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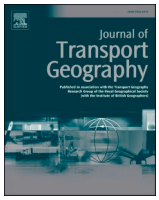

Critical review

Pedestrian travel behaviour and urban form: Comparing two small Mozambican cities

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ABSTRACT

Two main urban forms dominate the profile of Mozambican cities. Those built along national roads and those built inland. These urban forms have different impacts on travel behaviour, in particular walking, which is the main travel mode in many Sub-Sahara African cities. Taking a case study of Alto-molocue, a linear structured city built along the main national road and Milange, a relatively compact inland city, both being small cities with distinct urban forms, this paper aims to determine the influence of urban form on walking behaviour in the two cities. The empirical data used was collected among 130 pedestrian commuters in each city. GIS spatial analysis is used to explore and compare the relation of trip origin and destination on walking behaviour between the two cities. Then, Mann-Whitney non-parametric test is employed to examine the influence of socio-economic, travel behaviour and urban form factors on walking to different travel purposes. Generally, the study findings show that inland cities like Milange, present a better walking environment than linear structured cities built along road corridors like Alto-molocue. For both formal and informal jobs, urban form factors such as activity location and household residence have shown a more important influence on walking in Milange than in Alto-molocue. For other travel purposes (shopping and recreation), the study reveals that socio-economic factors such as income present a strong influence on walking in the city of Milange. The study also shows that inland cities like Milange exhibit shorter walking distances to shopping and recreation activities and people walk more frequently than in cities built along heavy traffic national roads like Alto-molocue. The study findings would be helpful to city planners and decision makers when designing strategies and promotional initiatives for more pedestrian-friendly cities.

1. Introduction

Walking is healthy, free of pollutants, less noisy travel mode and is widely considered by many as an expression of freedom and social integration (Herrero-Fernández et al., 2020; Kumar and Barrett, 2008; UN-Habitat, 2011; 2018; Zhang et al., 2020). In Sub-Sahara African (SSA) cities, walking is the most dominant commuting mode particularly for the urban poor (Sietchiping et al., 2012). For instance, the walking modal share in Douala (Cameroon) is 31%, Niamey (Niger) is 53%, Nairobi (Kenya) is 47%, Quelimane (Mozambique) is 45% and Kigali (Rwanda) is 52% (City_of_Kigali, 2019; Diaz Olvera et al., 2013; Kumar and Barrett, 2008; Mendiate et al., 2020), these being some of the few examples. The large proportion of walking trips in many African cities particularly small cities is explained by the high incidence of poverty (Diaz Olvera et al., 2008; Nkurunziza et al., 2012a, 2012b), and many families cannot finance their daily trips (Diaz Olvera et al., 2008; Nkurunziza et al., 2012a, 2012b). These cities are more so characterised by lack of public transport service (Kumar and Barrett, 2008), and the high prevalence of informal markets scattered around the city that often shorten their daily travel distances (Diaz Olvera et al., 2012).

According to the UN-Habitat (2010a, 2010b), there are typically two main urban forms that characterise Mozambican cities, those cities built

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along the national roads (N1). The structure of these cities is often characterised by linear urban growth with trip attractors like commercial, administrative and job activities, as well as urban basic facilities such as schools, hospitals often located along busy and heavy traffic national roads. The trip attraction urban developments form a linear buffer on major road corridors with no clearly defined central business district (CBD), while the trip generators such as residences are sparsely spread outside of these buffers. These cities are as well characterised by a scattered and poor street network with few or no walking facilities provided, thus presenting an uncomfortable walking environment. Cities built inland are the other predominant urban form in Mozambique. These cities are more often defined by a central core (CBD) where major commercial and administrative activities are concentrated. These cities are characterised by growing outwards of the central core with mixed use developments and experience low vehicular traffic volume, presenting a more safe and attractive walking environment. The influence of these two urban forms on walking has hardly been studied. From the authors' best knowledge, there exist very few examples of studies addressing this issue in SSA cities, which are Lall et al. (2017) and UN-Habitat (2010a, 2010b). The findings from these studies have helped little to shed light on the relationship between urban form and pedestrian travel behaviour in a SSA city context. There is a limited understanding of this relationship, and a lack of research-based information to guide decision-makers in identifying appropriate initiatives that can help in planning and promoting walking in SSA cities.

Current studies that aim to promote walking in cities often examine pedestrian travel behaviour based on two approaches: travel distance and the built environment (Cao et al., 2009; Cervero et al., 2009; Guo and Loo, 2013; Rastogi et al., 2011; Saelens and Handy, 2008). Based on the former approach, walking is preferable in short travel distances, while in the latter walking is preferable in areas with dense urban developments, mixed land use and in areas with high connectivity street networks (Cervero et al., 2009; Guo and Loo, 2013). However, both approaches seem to be unclear in explaining walking behaviour in SSA cities. Commuting by walking in SSA cities is common among the urban poor who often live in the city outskirts, far from jobs that are often concentrated in the inner city (Lall et al., 2017; Pochet and Cusset, 1999). Similar to studies from other developing countries like India (Mohan and Tiwari, 1999; Tiwari, 2002; Tiwari and Jain, 2012), commuters in SSA cities walk long distances due to a lack of travel alternatives (Pochet and Cusset, 1999). Moreover, walking paths are often inexistent or narrow, occupied by street vendors, and/or obstructed by garbage containers, open sewage chambers that contribute to increased road conflict between pedestrians and other transport modes (Datey et al., 2012; Sietchiping et al., 2012; UN-Habitat, 2018). Given this unique walking environment presented in SSA cities, we argue that combining both approaches to examine the linkage between pedestrian travel behaviour and urban form could enable a better understanding of walking behaviour in these cities. This can help in explaining the influence of urban form on walking, and consequently revealing information to help in defining clear policy initiatives to promote walking in SSA cities.

This study compares pedestrian travel behaviour in two small Mozambican cities, by defining important factors that better enhance walking in these cities. The study provides useful information that can guide future urban planning and development initiatives related to walking in small Mozambican cities, as well as other SSA cities of relatively same size, and similar urban structures. The rest of the paper is organized as follows: the second section discusses earlier literature in the field, the third section discusses methods and materials. Section four presents the study results which are later discussed in detail in section 5. Conclusions and final remarks are presented in section 6.

