UNIVERSIDAD POLITÉCNICA DE
MADRID

ESCUELA TÉCNICA SUPERIOR
DE INGENIEROS DE CAMINOS,
CANALES Y PUERTOS

Doctoral thesis

IDENTIFYING KEY EXPLANATORY VARIABLES FOR CYCLING IN SUB- SAHARAN AFRICA

Case study: Quelimane (Mozambique)

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Madrid, 2020

ACKNOWLEDGMENTS

Doing a Ph.D. was by a means of the logical consequence of my own lifetime cycling experience. For a person growing in Quelimane, Mozambique I experienced cycling from a very early age. Learn-to understand cycling and how these people perceive cycling among many adversities was my lifetime ambition. I thank myself that after these 3 years journey I could bring Quelimane to the world. Without the support of the following people, this journey could not be possible.

My first gratitude goes to my thesis Director, Professor Andres Monzon. I thank him for giving me this opportunity to come to Madrid and join his prestigious transport group. I want to thank him for the guidance he gave me during this time and the freedom to explore, test thing my own. His critical comments helped me to understand how vast science is and this led me to improve the quality of my research.

Special thanks go to my daily supervisor, Dr. Julio A. Soria-Lara. I would say that I was a fortunate student in having him as my daily supervisor. I sincerely appreciate his guidance and ideas that shaped and improved my analytical and technical writing. From him, I learn how to write scientific articles, which is very important for a researcher. His critical and methodological thinking helped me to improve the quality of my research. His words of encouragement gave me the strength needed to move forward.

I want to express my gratitude to Dr. Alphonse Nkurunziza, from the University of Rwanda for his support during the thesis. I sincerely want to thank him for his comments and advice particularly in the last stage of my thesis. I sincerely appreciate his guidance and support in writing some chapters of this thesis.

I'm deeply grateful to TRANSyT-UPM, for the support and assistance during the time I stayed in Madrid. Without your support, I could not be able to fulfill all the academic requirements to complete this research program. Special thanks go to the TRANSyT Director Ms. Rosa Ruiz, Carmen Pérez Martínez and Patricia Rico for their assistance which was so crucial. Thanks go to the other colleagues for their support and kindness.

I express my gratitude to the Ministry of science and technology of Mozambique, who sponsored my studies. Thanks are extended to Mr. Baiane Langa and Mr. Belarmino dos Santos, without you, this could have been not possible.

Finally, I would like to thank my brothers, my wife Laura Dias for their unconditional love, support, encouragement during my frustrations and successes. I want to dedicate this thesis to my family.

Classio Joao Mendiante

September 2020

ABSTRACT IN SPANISH

El ciclismo es saludable, respetuoso con el medio ambiente, permite un fácil acceso a los trabajos y también proporciona trabajos flexibles. El ciclismo está influenciado por muchos factores, como las características personales, factores de actitud, factores del entorno y factores naturales y ambientales. Sin embargo, la intensidad de estos factores en el ciclismo está muy influenciada por el contexto urbano, y en las ciudades medianas del África subsahariana (SSA) se ha probado muy poco.

El principal objetivo de este estudio es identificar quiénes son los ciclistas y dónde pedalean. El estudio busca pruebas empíricas a partir de datos recopilados entre 1084 viajeros de Quelimane, una ciudad de tamaño mediano en el centro de Mozambique. Primero, se lleva a cabo una revisión de la literatura para explorar los grupos de ciclistas existentes en las ciudades de SSA y los factores que influyen en su comportamiento ciclista. Luego, para identificar quiénes son los ciclistas, se determinaron los factores subyacentes que estructuran la muestra poblacional mediante análisis factorial y se aplicó un proceso de agrupamiento. A continuación, se recrearon los patrones de viaje de los ciclistas utilizando GIS para evaluar la influencia de la calidad de la carretera en el ciclismo. Los resultados identificaron tres grupos de ciclistas: trabajadores informales con niños, estudiantes de corta distancia y ciclistas ocasionales. Los grupos se basaron en la composición del hogar, la situación laboral y la frecuencia de ir en bicicleta al trabajo o la escuela. Se encontró que más del 40% de los viajes en bici se realizaban dentro de la periferia de la ciudad y 10% entre la periferia de la ciudad y las áreas suburbanas. La mayoría de la gente va en bicicleta para llevar productos para vender en los mercados locales y como bicicleta-taxi. Los resultados del estudio proporcionaron una comprensión clara de los ciclistas y sirvieron como base empírica para desarrollar políticas más específicas para fomentar el ciclismo. A continuación, se utilizó un enfoque de segmentación del mercado por actitudes para identificar los mercados potenciales de los desplazamientos en bici. El análisis factorial se utiliza para identificar factores latentes clave y el Modelado de ecuaciones estructurales (SEM) estima la correlación entre los factores latentes. Luego, el proceso de agrupación TwoStep se utiliza para segmentar el mercado de transporte en bicicleta en varios submercados. Se obtienen tres segmentos de mercado actitudinales que son Ciclistas exigentes, Ciclistas cautelosos y Ciclistas forzados. El estudio revela que los ciclistas exigentes tienen la actitud más positiva hacia el ciclismo y podrían estar motivados para más ciclismo proporcionando instalaciones adecuadas para ciclistas y un tráfico mejorado y buenas condiciones de infraestructura vial. Los ciclistas cautelosos con actitud ciclista moderada y baja podrían estar motivados para aumentar el uso de bicicletas proporcionando un fácil acceso a las bicicletas. Los Ciclistas Forzados con una alta necesidad económica, usan la bici para generación de ingresos. Los resultados proporcionan una base para planificar y desarrollar políticas y estrategias de promoción que más satisfagan las necesidades de cada segmento del mercado para aumentar los desplazamientos en bicicleta. Para identificar dónde pedalean las personas, se evaluó la importancia que 9 variables de elección de ruta ciclista recibieron de los individuos en 3 segmentos de ciclistas identificados en el capítulo anterior. Se utiliza una prueba no paramétrica de Kruskal-Wallis para explorar si la importancia atribuida a las variables de elección de ruta difiere según la hora de salida individual y los patrones de viaje. En general, el resultado revela que los ciclistas están más de acuerdo en que la falta de señalización de las calles, la mala calidad del pavimento

de las calles, el alumbrado público deficiente y la falta de cobertura de árboles en las calles son extremadamente importantes a la hora de definir un itinerario en bicicleta. En cuanto a la hora de salida, los ciclistas cautelosos que inician sus viajes por la tarde consideran que la frecuencia de accidentes de tránsito es más importante que los que comienzan por la mañana. La falta de cobertura de árboles a lo largo de las calles se consideró más importante para los ciclistas exigentes que viajaban dentro de las áreas planificadas que para aquellos que circulaban dentro de las áreas no planificadas. El estudio señala que para eliminar las barreras de elección de bici rutas, las iniciativas deben centrarse en mejorar la calidad de la superficie de las calles, proporcionar cobertura de árboles y promover iniciativas para calmar el tráfico. Los resultados del estudio proporcionan una comprensión clara de los factores clave que influyen en el itinerario de los ciclistas, lo que puede servir como base empírica para el desarrollo de medidas más específicas para fomentar el ciclismo.

Los resultados clave de este estudio son: en la mayoría de las ciudades de SSA, el ciclismo es básicamente para hombres y la bici es utilizada como herramienta de trabajo. Los ciclistas podrían agruparse en tres segmentos de actitud de ciclismo y son Ciclistas exigentes, Ciclistas cautelosos y Ciclistas forzados. Se encontró que la mayoría de las personas en las ciudades de SSA tienen una percepción moderada hacia el ciclismo. Sin embargo, el segmento de ciclistas exigentes tiene la percepción más alta. Las características socioeconómicas de cada segmento actitudinal no presentan diferencias estadísticas sustanciales, esto ya fue predicho en estudios previos. Al elegir una ruta en bicicleta, los ciclistas consideran la calidad de las carreteras, la falta de cobertura de árboles en las calles, muy relevante.

La contribución original de esta tesis es proporcionar datos de movilidad organizados sistemáticamente para una pequeña ciudad de SSA. En segundo lugar, a diferencia de la mayoría de la literatura, los viajes en bicicleta de alta intensidad tienen lugar dentro de la periferia de la ciudad en lugar de entre la periferia de la ciudad y el centro de la ciudad. Asimismo, la elección del ciclismo no debe verse como una función de la distancia recorrida. El estudio reveló que una bicicleta es una herramienta de trabajo, por lo tanto, es muy adecuada para largas distancias por ser más rentable

Palabras clave: desplazamientos en bicicleta, Quelimane, centro de la ciudad, periferia de la ciudad, área suburbana, comportamiento de viaje, actitud.

ABSTRACT IN ENGLISH

Cycling is widely perceived as healthy, environmentally friendly, enables easy access to jobs, and also provides flexible jobs. Cycling is influenced by many factors such as personal characteristics, attitudinal factors, built environment factors and natural and environmental factors. However, the intensity of these factors on cycling is very influenced by the urban context, and in medium- size Sub-Saharan Africa (SSA) cities it has been very little tested.

The main objective of this study is to identify who are the cyclists and where they cycle. The study searches for empirical pieces of evidence from data collected among 1084 commuters of Quelimane, a medium-sized city in central Mozambique. First, a literature review is conducted to explore the existing cyclist groups in SSA cities and factors influencing their cycling behaviour. Then, to identify who are the cyclists, the underlying factors structuring the population sample were determined through factor analysis, and a clustering process was applied. Cyclists' travel patterns were then recreated using GIS to assess the influence of road quality on cycling. The results identified three clusters of cycling commuters: informal workers with children, short-distance students, and occasional cyclists. The clusters were based on household composition, employment status and cycling frequency to work/school. It was found that over 40% of cycling trips took place within the city periphery and about 10% between the city periphery and suburban areas. Most people cycle to carry products to sell in local markets and as a bicycle-taxi. The study findings provided a clear understanding of commuter cyclists and served as an empirical basis for developing more targeted policies to encourage cycling. Next, attitudinal market segmentation approach was used to identify potential markets of bicycle commuters. Factor analysis is used to identify key latent factors and Structural Equation Modelling (SEM) estimates the correlation between those latent factors. Then, TwoStep clustering process is used to segment the bicycle commuting market into several submarkets. Three attitudinal market segments are obtained which are Demanding cyclists, Cautious cyclists, and Forced cyclists. The study reveals that Demanding Cyclists have the most positive attitude towards cycling and they could be motivated to more cycling by providing proper cycling facilities and improved traffic and good road infrastructure conditions. The Cautious Cyclists with moderate and low cycling attitude could be motivated to increased cycling by providing easy access to bicycles. The Forced Cyclists with a high need for the economy cycle purposely to generate income. The results provide a basis to plan and develop policies and promotional strategies that most serve the needs of each market segment for increased bicycle commuting. To identify where people cycle, the importance that 9 cycling route choice variables received from individuals in 3 attitudinal cycling segments (identified in the previous chapter) was assessed. A non-parametric Kruskal-Wallis test is used to explore whether the importance attached to the route choice variables differs based on the individual departure time and travel patterns. Overall, the result reveals that cyclists are more consensual that the lack of street signalization, the poor quality of street pavement, the deficient street lighting and lack of street tree cover are extremely important when defining a cycling itinerary. In regard to departure time, Cautions cyclists starting their trips in the afternoon consider the frequency of road accidents as more important than those starting in the morning. The lack of tree cover alongside the roads was considered as important for Demanding cyclists traveling within the planned areas than those cycling within the unplanned areas. The study

points that to remove cycling route choice barriers initiatives should focus to improve the quality of the roads surface, provide streets tree cover and promote initiatives for traffic calming. The study's findings provide a clear understanding of key factors influencing cyclists' itinerary, which can serve as an empirical basis for the development of more targeted measures to encourage cycling.

The key findings of this study are: in most SSA cities cycling is basically for male and it has been used as a working tool. Cyclists could be aggregated into three cycling attitudinal segments and are Demanding cyclists, Cautious cyclists, and Forced cyclists. It was found that most individuals in SSA cities have a moderated perception toward cycling. However, the segment of Demanding cyclists has the highest perception. The socio-economic characteristics of each attitudinal segment do not present substantial statistical differences between segments, this has been reported in early studies. When choosing a cycling route, they consider the quality of the roads, lack of street tree cover, highly relevant.

