such as cars parked and street vendors. The junction point defines the marked area where the pedestrian is measured. The pedestrian time was recorded at the entrance and out of the segment points by stopwatch. Finally, within the segment, the pedestrian walking speed is measured (HCM 2010).

Therefore, the models reviewed as follows: -

$S_A = L_T/(\sum(Li/Si) +(\sum di)$ Equation 2.7

Where: L_T – Whole motorway stretch under evaluation (meters), Li – Segment stretch 'i' (meters), dj – delay at the crossing j (s), Si – walking haste over section (i) (meters/second), and S_A – Mean speed, (meters/second).

2. Effective footpath width

HCM (2010) illustrated equation 2.8 to assess the effective walkway width. The distances are measured as follows: - the information on the walkway inventories is collected, and average walkway width measured. Walking width defines the side of the footpath without obstruction, while the gap between pedestrians and any other objects defines the shy distance.

$W_E = W_T – W_o$ Equation 2.8

Where: W_E – Actual path breadth (m), W_T – Whole path breadth (m), and W_o – the whole width plus the shy distance from obstacles on the paths.

3. Pedestrian flow

Equation 2.3 examine flow for each pedestrian feature. The pedestrian density changes with time as experimental pedestrian speeds examination are essential. The equation variable needs intensive investigation to establish.

4. Pedestrian speed

Speed is the distance travelled per unit of time. At the labelled sidewalks segment, estimate the pedestrian speed.

Speed S (meters/second) = Distance (meters) / Time (Second) Equation 2.9

Walkway facilities are examined based on peak hour demand although, traffic volume fluctuates periodically and is rhythmic. Peak hour factor (PHF) hourly relates peak hour volume and maximum flow rate (Roess et al. 2004).

The pedestrian area = Actual path breadth/ pedestrian volume at peak hour (PHV) (Equation 2.10)

Equation 2.10

Peak Hour Factor (PHF) = $V_p/(P*V_{mn})$ Equation 2.11

Where: V_p – PHV, V_{mn} – Maximum volume for an 'n' minutes

The volume counts; are alienated in development influence to obtain complete peak volume.

$EHF_i = V_i/V_t$ Equation 2.12

Where: Vi – Precise investigation period (i) volume from the controller tally, pedestrians, Vt – Total volume from the pedestrian count for the entire sampling period, and EHFi - Increase hourly element for the specific study hour (i). The modification element considers the precise daily average and weekly average. And weekend modification elements take into account the weekday average.

$A_{fi} = V_a/V_{di}$ Equation 2.13

Where; A_{fi} – Daily adjustment factor (i), V_a – Days with the highest volume count in the pedestrian control count (for example, an average of all weekday), and V_{di} - Specific study day (i) volume from the control count study period, pedestrians. Therefore,

$V_{aj} = V_{djc} * A_{fi}$ Equation 2.14

In which V_{aj} – Volume adjusted to represent a mean daily tally during the regulate count study period. V_{djc} – day volume (i) from the short count period.

5. Space and Density

Weidmann U. (1993) highlighted in equation 2.14 the relationship between longitudinal space and speed. This model variable is difficult to generate because it depends on other factors influencing the speed and peak features.

$$A(V) = A_{jam} - 0.52\ln\left(1 - \frac{V}{V_f}\right)$$ Equation 2.15

Where

V - the walking speed, V_f is the average free walking speed, ($V_f \approx 1.34$ m/s), A = LW - signifies the essential zone (For example, the longitudinal spatial use L multiplied by the lateral spatial use W). A_{jam} is the zone where walking is impossible ($A_{jam} \approx 0.19$ m^2).

Considers small cell C with dimension X × Y × T. Three quantities were determined for all pedestrian trajectories passing through the cell (Daamen, W, & Hoogendoorn, SP 2003).

$$v_x = \frac{q_x}{k} = \frac{\sum_{i\epsilon C} D_i}{\sum_{i\epsilon C} TT_i} \quad \text{and} \quad v_y = \frac{q_y}{k} = \frac{\sum_{i\epsilon C} Z_i}{\sum_{i\epsilon C} TT_i}$$ Equation 2.16

In which generalized density definition of k (in Ped/m^2).

$$k = \frac{\sum_{i\epsilon C} TT_i}{XYT}$$ Equation 2.17

Defined flow in x - y-direction

$$q_x = \frac{\sum_{i\epsilon C} D_i}{XYT} \quad \text{and} \quad q_y = \frac{\sum_{i\epsilon C} Z_i}{XYT}$$

Equation 2.18

The presumption of this chapter provided an appreciative knowledge of past pedestrian speed and LOS trends, with reviews fitness attained. Cross point speed studies frequent speed literature, the at-grade speed research necessitated pedestrian speed studies. Obtain findings, procedure, and study strength in methodology development, data collection, and analysis leading to the study objective.

6. Pedestrian Level of Service

Kagan, L. S, et al. (1978) tested LOS using equation 2.5, and results compared with values in table 2.1. The model merits application in all walkway environments.

2.9 Pedestrian Safety and Regulation

Pedestrians prefer walking to other modes of transportation because of its comfort and benefits. Pedestrian safety was not examined in this study, even though the questionnaire elaborates on pedestrian fear areas. The authority should decongest pedestrian traffic, improve the aesthetic value, and increase footpath LOS. Building performance characteristics, as per Xiao Hang (2009), enhance NMT usage. Through the improvement of street networks, street designs, density, land use, and safety.

2.10 Acts and Policy Papers

Although there is no mention of pedestrians in this Act, measures are employed to protect all road users. To Regulate outdoor advertisement, including billboards, the Physical Planning Act, Cap 286, outlines traffic and pedestrian security aspects. The Act enables the county to enforce the removal of publicity, including on footbridges, that affects traffic and pedestrian safety. The Nairobi County Government should ensure that all advertisements affecting pedestrian safety are detached to reduce the associated risks. The policy document Nairobi Metro (2030) outlines strategies for improving infrastructure and services to enhance the achievement of the 2030 vision. To enhance road capacity, develop bypasses, and develop priority road networks. The development and improvement of NMT are essential to the growth of other infrastructure needs. Nairobi Town Council By-Law (2007) outlines the following annoyance; commuter pollution, failure to obey stop signs, parking violations. It also includes anti-hawking provisions and establishes hawking rules in specific areas. The policy review through discussion of stakeholders was necessary to enhance and enforce this by-law.

2.11 Conclusion of the Literature Review

In planning and design, empirical pedestrian speed of 1.20 m/sec is recommended from most literature although, walking characteristics has changed since Fruin pioneered pedestrian study in 1970. From the past review, most research is focused on pedestrian crossing points, aiming to understand the adequacy of the cross point. But little research exists on pedestrian walking along the walkway in Kenya. Knowledge of the pedestrian characteristic in an urban area is vital for walkway development. The literature reviews finding aim to the development of the study methodology.

Chapter Three

3 METHODOLOGY

3.1 Introduction

The study adopts regression analysis to assess, examine pedestrian speed and the outcome presented in graphical form. Moreover, manual count methods were employed to evaluate individual pedestrian speed evaluated. Isolated pedestrian speed, determined as an independent flow variable. The study evaluates walkway usage and needs areas, focusing on the variable at-grade speed of individual pedestrians, the sample size obtained from the 2019 census report (Kenya Bureau of Statistics 2019 report). The manual speed count technique was employed to obtain pedestrian travel information and speed for one week. To illustrate speed within a flow, neglecting effect due to unilateral movement. The results adopt a minute model to define pedestrian speed, space and analyse data by presenting equations derived from other research papers. Microsoft Excel has been used to collect data on pedestrian speed and information analysis. And the findings are presented graphically or morphed to show appropriate flow representation. The study used a schematic design method to assess the research objective.

3.2 Desk Review and Site Visit

Reviewed secondary data from the internet, articles, publications, government policies and the relationship derived from documents used to understand sidewalks, citing obstacles to walking visibly across the street. The study opted for a field visit to gather footpath inventory. These inventories include sidewalk geometry (length and width), identification of survey areas, street lighting provisions, pavement conditions (for example, street furniture, smoothness of surface, broken surfaces, obstacles, pedestrian channelization patterns as well as cleanliness), crossing points assessment, and reviewing existing laws and policies on pedestrian mode. Tom Mboya, Haile Selassie avenue junction, National Archive, Posta stage, and Khoja roundabout were the pedestrian speed survey point.

3.3 Pilot Survey, Survey Points Selection Criteria and Timing Procedure

In one week, the researcher employed a pilot survey. To assess data collection limitations and to assort the procedure. This survey was from 18th December 2019 to 4th January 2020. The researcher trained the research assistants in the data collection procedures, pilot survey results analysed. And recommendations are drawn to improve the data collection. The survey aimed to improve teamwork, understand possible impediments or shortcomings. Walkway inventory collected, checklist developed and applied. The photos in appendix 8 describe the study area. During the survey, no disruption warrants any safety of the footpath use.

To establish a high-speed pedestrian area, the paths that lead to supermarkets, food points, bus stops, banks, post offices, and public toilets were selected. The established marked postings such as bollards, street systems, buildings, and roads, as the preferred marked speed examination segment. The four survey segments length was measured in meters and recorded in the data entry sheet. The time duration pedestrian takes to pass a survey segment was recorded in seconds. Afterward, the speed models were applied to evaluate speed.

3.4 Survey Team Selection and Sample Selection

The supervisor and five research assistants formed the research team. The basic requirements for the assistant were interaction skills and basic transportation knowledge. Most were from the fourth year of the 2019 academic year of Civil Engineering. Afterward, they received training in the questionnaire aspect, demographic data, and data form entry. The objective enhances the uniformity of data collection and presentation.

The sample population was based on the total number of peak pedestrians, applying a 5 percent sampling margin of error at 95 percent confidence. The population density was adopted based on the 2019 Census report to illustrate the sample concentration.

3.5 Data Collection Procedure and Speed Tally

Standard pedestrian data acquisition forms from HCM 2010, used to develop the standardized data collection form, capturing traffic conditions, site layout, and environmental data. The walking speed of pedestrians corresponds to pedestrian characteristics such as gender, age, and travel information collected. The sidewalks users, categorized as pedestrians, bicyclists, and motorists (motorists and pedestrians). Manual recording of the time duration pedestrian takes to traverse the market segment recorded in second using a stopwatch. The questionnaire enables the collection of pedestrian socioeconomic data. The pedestrian data were collected using Appendix 1 and Appendix 2 questionnaires. The speed counts were conducted during peak hours for one week within selected speed survey points. At least two samples were collected every 15 minutes randomly (data collection form Appendix 1, 2, 3, 4, and 5).

To evaluate speed, the time pedestrian takes to pass the survey point was recorded (time in and time out). The segment length was measured in meters and reordered. The time duration the pedestrian takes passing the section was recorded in seconds. The empirical formula is applied to evaluate speed using equation 2.9, and figure 3.1.

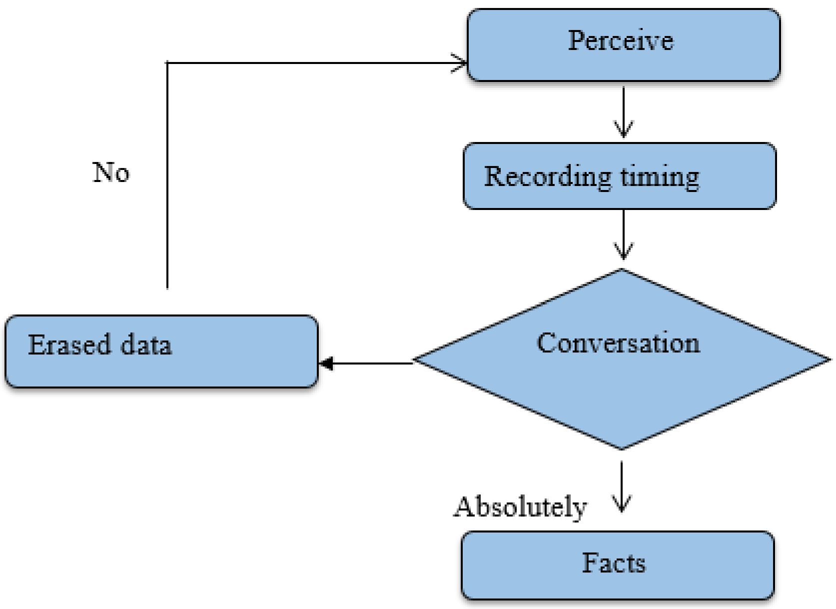


Figure 3. 1: Facts Assortment Flow chart

Source: Boon, Kulanthayan Wai (2012)

The walkers passing through the survey zone counted every 15 minutes during peak hours. The researcher employed a random counting technique manually. The peak hour count was from 6:30 a.m. to 9:30 a.m., 4:30 p.m. to 8:30 p.m., and the off-peak hour count was from 10:00 a.m. – 4:00 p.m. The screen line was selected randomly based on the pedestrian traffic concentration. The survey took three days, and the results were graphically presented, expressing the pedestrian 15-minutes trend. The data collection method has a limitation on the accuracy level as opposed to other advanced techniques such as photometric techniques. The speed was counted during peak hours, for a period of one week within the selected four-speed survey points, along the footpath, and at the preselected cross point examined in a single day. At least two samples were collected every 15 minutes randomly (data collection form Appendix 1, 2, 3, 4, and 5).

3.6 Data Collection and Pedestrian Sampling

Pedestrian travel Information gathering is the procedure of sourcing the variables to answer the research questions. Different data collection methods were used, including feedback form, annotations, surveys, examination of records and documents. The researchers obtain the primary data sources directly through experiments, surveys, and interviews, and secondary data obtained from conventional literature.

Manual random counts were made at particular points in the research area to achieve pedestrian volume. The pedestrian volumes count assessed, within a time range of 15 minutes, V15 peak volume, collected from 6:30 a.m. to 9:30 a.m. and 4:30 p.m. to 8:30 p.m. and off-peak from 10 a.m. to 4 p.m. The sample size of the road users was determined using equations 3.1 and 3.3 for sample size correction using binomial distribution formula (Cochran W G, 1963). Depending on the 2019 census, the margin of error was 5 percent, confidence was 95%, and the population density was 4850 persons per km^2 for the inhabitants of Nairobi.

$$Me = E = z\sqrt{\frac{p(1-p)}{n}} \qquad \text{Equation 3.1}$$

Where (1-p) characterised by ‘q’ hence: The z-value from the normal distribution table of 1.65 and P equal to 0.5.

$$N = (z^2pq)/E^2 = (1.652*0.5(1-0.5))/0.052 = 272.25 \qquad \text{Equation 3.2}$$

Where;

("Me" otherwise "E") remains the anticipated margin of error equals 5 percent, n- Section extent and z – z score for the standard dissemination at 95 percent interval of confidence, acquired from table and p - prior judgment of the exact value.