2. Literature review

Previous studies have identified many factors that influence walking behaviour. They can be summarized as socio-economic factors such as average household income, vehicle ownership, travel behaviour factors such as walking distance, walking frequency, walking purpose and urban form factors such as activity locations, household residence (Guo and Loo, 2013; Istrate et al., 2020; Lam et al., 2014; Li et al., 2020). Researchers that attempted to explore the linkage between walking behaviour and socio-economic factors found that walking is the main commuting mode for the majority of urban poor (Diaz Olvera et al., 2008; Kumar and Barrett, 2008). People walk long distances to reach activities such as jobs, markets (Lall et al., 2017). On the other hand, high-income people often walk for physical activity and leisure (Craig et al., 2002). Vehicle ownership has a strong negative influence on walking (Koh and Wong, 2013). For example, Cerin et al. (2009) show that having more cars is negatively correlated with walking. Moreover, Sehatzadeh et al. (2011) indicate that not having a car for work commute is a reason for more walking.

Travel distance, frequency and purpose are relevant travel behaviour factors when investigating walking. Optimum walking distance is a subject of large discussion among researchers (Diaz Olvera et al., 2008; Florindo et al., 2019; Millward et al., 2013). However, most of them agree that walking is suitable for short distances. The study by Millward et al. (2013) cites that walking is a dominant commuting mode for a distance of less than 2Km. Koh and Wong (2013) indicate that in residential areas, the comfortable first and last-mile distance to walk is 650 m. Howe (2001) found that in Temeke district in the city of Dar-es-Salaam, adults walk frequently between 0-2Km. However, this study still indicates that there is a significant number of people that work outside the district that walk commute between 2-8Km. Studies often differentiate between walking for work (formal and informal jobs) and walking for leisure/recreation (Millward et al., 2013). A study by Runa and Singleton (2021) indicates that walking is the main commuting mode for work in Portland, Oregon. Also, Lall et al. (2017), indicate that in the city of Nairobi, walking is the main commuting mode to work due to a lack of affordable commuting alternatives. Likewise, a study by Diaz Olvera et al. (2008) indicates that in order to reduce household travel expenditures to work, walking is pointed out as an alternative. A study by Howe (2001) conducted in Kenya and Tanzania points out that informal jobs especially subsistence activities like street vending have an enormous influence on walking behaviour as it encourages shopping along the route. Also when simulating the effect of street vendors in Addis Ababa, Hagos et al. (2020) found that the average pedestrian density changes with the location of vendors and the presence of customers' interaction with vendors. Moreover, Millward et al. (2013) show that non-utility walking purposes such as leisure/sports have also revealed important walking influence, as it enables easy socialization, crucial for tightening community bonds.

Activity locations and household residences are always taken into consideration when studying the influence of urban form on walking (Cerin et al., 2009; Millward et al., 2013). Cerin et al. (2009) found that high-intensity walking in Gombe (Nigeria) takes place between high density residential areas, and a high concentration of commercial land-use activities such as retails, local markets. Similarly, Guo and Loo (2013) when comparing pedestrian route choices in New York and Hong Kong had similar findings. Their study found that pedestrians in both cities often choose routes with a high percentage of retails frontage and sidewalk width which allow interaction with other pedestrians. Low walkability neighbourhoods often present low density residential, few commercial land uses, and unsafe walkways. For instance, Li et al. (2020) found that pedestrians consider it particularly hazardous to cross urban streets without traffic calming measures. Regarding residence location, Craig et al. (2002) cite that dense and mixed use residential areas are positive correlates of walking for many reasons that include short travel distances, and the increased likelihood to encounter other pedestrians, among others.

While these studies have attempted to examine the influence of socio-economic, travel behaviour and urban form factors on walking

behaviour, it is still unclear how these factors influence walking in the context of small SSA cities. This study aims to fill this gap by examining the relationship between socio-economic, travel behaviour and urban form factors and walking by comparing two small Mozambican cities.

3. Materials and methods

3.1. Case study description

The cities of Alto-molocue and Milange are both small with an almost similar area size of 6239.17 ha (SD = 250.98) and population size of 51,411 inhabitants, and 5811.10 ha (SD = 363.57) and population size of 55,015 inhabitants respectively (INE, 2019). These two cities are both located in the central province of Zambezia about 342 km and 380 km respectively from the city of Quelimane, the provincial capital of Zambezia (see Fig. 1). These two cities are proposedly selected as a case study for two reasons: First, for presenting the most dominating but differing urban form of Mozambican cities (UN-Habitat, 2010a, 2010b), i.e., the urban form characterised by cities located along the national road and those cities located inland. Second, for data availability as the lack of systematic mobility data is a challenge for most studies in SSA cities. The cities had the privilege of being included in a mobility study promoted by the Ministry of environment and rural development of Mozambique.

The city of Alto-molocue is located along the main national road which crosses the city throughout all the urban zones. The city road network is 83.55Km and only 15.90Km (19%) is paved, with 68% of the paved roads corresponding to the national road. From traffic count, the city has an average traffic of 527 vehicles per hour and a very vibrant informal economy along this road. From the survey, people in Alto-molocue produce on average 2.16 (SD = 1.36) walking trips per day. The city is divided into 15 neighbourhoods. The inner city (Z1) is composed of 5 neighbourhoods, corresponding to 9.03% of the city area and a population density of 38.59 inhabitants/ha. The built environment in Z1 is comprised of 37% of formal jobs and 87% informal jobs. 70% of the city paved roads are in Z1 and a large proportion (32%) correspond to the national road where 22% of formal jobs and 63% of the informal jobs are located. The city periphery (Z2) is composed of 5 neighbourhoods, that correspond to 40.89% of the city area and a population density of 8.54 inhabitants/ha. The built environment characteristics comprise 49% of formal jobs, 13% of informal jobs and 10% of the city's paved roads. The paved roads represent the total length of the national road that crosses Z2. More than 90% of all job types are located along the national road. The remaining 5 neighbourhoods are in the sub-urban area (Z3) that corresponds to about 50.08% of the city area and a population density of 2.51 inhabitants/ha. Z3 has 18% of formal jobs and 3% of informal jobs where more than 60% of these job types are located along the national road corridor. 20% of the city's paved roads are located in Z3. Paved roads represent the section of the national road that crosses Z3 with little or no walking facilities.