The original contribution of this dissertation is for providing systematically organized mobility data for a small SSA city. Second, differently from most literature, high-intensity cycling trips take place within the city periphery rather than between the city periphery and the inner city. Likewise, cycling choice should not be seen as a function of travel distance. The study revealed that a bicycle is a working tool, therefore, it's much suitable for long distances for being more profitable

Keywords: bicycle commuting, Quelimane, Inner city, city periphery, suburban area, travel behaviour, attitude.

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1

**CYCLING IN SSA CITIES.
DIFFERENCES AND
SIMILARITIES WITH OTHER
CONTEXTS**

1. INTRODUCTION

This thesis is focused on bicycle commuting in Quelimane, a medium-sized city in Mozambique. In Sub Saharan Africa (SSA), cycling is very popular in medium-sized cities and is around 35% of the mode share. However, little is known about cycling in these cities and most initiatives targeted to promote cycling are often imported from cities with different urban contexts, often revealing inaccurate. This thesis aims to identify who are the cyclists and key factors influencing their decisions to cycle. This thesis findings are crucial to help in defining accurate measures to promote bike use in this urban context. The introduction briefly explores the background of cyclists and the main factors influencing cycling decisions. It also briefly discusses how the different factors influencing cycling commuting are perceived in the context of medium-size sub-Sahara African (SSA) cities and key differences and similarities with cities in other contexts are highlighted. Then, the research objectives are presented, followed by the methodology and the case study. The fifth and sixth sections focus on identifying the type of commuters and their travel patterns. The defined groups of cyclists were used for further analysis. The seventh section identifies variables that affect the cycling itinerary of individuals in each cycling group. The last section is about conclusion and recommendation and further research lines are presented.

1.1. BICYCLE COMMUTING IN DEVELOPING COUNTRIES

Cyclists commuting presents several benefits over other modes of transport. Compared to cars or motorcycles, it is environmentally sustainable and faster in busy urban areas (Massink et al., 2011; Zuo et al., 2020). Cycling is active which means it helps in controlling obesity and cardiovascular diseases, requires less infrastructure space, it is cheaper, accessible for even the poor (Nkurunziza, et al., 2012). In addition in SSA cities, it allows fast connection to jobs and enables flexible jobs (Mendiate et al., 2020). Cycling commuting in SSA is popular in small and medium cities (Alando, 2017). One important feature is that cycling in most medium SSA cities is often for utilitarian proposes. People usually cycle long distances (> 3km) (Bryceson, Mbara, et al., 2003; Mutiso & Behrens, 2011) due to lack of public transport and spatial mismatch between jobs and residences (Cervero, 2000, 2013). Many bikers live in city-periphery while most formal jobs are located in the inner-city.

Recently, cycling in SSA cities has been addressed in both the attitude/behaviour perspective but also in economic, and social research. There are three reasons for this focus. The first reason lies in the fact that cycling commuting is dependent on individual cognitive states, and in SSA cities cycling is perceived as an inferior transport mode. The second reason is that the economic and social value of cycling is difficult to measure, but has a very relevant impact on cycling choice and helps to reinforce community relationship which is vital in African societies. Third, cycling is a working tool and source of income for many families. These people often commute without a specific destination but are directed for places that could find potential passengers and customers.

1.2. CYCLING IN SSA CITIES

Cycling use is influenced by many factors such as city size (de Souza et al., 2017). As from studies of Pochet et al., (1999) cycling share in larger SSA cities is reduced for example 1,2% Maputo/Mozambique (JICA, 2014) 2% Bamako/Mali, 4% Accra/Ghana (Kumar & Barrett, 2008). However, in smaller cities its higher as presented 47% Kisumu/Kenya (Alando, 2017), 35% Quelimane/Mozambique (Mendiate et al., 2020). Studies point for the built characteristics of the small cities, the high incidence of poverty and limited access to public transport as key factors that maintain the increased cycling share in these cities. As far as the authors know, currently, there is limited comprehensive literature on policies to promote cycling in medium-sized SSA cities. Most are usually evaluated considering initiatives defined in larger cities or western cities. These approaches are often unappropriated for two reasons. First, it excludes local culture habits (often stronger in smaller cities) which are essential for tightening community bones thus influence cycling. Secondly, they don't consider the deep unequal transport services, which forces many people to experience bicycle differently, as bicycle-taxi passengers. This is poorly reported in current travel behaviour studies. This chapter offers a comprehensive overview of the academic literature and identifies the existing groups of cyclists and key factors influencing bike use.

This chapter assesses to which extend early literature explains the groups of existing cyclists in SSA cities and what factors influence cycling behaviour. In so doing, it pays attention to two major issues. First, we explore what groups of cycling commuters exist and what are their actual travel behaviour. Secondly, assess what factors could influence cycling choice in medium cities and similarities with western cities are highlighted. We focus on socio-economic factors, built environmental factors, natural and environmental factors and attitudinal factors toward cycling.

1.2. IDENTIFYING GROUPS OF CYCLISTS IN SSA CITIES

Cycling commuters are grouped based on attitude and socio-economic characteristics (Anable, 2005; Bergström & Magnusson, 2003; Nkurunziza et al, 2012). Traditionally, two groups of cyclists are often discussed, which are those having a positive attitude toward cycling and consequently cycling frequently and those not having a positive attitude toward cycling and not cycling frequently (Heinen et al 2011). However, in SSA cities such a grouping approach seems to be incomplete and may exclude a larger number of cycling commuters. In these cities, there is a greater number of individuals who may not have a positive attitude towards cycling, but cycle frequently because they do not have adequate transportation options or because they do not have livelihood alternatives (Bryceson, Mbari, et al., 2003; Cervero, 2000; Moyo, 2013; Mutiso et al., 2011).

Due to lack of public transport, increased poverty, and long travel distance to jobs, cycling is the main form of transport available to most urban poor. Based on studies by Bechstein, (2010) captured two types of cyclists groups who are practical cyclists and captive cyclists. Practical cyclists find bicycling effective for getting around. They consider cycling to be an economical mode of transport. However, most cycle for recreation.

Captive cyclists use a bicycle because it is the only option available due to a lack of funds to afford other modes of transport. These cyclists are very likely to shift to motorized modes as income increases. Bryceson et al., (2003); Cervero, (2000); Mutiso et al., (2011) found the third group of cyclists in SSA cities, who are livelihood cyclists. They perceive cycling as a source of income. They are bicycle taxi operators who pedal to transport passengers, cargo and also to sell goods around the city. Their travel behaviour is difficult to predict as their cycling itinerary depends on the passenger.

When the third group of cyclists overlaps with the first two groups of cyclists and non-bicyclists group the fourth group of bicycle commuters is depicted. The literature often designates this group as bicycle-taxi passengers (Mutiso et al., 2011) (Figure 1). This is probably the largest group of cyclists in SSA cities. They experience cycling indirectly as passengers. They often point the need for reducing travel costs as the main motivator for experiencing cycling as passengers (Mutiso et al., 2011). Although the enormous influence that the informal bicycle-taxi service has on shaping mobility in medium-sized SSA cities, there is little research. This is because these transport services are often popular in poor cities and less attention paid by the authorities. Additionally, its because bicycle-taxi is an informal activity in many countries and not included in official mobility statistics. This group of cyclists is often seen in small towns like Quelimane (Mozambique), Mzuzu (Malawi), Kisumu (Kenya) (Alando, 2017; Kipandula & Lampiao, 2015; Mendiata et al., 2020; Moyo, 2013; Mutiso et al., 2011).

Figure 1: Scheme of existing cycling groups in SSA cities

1.3. EXPLANATORY CYCLING FACTORS IN SSA CITIES

A large number of studies have explored the relationship between cycling and the socio-economic factors, built environment factors, natural and environmental factors, and attitudinal factors (Acheampong, 2016; Bergström & Magnusson, 2003; Bryceson et al., 2003; Gatersleben & Appleton, 2007; Heinen et al., 2010; Jennings, 2015; Muñoz et al., 2013; Pochet & Cusset, 1999; Pucher & Renne, 2003; Winters & Teschke, 2010). Although a lot is known, the influence of these factors on cycling in SSA cities is under-researched. This section describes the results of the influence of these factors on cycling in SSA cities and systematically compares them with other urban contexts. Factors that have similar cycling influence in both SSA cities and other urban contexts are highlighted in Tables 1-4.

i) Socio-economic factors

In SSA cities, cyclists appear to be young people, men and ages between 25-35 years (Pochet & Cusset, 1999). A study by Bryceson, Mbari, et al., (2003) shows that the predominance of young cyclists in SSA cities is due to the physical and mental skills necessary to withstand the harsh cycling in these cities. Age yield different results in different studies (Fernández-Heredia et al., 2014; Moudon et al., 2005). Wardman et al., (2007) age is not strongly associated with cycling. Van Cauwenberg et al., (2018) Cycling declines with age. Wardman et al., (2007), age in cycling is irrelevant. Gender seems to be related to cycling culture than to bicycle use (Gerrard et al., 2008). Cycling is more popular among male adults (Bull et al., 2000; Xing et al., 2010). Some studies even point that women cycle more than men (Dill & Voros, 2007; Moudon et al., 2005; Witlox, 2004). This is observed in countries like the Netherlands and Belgium where cycling is a very popular transport mode. This indicates that the link between gender, age and cycling in SSA cities is clear while in other urban contexts remains vague.

Although the link between income and cycling in western cities is unclear (Heinen et al., 2010) in SSA cities, cycling has a strong association with poverty (Alando, 2017; Pochet et al., 1999). People cycle to reduce daily transport expenses (Diaz Olvera et al., 2008). The level of education level has more influence on perception than on cycling behaviour (Xing et al., 2018). They found that educated individuals tend to cycle more for perceiving its social, economic, environmental and personal benefits. However, a study conducted in Mzuzu (Malawi), points cycling for uneducated therefore poor individuals (Moyo, 2013; Pirie, 2011). From our observation, anyone regardless of educational background can experience cycling as passengers. This illustrated that the relationship between education level and cycling remains unclear in both urban contexts.

Acheampong & Siiba, (2018) and Oakil et al., (2016) found that household composition had little influence in cycling. Bryceson, Mbari, et al., (2003), parents of a larger household tend to produce more bike trips than those in smaller households. Boumans & Harms, (2005) had a similar conclusion, they point out that household composition influences the number of cycling trips and travel patterns instead of cycling choice. Gerrard et al., (2008) family size has a direct relation with bicycle use. A larger family is associated positively with bicycle use. This illustrates that the relationship between household composition and cycling is consensual. The relationship between employment

status and cycling is less clear. Full-time formal workers are expected to cycle less, since the bicycle is slower than a car and very physically demanding, inappropriate for daily commuting particularly in a hot climate (Pucher & Renne, 2003). Full-time informal workers are expected to cycle more (Bryceson, Mbara, et al., 2003). The bike helps to transport their products to the local markets at relatively lower costs. Part-time workers cycle more frequently than full-time formal workers (Boumans et al., 2005; Heinen et al., 2010). Heinen et al., (2010) found that if cycling facilities at the workplace are provided such as bicycle parking, facilities for dressing and showers, full-time formal workers would cycle more. While car ownership reduces the likelihood of cycle, bicycle ownership increases cycling odds (Handy & Xing, 2011). Bike ownership increases in 3.137 the odds of utility cycling (Acheampong, 2018). As cycling is becoming a means of public transport in most medium-sized SSA cities, it is relevant to highlight that passengers may be individuals having a car or not. The study by Mutiso et al., (2011) shows that passengers carried had different socio-economic backgrounds. This shows that the relationship between vehicle ownership and cycling in medium-sized SSA cities is harder to explain. More details in Table 1.