Consequently, population density modification was desired, equation 3.3 rectify the above "N" rate in equation 3.2. The samples were sampled randomly during the oral interview of 260 pedestrians.

$$N_a = \frac{N}{1+\frac{(N-1)}{Nn}} \qquad \text{Equation 3.3}$$

= 272.25 / (1+(272.25-1) / 4850) = 258 sample of pedestrians Where: n_a – Adjusted sample proportion, n – Original sample proportion, and N_n – Populace proportions.

3.7 Data Analysis

The pedestrian information and speed data were analysed using Microsoft Excel, and the analysis table for questionnaire entries was formed, which included expected responses in a drop-down menu. Microsoft Excel software generates graphs from the query design command. Figure 3.2 illustrates the analysis approach adopted with the tested hypothesis highlighted in Table 3.1 and the test variable procedure shown in Table 3.2. The Table provides the expression of the expected variable data and collection procedure. Further, the chapter envisioned the presumed data collection and analysis in the subsequent chapters.

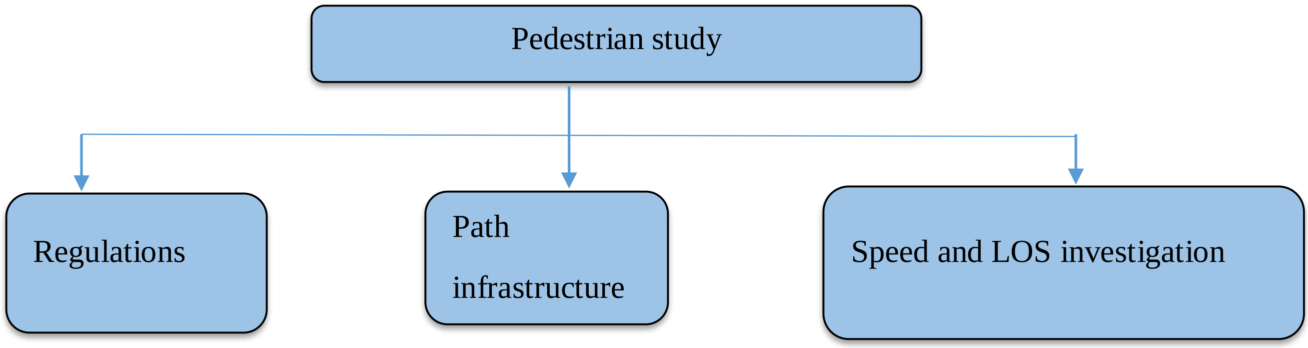


Figure 3. 2: Objective context structure.

Source: Author (May 2020)

Table 3. 1: Examination and Analysis Framework

Objective	Hypothesis	Quantifying technique	Analysis approaches	Probable yield
Define the mean speed alongside the path.	H_{01} pedestrian movement distinctive proficient promote walkway mobility?	Physical count in every 15 minutes, throughout the peak passé.	The variables, derived from the past review papers. Discrete speed evaluation	The pedestrian environment investigation.
Appraise Level of Service and planetary	H_{01} pedestrian actions in the walkway impactful instead of actual space managing?	Appraisal of LOS	The typical variable resulting from the prevailing footpath surroundings	The suggestion of appropriate essential developments
Appraise the pedestrian insight on footpath use and expansion	H_{01} Are pedestrian instincts on paths influence movement organization?	Current path information gathered is grounded on the path sizes.	Path sizes data were sampled and equated with the walkway standards. Analyze the changes on the prevailing walkway and pedestrian reaction.	The walker's typical appraisal outcome

Source: Author (2019)

Table 3. 2: A Study evaluation Framework

No	**Narrative**	**Variable examined**	**Data precision**		**Quantity**			**Comment**
			Definite	Estimate	Sources	Restraint	Assessment	
1	Trial extent	Numeral		5 percent	Y		Y	Based on accuracy expected
		Z- The score value		95 percent confidence level	Y		Y	Based on correctness probable. Z – acquired from the Z-table.
		Sample size	4,511 per/km^2		Y	The area is extremely populous	Y	Grounded on 2009 population survey
No	Narrative	Basis					Y	
1	Desktop assessment	Ancillary data from Internet, Journals, Published and Unpublished literature			Source review	Variation of area activities	Y	Present review used
A	Speed and path assessment							
1	Distinctive travel speed (m/sec)	Entire urban street span	✓		Field assessment	Automobile speedometer used (low precision)	Y	Road span measured three-time and average determined.

		Segment span	✓		Field assessment	Intrusion during information collection	Y	Measured using steel tape.
		Pedestrian intersection suspension		✓	Review	information from previous review (therefore low precision: walking variable have transformed)	Y	Information from preceding works
		Walking speed	✓		Designed standards	Meddling on information	Y	Discrete speed measured and mean speed worked out.
2	Operative path width	Overall path breadth (m)	✓		Field visit	Events distressing		Haphazard breadth
		Sum of breadth and span (m)	✓		Field visit	Actions distress space		Haphazard Walkway
3	Flow	Pedestrian Speed (m/min)	✓		Field visit	Difficulties in identifying grouped	Y	Both genders were quantified separately, the outcomes equated

								to other literature standards.
		Density (p/m^2)		✓	Literature	Time durational effect on density	Y	Haphazard checks are done often
4	Speed (section speed)	Section reserve (m/sec)		✓	Field visit	Activities affect space		Haphazard checks done
		Phase (sec)		✓	Timer Standardization earlier, during, and afterward.	Timing accurateness to be governed by the individual competency of survey assistants	✓	Coordination is essential for the survey aide's
5	LOS	Actual path breadth (m)		✓	Field visit	Activities affect space		Path breadth checked continuously.
		Outermost 15 min flow degree	✓		Field visit			Continuously monitored
		Flow degree (p/min/m)	✓		Intended values	Interfering during information assortment	Y	Timing checked constantly
B	Pedestrian speed and flow computation							

	Tally phase	Period	Evaluation interval	Information obtained	Outcomes	Precision	Assessment	Comments
	Ultimate (Peak)	6:30 – 9:30 am. and 4.30 – 9:30 pm.	fifteen minutes	Maximum/Minimum pedestrian speed	Charts and tables	Great	Y	Related with other discoveries
	off-peak	10:00 – 4:00 pm.	fifteen minutes	Maximum/Minimum pedestrian speed	Charts and tables	Great	Y	Related with other discoveries
C	Land use besides Path assessment							
			Definite	Estimate	Foundations	Restraint	Examination	Comment
1	Path	Road illumination	✓		Field assessment	Nearly most bulbs are not functioning	Y	Distinct lighting post totaled
		Path state		✓	Field assessment	Lack of consistency and intrusion	Y	Assumed used walking areas
		Junction position		✓	Field assessment	No defined crossing location	Y	Common jaywalking
2	Land usage	Building front usage		✓	Field assessment	Intrusion distressing motion	Y	Supposed walking zones

3	Pedestrian Administration	Strategy	✓		Desktop review	Deficiency of monitoring and assessment guidelines	Y	Policy and By-Law review

Source: Author (2019)

Chapter Four

4. RESULT ANALYSIS AND DISCUSSION

4.1 Pedestrian Surveys Evidence

4.1.1 Walkway Summary

Out of the 260 walkers surveyed, 121 were female the remainder were male. The chosen pedestrians were not in the category of PWD and were presumed fit for the study. Figure 4.1 displays the number of pedestrians surveyed. The most frequent age groups ranged from 15 to 40 years of age. Sporadic terminal points were along the street PSV terminates their journey along the study streets.

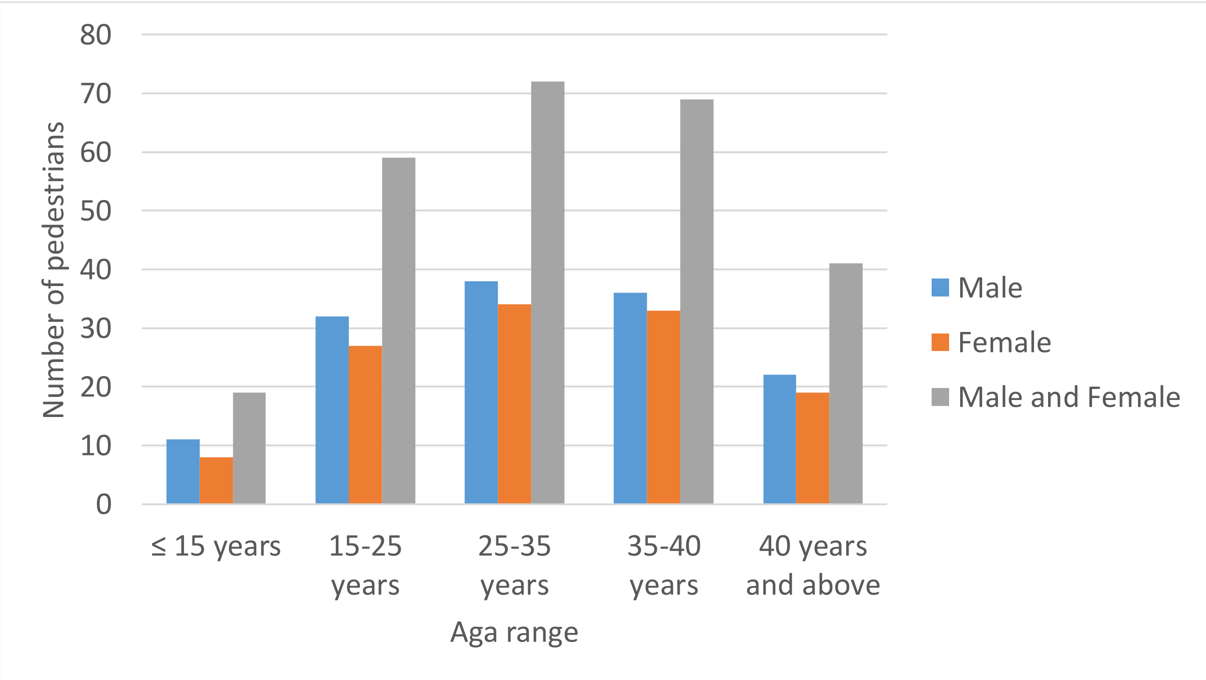


Figure 4. 1: Pedestrian volume interviewed based on age and gender

Source: Author (2020)

4.1.2 Age Group of Pedestrian

The largest group of pedestrians interviewed were between 25 to 35 years of age, accounting for 28 percent of those surveyed, followed by 26 percent of interviewees in the 35-year to 40-year age groups and 16 percent of respondents over 40 years of age. Young pedestrians below 15 years did not form part of the interview, although 7 percent were below the required age by the study (Figure 4.2).

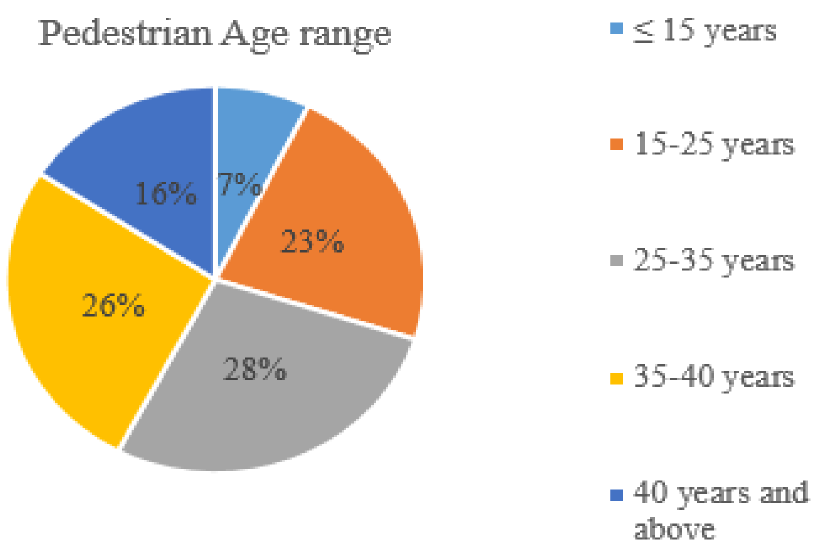


Figure 4. 2: Age collection of the pedestrians interviewed.

Source: Author (2020)

4.1.3 Wages Level of Pedestrians

In Kenya, wage has a significant impact on pedestrian behaviour. The findings on pedestrian income levels show that pedestrians majority earn between KSH. 10,000 and KSH. 20,000, which is 24.6 percent of those interviewed are in this category, 5.4 percent of people have no income; they are either not employed or college and university students (Figure 4.3).

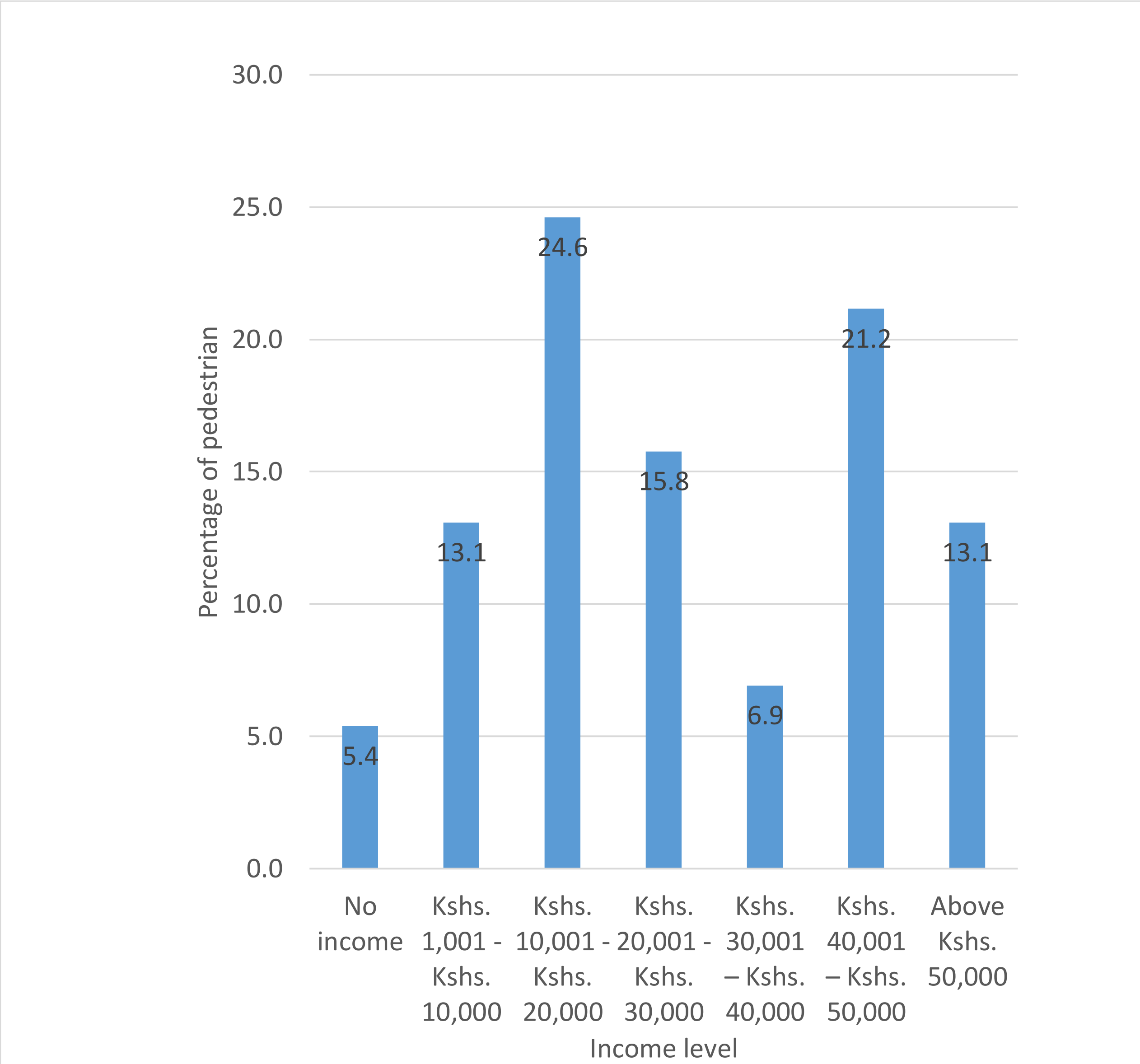


Figure 4.3 Wage distribution of Pedestrians

Source: Author (2020)

4.1.4 Trip Makers Livelihood

The livelihoods of the journey were categorized as follows; engineers, doctors, lawyers, teachers, nurses, accountants, and other professionals fell into the first category. The second categories were college, secondary and primary school students. The students, hawkers, and technicians dominate the walkway, scoring 18.5 percent, 14.7 percent, and 14.2 percent in addition to others shown in Figure 4.4.