Milange is an inland city located on the border of Malawi. The city is crossed by a regional road that connects Mozambique to Malawi,

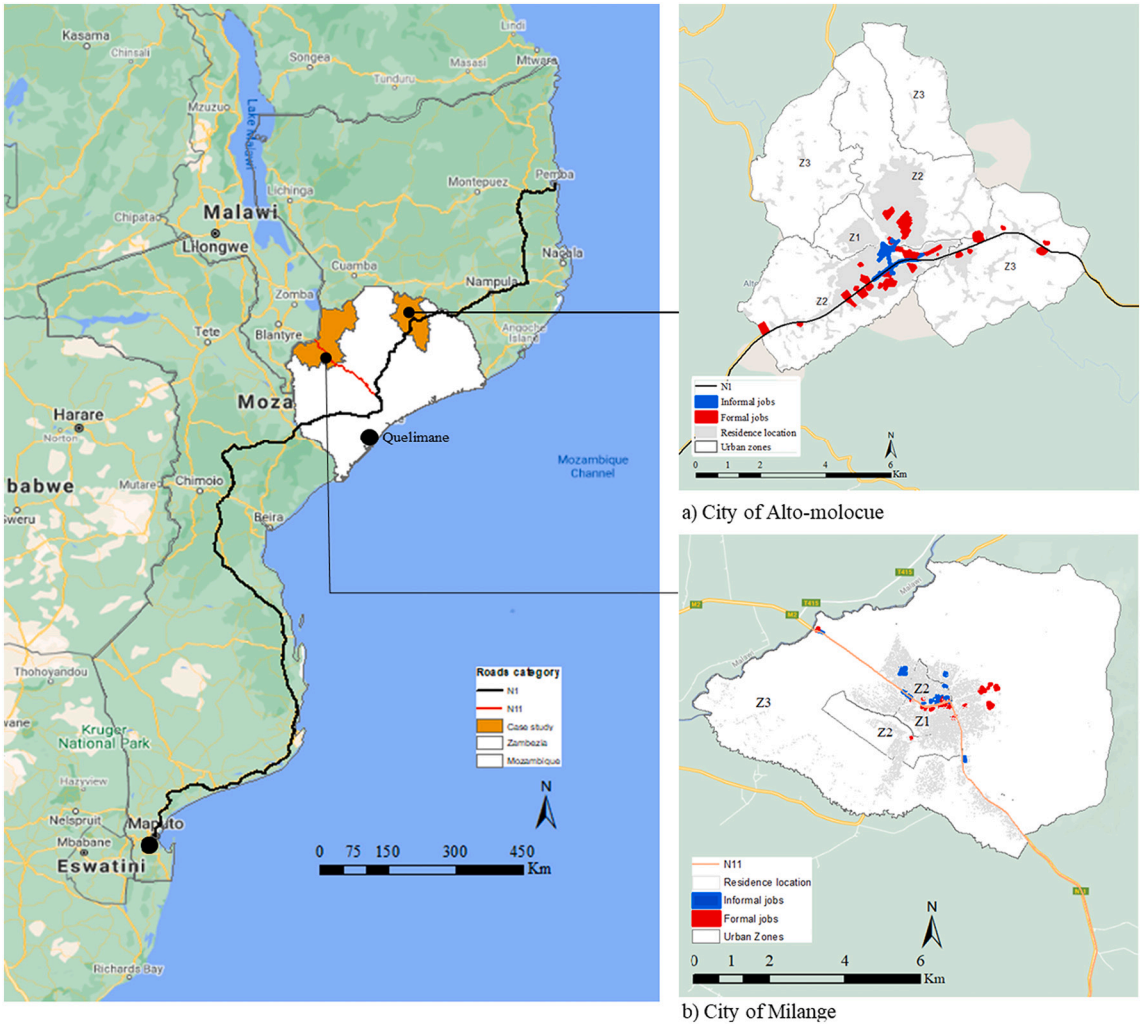

Fig. 1. Case study location.

however, this road has little economic relevance. The road network is about 238.93Km where 11.52Km (5%) is paved and often the street network presents paved sidewalks. From traffic survey observations, the records indicate an average of 17 vehicles per hour, often toward the border. People in Milange produce around 3.37 (SD = 1.45) walking trips per day. The city is divided into 17 neighbourhoods. The inner city (Z1) is composed of 2 neighbourhoods, corresponding to1.67% of the city area and with a population density of 76.97 inhabitants/ha. This urban zone comprises 40% of formal jobs, 1% of informal jobs and 48% of the city's paved roads. The city periphery (Z2) covers an area of 6.7% of the city area and a population density of 36.66 inhabitants/ha. This area concentrates 47% of formal jobs, 80% of large informal markets and 23% of the city's paved roads. The suburban area (Z3) covers the largest city area, 91.63% with a population density of about 6.22 inhabitants/ha. In regard to the built environment characteristics,13% of formal jobs and 19% of informal jobs and 29% of paved roads are located in the Z3.

3.2. Data collection

The data used for the study come from a survey conducted from January to April 2019, during the design of the urban master plan for the cities of Alto-molocue (AM) and Milange (MIL). This was an initiative of the Ministry of environment and rural development of Mozambique. 131 and 134 sample pedestrians were interviewed in Alto-molocue and Milange respectively. This sample represents a 95% confidence level and around an 8% margin of error. This survey was enabled by administering a face-to-face structured survey using electronic gadgets such as smartphones and tablets. In both cities, the interviews were carried out in large markets and major intersections. We believed that at these places, we could intersect people with different socio-economic and travel behaviour characteristics of the target walking population.

The questionnaire was divided into 3 major sections. The first section covered questions about individual vehicle ownership and use. In this section, respondents were asked to indicate which travel modes they own, and use for daily activities. The daily activities were defined and aggregated as formal (work, school), informal jobs (selling in markets, in streets) and other purposes (shopping and recreation). The second section covered individuals' travel patterns and travel behaviour (self-reported travel time). Respondents were asked to indicate their previous day's trip itinerary. This included their Origin and Destination (O-D) and travel purpose, coded as formal jobs, informal jobs and other purposes. From their origin, we extracted their household residence location (as those residing in the inner city; city periphery and suburban area). Additionally, from the O-D, we extracted the complete walking chain, walking frequency, walking distance and walking intensity. Since walking is the main commuting mode in these two cities, it was of our interest to only consider walking trips for the analysis. Potential responses were coded as within Z1 = those walking within the inner-city. Between Z1and Z2 or Z3 = Those walking between the inner-city and city periphery or suburban area. Between Z2-Z3 = Those that walk within the suburban area or city-periphery. The last section of the questionnaire covers the standard socio-economic variables such as age, gender, income and employment level.