Table 1: Summary of the influence of socio-economic factors on cycling by the urban context

<i>Factors</i>	<i>Factor Influence in SSA cities</i>	<i>Factor influence in other urban contexts</i>
Age	Cycling is popular among young (Acheampong, 2016; Mendiata et al., 2020; Mutiso et al., 2011; Pochet et al., 1999)	Age yield different results in different studies (Fernández-Heredia et al., 2014; Moudon et al., 2005). Wardman et al., (2007) age is not strongly associated with cycling. Van Cauwenberg et al., (2018) Cycling declines with age
Gender	A study in Ouagadougou (Mali) shows that 71% of cyclists are male (Pochet et al., 1999). Bechstein, (2010) found in a study in South Africa found all cycling commuters are male	Gender seems to be more related to cycling culture than use (Garrard et al., 2008). Cycling is more popular among male adults (Bull et al., 2000; Xing et al., 2010). Dill et al., (2007); Moudon et al., (2005); Witlox, (2004) women cycle more than man.
Income	Bicycle commuting is linked with poverty (Alando, 2017; Diaz Olvera et al., 2008; Pochet et al., 1999).	High-income individuals are expected to cycle less (Pucher & Buehler, 2006). Low-income residents generate fewer bicycle trips (Caspi & Noland, 2019).
Education level	Bicycle commuters have a low education level (Bechstein, 2010; Moyo, 2013; Pirie, 2011). Anyone regardless of the educational background can experience cycling as a bicycle-taxi passenger (Mutiso et al., 2011).	Higher educated individuals are more likely to make a higher proportion of bike rides for transportation than recreation (Xing et al., 2010; Xing et al., 2018).
Household composition	Acheampong et al., (2018) cycling is less influenced by household characteristics. Bryceson et al., (2003) larger households cycle more.	Boumans et al., (2005) larger households produce more bike trips. Oakil et al., (2016) household composition doesn't have a significant influence in cycling

Employment Status	Formal workers cycle less (Pucher et al., 2003). Informal workers cycle more (Cervero, 2000; Mbarara & Maund, 2003; Moyo, 2013; Mutiso et al., 2011; Pirie, 2011).	Part-time workers cycle more frequently than full-time workers (Boumans et al., 2005; Heinen et al., 2010).
Vehicle ownership	Bike ownership increases the chances of utility cycling (Acheampong, 2018). Bicycle is a means of public transport, (Mutiso et al., 2011). Therefore passengers may have bicycle or not.	Car ownership reduces bicycle use. bicycle ownership increases cycling odds (Handy & Xing, 2011).

ii) Built environment factors

Most studies in SSA cities indicate that the following built environmental factors, such as pavement quality, street lighting, traffic speed, traffic volume, street signage, road encroachment by street vendors and travel distance, as relevant to influence the cyclists' behaviour (Acheampong et al., 2018; Kumar et al., 2008; Mbarara et al., 2003; Sietchiping et al., 2012; UN-Habitat, 2011).

Researchers are consensual that the quality of the road network has an enormous influence on cyclists' route choice (Bryceson, Mbarara, et al., 2003; de Sousa & da Penha-Sanches, 2019; Kang & Fricker, 2013; Moyo et al., 2018; Sener et al., 2009; Stinson & Bhat, 2004; Winters & Teschke, 2010). Cyclists often opt for good quality roads, which contribute to a smooth ride and avoid unpaved roads (Segadilha & da Penha Sanches, 2014; Winters & Teschke, 2010). In SSA cities, about 30% of the streets are paved and most located in the inner city (Lall et al., 2017). The capacity of the roads is limited, the high road share and detouring pavement influence traffic management in scope and extend, making accidents more frequent (Kumar et al., 2008). Moyo et al. (2018) found that during peak hour cyclists choose longer, even poorly paved roads to avoid fast-moving motorized traffic on main roads that are usually paved. This shows that cyclists are consensual that good roads make cycling comfortable. However, due to the bad drivers' behaviour, cyclists often opt for unpaved and calms streets because they are safer.

Street lights are crucial for crime prevention, to avoid obstacles at night and to ensure a general sense of safety for cyclists (Chandra et al., 2017; Chandra & Radhakrishnan, 2015; Haans & de Kort, 2012; Lusk et al., 2019; Winters et al., 2011). Street lighting can reduce the perception and fear of crimes (Painter, 1996) and increase bicycle use. Bicycle lanes that are not well lit are strongly linked to the reduction of cycling rates (Winters et al., 2011). In addition, areas on the bike path that does not have street lights, at night can generate discontinuity in the quality of the network (Chandra et al., 2015). In SSA, most tertiary roads that connect the city-periphery to the inner city, have low road amenities (Kumar et al., 2008) such as street lights. Therefore, at night most bicycle trips take place on the busy main roads, as they are lit up. A study by Verster & Fourie, (2018) reported late afternoon and night to be dangerous hours for cyclists in South African roads. They point to over speed, associate with drink and driving behaviour of the drivers, as the main cause of accidents. This illustrates that there is a clear link between street lights and the choice of the cycling route.

The level of traffic volume and speed have an enormous influence on cycling (Cai et al.; Cantisani et al., 2019; de Souza et al., 2017; Heinen et al., 2010; Sener et al., 2009; Winters, Brauer, et al., 2010). There is a substantial variation in how cyclists perceive traffic volume and speed. Winters, Brauer, et al., (2010) found that cyclists prefer routes with less traffic volume and slow speed. Jacobsen, (2015); Jacobsen et al., (2009) reveal that cyclists often prefer busy roads, which could encounter many other cyclists. They feel safe in numbers. Car drivers are expected to adjust their behaviour in the expectation of finding cyclists. Pochet et al., (1999) in the study in Ouagadougou (Burkina Faso) and Bamako (Mali), found that cyclists are afraid to bike on heavy traffic roads. They cite that they are not respected in traffic and, if there is an accident, the car drivers do not stop. Mbarara et al., (2003); Moyo, (2013); Mutiso et al., (2011) bicycle-taxi operators often opt for busy streets that could intersect many passengers. Additionally, Sener et al., (2009) found that the level of perception depends on cyclists' experience and trip length. Bicyclists who travel long distances are especially sensitive to heavy traffic volume due to a longer duration of exposure to traffic and related safety concerns. This indicates that the associations between traffic volume and traffic speed to cycling is still unclear.

The effect of the street signalization on cycling is a subject of conflicting results (Broach et al., 2011; Segadilha & da Penha Sanches, 2014; Sener et al., 2009). Well-signalized streets are very attractive, particularly for individuals with relatively less experience in bicycling (Sener et al., 2009). Broach et al., (2011) turns without traffic signals have a significant negative association with the level of cycling, especially with a heavy traffic volume. Fajans & Curry, (2001), routes with a large number of stops require an additional cycling effort to stop and shortly after resuming the trip. Studies conducted in SSA cities have found street signalization has little influence on encouraging cycling because many streets have no street signs but also these signs are often not respected by drivers. Moyo et al., (2018) found that in Johannesburg (South Africa) some motorists deliberately disrespect street signalizations. It is often reported that car drivers park in bicycling and walking lanes to load and offload. Usami et al., (2020) found that drivers do not respect traffic signs and are distracted by the unappropriated use of technological gadgets. This contributes to frequent accidents involving pedestrians and cyclists.

The influence of road encroachment in cycling is mostly discussed in the literature in developing countries (Cervero, 2000; Mutiso et al., 2011; Pochet et al., 1999; Sietchiping et al., 2012). Even so, researchers are not consensual about the correlation between road encroachment and cycling route choice. Street vendors are permanent road users, they occupy the roadsides, reducing the road section mainly at major intersections, forcing cars, motorcycles, cyclists, and pedestrians to share the same road (Kumar et al., 2008). Based on Pochet et al., (1999); Sietchiping et al., (2012) street vendors turn the main intersections into conflicting areas and often result in accidents between different modes, cyclists often avoid such junctions. Cervero, (2000); Mbarara et al., (2003); Mutiso et al., (2011) bicycle-taxi operators often include busy road intersections into their cycling itinerary, they consider such junctions ideal places that can meet potential passengers.

When investigating cycling choice, distance is always taken into consideration (Broach et al., 2012; Florindo et al., 2018; Heinen et al., 2010; Mbarara et al., 2003; Menghini et al., 2010; Rondinella et al., 2012; Tsunoda et al., 2020; Wallrapp & Faust, 2008; Zhao, Nielsen, et al., 2018; Zhao et al., 2019; Zuo et al., 2020). The bicycle is mostly used for

short distances (Heinen et al., 2010; Menghini et al., 2010; Rondinella et al., 2012). Based on van Wee & Maat, (2010); Van Wee et al., (2006) an increase in distance disproportionately discourages people from cycling because of the physical effort needed. Distances between 0.5km to 3.5km are the most preferred for cyclists (Heinen et al., 2010; Menghini et al., 2010; Tsunoda et al., 2020). Some studies carried out in SSA cities had very different findings from the interaction between distance and bike use. Wallrapp et al., (2008) in their study about cycling in rural Uganda, found that bicycle ambulance transports seriously sick patients up to 15km. Mutiso et al., (2011), bicycle-taxi operators tend to cycle long distances since their fares are based upon the travel distance. The study by Lall et al., (2017); Pochet et al., (1999) cites that an increase in travel distance to the CBD increases the likelihood of walking and cycling. More details in Table 2.

Table 2: Summary of the influence of built environment factors on cycling by the urban context

<i>Factor</i>	<i>Factor Influence in SSA cities</i>	<i>Factor influence in other context</i>
Road pavement quality	Moyo et al. (2018) unpaved roads are uncomfortable for cyclists but are safe.	Cyclists prefer paved roads and avoid unpaved roads (Segadilha & da Penha Sanches, 2014).
Street lighting	At night most cyclists prefer busy main roads (Verster et al., 2018) since most tertiary roads are not well lit (Kumar et al., 2008).	Street lighting are crucial for enabling good visibility and safety for cyclists (Chandra et al., 2017; Chandra et al., 2015; Haans et al., 2012; Lusk et al., 2019; Winters et al., 2011).
Traffic speed and volume	Bicycle-taxi operators often opt for busy streets (Mbara et al., 2003; Moyo, 2013; Mutiso et al., 2011). Study in Ouagadougou (Burkina Faso) and Bamako (Mali), cyclists are afraid of biking in heavy traffic roads (Pochet et al., 1999).	(Winters et al., (2010) cyclists prefer routes with lower traffic volume and slow speed. Jacobsen, (2015); Jacobsen et al., (2009) cyclists often prefer busy roads, which could encounter many other cyclists.
Streets signalization	Street signalization has little influence in cycling since it is often disrespected by drivers (Moyo et al., 2018; Usami et al., 2020)	Streets well signalized encourage cycling (Broach et al., 2011; Sener et al., 2009). Streets with a large number of stops are not attractive to cyclists (Fajans et al., 2001).
Road encroachment	Street vendors turn the main intersections into conflicting areas and cyclists often avoid such places (Pochet et al., 1999; Sietchiping et al., 2012). bicycle-taxi operators often include the busy intersections in their cycling itinerary (Cervero, 2000; Mbara et al., 2003; Mutiso et al., 2011)	-
Travel distance	Any increase in the travel distance increases the likelihood for cycling (Mutiso et al., 2011; Pochet et al., 1999)	Cycling is often for short distances (Heinen et al., 2010; Menghini et al., 2010; Rondinella et al., 2012).

iii) Natural and environmental factors

Studies point out that weather conditions such as high or low temperature, rain and tree cover along the streets are some of the most natural and environmental factors that influence cycling (An et al., 2019; Bergström et al., 2003; de Sousa et al., 2019; Klemm et al., 2015; Liu et al., 2015; Nahal & Mitra, 2018; Qiu et al., 2019; Wadud, 2014; Ziter et al., 2019). Wadud, (2014) found that there is a clear non-linear impact of temperature on cycling ridership. The high and low temperatures reduce bicycle use. However, the optimum temperature can vary from country to country. A study conducted in Sweden found that cycling share increases as the mean temperature rises and keeps stable until the temperature is up to 12⁰c (Liu et al., 2015). The hot and humid weather in Dar es salaam leads to a lower likelihood of cycling by the for less experienced cyclists (Nkurunziza et al., 2012). Buehler & Pucher, (2012) found weather not a statistically significant predictors of bicycle commuting in large US cities. A similar perception had Acheampong, (2016) when exploring attitude and perception among adult cyclists in Ghana found that the warm climate statistically insignificant for the cycling attitude. This reveals that the association between weather and cycling is the subject of different understanding among the researchers

The relationship between cycling and rain is consensual among many researchers. They found that cycling declines with the presence of rain (Cervero & Duncan, 2003; Heinen, Maat, & van Wee, 2011; Pucher et al., 2006; Wadud, 2014; Winters et al., 2011; Winters et al., 2007). Studies in SSA cities had similar findings. Kumar et al., (2008) cite that during the rainy season, in low-income areas it results in flooding, obviously this influences not only the cycling choice but also the route choice. Nkurunziza et al., (2010) found that people in the pre-contemplation cycling stage cite that they will cycle if the weather is conducive. This means that if it rains, people not intending to cycle will not perform the behaviour. Nevertheless, few studies have found that rain has no significant statistical influence on cycling (Buehler et al., 2012; Rashad, 2009).