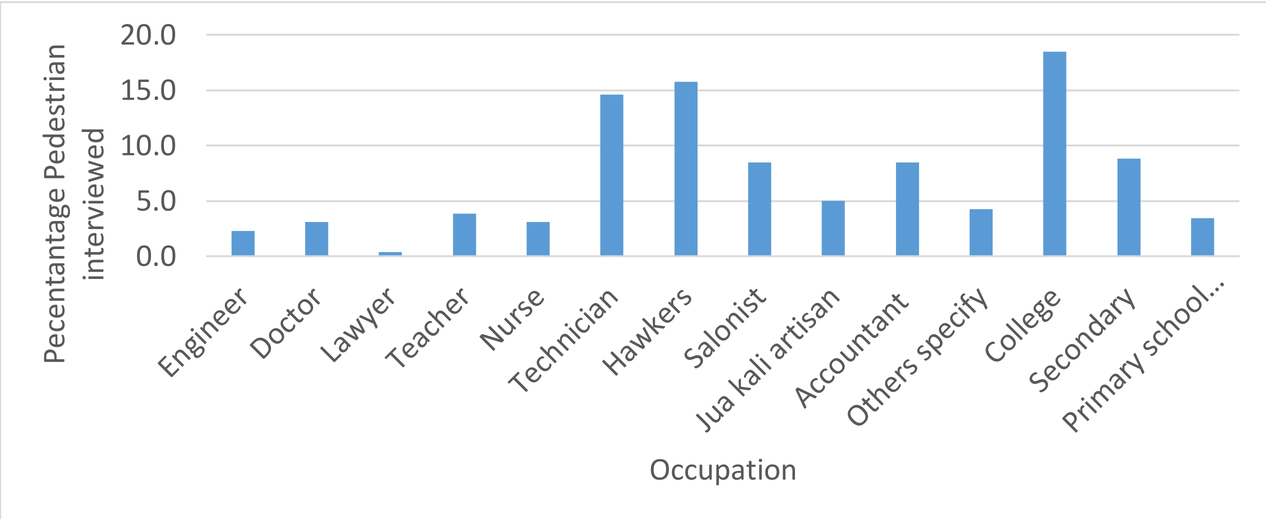


Figure 4. 4: Occupation of the trip makers

Source: Author (2020)

4.2 Journey Assessment

4.2.1 Trip Motivation

Trips were categorized as follows; work, business, shopping, school, and entertainment. Students made up the largest group of pedestrians, accounting for 23 percent of the total, while 17 percent were on business trips and 27 percent were on a work trip, with recreational trips accounting for 13 percent of the total (Figure 4.4).

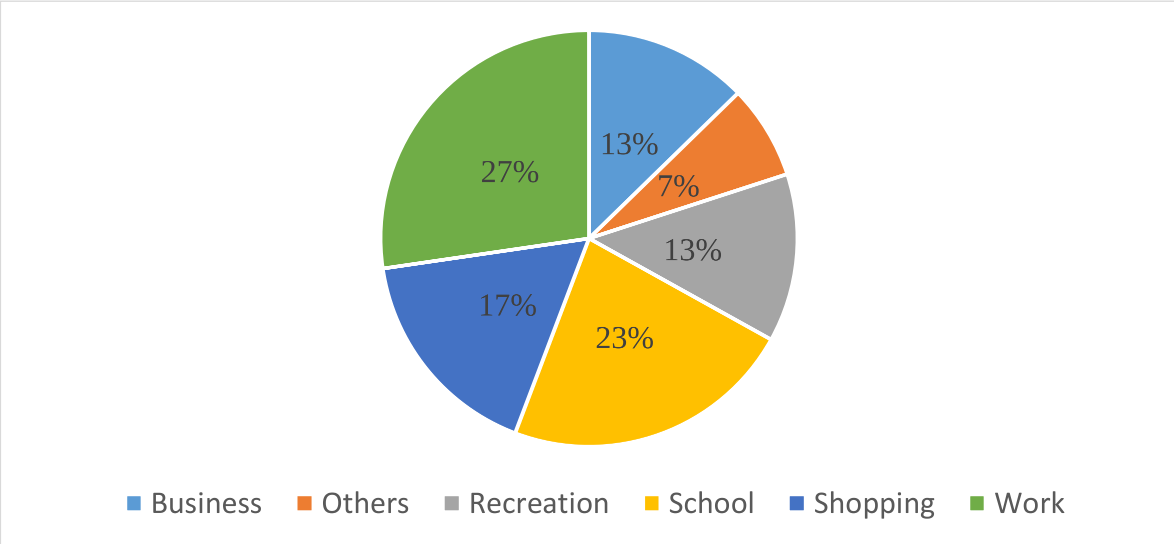


Figure 4. 3: Drive for the trip

Source: Author (2020)

4.2.2 Favourite Means to Access Tom Mboya Street

People accessed the study area primarily through paratransit and ineffective public transportation means. Pedestrians preferred public transportation to get to Tom Mboya Street, with 34 percent and walking at 26 percent. The company vehicles are the least used mode, accounting for 7 percent of all trips (Figure 4.5).

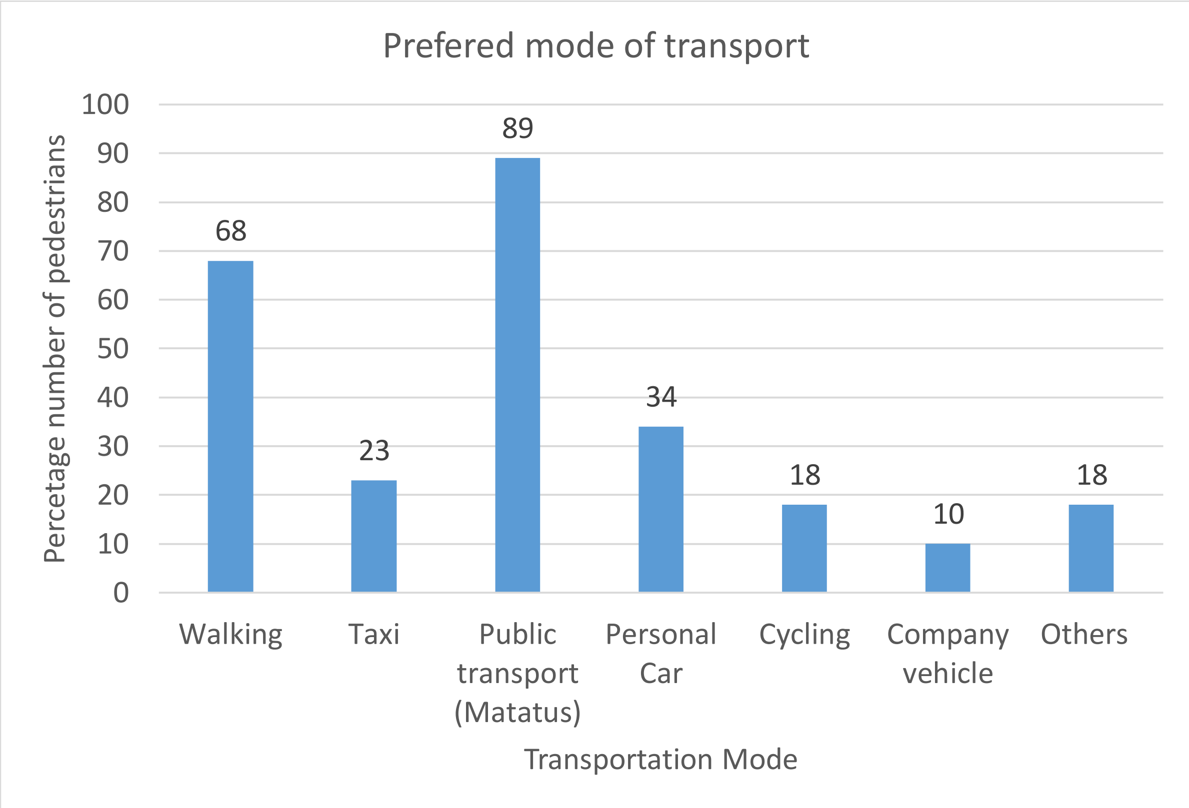


Figure 4. 4: Pedestrian Preferred mode choice.

Source: Author (2020)

4.2.3 Aims of Walking on the Study Area

The pedestrians outlined various reasons for choosing walking over other transportation modes. The questionnaire evaluated the pedestrian preference based on the following; financial constraints, comfort, efficiency, exercise, lack of PSV, and others were among the reasons given. Most pedestrians preferred walking over other modes due to socioeconomic challenges. The majority of pedestrians preferred walking at 34.2 percent for comfort and 25 percent due to financial issues. While PSV deficiency received 5.4 percent and lack of exercise scored 15 percent (Figure 4.6). Pedestrians prefer other modes during the dark, late hours, and the rainy season (Figure 4.7).

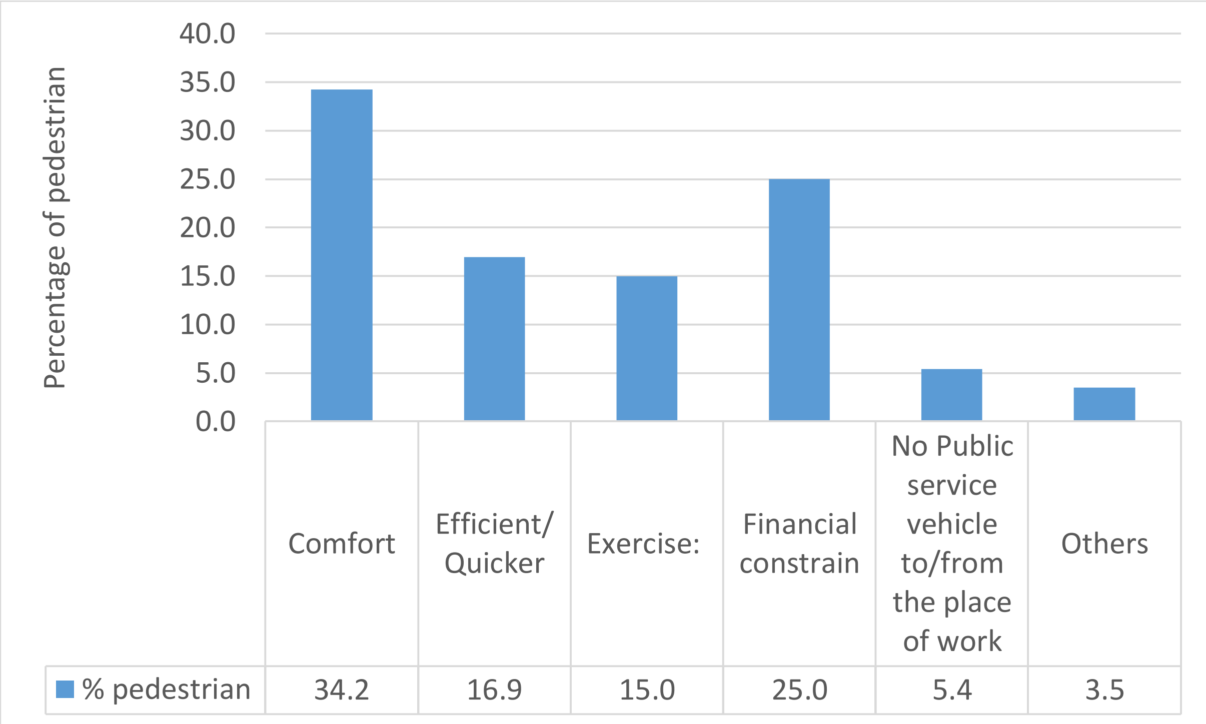


Figure 4. 5: Reasons for choosing walking

Source: Author (2020)

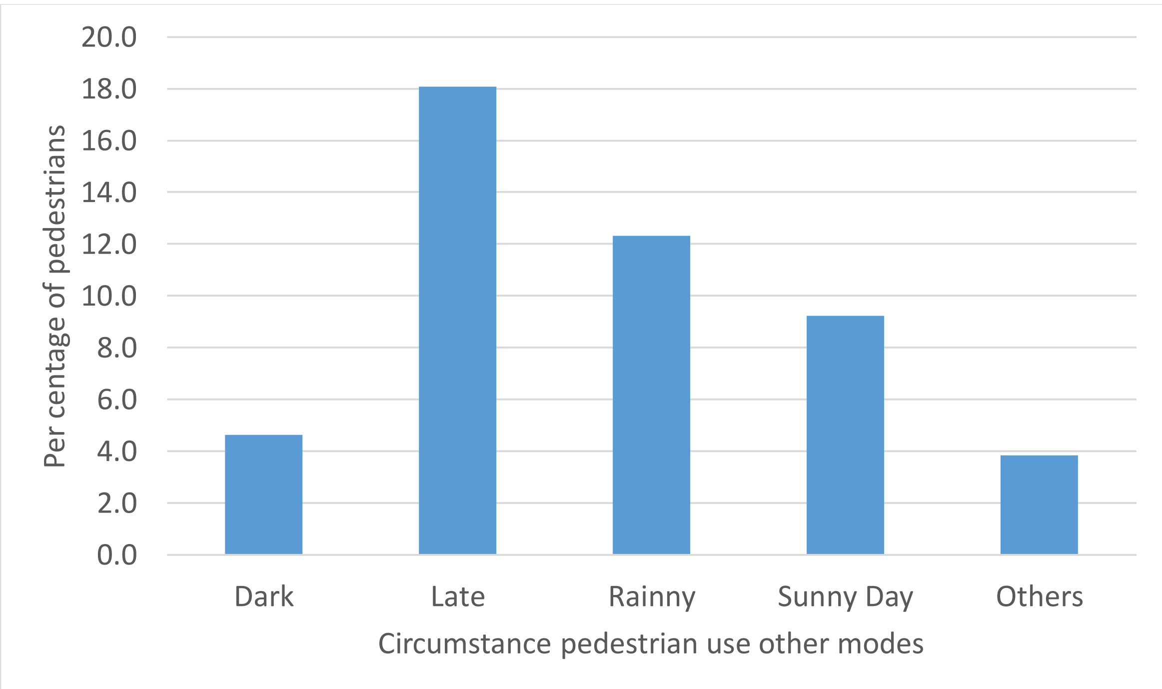


Figure 4. 6: Circumstances pedestrian use other modes

Source: Author (2020)

4.2.4 Factors Causing Discomfort Among Pedestrians

The study evaluated pedestrian comfort, evaluating interference caused by vehicle traffic, walking lanes, congestion, street vendors, and assault fear factors. Overcrowding was the main reason people avoid walking along the study area, cited by 24.2 percent of the respondent as the primary reason they avoid walking, while traffic flow interference by 6.9 percent and 17.3 percent of the respondent were afraid of assaults. Hawking and other activities in the area impact pedestrian comfort. Pedestrians shunned paths in the evening due to hawking activities (Figure 4.8).