3.3. Data analysis procedure

The overall analysis procedure to compare pedestrian travel patterns in two small Mozambican cities involves 3 main stages and is detailed as follows.

- Stage 1: Descriptive Analysis

Descriptive analysis is conducted to define the socio-economic, travel behaviour and urban form factors of the survey sample in Alto-molocue and Milange. This helps to understand the profile of pedestrians in each city. The results of this analysis are presented in Table 1.

- Stage 2: GIS spatial analysis

After defining the socio-economic characteristics of the survey samples in each city, a direct distance skim matrix of PTV Visum was used to automatically generate the O-D pairs of network travel distances between different neighbourhoods. Based on the findings from different studies such as Rahul and Verma (2014), Diaz Olvera et al. (2003) and Howe and Bryceson (2000), the average walking distance to most destinations in cities in developing countries is between 1 and 2 Km, which reflects big land use separation and the fact that more often destinations occur far from the origin in these cities. Therefore in the GIS Analysis, all the walking distances were aggregated based on the threshold of 1.5Km and detailed as follows. Less than 1.5Km including all the trips produced within the neigbourhoods. The remaining were aggregated as between 1.5Km to 3Km and more than 3Km. GIS spatial analysis was used to spatially represent the walking chain, frequency and patterns of people in the survey samples for each city. This analysis was disaggregated per different purposes (formal, informal jobs and other purposes like shopping and recreation). Walking trips produced within each neighborhood were not spatially reported but were considered in the statistical analysis. The trip frequency was represented by variation of graduated symbols and aggregated from less than 2 trips per day, between 2 and 4

Table 1
Socio-economic, travel behaviour and urban form factors of the survey samples in the two cities.

Socio-economic factors	Alto-molocue (n = 131)	Milange (n = 134)
Average monthly income (1000Mts ≈ 14USD)		
%Less than 3600Mts	34	35
%Between 3600Mts-10000Mts	40	23
%Between 10000Mts-21000Mts	16	20
%More than 21000Mts	10	22
Employment status		
%Unemployed	11	14
%Informal jobs	32	24
%Formal jobs	57	62
Vehicle ownership		
%None	73	66
%Only bicycle	9	23
%Bicycle and other modes (Car or motorcycle)	2	6
%Only other modes (Car or motorcycle)	16	5
Travel behaviour factors		
Average walking distance		
%Less than 1.5Km	49	51
%Between 1.5Km to 3Km	35	34
%More than 3Km	16	15
Walking purpose		
%Formal jobs	37	48
%Informal jobs	26	15
% Other purposes (Shopping and recreation)	37	37
Walking frequency		
%Less than 2 trips per day	71	45
%Between 2 and 4 trips per day	25	42
%More than 4 trips per day	4	13
Urban form factors		
Activity locations		
%Within the Z1	40	6
%Between the Z1 and Z2 or Z3	41	11
%Between the Z2-Z3	19	83
Household residence		
%Inner city	40	12
%City periphery	41	31
%Suburban area	19	57

trips per day and more than 4 trips per day. The results of this analysis are presented in Figures and Tables 2-4.

- Stage 3: Non-parametric tests

The survey data were entered into SPSS (version 21) for analysis. In line with the primary aim of this study to examine the relationship between urban form and walking behaviour, the Mann-Whitney non-parametric test was adopted. Non-parametric tests are appropriate for analysing data that does not meet the assumptions of parametric tests such as if the data are not normally distributed or if the data are measurements on an ordinal or interval scale (McCrum-Gardner, 2008). The approach allows to overcome the problem of normal distribution of scores and eliminates the effect of skewness by ranking the data from lowest to highest. The analysis is then carried out on ranks rather than the actual data (Field, 2013). The test helped to examine and compare pedestrian socio-economic, travel behaviour and urban form factors of the two cities (Alto-molocue and Milange), and identifying important factors that better enhance walking to different travel purposes (formal, informal jobs and other purposes).

The Mann-Whitney test was suitable for the analysis for the following reasons: First, the two cities (Alto-molocue = 1 and Milange =2) were considered as grouping variables since they are presented as nominal variables. The socio-economic, travel behaviour and urban form factors were considered as test variables and measured on an ordinal and interval scale. Second, the test of normality assumption of the scores of the dependent variables shows that the data do not assume a normal distribution. Kolmogorov-Smirnov (K-S) = 0.344–0.528, df = 255, Sig = 0.000 and Shapiro-Wilk (S-W) = 0.353–0.636, df = 255, Sig = 0.000. Per each travel purpose (formal, informal job and other purposes), the following assumption was tested: *Between the two cities, there are no walking influence differences for the socio-economic,* travel *behaviour and urban form factors to different travel purposes.*

In interpreting the Mann-Whitney test results, three key statistics are discussed in Field (2013). First, the Mean Rank score of each grouping variables (cities) Alto-molocue and Milange. Since the Mann-Whitney test is based on ranked scores from lowest to highest, the greatest mean rank indicates that people present high scores in specific factors. The second statistic is *Z*-score (Z) which is the statistical measurement of the relationship between the score and the mean score in each independent group. Third, the *p*-value (*p*) indicates whether the observed difference between the independent variables is significant. Following the criteria presented in Field (2013), the effect size (R) below 0.3 is small, between 0.3 and 0.5 is considered moderate while above 0.5 is considered a large effect. The effect size is calculated by dividing the Z-score by the squared root of the total observation (N); $R = Z/\sqrt{N}$. The results of this analysis are presented in Tables 5-7.

Table 2
Travel behaviour of the sampled respondents in Alto-molocue and Milange in regard to formal jobs.