The link between cycling and tree cover is very consensual (Buehler et al., 2012; Klemm et al., 2015; Lusk et al., 2019; Mboup, 2013; Mertens et al., 2017; Sundquist et al., 2011; UN-Habitat, 2018; Winters, Brauer, et al., 2010; Zhao, Nielsen, et al., 2018; Ziter et al., 2019). Bicycle commuters tend to choose roads with dense tree cover for providing shade, comfort, and above all pure air (de Sousa et al., 2019; Winters, Brauer, et al., 2010). Continuous tree shade reduces the temperature, making it more comfortable for people to walk and cycle, even during summer afternoons. This is especially important in SSA cities with humid climate or harsh daytime sun (UN-Habitat, 2018). The green infrastructures improve the perceived thermal comfort particularly during the summer (Klemm et al., 2015) which is comfortable for cycling. The presence of trees along the roads increases by 15.65 times the odds of cycling for transport (Mertens et al., 2017). However, few studies have found a negative association between cycling and the presence of tree cover. Lusk et al., (2019) found that dark, tree-covered two-way cycle tracks increase cyclists' risk of crime and vulnerability. More details in Table 3.

Table 3: Summary of the influence of the natural environmental factors on cycling by the urban context

<i>Factor</i>	<i>Factor Influence in SSA cities</i>	<i>Factor influence in other contexts</i>
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Temperature (heat and cold)	The hot and humid weather leads to a lower likelihood of cycling for less experienced cyclists (Nkurunziza, Zuidgeest, Brussel, et al., 2012). The hot climate is statistically insignificant for cycling perception (Acheampong, 2016).	Cycling share increases as the mean temperature rises (Liu et al., 2015). There is a non-linear impact of the temperature on cycling ridership (Wadud, 2014).
Rain	Nkurunziza et al., (2010) people not intending to cycle will not cycle if it is rainy. Kumar et al., (2008) during the rainy season, roads become flooded making cycling difficult.	Cycling declines with the presence of rain (Cervero et al., 2003; Heinen, Maat, & van Wee, 2011; Pucher et al., 2006; Wadud, 2014; Winters et al., 2007).
Road tree cover	Streets with a continuous tree shade are comfortable for cyclists during the summer (UN-Habitat, 2018)	Bicyclists often choose roads with dense tree cover (de Sousa et al., 2019; Lusk et al., 2019; Winters, Brauer, et al., 2010)

iv) Attitudinal factors

Recent studies aiming to promote cycling focus on the effect of attitudinal factors on travel behaviour and mode choice. This section examines the existing knowledge on psychological factors influencing cycling. However, the intensity of these factors on cycling depends among many factors on the urban context, cycling frequency. This enabled a comparison between the literature of different urban contexts.

Among the attitudinal factors influencing cycling, researchers are unanimous that cycling is healthy, cheap, comfortable, flexible (Abane, 2011; Acheampong et al., 2018; Acheampong, 2016; Anable, 2005; Bergström et al., 2003; Biernat et al., 2018; Heinen, Maat, & van Wee, 2011; Heinen et al., 2010; Iwińska et al., 2018; Nkurunziza et al., 2010; Nkurunziza, Zuidgeest, Brussel, et al., 2012; Pucher et al., 2010; Rondinella et al., 2012; Xing et al., 2010). Additionally, literature in SSA cities point that cycling, enable flexible jobs, but also it is perceived as an inferior transport mode and rural like (Acheampong, 2017; Acheampong et al., 2018; Acheampong, 2016; Alando, 2017; Bechstein, 2010; Diaz Olvera et al., 2008; Jennings, 2015; Nkurunziza, Zuidgeest, Brussel, et al., 2012; Nkurunziza, Zuidgeest, & Van Maarseveen, 2012; Pochet et al., 1999; Verster et al., 2018).

Cycling is widely perceived as a healthy means of transport (Acheampong, 2016; Brussel & Zuidgeest, 2012; Gatersleben & Appleton, 2007; Heesch et al., 2015; Heinen et al., 2010; Massink et al., 2011; Muñoz et al., 2013; Pucher et al., 2010; Šťastná et al., 2018; Van Cauwenberg et al., 2018; Winters et al., 2007). However, there is no linearity between cycling frequency and its perception as a healthy mode. For instance, a study conducted in Madrid by Fernández-Heredia et al.,(2014); Muñoz et al., (2013) found that cyclists strongly agreed that cycling has health benefits and this perception is similar among frequent and non-frequent bicycle commuters. Acheampong, (2016) in their study in Kumasi (Ghana) had similar findings. However, when comparing men and female they perceive differently regardless of their cycling experience. Other studies even found cycling prejudicial to health. For instance, a medical study conducted in Malawi found

that for bicycle-taxi operators, excessive cycling loaded with heavy goods is causing health problems (Kipandula et al., 2015).

Heinen et al., (2011) when estimating cycling use models, found that frequent cyclists consider cycling cheap, but careless about comfort and flexibility. Such a perception is not consensual. For instance, Li et al., (2013) frequent cyclists had a moderate to a low desire for comfort. Muñoz et al., (2013) commuter cyclists perceive cycling as cheap, comfortable, and quick to get around places. Nkurunziza et al., (2012) in Dar-es-Salaam, the frequent cyclists, perceive that the low bicycle price increases in 1.7 the likelihood of cycling. Acheampong, (2017); Acheampong, (2016); Diaz Olvera et al., (2008); Sietchiping et al., (2012) found that frequent cyclists perceive cycling comfortable, flexible however it is not perceived as a cheap transport mode particularly for the poor majority. Pochet et al., (1999), in the study conducted in Ouagadougou (Burkina Faso), the bicycle is the cheapest mode to purchase and operate however it is too expensive for many poor frequent cyclists. Jennings, (2015) bicycles at the lowest pricing scale can cost some three times the weekly minimum wage for an unskilled worker.

In SSA cities, the commercial use of the bicycle is probably the major cycling motivator for both frequent and non-frequent cyclists (Jimu, 2008; Kipandula et al., 2015; Mbarara et al., 2003; Moyo, 2013; Mutiso et al., 2011; Pirie, 2011; Pucher et al., 2003). A study by Wallrapp et al., (2008) found that due to barriers to access health facilities, bicycle ambulance is very popular particularly in villages in the central region of Uganda and this service cover almost 90% of rural people that rely on walking. Mutiso et al., (2011) estimate that bicycle-taxi service trip rates in Kisumu are about 160.000 trips per day. This service is popular among frequent commuters such as employed people and students. Bryceson et al., (2003) a large proportion of bicycle trips in Uganda is for commercial taxi hire operated with more than 250.000 operators which serves as a feeder for the main public transport routes.

The link between image prestige and cycling is different from SSA cities and western cities. In SSA, the bicycle is perceived by many as an inferior transport mode, a rural transport mode and is a transport for the poor. This has been pointed by many researchers as the main reason for a negative attitude toward cycling in these cities (Acheampong, 2017; Acheampong et al., 2018; Acheampong, 2016; Alando, 2017; Bechstein, 2010; Diaz Olvera et al., 2008; Jennings, 2015; Nkurunziza et al., 2012; Nkurunziza et al., 2012; Pochet et al., 1999; Verster et al., 2018). Literature in western cities had different findings. When exploring the influence of image and prestige among non-cyclists in Mexico city, Cepeda Zorrilla et al., (2019) found that the social image has very little explanatory power on cycling use. When comparing the common cycling mind-set between Balkans and the Netherlands Pojani et al., (2017) found that unlike the Balkans city, in the Netherlands cycling is fashionable, is being environmental-conscious. More details in Table 4.

Table 4: Summary of the influence of attitudinal factors on cycling by the urban context

<i>Factor</i>	<i>Factor Influence in SSA cities</i>	<i>Factor influence in other contexts</i>
Cycling is healthy	Excessive cycling loaded with heavy goods leads to health problems (Kipandula et al., 2015).	Muñoz et al., (2013); Fernández-Heredia et al., (2016) commuter cyclists value cycling as healthy

	Frequent cyclists consider cycling to improve health (Acheampong, 2016)	
Cycling is cheap, comfortable and flexible	Overall the bicycle is cheap but is very expensive for the majority of unskilled workers (Jennings, 2015; Pochet et al., 1999) Frequent cyclists consider cycling comfortable and flexible (Acheampong, 2017; Diaz Olvera et al., 2008).	Cycling is cheap (Heinen, Maat, & van Wee, 2011). Cycling is comfortable and quick to get around places (Muñoz et al., 2013). Frequent cyclists had a low desire for comfort (Li et al., 2013).
Cycling enables flexible jobs	Bicycle-taxi is a feeder for public transport (Bryceson et al., 2003). In Uganda bicycle ambulance services cover almost 90% of the rural people (Wallrapp et al., 2008)	-
Image prestige	Cycling is rural like lifestyle (Pochet et al., 1999). Frequent cyclists perceive cycling as an inferior transport mode (Acheampong, 2016)	Pojani et al., (2017) In the Netherlands cycling is fashionable

2

OBJECTIVES

2. RESEARCH OBJECTIVES

2.2. RESEARCH GAP

In order to develop policies that could help to promote cycling in SSA cities, it is important to first identify what cycling groups exist, and what determinates cycling behaviour in each of these cycling groups. Despite the increased attention on cycling in the scientific literature, several gaps can be identified in the current knowledge in SSA cities. The very first gap is the lack of systematically organized mobility data. To develop any cycling action, without any doubt cycling mobility data such as socio-economic characteristics of the cyclists, their cycling perception and cycling behaviour is needed. The effect of these factors on cycling commuting in many African cities has not been fully tested despite been widely studied in western cities. Since knowledge cannot easily be transferred from one country to another, particularly when they have deep socio-economic differences, such data would not only be useful for Mozambican cities but many other SSA cities.

Second, the classical understanding of cycling in SSA cities suggests that it often takes place between the city periphery to the inner-city (Cervero, 2000; UN-Habitat, 2011). They consider that most people cycle in search of formal jobs most located in the CBD. However, they ignore the fact that cycling in SSA is for the poor, most uneducated, and often working in the informal sector (Cervero, 2000; Pochet et al., 1999), which is well established in the city periphery. Interesting questions that still unclear are: (i) Who are the cyclists? (ii) Where are they spatially located in the city? (iii) and What are their travel patterns?

Third, another set of factors that are rarely taken into consideration is the fact that individuals in small or rural SSA cities cycle more frequently than those in larger cities. Small cities are where poverty and transport exclusion predominates, making cycling the main transport option. Transport policies aiming to develop cycling in those cities are traditionally exported from developed in larger cities, not responding to the real need of people in medium cities. They can explain little what are their desire and their travel behaviour.

Finally, when it comes to commuter's route choice it often considered that commuters have similar route choice behaviour throughout the day (Broach et al., 2012; de Sousa et al., 2019; Emond & Handy, 2012; Kang et al., 2013; Winters & Teschke, 2010). They neglect that route choice is a dynamic decision. The bicycle route choice is highly dependent on the departure time. In most SSA cities due to hot weather during the day and at night most streets lack lighting, route choice is difficult to predict. Besides, the unique built environment of most SSA cities characterized by the concentration of most quality infrastructure in the inner city (Lall et al., 2017), has an enormous influence on cycling patterns. Therefore, it is relevant to distinguish in each cycling group which route attributes are relevant for (i) those departing in the morning over those departing in the afternoon and (ii) those cycling in planned urban zones over those cycling in unplanned urban zones. This thesis addresses these four research gaps.