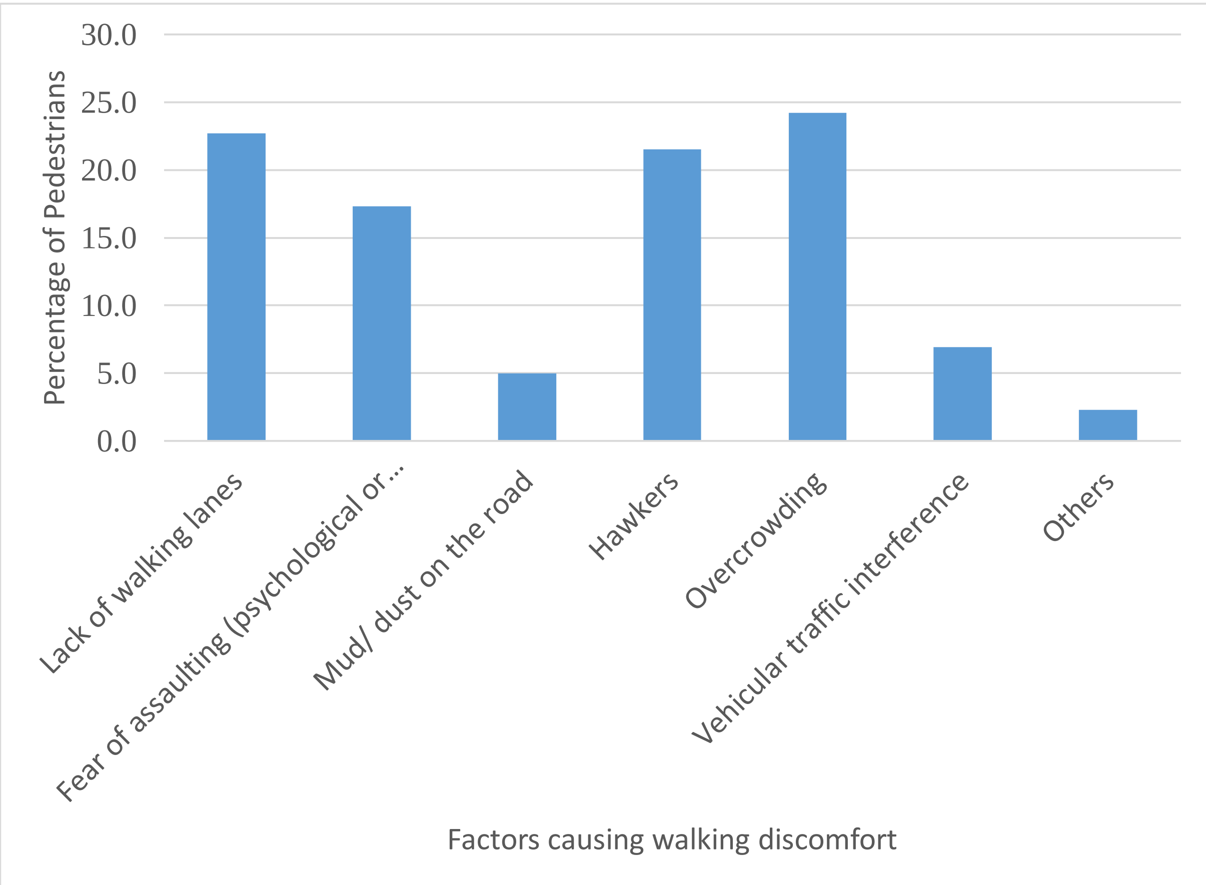


Figure 4. 7: Factors causing pedestrian discomfort Within the area of study

Source: Author (2020)

4.2.5 Preferential Areas of Improvement

The pedestrians highlighted their preferred need areas to promote walking. The pedestrian wishes for more appealing sidewalks paving 34.2 percent preferred walkway improvement to improve pedestrian use, 14.6 and 18.5 percent proposed resting area and zebra crossing respectively. Furthermore, 12.7 percent prefer reforestation on the path, similar to sports and entertainment areas (Figure 4.9).

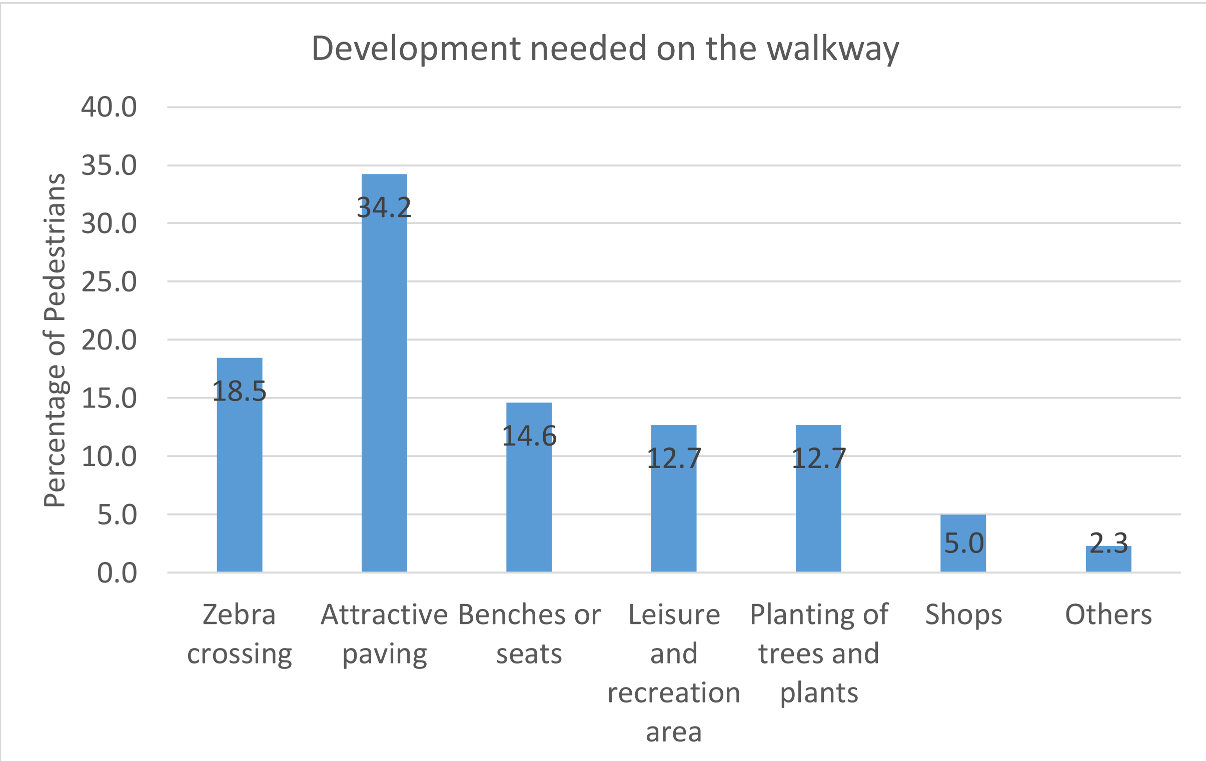


Figure 4.9: Pedestrian Preferential Areas of Improvement

Source: Author (2020)

4.3 Walking Rules and Principles

The policy and regulation investigation aimed to understand the law application, promote walking and establish a pedestrian understanding of the law. The finding shows that 52 percent of pedestrians were aware of the by-law existence to regulate pedestrian mode. However, 36 percent are unaware of these by-laws, and 12 percent have no idea (Figure 4.9). The majority of these pedestrians are aware of the by-law governing jaywalking in Nairobi; 47 percent of those polled say they acknowledge the by-law that governs pedestrians. However, 38 percent of people are unaware of the by-law, while 15 percent are unaware (Figure 4.9 on the left). The by-law implementation and legislation have been derailed, resulting in 26 percent of pedestrians having faith in it, with 57 percent showing little faith in by-law application and 17 percent unaware of the regulation (Figure 4.10). There exists insufficient enforcement of the by-laws, attributed to limited infrastructure for controlling the flow (Figure 4.11). Figure 4.11 illustrates the comprehension of penalty ranges.

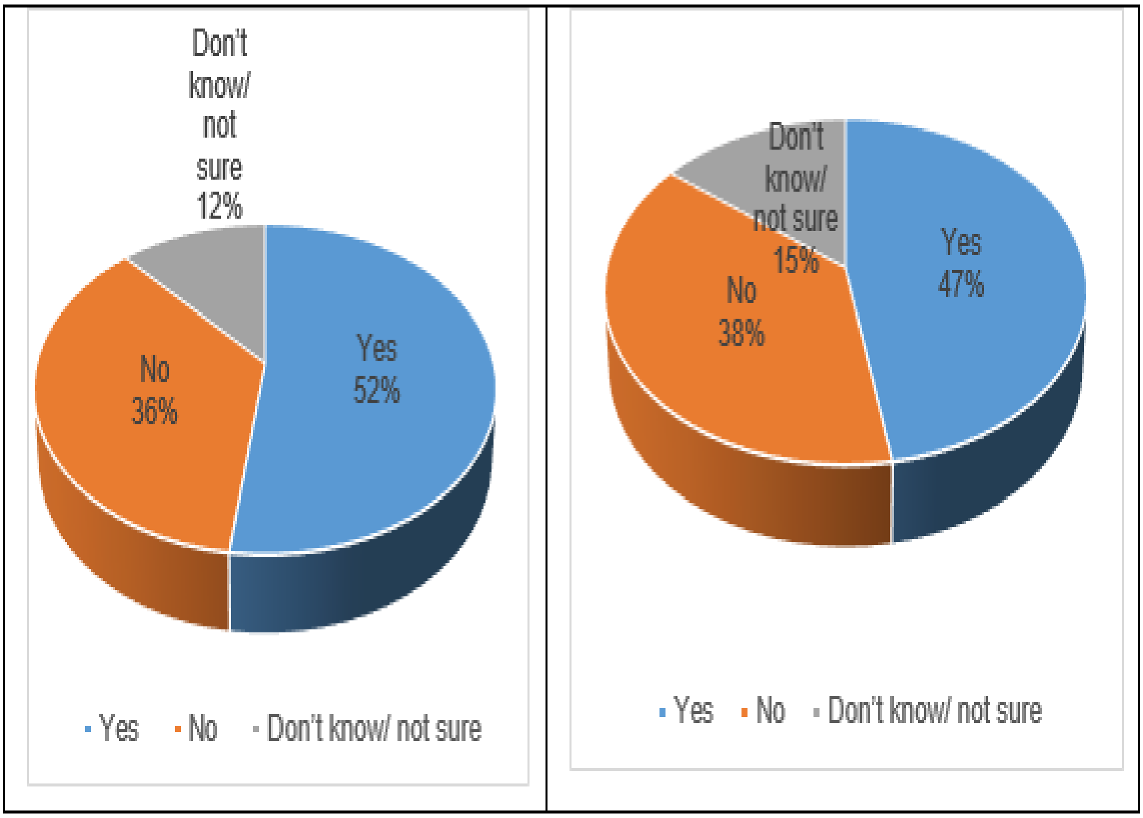


Figure 4. 8: Pedestrian mode knowledge on the by-law (on the left) and by-law regulating walking (on the right)

Source: Author (2020)

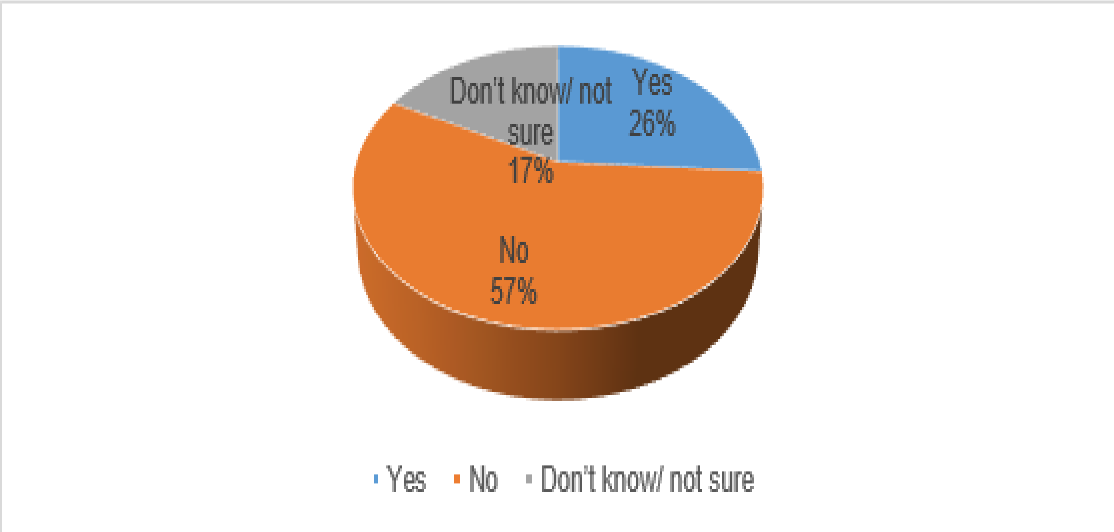


Figure 4. 9: Enforcement of jaywalking

Source: Author (2020)