Travel behaviour factors	Alto-molocue ($n = 114$)	Milange ($n = 278$)
Walking distance		
% less than 1.5Km	47	38
% between 1.5Km and 3Km	28	33
% more than 3Km	25	29
Walking frequency		
% Less than 2 trips per day	68	30
% between 2 and 4 trips per day	21	53
% more than 4 trips per day	11	17
Urban form factors		
Activity locations		
% within Z1	39	6
% between Z1and Z2 or Z3	40	7
% between Z2 and Z3	21	87

Table 3
Travel behaviour of the sampled respondents in Alto-molocue and Milange in regard to informal jobs.

Travel behaviour factors	Alto-molocue ($n = 63$)	Milange ($n = 87$)
Walking distance		
% less than 1.5Km	42	57
% between 1.5Km and 3Km	35	39
% more than 3Km	23	4
Walking frequency		
% Less than 2 trips per day	76	58
% between 2 and 4 trips per day	21	36
% more than 4 trips per day	3	6
Urban form factors		
Activity locations		
% within Z1	17	3
% between Z1-Z2 or Z3	46	9
% within Z2 or Z3	37	88

Table 4
Travel behaviour of the sampled respondents in Alto-molocue and Milange in regard to shopping and recreation.

Travel behaviour factors	Alto-Molocue ($n = 94$)	Milange ($n = 115$)
Walking distance		
% less than 1.5Km	35	48
% between 1.5Km and 3Km	38	33
% more than 3Km	27	19
Walking frequency		
% less than 2 trips per day	74	50
% between 2 and 4 trips per day	24	42
% more than 4 trips per day	2	8
Urban form factors		
Activity locations		
% Within Z1	12	7
% Between Z1-Z2 or Z3	27	4
% Within Z2 or Z3	61	89

Table 5
Influence of the socio-economic, travel behaviour and urban form factors on walking for formal jobs.

Socio-economic factors	Mann-Whitney statistics ($N = 124$)					
	Mean Rank					
	AM	MIL	*U*	*R*	*Z*	Sig
Average monthly income	60.98	64.22	1738.00	−0.0469	−0.523	0.601
Employment status	65.26	61.64	1727.00	−0.0689	−0.767	0.443
Vehicle ownership	59.91	64.08	1688.00	−0.0606	−0.675	0.499
Travel behaviour factors						
Walking distance	47.55	68.69	1102.00	−0.3107	−3.460	0.001*
Walking frequency	45.54	72.85	1012.50	−0.3829	−4.264	0.000*
Urban form factors						
Activity locations	34.14	79.81	476.50	−0.6818	−7.593	0.000*
Household residence	39.81	76.97	743.00	−0.5326	−5.931	0.000*

Notes: AM = Alto-molocue; MIL = Milange; U = Mann-Whitney test value; R = effect size; Z = *Z*-Score value; *p*- value <0.05 (2- tail)*.

4. Results

The main results of the study are presented below. Section 4.1 defines the socio-economic, travel behaviour and urban form factors of the survey sample in Alto-molocue and Milange. The subsequent sections outline the main walking travel pattern differences. Precisely, section 4.2 presents the influence of the urban form on travel behaviour by exploring spatial travel patterns per different walking purposes (formal

Table 6
Influence of the socio-economic, travel behaviour and urban form factors on walking for informal jobs.

Socio-economic factors	Mann-Whitney statistics ($N = 57$)					
	Mean Rank					
	AM	MIL	*U*	*R*	*Z*	Sig
Average monthly income	26.44	32.52	311.50	−0.2101	−1.586	0.113
Employment status	27.83	30.60	357.50	−0.0932	−0.704	0.481
Vehicle ownership	26.88	31.92	326.00	−0.1767	−1.334	0.182
Travel behaviour factors						
Walking distance	28.06	29.08	370.00	−0.0334	−0.252	0.801
Walking frequency	24.24	35.54	239.00	−0.3572	−2.697	0.007*
Urban form factors						
Activity locations	20.82	40.25	126.00	−0.6226	−4.701	0.000*
Household residence	22.15	38.42	170.00	−0.5249	−3.963	0.000*

Notes: AM = Alto-molocue; MIL = Milange; U = Mann-Whitney test value; R = Effect size; Z = *Z*-Score value; *p*- value <0.05 (2- tail)*.

Table 7
Influence of the socio-economic, travel behaviour and urban form factors on walking for shopping and recreation.

Socio-economic factors	Mann-Whitney statistics ($N = 77$)					
	Mean Rank					
	AM	MIL	*U*	*R*	*Z*	Sig
Average monthly income	29.99	52.37	298.50	−0.5342	−4.688	0.000*
Employment status	41.83	34.81	583.00	−0.1679	−1.474	0.141
Vehicle ownership	39.15	38.77	706.00	−0.0100	−0.088	0.930
Travel behaviour factors						
Walking distance	39.15	34.08	560.50	−0.1326	−1.164	0.244
Walking frequency	31.41	50.26	364.00	−0.4334	−3.803	0.000*
Urban form factors						
Activity locations	31.30	50.42	359.00	−0.4552	−3.994	0.000*
Household residence	33.09	47.77	441.00	−0.3456	−3.033	0.002*

Notes: AM = Alto-molocue; MIL = Milange; U = Mann-Whitney test value; R = Effect size; Z = Z-Score value; *p*- value <0.05 (2- tail) *.

job, informal job and other purposes). While section 4.3 presents the main statistical test results of the influence of the socio-economic, travel behaviour and urban form factors on walking in the two cities.

4.1. Socio-economic characteristics of the survey samples

Table 1 presents the socio-economic, travel behaviour and urban form characteristics of the sample population in each city, Alto-molocue and Milange. The average monthly income of the sample population in Alto-molocue is between 3600Mts-10000Mts and represents 40% of the sample. In Milange 35% of the pedestrians earn low income with an average monthly income below 3600Mts. A considerable proportion of high-income individuals walk frequently in Milange (22%), while in Alto-molocue only 10% of the high-income people walk frequently. In both cities, more than 50% of the pedestrians have formal jobs and more than 20% have informal jobs, while below 15% are unemployed. 73% of the sample in Alto-molocue rely only on walking for commuting and 16% own and use motorized modes. In Milange, 66% rely only on walking and 23% own and use only a bicycle. In both cities, most people walk for formal jobs and other purposes such as shopping and recreation. They often walk short distances (less than 1.5Km). 71% and 45% of the sampled population in Alto-molocue and Milange respectively, walk less frequently (less than 2 trips per day). While 45.5% of the sampled respondents in Milange make between 2 and 5 trips per day. In relation to urban form, in Alto-molocue, 41% of the trips take place between the inner-city and city-periphery or suburban area while in Milange 85% of the trips take place between the city-periphery and suburban area. In Alto-molocue, 40% of the sampled population live in the inner-city and 41% live in the city periphery while in Milange, 57% reside in the suburban area.