2.3. RESEARCH OBJECTIVES

Policies to promote cycling in medium SSA cities often assume initiatives designed for larger cities, since few scientific studies are conducted in such cities' context. These policies reveal unrealistic for not considering the factors related to those cities' context. Different cycling groups exist in larger and medium SSA cities. Nkurunziza et al.,(2012) found six cycling attitudinal segments while Bechstein, (2010); Mutiso et al., (2011) found three cycling segments where bicycle-taxi operators are highlighted for having different cycling behaviour from an ordinary cycling commuter. This thesis aims to contribute to the empirical knowledge of variables affecting bicycle commuting in middle-sized SSA cities, especially to identify existing groups of cyclists and the key factors influencing their cycling route choice behaviour. Knowledge about cycling choices will determinate appropriated policies adjusted to the existing group of cyclists, which often proves to be more accurate and can contribute to more sustainable mobility and a healthy community.

This resulted in a key research objective (RO 0) and three sub-research objectives (RO1-3), successively addressed in chapters 6 to 8 (Figure 2).

Figure 2: Research approach

Figure 3 shows that the RO1, explicitly explores to identify different types of bicycle commuters based on socio-economic and bicycle use variables. This approach took advantage of the socially stratified urban form of most SSA cities, to help in spatially locate the different groups of cyclists and explore their travel patterns. RO2 uses the attitudinal variables to identify different segments of commuter cyclists. This allowed us to explore different attitudinal market segments and key factors influencing cycling use. RO3 focuses on identifying different factors influencing cyclists' itinerary, which is crucial for successful cycling promotional initiatives.

Figure 3: Connection between chapters, and research question

From Figure 2 can be inferred that:

RO1: To identify who are the cyclists, their main socioeconomic characteristics, residential location, and travel patterns

In studying who are the potential cyclists in SSA cities, limited studies have been taken to cluster commuter cyclists based on socio-economic and bicycle use variables. This topic has been widely discussed by the literature of western cities and still unclear which approach best helps in identifying groups of cyclists. RO1 addresses the question and identifies groups of commuter cyclists based on socio-economic variables and cycling use variables. Findings suggested that such an approach not presenting homogenous groups of cyclists.

RO2: To explore the existing attitudinal cycling segments and their main cycling drivers

Following the advice addressed in RO1, commuters were grouped based on their attitude toward cycling. This provided much robust and heterogeneous attitudinal groups of cyclists. In addition, it helped to identify key factors influencing the cycling attitude in each group. This sheds light to define cycling policies targeted to each cycling group.

RO3: To identify factors influencing cyclist's itinerary

This chapter identifies the importance of each cycling route choice variable has on cyclists' itinerary. It is assumed that route choice is a dynamic decision and cyclists are likely to change their route depending on the departure period. This research objective provides an insight into the effect several route choice attributes have on the definition of the cycling itinerary.

2.4. GENERAL RESEARCH STRUCTURE

This thesis follows the standard structure of scientific research as graphically shown in Figure 4. It's composed of mainly eight chapters as detailed. The first Chapter is the research problem in which presents the background of cyclists in SSA cities and main behavioural differences with cyclists in other urban contexts. This reveals the deep need for research in SSA cities. The second Chapter is regarding the research objectives. Since the introduction has shown that little knowledge about cycling in SSA cities, it is obvious that the main objective of this study is to identify who are the cyclists and their travel behaviour. The methods used are presented in Chapter 3. It starts by describing the data collection process, followed by the analytical procedure used to identify groups of cyclists and their travel behaviour, key factors influencing bicycle use, and factors influencing cycling itinerary. Chapter 4 discusses the case study and presents the main transport and road infrastructure challenges. Chapter 5 presents a description of the survey results.

The results are presented from chapters 6 to 8. Chapter 6 addresses the RO1 which identifies who are the cyclists, their travel patterns. This was analysed by defining clusters of commuter cyclists based on socio-economic and bicycle use variables. An earlier version of this chapter is published. Chapter 7 addresses the RO2 which aims to explore the existing cycling market segments. This helped to identify the existing attitudinal segments and key factors influencing bicycle use. Chapter 8 explores the RO3, which is to identify factors influencing cyclists' itinerary. This helps to understand what factors influence cycling route choice in each cycling group. Finally, the conclusion is presented in Chapter 9. This summarizes the chapters and highlights and key findings and provides further research orientation.

Figure 4: Research structure

3

METHODS

3. RESEARCH METHODS

3.1. SURVEY AND GIS MAPPING

In this chapter a detailed description of the official data used, the survey and sampling technique will be described. The official data was collected at the municipality of Quelimane (CMCQ), the National Bureaus of Statistics (INE), the Electricity of Mozambique EP (EDM), and the Association of bicycle-taxi operators (ATAMOZ). Collected data was divided into non-spatial and spatial data. The survey enabled understanding user perception and attitude toward cycling, their cycling patterns and socio-demographic characteristics. Sampling technique and sample size have been defined after considering the available financial and human resources, the available data from the transport authorities. On this basis, qualitative and quantitative frameworks and methods have been chosen for proper examination and provide an answer to proposed research objectives.

3.2. SAMPLING AND SURVEY TECHNIQUES

Recently, a combined method of intercepting interviewers and an online survey to explore the opinion of the transport or infrastructure users as gained prominence (Monzon et al., 2020). Such techniques enable flexibility, scientific rigor, the commodity for interviewers thus, reduce bias introduction and above all easy gathering and analysis of collected data. This will be described following a series of steps in each of the 2 survey stages (Figure 5).

Figure 5: Survey procedure scheme

First survey stage (Questionnaire design)

i) Definition of the survey objectives, the proposal of the main topics and an initial survey plan were outlined;

ii) A draft questionnaire was designed and developed by a survey development tool It is a cloud-based software allowing customized surveys, sample selection, conduct basic statistical analysis, and also receive feedback from respondents which allowed defining the final questionnaire.

iii) Once the draft version of the questionnaire was defined, invitation cards with individual access codes (URL/or QR code) to the web-based questionnaire were printed (Figure 6).

Figure 6: Sample of invitation cards used for survey

1. An online pilot survey was launched in June 2017, to test the adequacy of the questionnaire and to determine the initial data for the primary outcome measure (Lancaster et al., 2004). This was carried out on 32 individuals with different socio-economic backgrounds and mobility habits. The objective was to measure how respondents understand the questions. Several comments were received asking an explanation about some questions and complaints about slow internet speed. This interaction helped to correct the questionnaire by rephrasing some texts, adjusting to the local vocabulary. It also allowed considering the face-to-face survey as the main sampling methodology to improve sample coverage.

Second survey stage (sampling procedure)

2. Both online and face-to-face surveys were used as sampling methodology. For respondents that stated to have access to the internet, the invitation card with individual access code was given. It enabled us to fill out the questionnaire from any mobile device. From Table 5, its see that a total of 1284 invitation cards were delivered. 550 responses were received and these only 315 responses were valid for this study. The average response rate for the online survey was 43% and a questionnaire completion rate of 56%.

Table 5: Evolution of the online survey

Months	Cards delivered	Responses received	Valid responses received	Response rate	Completeness rate
July	243	104	72	43%	69%
August	223	110	95	49%	86%
September	216	85	84	39%	99%
October	124	80	0	65%	0%
November	137	57	11	42%	19%
December	220	89	32	40%	36%
January/2018	121	25	21	21%	84%
<i>Total</i>	<i>1284</i>	<i>550</i>	<i>315</i>	<i>43%</i>	<i>56%</i>

For those not having access to the internet, a face-to-face interview was conducted. It was carried out by 3 interviewers (university students) after receiving a short training by the project coordinator. Mobile devices were used to introduce the respondent's answers to the online questionnaire. 535 individuals have been interviewed (Figure 8).

Figure 7: Interviewer conducting a face-to-face survey through a mobile phone that accesses the online questionnaire

3. A prize was drawn among respondents with completed responses. The drawn was trimester and announced through a local radio Quelimane FM (Figure 8).

DIVULGAÇÃO DO RESULTADO DO SORTEIO PARA OS PARTICIPANTES AO INQUÉRITO SOBRE OS DRIVERS E BARREIRAS DO CICLISMO PARA VIAGENS URBANAS NA CIDADE DE QUELIMANE

No âmbito da pesquisa com o título acima referido, que cujo a recolha de dados primários teve o início no dia 20 de Julho de 2017, a equipa de pesquisadores comunica que desde a data até a hoje, participaram no inquerito 766 inqueridos.

Feito o sorteio aleatório dos números dos participantes, foram apurados como sendo os números vencedores os seguintes:

13566 (receberá 1500Mts), **12244** (receberá 500Mts), **33255** (receberá 300 Mts), **12713**(receberá 100Mts), pelo que desde já os parabenizamos.

Para o levantamento do seu prémio, solicitamos que os vencedores contactem nos através do número de contacto ou email que estão no seu cartão de convite num prazo máximo de 7 dias (contando do dia 19 de Dezembro de 2017), findo período sem a devida reclamação do prémio iremos convocar pelas mesmas vias os segundos classificados.

Gostaria de endereçar os nossos profundos agradecimentos a todos que se dignaram em participar na primeira fase da nossa pesquisa.

Quelimane 19 de Dezembro 2017

A equipa de pesquisadores

Hosting institution/University

Study sponsor

Thesis title

Randomly selected survey ID numbers of the winner participants and respective prize.

Announcement date

Figure 8: Draw prize announcement sent to the radio Quelimane FM

The survey was conducted from July 2017 to January 2018. The pilot survey was administrated in June 2017. It served to refine and improve the questionnaire and to

eliminate perception errors in particular for the online survey. Interviewers randomly distributed invitation cards with access codes (for the online survey). Cards were delivered at the university campus and in supermarket areas. From the 1284 cards delivered only 550 answered the questionnaire. The average questionnaire completion time was 26min. The face-to-face interview was conducted mainly at the large markets, the main intersection where bicycle taxi mode is a predominant mode (Figure 9). It was conducted from Tuesday to Saturday. It enabled capturing the full trips chains executed during working days. The overall average questionnaire completion rate was 82%. More details are presented from Chapters 6-8.

Figure 9: Number of responses obtained by the online survey and face-to-face survey

3.3. MAPPING THE SURVEY AREA

In line with the sampling approach, the study area was divided into 3 homogenous sampling zone. These areas were characterized by having i) large markets, ii) university campus and iii) commercial area. Interviewers were advised to deliver the cards randomly. However, before that, they should give a brief explanation of the research aim and next to ask if the person has access to the internet. Only those with access to the internet were given the card and explanation on how to accede the questionnaire. The invitation cards for the online survey (red dots) were mainly delivered at the university campus and commercial areas. The face-to-face survey (green dots) was mainly conducted at large markets. Like the online survey, respondents were randomly intersected (Figure 10).

Figure 10: Sampling area

3.4. COMPLEMENTARY DATA

For this study, a set of non-spatial and spatial data was required to address the research questions. Table 6 presents the list of acquired data, its source, description and research objective aiming to address. The non-spatial data vehicle ownership was collected at the Municipality of Quelimane. The data contains records of the number of the car, motorcycle, bicycle and bicycle-taxi operators registered at the Municipality. This information was used only for an overview of the mode share. It is because the significant percentage of the vehicles registered in Quelimane come from other districts that do not have the registration service. The population was extracted at the National Bureau of Statistics. It contains a desegregated population data such as gender, age intervals per neighbourhood and the urban zone. However, in Abril 2019, the Government of Mozambique released an updated population census data. This information was only used for statistical comparisons since this survey was prepared based on the previous census

data. ATAMAZ provided detailed data regarding bicycle-taxi operators. It contains information such as age and residency location. They also provided information regarding their visions and strategies to make bicycle-taxi services safer and attractive.

Spatial data was produced by the Millennium Challenge Account (MCA) - Verde Azul (VA) during the project entitled “Land Tenure Services Project” from 2009-2013. This dataset was produced from a large land survey. However, some updates were made to meet the research objectives and requirements. For example, the road network attributes such, pavement type and street lighting was updated based on ground truth and information received from the EDM.