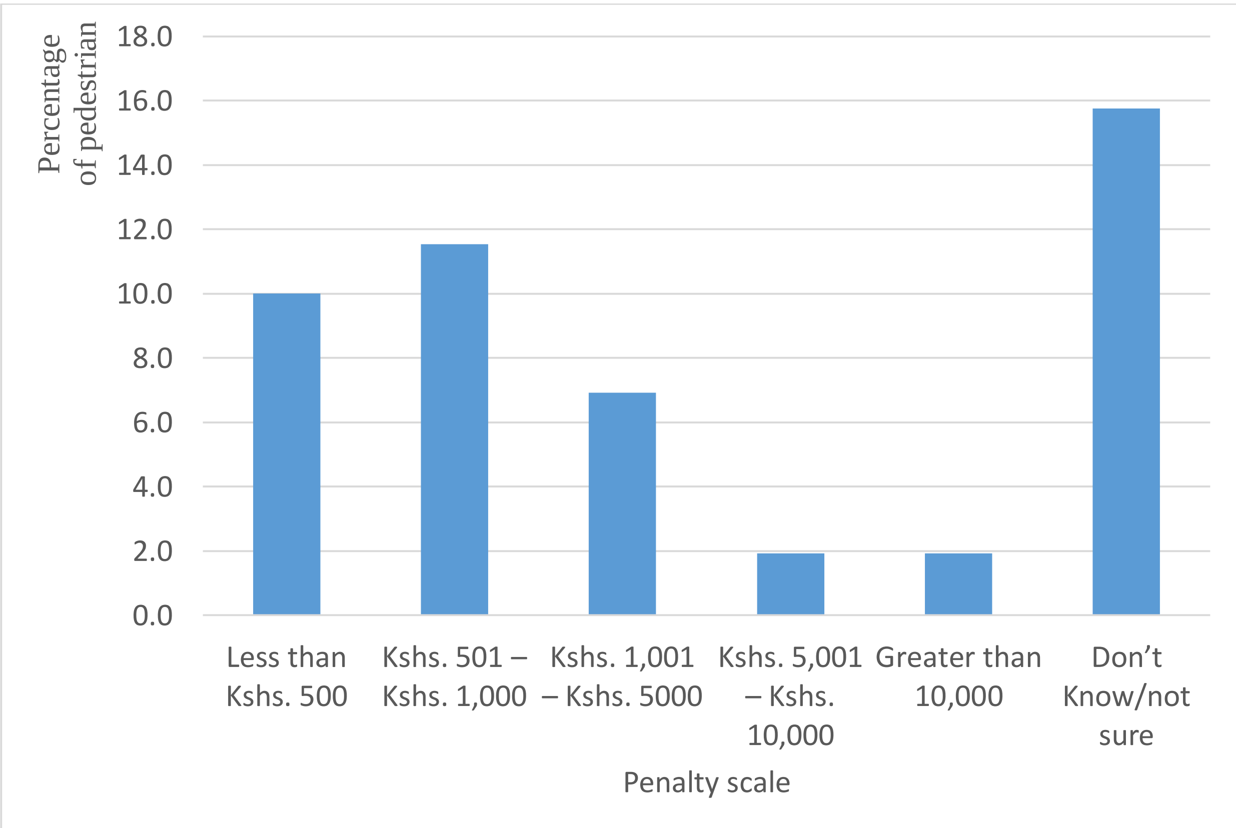
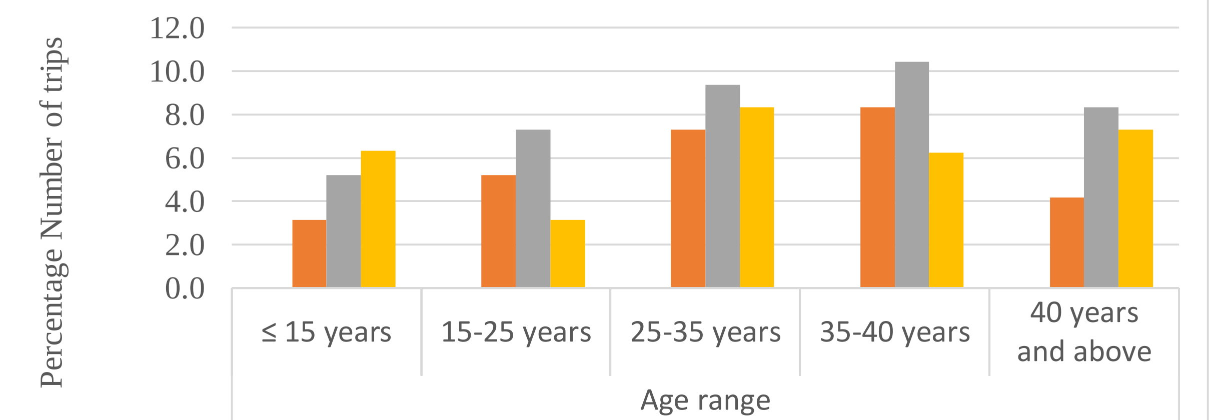


Figure 4. 10: Penalty associated to Jaywalking

Source: Author (2020)

4.4 Journey Rate

The incidence of travel relates to the Moussavi trip generation theory outlining the trip sequence influence on a trip generation. Moussavi (2012) suggested that educated and trained pedestrians are more likely to engage in work trips while students make school trips. The results show that pedestrians aged 35 years to 40 years old make three to five trips by 10.4 percent. It could be due to the nature of the works engaged by this group (Figure 4.14).



	≤ 15 years	15-25 years	25-35 years	35-40 years	40 years and above
None	0.0	0.0	0.0	0.0	0.0
1 to 2 Trips	3.1	5.2	7.3	8.3	4.2
3 to 5 Trips	5.2	7.3	9.4	10.4	8.3
6 to7 Trips	6.3	3.1	8.3	6.3	7.3

Figure 4. 11: Week Trip Frequency

Source: Author (2020)

4.5 Path Capacity Estimation

The path capacity displays the maximum accommodated pedestrian flow. The study adopted the manual count technique, illustrating hourly flow volume data. Appendix 8-D shows data for the one-day 15-minute flow count as of 4th May 2020. The results show that between 6 a.m. - 6 p.m. on Monday, there was an average hourly pedestrian peak volume of 1259 pedestrians, an average of 425 pedestrians counted every 15 minutes. Figure 4.15 depicts the change in pedestrian volume over each 15-minute interval. The R-square value is 0.7, considered of moderate effect predicting 70 percent variance to the dependent variable. The descriptive parabolic line is defined by equation 4.1.

$Y = 0.5733X^2 - 20.637X+1130.7$ Equation 4.1

$R^2 = 0.6972$

Where Y – Number of pedestrians and X – 15 minutes' time band

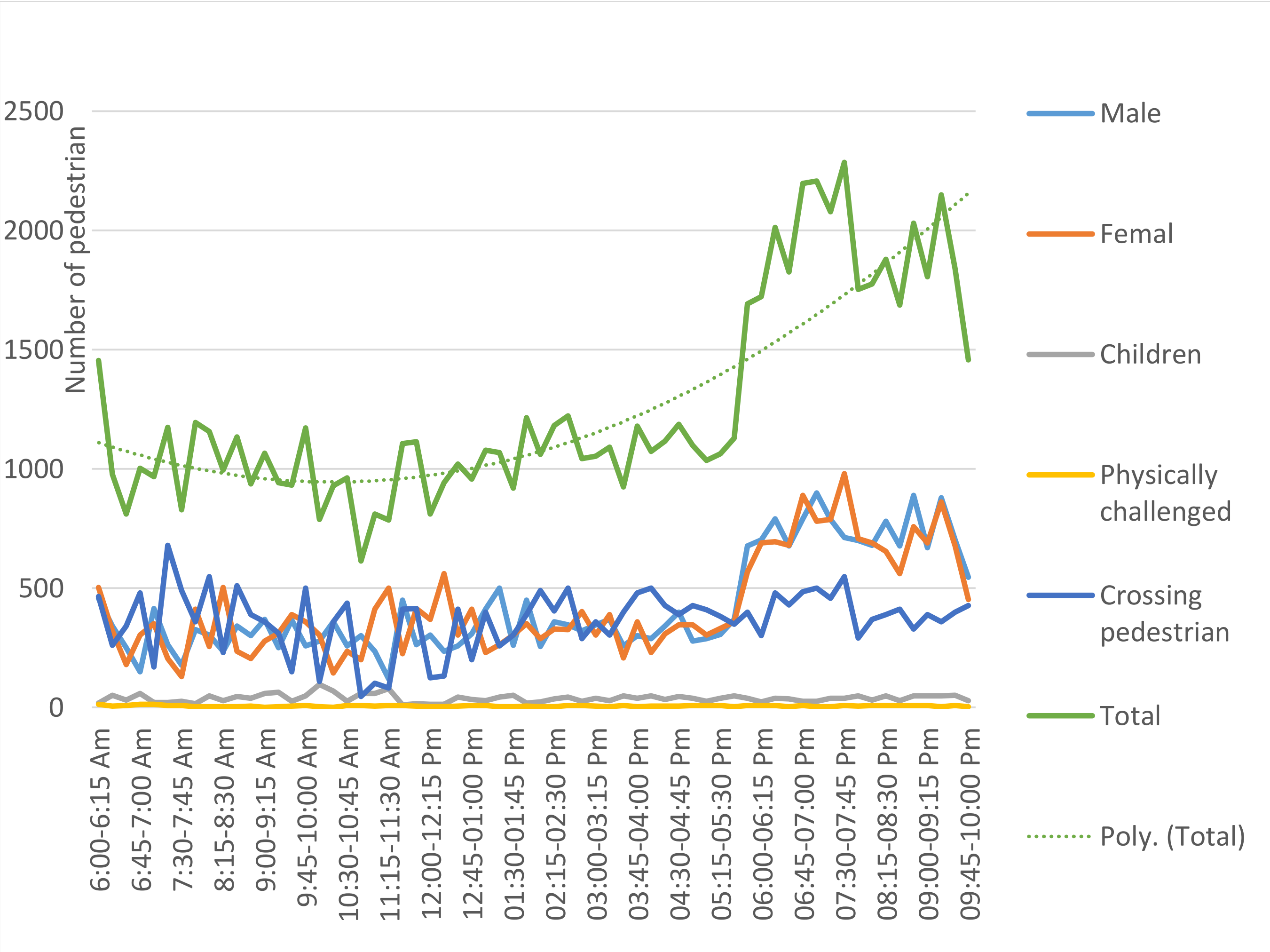


Figure 4. 12: Single day tally

Source Author (2020)

4.6 Factors Detected to Impact Walking During the Survey

The general pedestrian behavior impacts movement. Idling pedestrians, cell phone use, peddling, extolling, mugging, goods movement using shopping trolleys, and intersecting Boda Boda drivers trying to ride on the sidewalk are just a few other examples.

4.6.1 Pedestrians Idling on the Pedestrian Path

The pedestrian flows are influenced primarily by idling behavior, such as kneeling on the regulated bollards and potted plants. The crowding around newspaper vendors creates additional obstacles majority of residents in the neighborhood gather to read newspapers, particularly in the morning. Those other behaviors impact traffic flow, flow, and speed.

4.6.2 Social Behavior of Pedestrians

The pedestrians who have a good understanding of each other walked together, holding hands and conversing. Moreover, friends stand in the middle of the path talking. Group pedestrians impact LOS and flow. Walking movement is affected by hawking, sales, and display of goods in front shops along footpaths. The activities disrupt the pedestrian flow and speed (See Appendix 6).

4.6.3 Pedestrians Carrying Goods

Transportation involves the transport of goods, and pedestrian movement frequently involves goods movement. Female pedestrians typically carry handbag regularly of different sizes and shapes. This luggage changes the strength and height of road users, influencing other pedestrian mobility. And the shy distance between passing pedestrian increase based on the nature of the load and available space and noise to scare other pedestrians to clear the way.

4.6.4 Walkway Configuration

The footpaths are on both sides of the street. The efficient walking width provided on each side was about 1.95m (table 9). Although lane ideas are not applicable in pedestrian analysis from the HCM 2010, studies have shown that pedestrians do not walk linearly on the path. Because the irregular overhanging construction cartridges are part of the protection, the footpaths do not provide adequate shade to protect pedestrians during harsh weather. Furthermore, the pedestrian avoids touching the walls at all costs. The pedestrian area use and movement are affected by the uneven paving of the walking surfaces. For different users, the path lacks user interoperability. Since there is no route continuity at the interrupted points, pedestrians with disabilities are generally determined.

4.7 Technical Aspects of Pedestrian Footpath

Building and preservation Tom Mboya Street and Walking Cost is non-existence. Moreover, the Government has developed an elaborate approach towards road construction connecting Nairobi and NMT facilities. Although, NMS is steadily increasing investment in NMT structures. However, the Government is currently implementing policy, regulatory, and administrative frameworks in the transportation organization to support driver efficiency.

4.8 Walking Speed

4.8.1 Evaluation of Walking Speed

The study adopted a random sampling technique. The study generally had a sample population of 258 pedestrians, where 126 of the sample tested through a questionnaire. The remaining 130 tested on speed. This value was distributed evenly in all five survey points, with approximately 26 population samples in each survey point. Although the sampling techniques were biased, advanced speed calculation techniques can reduce this biasness. The bias occurs when the test population has to pass a stage and area, ignoring the other sample.

The pedestrian speed; were evaluated in the following areas; Khoja Mosque, Posta Stage, Near Tom Mboya, and Haile Selassie Avenue junction survey points. The speed information was gathered with caution, not to impact the movement. Bollard posts were already available, and passing duration data were collected using the stopwatch, using the speed information for pedestrians utilizing the pedestrian speed assessment form in Appendix 4. Equation 2.9 calculated the pedestrian speed, and the results are as follows: -

Speed (S) = Distance (D)/Time (T) Equation 2.9

Where; S – Section speed (m/sec), D – Section space (m), and T – Time (sec)

a) Posta stage Count station

The speed ranges from 1.20 meters per second to 1.31 meters per second, extreme speed noted on Monday. The mean footpath walking speed was 0.91 m/sec - 0.97 m/sec, weekly pedestrian speeds reduce. (table 4.1 and figure 4.16). The equation of the polynomial line in figure 4.16 is given by equation 4.2. The R square value indicates a moderate effect on the variable correlation. The speed variances are 42.7 percent, attributed to the study biasness.