4.2. Spatial travel patterns per different walking purposes

4.2.1. Formal jobs

Fig. 2, shows the spatial patterns of walking trips for the sampled population in Alto-molocue (a) and Milange (b) regarding formal jobs and Table 2 presents the key statistics. It is observed that in Alto-molocue the most intense walking trips for formal jobs are oriented toward the inner-city (40%) and 39% of walking trips take place within the inner-city. Table 2 indicates that 47% of the sampled respondents often walk short distances (less than 1.5Km, but walk less frequently than those in Milange. In Milange, the walking travel patterns for formal jobs indicate that 87% of trips take place between the city periphery and suburban area. 38% of the sampled respondents in Milange walk less than 1.5Km. The city has a relatively high percentage of people that walk long distances and do so more frequently (between 2 and 4, and more trips per day).

4.2.2. Informal jobs

Fig. 3 and Table 3 show the walking patterns of the sampled population in Alto-molocue and Milange regarding informal jobs. In Alto-molocue, it is observed that 46% of people walk between the inner-city and city periphery or sub-urban area and 37% walk within the city periphery and sub-urban zones. In general, 42% of the sampled respondents walk less than 1.5Km, and 76% walk less frequently. Overall the sampled pedestrians in Alto-molocue walk longer distances than those in Milange. In Milange, the walking patterns for informal jobs are very different from that of Alto-molocue. Around 88% of the walking trips take place within the city-periphery and sub-urban area. Results indicate that 57% of the sampled population walk less than 1.5Km, and produce more walking trips.

4.2.3. Other travel purposes (shopping and recreation)

Fig. 4 and Table 4, present the walking patterns of the sampled population in Alto-molocue and Milange regarding shopping and recreation purposes. From the analysis, it is observed that the sampled respondents reveal different walking travel patterns for shopping and recreation in both cities. For example, in Alto-molocue, more than 60% of the walking trips take place between the city-periphery and sub-urban area. 35% walk relatively short distances (less than 1.5Km), and more than 70% often produce less than 2 walking trips per day. In Milange, however, it is observed that close to 90% of the walking trips take place within the city periphery and sub-urban area. Unlike in Alto-molocue, more than 45% of the people in Milange walk less than 1.5Km and 50% produce more than 2 walking trips per day.

4.3. Influence of socio-economic, travel behaviour and urban form factors on walking for different travel purposes

4.3.1. Formal jobs

The summary of the Mann-Whitney test comparing the influence of the socio-economic, travel behaviour and urban form factors on walking for formal jobs is presented in Table 5. Within this group ($N = 124$); AM = 37.90% and MIL = 62.09%. The analysis tests the null hypothesis that between the two cities, the socio-economic, travel behaviour and urban form factors present no differences in walking influence in relation to formal jobs. The results indicate that travel behaviour and urban form factors present a significant difference in walking behaviour between the two cities. These variables are walking distance, walking frequency, activity location and household residence. The effect size of these factors

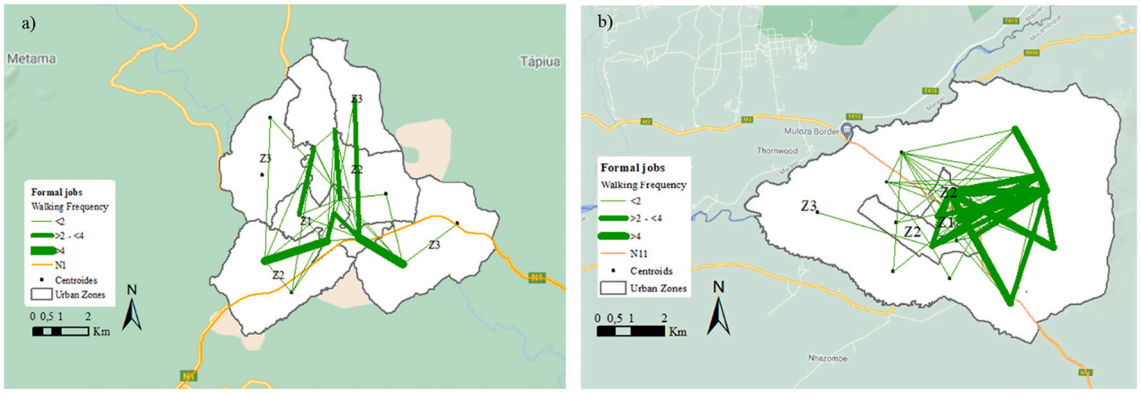

Fig. 2. Walking frequency maps of the sampled population for formal jobs in Alto-molocue (a) and Milange (b).

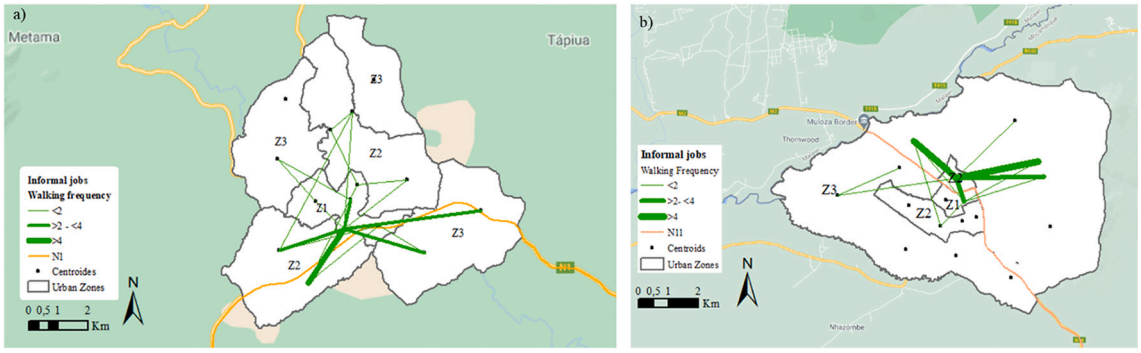

Fig. 3. Most frequent O-D pairs of walking trips by the sampled population for informal jobs in Alto-molocue (a) and Milange (b).