Table 6: Summary of primary and secondary data collected

<i>Non--spatial dataset</i>	<i>Data source</i>	<i>Description</i>	<i>Research Objectives</i>
Vehicle ownership	CMCQ, 2017	Profile and number of bicycle taxi operators	RO1, RO2&RO3
Population	INE- National Bureau of Statistics, 2017	Census of 2007 Population per ward	RO1, RO2& RO3
Bicycle-taxi regulation	ATAMAZ, 2017	Regulation, policies and initiatives to promote bicycle-taxi	RO2&RO3
<i>Spatial Dataset</i>	<i>Data source</i>	<i>Description</i>	<i>Research Objectives</i>
Land use 2013	CMCQ, 2010 Geoeyes, 26 October 2009	Land use classes: ID, area	RO1, RO2&, RO3
Road network	CMCQ, 2010 EDM, 2017	Road categories and pavement type (paved and not paved) and length, lighting, tree cover	RO3

Jobs and Services	CMCQ, 2017	Centroid of each building and use class (formal and informal jobs)	RO1 & RO3

Urban zones and wards boundaries	CMCQ, 2010	Transport analysis zones, area	RO1

3.5. ANALYTICAL PROCEDURE

The study adopts the mixed analytical procedure to investigate the key research objective presented in 2.3. This procedure is deemed practical in enabling having a full picture of who are the cyclists in Quelimane and what are the factors influencing their cycling itinerary. This approach also permits to have an easy connection between different research objectives which enables easy replication of this research experiment.

General analytical scheme

The overall analytical scheme used in this research is presented in Figure 11. The survey parts briefly discuss the questionnaire. The questionnaire is divided into 3 main blocks labelled as follows (i) *You and bicycle*: contains questions regarding mode use and cycling patterns. (ii) *Attitude towards cycling*: questions to measure the attitude toward cycling and cycling route (iii) *Personal details*: standard socio-economic characteristics of the trip makers. To meet the above aims, and to make the questionnaire simple and easy to fill, most survey questions were answered by rating on the psychometric Likert scale. The scaling method is bipolar, measuring either positive or negative response with a middle option. This scaling is popular in social science research depict of limitations and bias. The value assigned to each scale is determined by the researcher. Many psychometrics assign progressive positive integer values and typically range from 2 to 10. In the present survey Likert-type scale of seven categories (1 to 7 with 4 as a neutral point) is employed for all parts of the survey to make the data homogenous, easy to interpret, standardize, codify and conduct statistical analysis. Since the survey was conducted in Quelimane, it was translated for Portuguese, which is the official language in Mozambique

Factor analysis was then used to test and determine the underlying factor structure that exists among the variables (Harrington, 2009; Thompson, 2004). Factor analysis was designed to minimize multiple measures of similar constructs by identifying the latent variables, this helped to answer the RO1&RO2. The multivariable data exploration tool of cluster analysis is applied to identify homogenous groups that share similarities, this was used to explain the RO1& RO2. To fully answer the RO1, after identifying the

clusters of cycling commuters, Geographic Information System (GIS) was used to build an origin-destination matrix (O-D) by replicating the commuter cyclists' itineraries. This enabled us to spatially visualize the travel patterns of groups of commuters identified in the previous step. Structural equation modelling is used as a previous step to identify cyclists attitudinal market segments as expected in the RO2. This gives a form of a causal relationship between latent variables and measured variables. Analysis for the RO3, Non-parametric test was used to compare the significant differences between two or more independent samples (Field, 2013). This enabled identifying whether the importance given to route choice variables differs based on the individual departure time. The basic and advantaged statistics used in this dissertation were conducted on SPSS and SPSS AMOS.

Figure 11: Overall research analytical scheme

Methodological scheme to answer each research objective

Figure 12, summarizes the methodological scheme per research objective. It shows the relation, between the research objectives, methods used and expected results. In the chapter presenting research results some further information on methods, details on the calculation and procedures are described.

For the RO1 a gathering of literature served as an inspiration concept to answer this research objective. Since cycling in SSA cities is for poor, socio-economic variables and bicycle use variables were used as input variables for the factor analysis. The principal component was used as an extraction method. The significant factor groups were used for cluster analysis. The Twostep cluster analysis was used, log-likelihood was considered as distance measure while the Akaike's Information Criterion (AIC) was considered as a clustering criterion. The cycling patterns presented by each cluster were spatially visualized using GIS. The New O-D cost matrix tool of the network analysts was used for this task. This allowed visualizing the cycling intensity between different urban zones.

The methodological procedure used to answer the RO2 includes factor analysis. The attitudinal variables toward cycling were considered input variables. These variables were captured in section 2 of the questionnaire. The extraction method used is similar to RO1. Structural Equation Modelling was used to measure the correlation between the target factor group with the other factor groups. Those factor groups presenting a weak and insignificant association with the target factor group were not considered for clustering. The cluster analysis procedure is similar to presented in RO1. The obtained groups of cyclists represented the existing cycling attitudinal markets and enabled identifying key variables influencing cycling use.

Analysis to answer the RO3 included non-parametric tests. The list of variables influencing cycling route choice was considered test variables. The different departure time groups ranging from 1 (AM) and 2 (PM) were used as grouping variables. Kruskal-Wallis was selected as the test type. This allowed comparison of the route choice variables importance between individuals in the same segment but with different travel behaviour.

Figure 12: Relation between the research objective, main methods used and expected outcomes

4

**QUELIMANE, THE
MOZAMBICAN “CAPITAL
CITY OF CYCLING”**

4. CASE STUDY DESCRIPTION: CITY OF QUELIMANE

4.1. CITY DESCRIPTION

The empirical focus is the city of Quelimane, Mozambique. It is a representative example of SSA medium-size cities. It has a population of 195.758 inhabitants (INE, 2008); being the fourth largest city in Mozambique. It is located about 1621.6km north of the capital city, Maputo. Quelimane is divided into three different functional zones (Figure 13). At the core is the central business district- CBD (Z1); it has 25.2% of the total population (density of 85.4inh/ha) and a job density of 4.8 jobs/ha. The city-periphery (Z2) is a mix of formal and informal settlements reaching 44.8% of the total population, with population and jobs per hectare of 28.2 and 0.9 respectively. The suburban areas (Z3) are mainly low-density informal settlements, vast agricultural areas. It has 30% of the total population, 9.5 inhabitants per hectare and a job density of 0.8. While Quelimane systematically tends to sprawl, a large number of services and transport infrastructures are still located in the inner city. That results in small clusters of high-income residents in the inner city, being the majority of low-income residents living in the periphery. The experienced urban sprawl dynamics reinforce car use originating a higher number of long commuting trips mostly covered by motorized modes.

Figure 13: Research area

Land use

The compactness of the city along the two main roads is the built-up characteristic of Quelimane. The most predominant land use in the inner city is residential 2% (high and medium standard houses), industrial and institutional with 1% of the total land use

respectively. The city periphery is predominantly residential (informal settlement). It makes 14% of the total land use in the study area. The suburban area is predominantly agricultural (39%) and wetland (24%). Such land-use distribution contributes to spatial disjunction, long travel distances to jobs thus cycling reduction (Figure 14).

Figure 14: Land use patterns per urban zone

Weather

Quelimane has a tropical savanna climate. The average annual minimum temperature is about 20.0°C, mean is 24.7°C and maximum 30.0°C. The average annual daily sunshine hours are 7.8 and it's between 8 AM to 4 PM. Rain is expected from November to April and the average precipitation a year is about 1461mm/year. The average precipitation days are 95.9 days and the average daily sunshine hours 2852.9 hours. As a result, the city has a warm and humid microclimate (about 77%), in particular in between January to August (INAM, 2019). This makes cycling harder.

4.2. TRANSPORT SYSTEM

Quality of the road infrastructures

Despite the growing number of motorized vehicles in Quelimane, the road infrastructures remain disconnected and not paved. On average, 25% of the roads are paved and 75% not paved. These, 15% of the paved roads are in the inner city, 7% in the city periphery and 3% in the suburban area. 40% of the non-paved roads are in the city periphery, 29% in the suburban area and 6% in the inner city. The high percentage of the non-paved road in the city periphery, turn this area less accessible particular to motorized modes and more accessible by cycling and walking (Figure 15).

Figure 15: Road quality per urban zone

Street lighting

Figure 16, shows the percentage of streets lit per urban zone. On average 48% of all roads in the study case are fully lit, 12% are partially lit, and 40% are not lighted. 34% of lit streets are located in the city periphery. In the inner city, the existing streets are almost all fully lit and they represent about 7%. Only 3% of the streets in the suburban area are fully lit and more than 34% are not lit. This has an enormous implication on cyclists route choice particular at night. Lack of street lights creates insecurity and an atmosphere for the crime.

Figure 16: % of Streets lighted per urban zone

Street tree cover

Figure 17, shows the percentage of streets that have tree cover. Overall, only 12% of the roads have greening protection. Most of the greening along the roads is observed in the inner-city (5%) and the suburban area (5%). From all the roads having street tree protection, 2% are located in the city-periphery. Roads that do not have tree protection

are mainly located in the city periphery (51%), followed by suburban areas (33%) and the inner city (7%).

Figure 17: % of streets with tree cover

4.3. MOBILITY PATTERNS

Modal share

There is no official mobility data from the transport authorities. From our survey conducted during the fieldwork for this thesis in 2017, the modal share captured in 7 main intersections in Quelimane is presented as follow: Walking (40%) followed by Cycling (35%), Private car (17%) and Motorcycle (8%). Figure 18 for details. It's worth saying that there is no public transport. People traditionally relay on walking and bicycle-taxi services to meet their daily travel needs. Commercial bicycle taxi services emerged since 2006, to fill the gap left by the lack of public transport. This activity is gaining prominence

due to the high unemployment rate and poverty in particular among the young man. These factors have been pointed out at the core drivers for cycling in Quelimane.

Figure 18: Modal share in the study area (the year 2017)

Opportunities for bicycle-taxi

As a result of the lack of public transport and poor road connectivity, bicycle-taxi emerges as a suitable mobility solution for the large majority poor facing difficulties in financing daily trips. Bicycle-taxi is a bicycle with a padded cushion fitted into a reinforced rear seat capable of transporting both passengers and goods (Mutiso et al., 2011). Its door-to-door transport, very reliable for individuals living in the informal settlements, and it is cheap in comparison with other modes that are seen attractive for most households. From the municipality data, until 2016 they have registered 2299 bicycle-taxi operators (64%) residing in Quelimane and the remain 36% coming from the neighbouring districts. This reveals the relevance of this activity in generating informal jobs, particularly among the young man. Additionally, the popularity of these services lies on one hand for the growing demand, but also for lacking appropriated regulation. Figures 19 and 20.

Figure 19: % of bike-taxi operator per residential origin

Figure 20: Bicycle-taxi operator and passengers

Jobs location and their influence on cycling

The spatial distribution of jobs and economic activities in the study case plays a relevant influence on cycling mobility. In regard to formal jobs, 48% are located in the inner city, 41% in the city periphery and 11% in the suburban area. Larger commercial areas are very attractive destination for bicycle-taxi operators for enabling the intersection of many potential passengers, Figures 21- 23.

Figure 21: Bicycle taxi operators gathering close to a supermarket

Most informal jobs are located in the city periphery 81%, in the suburban area 8% and 8% in the inner city. In Quelimane, informal jobs influence the destination choice for many bicycle-taxi operators but also this is seen as a barrier for other cyclists. Large markets are gathering places for people with different socio-economic, thus potential bicycle-taxi passengers. Therefore, bicycle-taxis operators often include such places in their itinerary. For other types of cyclists, larger markets along the streets are often perceived as cycling barriers for attracting agglomerations of street vendors which often

occupy the roads transforming it into disputed terrain between different modes (Sietchiping et al., 2012). Cycling in such conditions is proven difficult (Figures 22).

Figure 22: Road encroachment caused by street vendors and cars parked along the streets

Figure 23: % of jobs per urban zone

5

DESCRIPTIVE SURVEY RESULTS

5. DESCRIPTIVE SURVEY RESULTS

This chapter gives a brief description of the respondents. First, the basic socio-economic characteristics of the sample is presented. This allows understanding how well the sample represents the population, comparing the distribution of the sample (by age group and gender) with the census population. Then the description of other socio-demographic characteristics and travel behaviour is presented. The main objective is to identify variables and tendencies that might be relevant in identifying the key variables for cycling in SSA cities.