$Y = 0.0033X^2 - 0.0292X + 0.9879$ Equation 4.2

$R^2 = 0.4275$

Where Y – Average speed and X – day of the week (Monday is assigned day one in that order up to Sunday day seven)

Table 4. 1: Posta stage - Speed

No	Day	Maximum speed	Minimum Speed	Average Speed	LOS	Trial Number
1	Monday	1.31	0.59	0.95	F	26
2	Tuesday	1.27	0.67	0.97	F	26
3	Wednesday	1.20	0.64	0.92	F	26
4	Thursday	1.23	0.59	0.91	F	26
5	Friday	1.24	0.64	0.94	F	26
6	Saturday	1.26	0.59	0.93	F	26
7	Sunday	1.29	0.61	0.95	F	26
Standard deviation		0.00139	0.00101	0.00043		

Source: Author (2020)

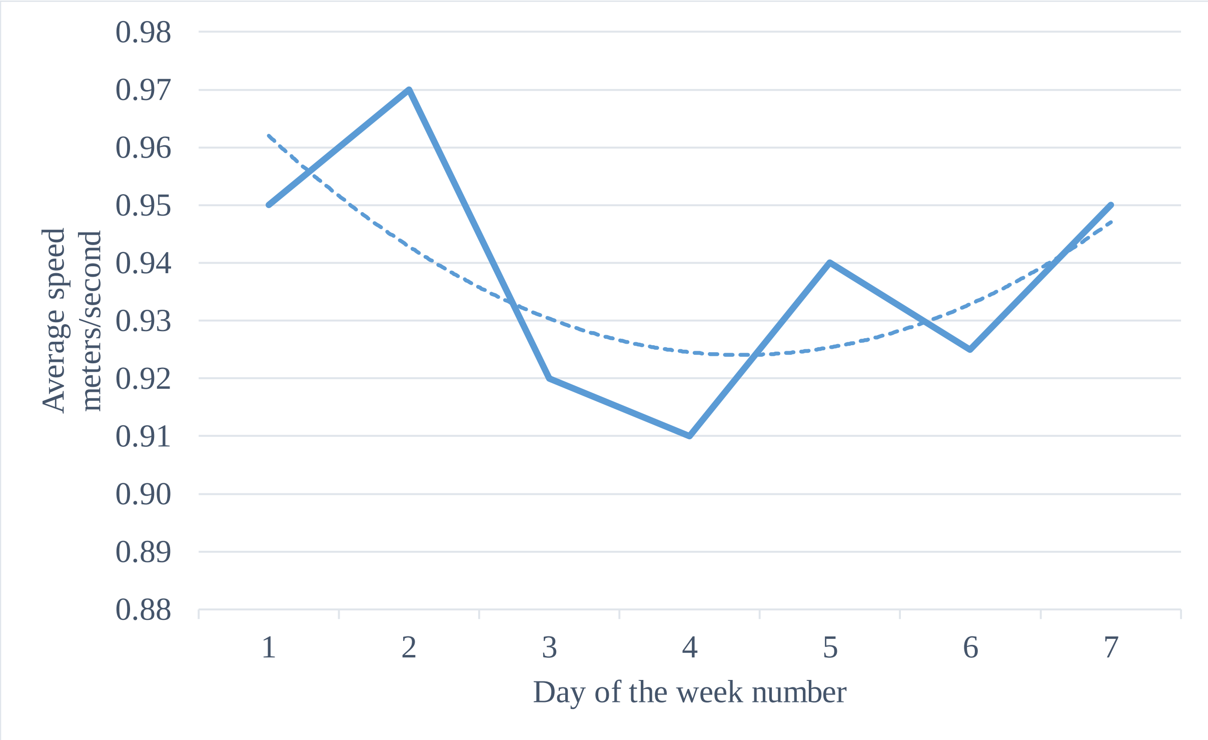


Figure 4. 13: Speed count within Posta Stage

Source: Author (2020)

b) Tom Mboya – Haile Selassie Avenue Junction count station

Peak pedestrian speeds range 1.07 m/sec to 1.22 m/sec, Monday recorded maximum speed. The average recorded pedestrian speed was 0.82 m/sec to 0.92 m/sec, declining polynomial over the week (See Table 4.2 and Figure 4.17). The trend line in Figure 4.16 is given by equation 4.3. The speed variances are 27.87 percent suggesting that the effect is weak to relate the independent and dependent variable speed.

$$Y = 0.006X^2 - 0.049X + 0.9536 \qquad \text{Equation 4.3}$$

R2 = 0.2787

Where Y – Average speed and X – day of the week (Monday is assigned day one in that order up to Sunday day seven)

Table 4. 2: Tom Mboya - Haile Selassie avenue - Speed

No	Day	Maximum speed	Minimum Speed	Average Speed	LOS	Trial Number
1	Monday	1.22	0.62	0.92	F	26
2	Tuesday	1.19	0.57	0.88	F	26
3	Wednesday	1.07	0.56	0.82	F	26
4	Thursday	1.13	0.68	0.91	F	26
5	Friday	1.11	0.53	0.82	F	26
6	Saturday	1.13	0.69	0.91	F	26
7	Sunday	1.18	0.59	0.89	F	26
Standard deviation		0.00269	0.00370	0.00181		

Source: Author (2020)

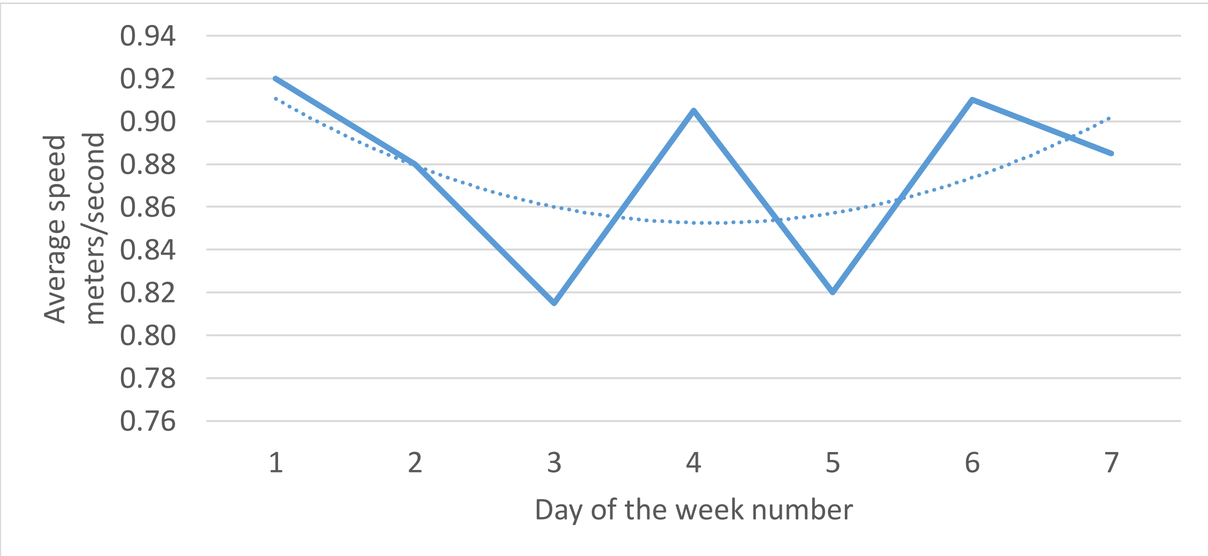


Figure 4. 14: Speed count within the Junction of Tom Mboya and Haile Selassie Avenue

Source: Author (2020)

c) National Archives Speed count station

Monday, registered the highest average speed of 0.92 meters/second, while the weekend registered the least (Table 4.3 and Figure 4.18). Equation 4.4 defines the polynomial line in Figure 4.17. The R square values indicate that the dependent and independent variables are near correlation.

Table 4. 3: National Archives – Speed count station

No	Day	Maximum speed	Minimum speed	Average speed	LOS	Trial number
1	Monday	1.19	0.64	0.92	F	26
2	Tuesday	1.15	0.61	0.88	F	26
3	Wednesday	1.22	0.53	0.88	F	26
4	Thursday	1.13	0.51	0.82	F	26
5	Friday	1.21	0.45	0.83	F	26
6	Saturday	1.11	0.52	0.82	F	26
7	Sunday	1.14	0.51	0.83	F	26
Standard deviation		0.00180	0.00421	0.00148		

Source: Author (2020)

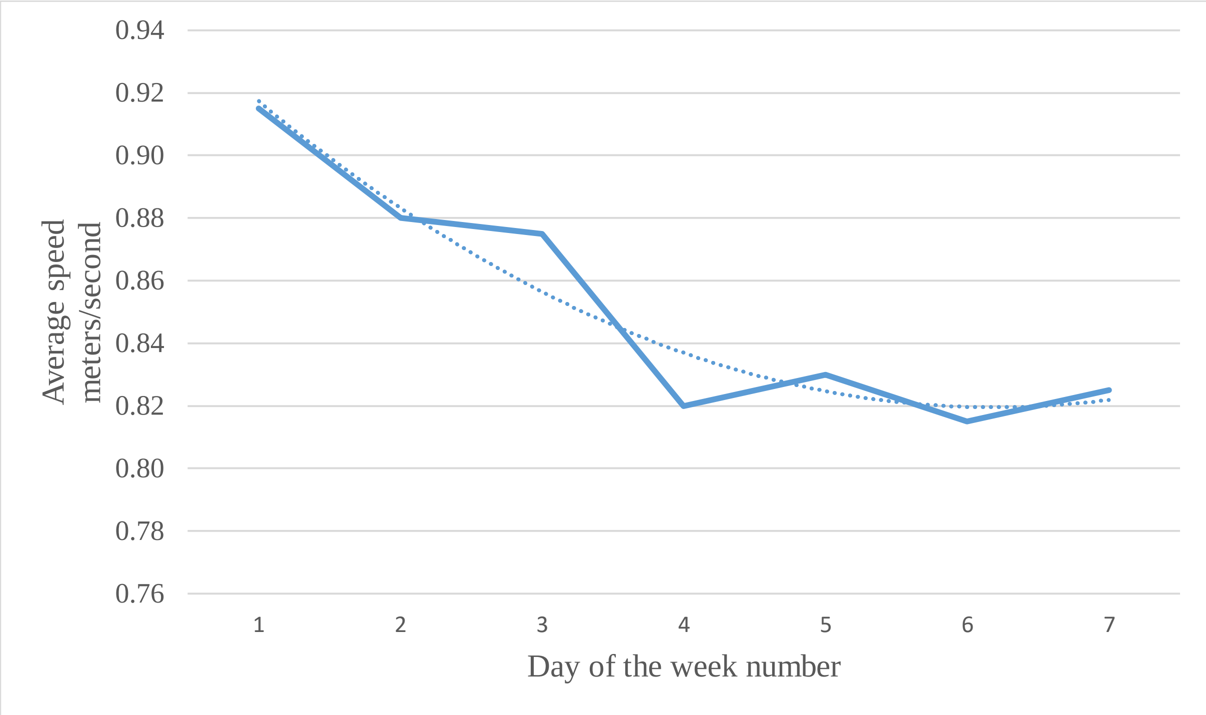


Figure 4. 15: Speed Count within National Archive

Source: Author (2020)

$Y = 0.0036X^2 - 0.0449X + 0.9586$ Equation 4.4

$R^2 = 0.9206$

Where Y – Average speed and X – day of the week (Monday is assigned day one in that order up to Sunday day seven)

d) Khoja Mosque Roundabout Count Station

The extreme speed achieved ranges from 1.11 - 1.33 meters/second. The average pedestrian speeds recorded were 0.82 - 0.92 meters/second, decreasing through a polynomial trend over the week (See Table 4.4 and Figure 4.19). Equation 4.5 defines the polynomial graph in Figure 4.18 below.

$Y = 0.0002X^2 - 0.0084X + 0.9421$ Equation 4.5

$R^2 = 0.7004$

Where Y – Average speed and X – day of the week (Monday is assigned day one in that order up to Sunday day seven)

Table 4. 4: Khoja roundabout - Speed

No	Day	Maximum speed	Minimum Speed	Average speed	LOS	Trial number
1	Monday	1.31	0.54	0.93	F	26
2	Tuesday	1.27	0.61	0.94	F	26
3	Wednesday	1.20	0.63	0.92	F	26
4	Thursday	1.33	0.51	0.92	F	26
5	Friday	1.24	0.55	0.90	F	26
6	Saturday	1.26	0.52	0.89	F	26
7	Sunday	1.29	0.51	0.90	F	26
Standard deviation		0.00191	0.00236	0.00032		

Source: Author (2020)

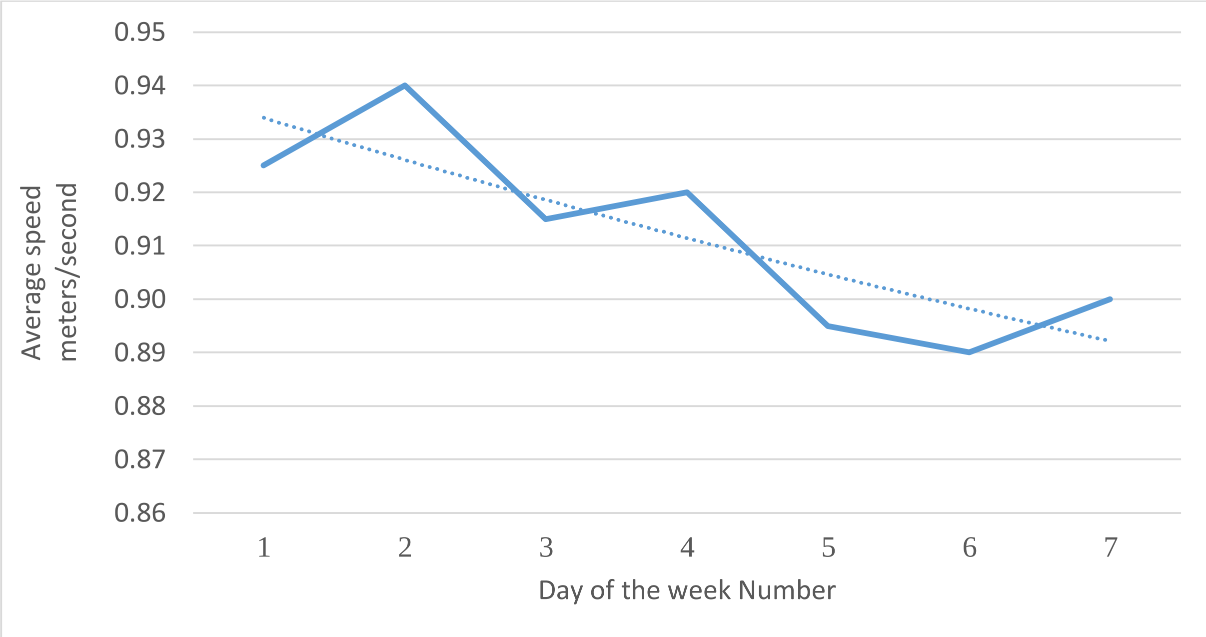


Figure 4. 16: Speed Count within Khoja Roundabout

Source: Author (2020)

e) Average of the four survey stations

The mean walking speed documented was 0.82 – 0.92 meters/second, and during the week declines linearly. The four-station maximum speed value range between 1.17 - 1.26 meters/second. However, the average speed is from 0.87 m/sec to 0.93 meters/second (Table 4.3: Pedestrian speed – National Archive, Table 4.5 and Figure 4.20). The standard deviation of 0.000413 illustrates the difference from the average speed. The R-value suggests near correlation existence on the dependent and independent variables. Equation 4.6 defines the polynomial line in figure 4.19. The data result for the daily speed obtained from the aggregation of the daily traffic information.