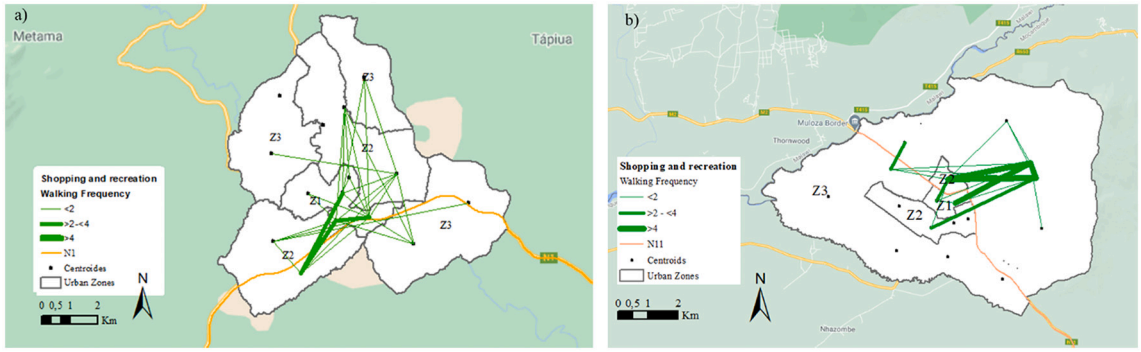

Fig. 4. Most frequent O-D pairs of walking trips by sample population to shopping and recreation travel purposes in Alto-Molocue (a) and Milange (b).

ranges from moderate to large. Walking distance (U = 1102.00; R = -0.3107; Z = -3.460; $p < 0.01$), walking frequency (U = 1012.50; R = -0.3829; Z = -4.264; $p < 0.01$) present a moderate effect size. Activity location (U = 476.500; R = -0.6818; Z = -7.593; $p < 0.01$) and household residence (U = 730.00; R = -0.5326; Z = -5.931; $p < 0.01$) present the highest effect size. For both activity location and household residence factors, the Mean Rank is higher for Milange than Alto-molocue. This means that among the sampled population, urban form factors such as activity location and household residence present a high influence on walking for formal jobs in Milange than in Alto-molocue.

4.3.2. *Informal jobs*

The influence of the socio-economic, travel behaviour and urban form factors on walking for informal jobs in AM and MIL is presented in Table 6. Within this group ($N = 57$); AM = 57.89% and MIL = 42.10%. The analysis tests the null hypothesis that between the two cities, the socio-economic, travel behaviour and urban form factors present no difference in walking influence in relation to informal jobs. The Mann-Whitney test indicates that three factors present statistically significant differences in walking behaviour between the two cities. These factors are walking frequency, activity location and household residence. The effect size ranges from moderate to large. Walking frequency (U = 239.00; R = -0.3572; Z = -2.697; $p < 0.01$) has a moderate effect size while activity location (U = 126.00; $R = -0.6226$; Z = -4.701; $p < 0.01$) and Household residence (U = 170.00; R = -0.5249; Z = -3.963; $p < 0.01$) present the highest effect size. For these factors, the Mean Rank of Milange is higher than Alto-molocue. This indicates that among the sampled population, urban form factors such as activity location and household residence present more influence on walking for informal jobs in Milange than in Alto-molocue.

4.3.3. Other travel purposes (shopping and recreation)

Table 7 indicates the summary of Mann-Whitney test comparing the influence of socio-economic, travel behaviour and urban form factors on walking for other purposes in both cities. The analysis tests the hypothesis that between the two cities, the socio-economic, travel behaviour and urban form factors present no differences in walking influence in relation to other purposes. Within this group ($N = 77$); AM = 59.74% and MIL = 40.25%. The analysis reveals that four factors yielded a statistically significant difference in walking influence between the two cities. These factors are average income, walking frequency, activity locations and household residence. The effect size ranged from moderate to large. Household residence (U = 441.000; R = −0,3456; Z = -3.033; $p < 0.01$), walking frequency (U = 364.00; R = -0.4334; Z = -3.803; $p < 0.01$) and activity location (U = 359.00; R = -0.4552; Z = -3.994; $p < 0.01$) present a moderate effect size. Average monthly income (U = 298.50; $R = -0.5342$; Z = - 4.688; $p < 0.01$), presents the highest effect size. Milange presents the highest Mean Rank than Alto-molocue. This means that among the two cities, walking for shopping and recreation in the city of Milange is highly influenced by the average income.

5. Discussion

The influence of socio-economic, travel behaviour and urban form on walking behaviour for the two small Mozambican cities, Alto-molocue and Milange is examined for different travel purposes (formal jobs, informal jobs and other purposes (shopping and recreation).

For formal jobs, Fig. 2 and Table 2 present pedestrians' spatial travel patterns, while Table 5 shows the influence of socio-economic, travel behaviour and urban form factors on walking behaviour in each city. Generally, activity locations and household residence have an important influence on walking in Milange than in Alto-molocue (Table 5). People in Milange walk longer distances and more frequently to formal jobs than those in Alto-molocue (Table 2). This would be explained by the fact that most formal jobs in Milange are scattered within the city periphery and sub urban zones (Fig. 1b), and most people reside in the suburban area with few of them owning cars (Table 1). This leads to long walking distances between the city-periphery and suburban areas. The observed more frequent walking to formal jobs in Milange may be explained by the lack of other travel options and a safe walking environment in the city periphery and suburban zones. These findings are consistent with Lall et al. (2017) in their study in Nairobi which indicates that due to lack of affordable travel alternatives and spatial mismatch between jobs and residence, the majority of urban poor walk long distances to workplaces. Differently from Milange, most people in Alto-molocue reside in the inner-city and city-periphery (Table 1) and most formal jobs are concentrated in the inner city along the national road (Fig. 1a). This indicates that people in Alto-molocue walk short distances for formal jobs (Table 1). Despite that, they walk less frequently than those in Milange (Table 2). This may be explained by the fact that many people in Alto-molocue own cars or motorcycles (Table 1). These findings are in line with Cerin et al. (2009) study which shows that having more cars is negatively correlated with walking. Also, according to Guo and Loo (2013), people are more likely to walk more frequently in places where they can encounter more pedestrians and low motorized traffic, which is not the case for the city of Alto-molocue built along the very busy motorized traffic national road.