5.1. BASIC SOCIO-ECONOMIC CHARACTERISTICS OF SAMPLE

The desired sample size is 1062. The sample size was calculated based on the total population of 195.758 inhabitants (INE, 2008). The level of confidence considered was 95% and the margin of error 3%. This margin of error was defined to increase the representation of the sample, since the population base used for the sample size calculation date of almost 10 years ago. The desired sample should be composed of 51.3% male and 48.7% female. 38.2% should be young male (<35 years old) and 36.5% is a young female. They should represent the larger sample population. Male should represent 51.3% of the sample population and female 48.7%. The obtained sample is composed of 1085 respondents. 70.6% male and 29.4% female. 53.8% are young male while 21.0% is a young female (Table 7).

Table 7: % of the sample population per gender and age

Gender	Male				Female			
	< 35	35-55	>55	Total	< 35	35-55	>55	Total
Age intervals								
% of population (Census 2007)	74,6	22,8	2,6	51,3	74,7	22,2	3,1	48,7
Desired sample (%)	38,2	11,7	1,3	51,3	36,5	10,8	1,5	48,7
Obtained sample (%)	53,8	15,5	1,3	70,6	21,0	7,6	0,7	29,4
Number of respondents	584	168	14	766	228	83	8,0	319

The general characteristics of the respondents can be summarized in Table 8 and presented as follows.

Table 8: Characteristics socio-demographics of the sample population

Characteristics socio-demographics	% of respondents
Level of education	
Others levels of education	7
Primary	24
Secondary	59
University	10
Employment status	
Unemployed	15
Students	41
Informal jobs	32
Formal jobs	12
Family income (1000 Mts $\approx$ 14 €)	

<3.642,0Mts	52
Between 3.642-10.000Mts	39
Between 10,000-25,000	6
> 25.000,1Mts	3
Household composition	
Single parent with children;	55
Single in the household;	3
Couple without children;	7
Couple with children	35
Vehicle ownership	
None of the modes	30
Bicycle	49
Motorcycle	14
Car	7

- Males are overrepresented (53.8% in the sample Vs 38.2% in the population), while the female is underrepresented (21.0% in the sample Vs 36.5% in the sample). The unequal gender distribution is basically by three aspects: i) most of the women in Quelimane are not integrated into the economic activities, ii) they have limited access to the internet, which has forced us to conduct long face-to-face interviews often resulting in incomplete questionnaires, iii) less or even no woman use bicycle for taxi activities.
- Young people, students having secondary education degrees tend to be more representative in the survey (74.8%). This seems to be explained since the sample follows the natural structure of the population in the study area (74.7%). This is also explained by the fact that they have more access to the internet than other age groups (USAID, 2016), thus more familiarity with online tools, such as survey websites.
- The second most representative employment category is informal jobs (32%). This is justified since in Mozambique the unemployment rate is around 24.5% in 2017 (INE, 2019). This has a direct influence on the income (52% below the minimum wage) and vehicle ownership (79% own only a bicycle or do not own any mode of transport.). In small and medium-sized cities, such an unemployment rate induces the emergence of commercial bicycle services, which were largely surveyed in this study.

Single parents with children are the most representative household category, most are female-headed. This is a very common household type in most SSA cities (Castillo-Riquelme et al., 2008).

5.2. TRANSPORT MODES

Daily mode of transport

Figure 24 illustrates the relationship between mode use and travel purpose. 38.31% of respondents often travel to work purposes. 18.12% use bicycles, 12.90% walking, and 3.88% private car. 41.51% of the respondents travel to sell goods in the market or streets. Walking is the main transport mode for this purpose (30.90%), followed by cycling (15.01%). 53.78% of the respondents travel to school or university. Cycling is the main transport of 23.92%, and 23.16% travel by walking. In general, cycling is largely used for shopping (44.30%), followed by visiting family/ friends (43.77%).

Figure 24: Daily mode of transport per travel purpose

5.3. CYCLING FREQUENCY

Cycling frequency to different purposes

Most respondents cycle daily to school/university (17.34%), and 16.67% cycle daily to working and shopping. Irregular cycling (three times a week or more) is for visiting family/friends (62.82%), and leisure (55.38%). Bicycle-taxi was pointed by most respondents (81.61%) for never being their cycling purpose. 73.71% never cycle to working (Figure 25).

Figure 25: Cycling frequency per purpose

5.4. CYCLING MOBILITY PATTERNS

Preferred cycling travel time

The average cycling time of the sample is between 20-30min and it is often for shopping (Figure 26). For working, 11.22% of the respondents' cycle <10min and 9.79% between 10-20min. 13.08% of the respondents cycle to sell goods in markets/street in between 10-20min and 10.96% in >60min. For school/university, 16.71% of the respondent cycle in between 10-20min, and 15.66% between 20-30min. In general, most respondents cycle shorter travel time (<10min) for shopping (13.03%) and longer travel time (>60min) for visiting friends/ family (21.34%).

Figure 26: Average cycling distance per purpose

Departure time

Figure 27 shows the departure time divided into 3 categories according to weather changes throughout the day. This provides additional information to understand which tendencies can be considered when attempting to perceive travel behaviour. The morning peak is observed at around 6 AM. This may be justified due to the spatial disjoint between jobs and residential, therefore people should depart early for jobs, health facilities, most located in the inner centre. At this time, it is still relatively dark, but the weather is cool. Between, 9 AM- 4 PM is the hottest day interval (INAM, 2019). The peak of cycling occurs around 12PM. At this time, cycling is unpleasant due to heat exposure. The evening peak is observed from 5 PM to 8 PM. At this time, is getting cool but dark. Cycling is pleasant but unsafe due to a lack of lighting in most streets. This is relevant for understanding cycling route choice behaviour.

Figure 27: Departure time per weather changes categories along the day

6

**TYPE OF
COMMUTERS**

6. IDENTIFYING CLUSTERS OF CYCLING COMMUTERS AND TRAVEL PATTERNS: THE CASE OF QUELIMANE, MOZAMBIQUE¹

6.1 INTRODUCTION

Cycling is currently being promoted as a sustainable mode of transport (Van Cauwenberg et al., 2018; Winters, Brauer, et al., 2010) because it does not emit any pollutants (Massink et al., 2011) and occupies little space. It is also flexible, affordable and efficient in crowded urban areas (Heesch et al., 2015). Notwithstanding these benefits, cycling levels in many cities around the world are still considerably low (Heesch et al., 2014). In some cities in developed countries, low rates of cycling may be associated with high vehicle-ownership rates (Yao & Wang, 2018), high living standards (Dimitriou, 2006), and land-use and housing policies that generate long distances and give rise to a culture of motorized-trips (Yang & Zacharias, 2016).

Adaptation rates for cycling in developing countries can be explained by its association with rurality and poverty, and the perception of the bicycle as an inferior mode of transport (Diaz Olvera et al., 2008; Pendakur, 2005). However, there are still some exceptions where cycling is the predominant commuting mode, either due to the poor quality of public transport or to the fact that cycling is cheap and offers flexible job opportunities (Nkurunziza, Zuidgeest, Brussel, et al., 2012). This is the case of some African cities such as Tamale, Ghana, and Ouagadougou, Burkina-Faso, among others (Abane, 2011; Acheampong et al., 2018). The modal share of cycling in some of these cities is estimated to be as much as 30% (Wallrapp et al., 2008), although this figure is currently in decline due to a wide range of local anti-cycling measures such as banning cycling from the most prestigious places in the city (Alando, 2017) and to the consideration of cycling as an outdated mode of transport (Pochet & Cusset, 1999).

Numerous pro-cycling initiatives have been enacted in many cities across the world, including the installation of cycling infrastructures and facilities (Pucher et al., 2010), public awareness campaigns to promote safe on-road behaviour (Assailly, 2017) and residential and job allocation to reduce travel distances (Oakil et al., 2016). However, these initiatives have a limited impact in SSA cities due to a lack of empirical mobility data, which makes it difficult to have a real diagnosis of potential cycling users. Cycling policies and initiatives developed in western cities cannot usefully be exported to SSA, reinforcing the need to develop *ad hoc* studies in this region. These studies should set out to cover several aspects, such as the generation of mobility databases and local knowledge on cycling patterns, and a better understanding of the role of cycling in achieving sustainable mobility. They should be validated by specific pilot studies designed to test policy measures for improving cycling levels.

This research aims to identify clusters of cycling commuters and map their travel patterns in the context of African cities. The analysis also considers some built-environment

¹ This chapter is based on Mendieta, C. J., et al. (2020). Identifying clusters of cycling commuters and travel patterns: The case of Quelimane, Mozambique. *International Journal of Sustainable Transportation*, 1-12. doi:10.1080/15568318.2020.1774947

aspects such as the urban fabric and the quality of the road infrastructure, in addition to the lack of reliable public transport services. The clusters consider socio-demographic and cycling-use variables. The case study refers to the city of Quelimane, Mozambique. The remainder of the paper is organized as follows: Section 6.2 discusses previous studies in the field; Section 6.3 describes the analysis methods, while Section 6.4 presents the main results. Finally, Section 6.5 highlights some concluding remarks and further research lines.

6.2. THEORETICAL BACKGROUND: THE IDENTIFICATION OF CYCLING CLUSTERS

There are an increasing number of studies that seek to cluster commuter travel behaviour (Kroesen & Handy, 2014; Vandenbulcke, Thomas, de Geus, Degraeuwe, Torfs, Meeusen, & Int Panis, 2009). Two main clustering approaches can be identified: i) clustering based on socio-demographic variables (Bergström et al., 2003; Heinen et al., 2010); and ii) clustering based on mode-use variables (Anable, 2005; Gatersleben et al., 2007). This study considers socio-demographic variables, a set of personal characteristics that define an individual, while mode-use variables show the cognitive state of readiness towards a transport mode. Both sets of variables (socio-economic and mode-use variables) were used for clustering since this approach identifies the cyclists precisely and offers a complete picture of their commuting patterns.

Previous research has found that cycling is related to a combination of socio-demographic variables, environmental aspects and cycling characteristics (Heinen, Maat, & van Wee, 2011; Zhao, Nielsen, Olafsson, Carstensen, & Meng, 2018). In terms of socio-demographic variables, cycling use is influenced by age, gender, household composition, employment status, income and education (Fernández-Heredia et al., 2014). Age generally influences sensorial abilities. Previous studies have concluded that cycling abilities decline with age (Van Cauwenberg et al., 2018). Gender appears to be more related to cycling culture than use (Garrard et al., 2008), but other researchers have reported that cycling is more popular among young male adults (Bull et al., 2000; Xing et al., 2010). Household composition influences cycling frequency; larger households are likely to cycle more frequently (Boumans et al., 2005). Employment status and income affect vehicle ownership and purpose choice. Pucher & Renne (2003) found that non-car-owning low-income employees greatly increased their likelihood of walking and cycling, while high-income employees tended to cycle for sport or leisure. Education has more influence on perception than on cycling frequency, which may be due to the view of the environmental, social, and economic and personal benefits of using this mode of transport (Xing et al., 2018).

In regard to cycling-use variables, both environmental (e.g. zero CO₂ emissions) and non-environmental aspects (e.g. traveling flexibility and opportunities for commercial activities) are seen as essential for adopting the bicycle for commuting (Bryceson, Maunder, et al., 2003; Mbara et al., 2003; van Wee et al., 2010). Cycling is perceived as environmentally friendly, which influences its share among pro-environmental riders (Clark et al., 2016). Woods & Masthoff (2017) associate cycling with flexibility, particularly in congested urban areas, while other authors state that cycling is even more convenient for suburban residents in SSA cities (Cervero, 2000, 2013), as it offers speedy access to jobs, health services and social activities, most of which are connected by unpaved roads in high-density unplanned settlements that are impenetrable by car. The

perceived cycling opportunities for commercial activities were reported by (Kipandula et al., 2015; Mutiso et al., 2011), who found that in most SSA cities, cycle-taxis are a feeder to public transport and serve as a source of income for many families.

The objective of this research is therefore to identify which socio-demographic and cycling-use variables can be used to identify the cluster of cycling commuters, using travel pattern mapping to reveal how far cycle commuting in SSA cities is similar to other locations where cycling has been studied in depth. Combining quantitative and qualitative approaches could provide additional insights for understanding cycling potential in developing cities in the African context.

6.3. RESEARCH METHODOLOGY

Research design

A four-stage approach was designed to identify and profile clusters of cycling commuters based on socio-demographic and cycling-use variables. A map of their travel patterns was obtained from cyclists' historical trip data, captured after recreating their previous day's trip and schematized as follows (Figure 28).