$Y = 0.0033X^2 - 0.0329X + 0.9605$ Equation 4.6

$R^2 = 0.8701$

Where Y – Average speed and X – day of the week (Monday is assigned day one in that order up to Sunday day seven)

Table 4. 5: Average speed of the four survey stations

No	Day	Maximum speed	Minimum Speed	Average speed	LOS	Trial number
1	Monday	1.26	0.60	0.93	F	26
2	Tuesday	1.22	0.62	0.92	F	26
3	Wednesday	1.17	0.59	0.88	F	26
4	Thursday	1.21	0.57	0.89	F	26
5	Friday	1.20	0.54	0.87	F	26
6	Saturday	1.19	0.58	0.89	F	26
7	Sunday	1.23	0.56	0.89	F	26
Standard deviation		0.000752	0.000618	0.000413		

Source: Author (2020)

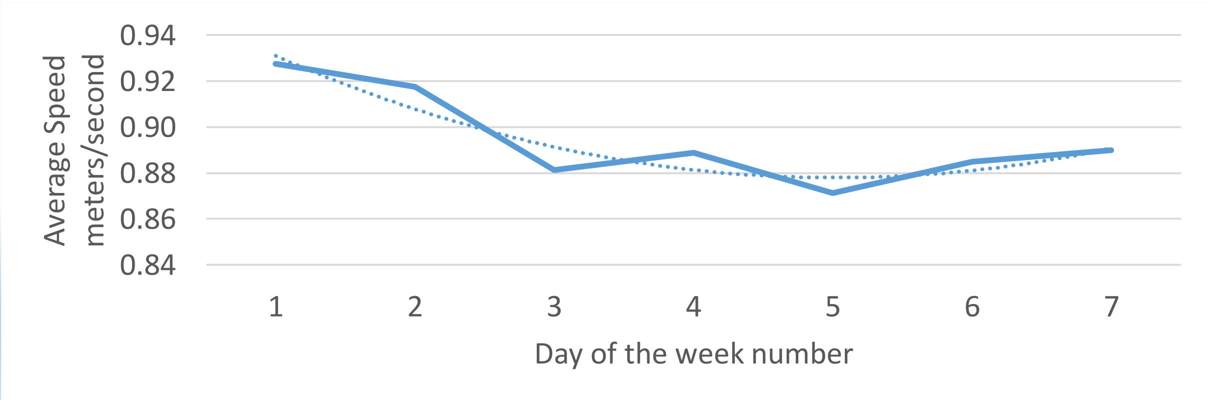


Figure 4. 17: Pedestrian speed – Average speed of the four points

Source: Author (2020)

f) Speed Observation Made on the Four Survey Points

During the weekend, hawking activities dominated the walkway, impacting pedestrian movement and speed. Hawking activities are not often uninterrupted by the enforcement unit on weekends. Figure 4.5 defines movement reasons 27 percent of pedestrian movement are work-based. The working cultures in Kenya, where weekend people work half a day on Saturday, impact weekend speed. Pedestrians are not in harry on weekends compared with other days of the week.

4.8.2 Observed At-grade Pedestrian Haste

The pedestrian haste varies with a period of daytime and sex. Through peak time, the motion is gentle since different activities block pedestrian flow. The result shows average male motion speed was 0.96 meters/second with an extreme motion speed of 1.26 meters/second, and females achieved 1.03 m/sec. Moreover, the motion speed attained was 1.30 meters/seconds in both genders. The minimum motion speeds recorded in peak hours are mainly between 7:30 a.m. – 10:00 a.m. and 4:00 p.m. – 9:30 p.m. during the week, with an exemption of Sunday when low flows occur. For the pedestrians walking along the study street, the average walking speed was 0.89 meters/second. Although most women walk with handbags, this luggage has a negligible effect on motion.

4.8.3 Crossing Speed

The crossing speed data were collected at the intersection of Luthuli Avenue and Tom Mboya street, along the single 7-meter road width. Female pedestrians crossed faster than males; the average crossing speed for males was 1.17 meters/second, and 1.10 meters/second were females. The total average pedestrian crossing speed was 1.14 meters/second. It takes 4.3

seconds and 8.6 seconds consecutively to cross each lane, which implies pedestrian cross running.

4.8.4 Walkway Area

The average walkway area covered was computed by subtracting a walkway width between the effective walkway area, peak hour pedestrian volume, and the formula shown in Table 4.6. Space and speed are correlated suggested by scientific investigations (Weidmann, U. 1993).

Average pedestrian area = Effective walkway area/Peak hour pedestrian volume.

$A(V) = A_{jam} – 0.52\ln (1- (V/V_f)$ Equation 2.14

Where:

V - speed, Vf - average free walking speed (Vf ≈ 1.34 meters/second), A(V) = Length (meters)*Width (meters) signifies the essential area (For example, spatial use L multiplied by the lateral spatial use W), Ajam is the largest area, where mobility is intolerable (Ajam ≈ 0.19 square meters) and L=1050 meters, W=1.95 meters, V=0.89 meters/second.

$A(_V) = 0.19-0.52\ln (1-(0.89/1.34)) =0.76$ square meters (Zone essential to take a stride).

4.9 Observation at the Walkway and Minibus Terminus along the Study area

The public transport consequence caused by the dropping of passengers interferes with the pedestrian flow blocking footpaths, making noise, and scrambling for the passengers, leading to congestion and flow interference affecting the safety of walkway users. Public service vehicles (PSV) pick up and drop commuters at the undesignated location along the street.

Besides, public transport vehicles have no clear schedule, and they queue up until the bus is full. Sometimes minibus is parked along pathways blocking pedestrian access creating a bottleneck. A minibus is a commuter bus service operating similar to paratransit. The pedestrian bottleneck is the congestion that happens when traffic demand exceeds capacity.

4.10 Level of Service

Table 4.6 illustrates the walkway width of 1.95 m conveying 1280 pedestrians on both sides every 15 minutes. The observed LOS E was obtained using the speed values and compared with values in Table 2.1. The study presented an average pedestrian area of 1.60 m^2/pedestrian and an average pedestrian speed of 0.89 m/sec for speed assessment in Appendix 9. Table 4.6 suggests LOS D.

Table 4. 6: Walkway width evaluation

Element	Consideration	Method	Calculation	Outcomes	Remark
Actual walkway width	Curbs breadth Road furniture breadth Building projection Intimate allowance	Actual Breadth W_E= Total breadth W_1- Total obstacle breadth W_2	$W_E = W_1 - W_2 =$ 1.95m	1.95m	Results acquired on site Equation 2.8
Walkway Ultimate Volume, V_P		Ultimate volume V_P =1280 Walkers		1280 walkers	
Whole walkway span		Walkway span L = 1,050 m		1,050 m	Street span measured physically

Actual path area		The path area is $W_A = W_E*L$. Equation 4.7 Source HCM (2010)	=1.95*1050 = 2047.5 m^2	2047.5 m^2	
Mean pedestrian space		Pedestrian area =Walking Area/ultimate volume V_P Equation 4.8 Source HCM (2010)	Area =2047.5/1280 =1.60 m^2/pedestrian	1.60 square meters/pedestrian	
Corresponding LOS				Level of service D	Outcome acquired from Table 2.1

Source: Author (2020)

DISCUSSION

4.11 Effect of Land Use on Movement

Land use affects travel desires influencing the walker flow and density. The results presented the effect of land use. The analysis of size helped determine commuter design as well as safety. Because of regional transit access, land use mix, and job density, pedestrian numbers increase. Peak flows are useful in design and planning (Roess et al. 2004). The area attracts a lot of pedestrian traffic, with a weekly count suggesting that; Sunday receives the lowest pedestrian volume, and the street is more vibrant all other days of the week.

4.11.1 Volume and Space of Pedestrian

The finding shows that pedestrian requires 0.76 m^2 to make a step. Assessments of existing structures and road development change strategies are necessary to accommodate large pedestrian numbers in CBD. Table 4.6 established that a pedestrian area of 1.60 m^2/ped was adequate to provide LOS D, with a flow rate of 33 ped/min/m to 49 ped/min/m value obtained from Table 2.1. As a result, street and walkway restructure are essential to improve the walkway to LOS C. When space decline to less than 0.4 square meters/pedestrian, the flow rate rapidly decreases (HCM 2010). When the capacity of 0.2 - 0.3 square meters/pedestrian, movements may be blocked and stopped (HCM 2010).

The manual technique results correlate to other finding techniques. Age-including demographics influence choice and travel behavior. Age affects travel distances, whereas older people travel less (Schneider, 2011 and Kadiyali, 2002), relating to the age theory championed by Schneider (2011) and Kadiyali (2002), against the travel rate or distance.

4.11.2 Usability, Comfort, and Economic of Walkway

The result reveals, most pedestrians earn Ksh 10,000 - 20,000 (Figure 4.3). Most of them are students from college at 18 percent (Figure 4.4), students and businesses contribute 23 -17 percent respectively (Figure 4.5). To access the study area, most pedestrians use public transport due to financial constrain (Figure 4.7). The discomfort for pedestrians is congestion at 24.2 percent, vending, and absence of paths contribute to 21.5 - 22.7 percent correspondingly (Figure 4.9). Though pedestrians under the age of 15 years and physically challenged pedestrians were few. These pedestrians of all ages used the walkway. The majority of the pedestrian are between the ages of 15 years and 35 years. Moreover, pedestrians of various income levels used the walkway. The frequent users are of income below KSH 50,000. Home-work trips and home-education dominate the trip purpose. And walking is the preferred mode, with 68 percent citing comfort and efficiency as the primary reasons. The higher group of pedestrians are aged 25 years to 35 years are mainly University and college students and hawkers, although the female populations were slightly more. To curtail pedestrian population fluctuation and promote sustainable sidewalks. In Nairobi, community responsibility resulted in the development of Mama Ngina lane, resulting in increased business opportunities and feasible walking environment development. Some suggestions for improving walkway usage in Nairobi include providing attractive paving, improving crossing points, providing pedestrian rest areas, and planting trees, among many other things, as well as improving the implementation of all laws encouraging walking. The study proposed walkway improvement to higher LOS.

4.12 Walkway Density and Space

The findings suggest every pedestrian operates at an area of 1.60 m^2/ped, movement restricted, and unidirectional flow reduced. Table 2.1 and LOS D established a flow rate of 33 – 49 Pedestrian/minute/meters used to evaluate the flow rate. HCM (2010) at LOS D pedestrian speed is severely restricted, and careful steps movement made to excuse on-coming pedestrians. In assessing the shopping facilities. The pedestrian area of 0.75 m^2, utilized as bumper zones for every pedestrian, and 400 ped/hr default flow was recommended (HCM, 2010). If spaces are less than 0.75 m^2 physical space, contacts with other road users are frequently unavoidable. For a pedestrian facility, the acceptance space of 75 Pedestrians/minute/meters or 4,500 pedestrian/hour/meter is reasonable if the indigenous data are not obtainable. At this level, a speed of 1.14 meters/second was deemed acceptable (HCM 2010). With the irregular and unstable flow, cross-flow and reverse-flow movements were nearly impossible. The area was more suited to relocating pedestrian streams than to queuing pedestrians. The path needed improvement to LOS C to accommodate 2.2 - 3.7 square meters/pedestrian, at a flow rate of 23 -33 pedestrian/minute/meters. The level of service C is adequate to allow usual walking speed and unidirectional pedestrian flow (HCM 2010). However, Weidmann (1993) suggested that walkway conditions opposing pedestrian flows reduce pedestrian flow capacity by up to 14.5 percent, and divergent pedestrian maneuvering effect omitted. Although developmental impact walking, this study highlighted the feature of the road user, primarily social aspects. Pushkarev and Zupan (1975) showed that the use and size of buildings on New York city streets were proportionate to traffic.

4.13 Pedestrian Speed and Space

4.13.1 Pedestrian At-grade Walking Speed

The Tom Mboya street findings offer the maximum pedestrian speed ranging from 1.17 - 1.26 meters/second, with a mean speed of 0.89 meters/second for different ages. Pushkarev and Zupan (1975) recommend 1.5 meters/second to enhance free flow. The walking on leveled sidewalks varies between 1.07 - 1.37 meters/second, dependent on temperature, ground type, texture, and sidewalk concentration (Traffic Engineering Handbook 2007). Although these considerations were not the premises of this study, (Garbe and Hoel 2009) noted that time of day, temperature, traffic composition, and trip purpose all affect pedestrian speed.

4.13.2 Examined Crossing Speed

A crosswalk pedestrian achieves a speed of 1.14 m/sec. Male pedestrians, for example, crossed at a speed of 1.17 m/sec, while female pedestrians crossed at a speed of 1.10 m/sec. A pedestrian crosswalk is a 7-meter carriageway at 5.5 seconds, according to Mutullah et al. (2011), at speeds ranging from 1.2 - 1.3 meters/second in busy crossing points, with a variety of age groups for pedestrians. In Kenyatta avenue and University Way Avenue, crossing speeds recorded were 1.20 and 1.13 meters/second individually (Mbeche and Otieno 2001). Higher than the Fruin recommendation of 1.02 m/sec (1970). Table 4.7 summarizes the study findings. The pedestrians on this street are slow. Boon et al. (2012) suggested that the average speed for pedestrians in Malaysia at non-signalized cross points is 1.39 meters per second. In Malaysia, 85th - 15th percentile pedestrian speeds at signalized crosswalks are 1.31, 1.53, and 1.09 meters per second. Non-signalized crosswalks have mean pedestrian speeds of 1.39 meters per second, 1.63 meters per second, and 1.15 meters per second, and the pedestrian speed recorded along the study area suggests that pedestrians are slow.