For informal jobs, Fig. 3 and Table 3 present the pedestrians' spatial travel patterns while Table 6 presents the influence of the socio-economic, walking behaviour and urban form factors on walking in each city. People in Milange walk short distances and more frequently than those in Alto-molocue for informal jobs (Table 3). In addition, activity location and household residence present an important influence on walking for informal jobs in Milange than in Alto-molocue (Table 6). This can be explained by the fact that in Milange most people reside in the suburban area (Table 1) and most informal jobs are concentrated in the city-periphery and suburban area (Fig. 1b). This leads to short and frequent trips within the city-periphery or sub-urban area. These findings are consistent with the UN-Habitat (2010a, 2010b) study which cites that the city-periphery in SSA cities concentrates a vast and dense network of informal markets and undoubtedly reduces the average travel distance, thus increasing the walking frequency. Also, according to Mukwarami et al. (2018), most families living in vibrant city peripheries often hold small informal grocery shops located in the front room of their houses. Consequently, these contribute to an overall increased walking frequency for informal jobs. Moreover, Florindo et al. (2019) cite that walking is suitable for short travel distances and particularly for those walking carrying a heavy load of goods to sell in local markets. In Alto-molocue, however, most people reside in the inner-city and city-periphery, with informal jobs (Table 1) scattered in all neighbourhoods crossed by the national road (Fig. 1a). This makes people walk long distances and less frequently.

For other purposes (shopping and recreation), Table 4 and Fig. 4 present the pedestrians' spatial travel patterns while Table 7 presents the influence of the socio-economic, travel behaviour and urban form factors on walking for other purposes. It is observed that in Alto-molocue, people walk longer distances and less frequently, while in Milange, most people walk short distances (less than 1.5 km) and most frequently to shopping and recreation activities (Table 4). Moreover, socio-economic factors such as average income indicate high influence on walking for shopping and recreation purposes in Milange than in Alto-molocue. This can be explained by the fact that most people in Milange have low income with a large proportion of them residing in the suburban area (Table 1), close to shopping and recreational areas that are often located in the city periphery and/or suburban area (Table 4). These findings are consistent with Bryceson et al. (2003) who cite that low-income residents in SSA cities are likely to make short and frequent shopping trips due to a high incidence of the informal market in these residential areas. In Alto-molocue however, most people reside in the inner city and city periphery and most shopping and recreational areas are located along the neighbourhoods crossed by the national road (Fig. 1a), contributing to relatively long distances for this trip purpose. These findings are consistent with Roever and Skinner (2016) study which indicates that people are less likely to walk long distances for shopping purposes.

6. Conclusion

This study contributes to the existing knowledge on the linkage between travel behaviour and urban form. The study examines and compares pedestrian travel behaviour in two small Mozambican cities with different urban forms: the city of Alto-molocue (located along the national road) and Milange (an inland city). The analysis helps in defining important factors that better influence walking to different travel purposes (formal jobs, informal jobs and other purposes like shopping and recreation) in the two cities.

The study findings show that inland cities like Milange, present a better walking environment for utility purposes such as formal and informal jobs. For both formal and informal jobs, urban form factors such as activity location and household residence have an important influence on walking in inland cities like Milange than in cities built along national roads like Alto-molocue. The study reveals that cities built along the national road like Alto-molocue are less walkable for both formal and informal jobs despite exhibiting short travel distances for formal jobs. The study indicates that the concentration of formal and informal jobs along busy traffic national roads shorten the overall travel distance to jobs but reduces the walking frequency due to unsafe and uncomfortable walking environment. Thus, policies and strategies should be directed to promote safe walking in the neighbourhoods along or crossed by the busy national roads, and by discouraging motor vehicle use particularly for short travel distances in cities like Alto-Molocue.

For other travel purposes (shopping and recreation), the study reveals that socio-economic factors such as income present a strong influence on walking to shopping and recreation activities in the city of

Milange than in Alto-molocue. The study also shows that inland cities like Milange exhibit short walking distances and people walk more frequently than in cities built along heavy traffic national roads like Alto-molocue. This is strongly supported by the high mix of residential, retail shops and recreational activities in the city periphery and suburban zones of an inland city where the majority of the city population live. To encourage people to walk and do so more frequently for shopping and recreation, in cities like Alto-molocue, retails, shopping centres and recreational activities should be concentrated in the inner city and city periphery residential areas. While in inland cities like Milange, it is crucial to locate these shopping and recreational services in low-income city periphery and suburban areas.

Finally, when comparing the two urban forms, generally the city of Milange has shown to provide a better walking environment than the city of Alto-molocue. The urban form of Milange characterised by inner city central core, mixed uses such as residential, formal and informal jobs, retail, shopping and recreational activities spatially distributed in all zones especially the city periphery and suburban zones has enabled the inland city's overall short walking distance and increased number of walking trips. The study has shown that most walking trips in the city of Milange experience low moto-vehicular traffic which provides a safe walking environment for commuter pedestrians. Thus, in order to encourage and promote walking in SSA cities, in particular small cities, urban planners and decision makers should emphasize on urban developments with dense residential neighbourhoods and mixed uses of commercial retails, informal and formal jobs, shopping as well as recreational activities, supported by a high connectivity street network with low motorized traffic volume. Cities in SSA should limit and discourage linear urban developments along busy and heavy motor vehicle traffic road corridors. The study has shown that linear urban growth induces city sprawl with most jobs, commercial, public and basic urban services developed separately along a major traffic road corridor away from residential neighbourhoods, leading to unsafe, long walking distances and reduced walking trips.

Declarations

The authors declare that there no conflict of interest.

Authors contributions

Classio Joao Mendiate: Conceptualization; Data curation; Formal analysis; Writing - original draft, Writing - review & editing. **Alphonse Nkurunziza**: Conceptualization, Formal analysis, Writing - review & editing. **Constancio Augusto Machanguana**: Investigation; Writing - review & editing. **Roberto Bernardo**: Resources; review & Writing - review & editing.

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