Table 4. 7: Results summary

Crosswalk (meters/second)	Mean (meters/second)	Walking area (square meters)	Space (square meters/pedestrian)	Flow (pedestrian/minute/meters)	Level of Service
1.14	0.87	0.76	1.60	33-49 (from table 3)	D

Source: Author (2020)

4.14 Jaywalking Regulation

The study showed that pedestrian awareness of existing walking legislation was low, 52 percent of pedestrians were aware of existing laws, and the rest did not know about this law (Figure 4.12). Furthermore, only 47 percent of road users are aware of jaywalking (Figure 4.11), and 11.5 percent of those surveyed stated that the penalty for jaywalking was between KSH. 501 and KSH. 1000 (Figure 4.14).

Chapter Five

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 Examine and Determine the Average Speed, and Stream Flow Proportion of Pedestrians

In Nairobi, the average pedestrian walking speed ranged from 0.87 to 0.93 meters/second (Table 4.7). The roadways need redesigning, environmental management, and improving LOS to promote safe walking. The average pedestrian crosswalk speed was 1.14 m/sec taking 8.6 seconds taking 5.5 seconds to cross 7 m leg of the road. And the street has no clear demarcated cross point. Hence pedestrians wait within the island for an adequate crossing gap to exist. Jaywalking is a problem since there are no designated crossing points. More research is necessary to understand the effect of signage, walkway safety, and mobile communication use in urban mobility. The walkway speed ranges from 1.17 – 1.26 m/sec, mean of 0.89 m/sec. The average area for each pedestrian was 0.66 square meters/pedestrian at a flow rate of 49 -75 pedestrian/minute/meters, raised to 2.2 square meters with a flow rate of 23 -33 pedestrian/minute/meters.

5.1.2 Evaluate the Pedestrian Walkway LOS along the Study area

The path operates at LOS D. The LOS walkway worsens to a lower service value due to interruptions and poor walkway planning and organization. The impediment along the paths affects LOS.

5.1.3 Quantify the Pedestrian Perception Needs to Enhance Walkway use and development

The pedestrian income, evaluated by footpath user incomes, has no apparent impact on the entire span of trips although, the share of footpaths increases with a decrease in earnings. Gender and job opportunities are the most valued determinants of pedestrian travel behaviour, and both genders share the pedestrian mode choice equally. Employment status indicates that regular activities restrict the daily pattern of activities and access. All stakeholders need to be involved in walkway development. These stakeholders are pedestrians, the business community, minibus operators, and the authorities responsible for walkway development adopting the same approach used to develop Mama Ngina Street in Nairobi Central business district (CBD). Overcrowding is the source of discomfort. Nairobi County Government, Transport department has enhanced walkway development and vehicle circulation improvement. There was a resoundingly positive response to the need for education and awareness, consequently, improve pedestrian walkway usage. It is necessary to include and upgrade the walking areas highlighted during the oral interview.

5.2 Recommendations

This chapter examines actionable issues to increase pedestrian facility utilization and improve pedestrian speed throughout the study area. For efficient urban mobility, balanced planning and design to achieve sustainable mobility. This research demonstrates that analysing pedestrian walking speed provides more insight into the effectiveness of walking and interaction with their environment. And the values obtained are impactful to improving walkway operations indicators and societal indicators. Walkway advancement must be incorporated into all road development plans in Kenya to improve pedestrian travel speed and achieve the recommended LOS. The findings suggest a review of all relevant policies affecting the use of pedestrians. Traffic Act chapter 403 should be modified to refer to pedestrian mode. Proper legislation and enforcement are essential to managing walkway nuisance. The policy needs to develop standard advertising signage height and the income raised by advertisements utilized to promote NMT and the aesthetic value of the walking environment. Discourage changes in building plans as this leads to unplanned pedestrian activities (Physical planning Act chapter 286 – Kenya Law).

The study recommends a continuous pedestrian survey to understand the dynamics of pedestrian characteristics. AASHTO recommends sidewalk widths of 1.5 m to 2.4 m or more in commercial areas. Abolished hawking activities along the walkway to improve value for the effective walkway width. To discourage jaywalking, erect a barrier leading to pedestrian road crossing points, and implement all Motorized Transport (MT), NMT regulations, and legislation. Ensure that all road and pedestrian signage are in place with a proper maintenance plan. And the walkway surface should be uniform, with appropriate texture to guide PWD and improve safety and security. The authority should regulate traffic at the bus stop and remove obstructions along the pedestrian walkway since they impact pedestrian flow and speed. The study recommends the formation of the Kenya Federation of Pedestrians to help champion the right of pedestrians and walkway development. Future Town footpaths should operate at or above the suggested LOS C. The Government should balance its desire to increase mobility and ensure safety on the roads. Infrastructure policy is essential for promoting walking, and a cycling plan and a road safety action plan are necessary for non-car users.

Future Research

Further research is needed to enhance our comprehension of pedestrian behaviour. These include the following: -

1. Perform NMT user questionnaires, including their origin and the destination, to achieve monthly and seasonal movement variations.
2. Conduct counts at crossroads, emphasizing the transition between streets embracing new counting innovations such as video processing.
3. Create city macro scenarios simulations to model pedestrian flow volumes and speed.

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APPENDIX

Appendix 1: Facts gathering procedure

Introduction

Yours truly Francis Omondi, Nairobi University Master of Science in Civil Engineering Postgraduate candidate. Aiming to study the travel phase within Tom Mboya Street concentrating on the variable pedestrian speed, the assignment is purely educational. However, the transportation planners, urban experts, and designers may be anxious to use the outcome, endorsements, and certify pedestrian journey needs. Your responses will be confidential.

Form No___ Interview Date__Period__Month__

Designation of assessor____________Day Temperature ____________

Day: (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday) (Tick where applicable)

Weather: Sunny____ Cloudy_____ Investigation Position: ________________

Have you been assessed previously (Yes or No) (Tick where applicable)?

Sector A: General information

Age: (≤ 15 years, 15-25 years, 25-35 years, 35-40 years, 40 years and above__) (Tick where applicable)

Gender: (Male, Female) (Tick where applicable)

1. How much do you earn per month (in kshs)?

(No income, Less than 1,000, 1,001 - 10,000, 10,001 - 20,000, 20,001 - 30,000, 30,001 – 40,000, 40,001 –50,000 and Above 50,000) (Tick where applicable)

2. Outline your career?

Practice: (Engineer, Doctor, Lawyer, Teacher, Nurse, Accountant, (For example Business), and Student: College, Secondary, Primary school pupil and others specify______ Informal employment: Technician, Hawkers, Salons, Jua kali artisan, and other __) (Tick where applicable)

Sector B: Accessibility means

1. What is the trip purpose?

(Work, Shopping, Recreation, Business, School, and Others _____) (Tick where applicable)

2. Mode used to reach the study area?

(Walking, Cycling, Public transport (Matatu), Personal Car, Company vehicle, Taxi, and Others ____) (Tick where applicable)

3. Other than the other modes, which mode do you usually adopt when going to work?

(Walk, Cycling, Public transport (Matatu), Personal Car, Company vehicle, Taxi, Train, and Others ___________) (Tick where applicable)

Sector C: Walkers

1. What is the time taken to reach the end of your journey after alighting from the bus?

(< 15 min, 16-30 min, 31-45 min, and Over 45 min______) (Tick where relevant)

2. Why do you recommend walking over other modes? (Tick relevant section)

(Financial constraints, Comfort, Efficient/ Quicker, No PSV, Exercise, and Others _____) (Tick where relevant)

3. In what condition do you use other modes? (Tick relevant section)

(Late, Rainy, Dark, Sunny day, and Others ___) (Tick where relevant)

4. How frequently have you used the alternative model in the past week? (Tick where relevant)

(None, 1 to 2, 3 to 5, and 6 to 7) (Tick relevant section)

5. What are the discomfort along Tom Mboya Street?

(Interference from vehicle, Lack of path, Mud/dusty road, Lack of walking lane, Overcrowding, Hawkers, Fear of assaulting and Others _______________) (Tick the applicable one)

6. Which of the following would you like to appreciate? (Tick relevant section)

Benches or seats, Smart paving, Zebra crossing, Planting of trees and plants, Shops, leisure area, and Others _____)(Tick the applicable one)

Sector D: Policy and Regulation

4. Are there a by-law policy for pedestrian mode? (Yes, not any and not aware)

5. Are there any by-law policy on jaywalking? (Yes, not any and not aware)

6. Are the by-laws sufficiently imposed? (Yes, not any and not aware)

7. Why are these by-laws not well enforced?

inadequate execution staffs, Bribery, lack of resources, lack of movement controls, and Others _____ not aware

8. What are the associated penalties for jaywalking?

(Less than KSHS. 500, 501 – 1,000, 1,001 –5000, 5,001 –10,000, Greater than 10,000, and not aware)

Kind remark on the survey or outline any issue you find necessary for action.

____

____

____

THANK YOU VERY MUCH

Appendix 2: Stakeholders Questionnaire

Introduction

Yours truly Francis Omondi, Nairobi University Master of Science in Civil Engineering Postgraduate candidate. Aiming to study the travel phase within Tom Mboya Street concentrating on the variable pedestrian speed, the assignment is purely educational. However, the transportation planners, urban experts, and designers may be anxious to use the outcome, endorsements, and certify pedestrian journey needs. Your responses will be confidential.

Interview form

Part A: General information

Designation of respondent: ____________________________________ Date:______

Association name: ___________________ Title/Positions_________

Sex: (Male, Female) (Tick the applicable one)

Part B: Walkway construction and safety

1. Was the community consulted throughout the planning and construction of Tom Mboya Street? (Certainly, not any, and not aware) (Tick the applicable one)
2. To what extent were they involved, if so? (Radio, Television, Meetings, Community leaders, Others, not aware) (Tick the applicable one)

3. Is there any maintenance schedule for Tom Mboya walkway maintenance? (Certainly, not any, and not aware) (Tick the applicable one)

4. When were the improvements to the walkways done? (Last 5, 5 – 10, 10 – 20, 20 – 30, and 30– 50) year (Tick the applicable one)

5. What is the construction Cost for a pedestrian walkway along Tom Mboya street?

(Below 1 Million, 1 – 20 Million, 20 – 50 Million, 50 – 100Million, above 100 Million, and not aware) (Tick the applicable one)

Section C: Policy and regulation

1. Is there any by-law regulating pedestrian mode? Yes _____ No, I don't know/not sure.

2. Is there any by-law regulating jaywalking? Yes ___ No, I don't know/not sure.

3. Are these by-laws adequately enforced? Yes ______ No, I don't know/not sure.

4. Why are these by-laws inadequately enforced? Lack of enforcement personnel, Corruption, no punitive measures to the offender, no resources provided for the enforcement officers, Lack of infrastructure to control pedestrian movement, Others and Don't know/not sure.

5. If there are by-laws for jaywalking, what do you think are the related penalties associated with jaywalking? Less than KSH. 500, KSH. 501 – KSH. 1,000, KSH. 1,001 – KSH. 5000, KSH. 5,001 – KSH. 10,000, Greater than 10,000, and I don't know/not sure.

6. Do you have any case in court launched due to the poor state of footpaths in Kenya? (Certainly, not any, and not aware) (Tick the applicable one)

Section C: Revenue use

1. Outline the use of advertisement revenue? (Road and Walkway maintenance, Other use, and not sure) (Tick the applicable one)

Kind remark on the survey or outline any issue you find necessary for action.

____

____

____

THANK YOU VERY MUCH

Appendix 3: Path examination log

Locality ____ Road ____________________________

Day__________Phase________Highest fifteen minutes from_______Toward_____________

Kerb mark/ Footway Verge		
↑	W_{b1} (kerb) = ________ M	V_1 = _________ ⟵ Pedestrian/15minutes
W_T	W_{b2} (path fittings) = ________m	V_2 = _________ ⟶ Pedestrian/15minutes
↓	W_b (actual breadth) = _______ M	
	W_{b3} (shop window) = _______ M	
	W_{b4} (build overhangs) = _____ M	
	W_{b5} (intimate allowance) =___ m	
Kerb mark/ Footway Verge		

Volume of pedestrians

V_1 = _________ Pedestrian/15minutes

V_2 = _________ Pedestrian/15minutes

$V_p = V_1 + V_2$ = ________Pedestrian/15minutes

Footpath breadth

W_T = ________ meters

W_{actual} breadth= $W_{breadth\ 1} + W_{breadth\ 2} + W_{breadth\ 3} + W_{breadth\ 4} + W_{breadth\ 5}$ = __________ meters

$E_{ffective} = W_{Total} - W_{Breadth} =$ __________ meters

Mean path LSO

$V = V_p/15W_E =$ _______ pedestrian/minute/meter, LSO = _________

Source: HCM (2010)

Appendix 4: Procedure Speed Analysis

Form Number_______ Day of the week ___________ Phase ______________

Assessor Title_____________________ Study Position____________________

Day: (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday) (Tick the applicable one)

Weather: Sunny___________________ Cloudy____________________ Temperature________

_______ Length on path _____________(m)

Time of life: (≤ 15, 15-25, 25-35, 35-40, 40 years and above) (Tick the applicable one)

Timing form

Period In (second)	**Period Out (second)**	**Gender (male or female)**	**Age** **0 - young** **1- old**	**Personal items effect on speed** **0– nothing** **1-Yes no effect** **2- affect speed**	**Speed (meters/second)**	**Impediments** **0-no** **1-yes**
Standard deviation:						
Average	Period pause (s)					
	Speed (meters/second)					

Source: Author (2019)

Appendix 5: Pedestrian tally slips for Tom Mboya Street footpath (Volume count)

Title of evaluator: ………………… Investigation spot: ……………………

Day: (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday) (Tick the applicable one)

Period (a.m)	**Man**	**Woman**	**Teens**	**People with disability**	**Cross point**
6:00 - 6:15					
6:15 - 6:30					
6:30 - 6:45					
6:45 - 7:00					
7:00 - 7:15					
7:15 - 7:30					
7:30 - 7:45					
7:45 - 8:00					
8:00 - 8:15					
8:15 - 8:30					
8:30 - 8:45					
8:45 - 9:00					
9:00 - 9:15					

Source Author (2019)

Appendix 6: Plates

(a)

(b)

(f).

(c).

(e)

(d).

Plate: Sample of Walkability Problems along Tom Mboya Street

Source: Author, (2019)

Plate 2 description in a clockwise direction

a) Billboard beside Tom Mboya Motorway

b) Boda Boda (motor-bicycle operators) operate on Island as pedestrian pick location

c) Dilapidated paths nearby Nairobi Fire station along Tom Mboya Street.

d) Jaywalking and pedestrian pulling trolley utilize the street near National Archives Tom Mboya Street.

e) Venders and Hawkers selling on the walkways near Khoja round about

f) Pedestrians Jaywalking at Khoja roundabout (Jaywalking at Khoja roundabout)