Figure 28: Diagram of the research methodology

1) Data gathering

The study examines a broad array of the socio-demographic and cycling-use variables in the case study. Due to a lack of official mobility data from the municipality, an online and face-to-face survey was designed and administered to collect empirical data. The survey was conducted from July to December 2017 and the main target population was commuters, namely people who travel daily to reach various major activities (e.g. work, selling in the market, school and health care). An online survey was enabled by randomly distributing 1284 invitation cards at three university campuses and 15 large commercial areas, as it was considered more likely to find people with internet access in such places. A total of 550 surveys were finally obtained following this description. Since a large proportion of the population (around 33%) do not have regular access to the internet (USAID, 2016), face-to-face surveys were also conducted in 22 predefined locations across the city (e.g. markets, workplaces, cycle-taxi points). Several criteria were taken into consideration to identify suitable locations: i) places with a high concentration of people from a wide variety of socio-demographic backgrounds; ii) places with a high trip generation rate; iii) places where the cycle-taxi mode predominates. In all cases, respondents were randomly selected, and a total of 535 additional surveys were obtained. This sampling approach was highly appropriate for the case study, as only a limited number of people have regular access to the internet. Finally, a total of 1085 commuter respondents were obtained, indicating a level of confidence of over 95% and a margin of error of 5%. However, 449 of them were eliminated due to missing data, resulting in a total of 636 valid questionnaires.

The survey comprises three parts:

- The first part was mainly related to cycling-use variables, exploring the respondents' cycling frequency for different purposes (e.g. work, school, shopping, selling in markets, and leisure). Responses were scaled from 1-3 where 1= Never, 2= Irregular (less than three times a week), 3= Regular (three times a week or more).
- The second section asked about the trips taken the previous day and their itinerary, indicating the origins and destinations (O-D) and the departure time from each destination. This helped to understand cycling intensity among the different urban zones and assess the role of road quality in the cycling patterns. A set of different neighbourhoods were incorporated into the survey to increase the accuracy of the responses.
- The third section focused on standard socio-demographic variables. Respondents were asked to provide information about their age, gender, income, household composition, vehicle ownership, bicycle ownership, education level and employment.

The survey shows a modal split of 40% for walking, 35% for cycling, 8% for motorcycles, and 17% for cars. This confirms the high level of bike use, although it is declining as perceived by the city authorities.

2) Statistical analysis (sample characteristics and factor analysis):

Statistical analysis was carried out on 22 key socio-demographic and cycling-use variables, providing the basic information on the case study. A chi-square non-parametric test was done to measure the variables' significance (Field, 2013), and frequency statistics were then used to explore the central tendency and dispersion of the collected data. This statistical analysis gave a clear picture of the whole sample population.

All significant socio-demographic and cycling-use variables were tested through factor analysis to determine their underlying factor structure using the principal component method. Promax rotation was used as a rotation method for handling very large datasets (Field, 2013). The robustness of the result was tested through the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity to classify the relevant socio-economic and cycling-use variables that could help identify the cluster of commuter cyclists.

3) Cluster analysis

Finally, clusters of commuter cyclists were identified based on socio-demographic and cycling-use variables. This provided a basis to map cyclists' travel patterns and understand the influence of road quality on cycling mobility in the case study. Twostep cluster analysis was chosen as the clustering method due to its ability to handle very large categorical or continuous datasets and because this method automatically determines the optimum number of clusters (Field, 2013). The clustering criterion used was Akaike's information criterion (AIC), since it is sensitive to the variables in the study. Log-likelihood was specifically applied as a distance measure for its ability to mix different types of variables (Bacher et al., 2004).

4) Mapping cyclists' travel patterns

After identifying the clusters of cycling commuters, an origin-destination matrix (O-D) was built by replicating the commuter cyclists' itineraries, which were spatially represented by means of Geographical Information System (GIS). The O-D pairs considered the Euclidean distances among different zones. The top O-D pairs (>5 bicycle trips) were spatially represented by different coloured lines – for example, red (trips occurring within Z1), purple (between Z1- Z2) and light blue (Z2-Z2). This allows the identification of links with higher cycling intensity. The discussion focused on these O-D pairs to provide an important insight into the influence of road quality on cycling mobility. Cycling trips occurring within the same zone were considered to occur at the zone centroid, therefore not spatially represented. They were included in the statistics. The O-D pairs contain trip data such as cycling purpose, departure time and trip length.

6.4. RESULTS AND DISCUSSION

Sample characteristics

The survey set out to explore a large dataset of 12 significant socio-demographic and cycling-use variables influencing cycling commuters in the case study (Table 9). In terms of socio-demographic variables, the sample distribution is fairly similar to the distribution of the Mozambican population in regard to age, income and paid work. Students and single-parent households are overrepresented in the sample and women are underrepresented. Although the sample correctly represents the Mozambican population with respect to some socio-demographic variables, it should be noted that it includes only

daily commuters. A total of 636 correctly completed questionnaires were obtained, of which 71.1% were men. The unequal gender distribution is basically explained by three aspects: i) most of the women in Quelimane are not integrated in economic activities, ii) they have limited access to the internet, which forced us to conduct long face-to-face interviews and often resulted in incomplete questionnaires, and iii) fewer women or possibly even none use bicycles for taxi activities.

In regard to age, there was a large proportion of young respondents (average age 23). The household category of single parents with children (67.8%) was the most representative, followed by couples with children (25.8%). These household categories are also the most representative in Mozambique (Javier & Pedro, 2016). In regard to employment status, a large proportion of the respondents are students (55.8%), followed by informal workers (24.7%). The largest share among the different education categories is the secondary education level (63.2%), followed by primary education (21.5%) and university graduates (11.3%). This has an important influence on monthly household income and available modes in the household. A large proportion of the respondents have incomes below the minimum wage (57.2%) which is about 3642.00Mts/month ($\approx$ 51.87 Euros/month). 47.6% of the respondents own only a bicycle and 30.7% do not own any mode of transport. With respect to the number of bicycles owned, 58.5% of the respondents said they owned at least one or more bicycles.

In regard to cycling frequency to work/school, 44.3% of the respondents are regular cycling commuters (three times a week or more), 36.2% are irregular commuters (fewer than three times a week) and 0.9% are non-bicycle commuters (never cycle). Cycling frequency for selling in markets/streets is done mainly by irregular cycling commuters (16.0%), followed by regular cycling commuters (8.2%) and non-bicycle commuters (0.8%). Cycling frequency for bicycle-taxi is equally dominated by regular and irregular cycling commuters (7.7%). Cycling frequency for leisure/shopping corresponds mainly to irregular cycling commuters (56.6%), followed by regular commuters (10.1%). On average, the sample population made 3.36 bicycle trips per day, and the average cycling distance is 2.98 km (SD= 2.21 km).

Table 9: Socio-demographic characteristics and cycling use of the sample

Variables		Statistics (n=636)
Socio-demographic		%
Gender	Male	71.1
	Female	28.9
Age group	Young (<35 years old)	89.8
	Adults (35-55 years old)	8.3
	Elderly (>55 years old)	1.9
Household composition	Single parents with children	67.8
	One-person household	3.6
	Couple without children	2.8
	Couple with children	25.8
Employment status	Unemployed	6.4

	Student	55.8
	Informal job	24.7
	Formal job	13.1
Education level		
	Other levels	3.9
	Primary	21.5
	Secondary	63.2
	University	11.3
Income (1000 Mts $\approx$ 14 €)		
	<3,642 Mts	57.2
	3,642-25,000 Mts	41.2
	>25,000Mts	1.6
Vehicle ownership		
	None	30.7
	Only bicycle	47.6
	Bicycle and motorized modes	16.2
	Only motorized modes	5.5
Bicycle availability		
	No	41.5
	Yes	58.5
Cycling use (cycling frequency)		
Work/study		
	Never	0.9
	Irregular (less than three times a week)	36.2
	Regular (three times a week or more)	44.3
Selling		
	Never	0.8
	Irregular (less than three times a week)	16.0
	Regular (three times a week or more)	8.2
Bicycle-taxi/carrying loads		
	Never	0.6
	Irregular (less than three times a week)	7.7
	Regular (three times a week or more)	7.7
Leisure/shopping		
	Never	1.6
	Irregular (less than three times a week)	56.6
	Regular (three times a week or more)	10.1

Factor analysis

Table 10 shows the factor loadings of the variables influencing bicycle commuting in Quelimane. Six-factor groups were found, with the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.68, the goodness of fit = 772.97, df=120 and sig =0.00, which is statistically acceptable. However, only factor groups 1 to 4 (a total of 9 variables) were considered meaningful for cluster analysis based on an eigenvalue >1 and the scree plot.

Factor 1 (F1) includes age, household composition and employment status. These variables influence the social role of the individual and therefore their cycling frequency. Factor 2 (F2) refers to education level and income, variables that evidently impact individual social status and consequently cycling perception. Factor 3 (F3) consists of the type of vehicles available in the household and the number of bicycles and denotes an individual's mode availability dimension. Factor 4 (F4) is composed of the variables for cycling frequency to work/school and cycling frequency for leisure/shopping, which describes individual cycling habits.

Table 10: Factor loadings of variables influencing bicycle commuting

Variables	Factors			
	F1 (social role)	F2 (social status)	F3 (mode availability)	F4 (cycling habits)
Age	0.89			
Household composition	0.90			
Employment status	0.81			
Education level		0.87		
Income		0.76		
Vehicle ownership			0.66	
Bicycle availability			0.89	
Cycling frequency to work/school				0.63
Cycling frequency for leisure/shopping				0.90
Eigenvalue	2.77	2.23	1.56	1.19
% of variance explained (n=48.44)	17.31	13.96	9.72	7.45

Clusters of cycling commuters

Following the Twostep cluster analysis, three different clusters of cycling commuters were identified according to (i) household composition, (ii) cycling frequency to work/study and (iii) employment (Table 11). In Cluster #1 (informal workers with children), the individuals surveyed were basically couples with children who regularly commuted to work/study by bicycle (three times a week or more) and who had an informal job. This cluster accounts for 31.30% of the respondents. Cluster #2 (short distance students) comprised students in single-parent households with children who regularly commute to work/study by bicycle (three times a week or more). This cluster accounts for 47.90% of the respondents. Cluster #3 (occasional cyclists) contains students in single-parent households with children who irregularly commute to work/study by bicycle (less than three times a week). This cluster is composed of 20.80% of the respondents.

Table 11: Descriptive statistics of the cycling commuter clusters identified

Variables	Cluster 1 (informal workers with children)	Cluster 2 (short- distance students)	Cluster 3 (occasional cyclists)
Socio-demographic	Statistics (%)		

<hr/>			
Age group			
Young (<35 years old)	71.0	98.0	99.1
Adults (35-55 years old)	25.3	2.0	0.9
Elderly (>55 years old)	3.7	-	-
Household composition			
Single parents with children	-	94.8	96.3
Single-person household	3.7	4.0	3.7
Couple without children	7.4	1.2	-
Couple with children	88.9	-	-
Employment status			
Unemployed	4.3	6.0	5.6
Student	9.9	70.2	86.1
Informal job	52.5	16.5	6.5
Formal job	33.3	7.3	1.9
Education level			
Other	7.4	2.8	3.7
Primary	29.6	12.5	23.1
Secondary	46.9	74.6	63.9
University	16.0	10.1	9.3
Income (1000 Mts $\approx$ 14 €)			
<3,642 Mts	42.0	55.2	65.7
3,642-25,000 Mts	54.9	44.4	34.3
>25,000Mts	3.1	0.4	-
Vehicle ownership			
None	16.7	24.6	40.7
Only bicycle	57.4	56.5	31.5
Both bicycle and motorized modes	19.8	14.5	18.5
Only motorized modes	6.2	4.4	9.3
Bicycle availability			
No	31.4	34.6	50.0
Yes	68.6	65.4	50.0
Cycling-use variables (cycling frequency)			
Work/school			
Never	-	-	5.6
Irregular (less than three times a week)	30.9	32.7	94.4
Regular (three times a week or more)	69.1	67.3	-
Leisure/shopping			
Never	0.8	0.5	9.7
Irregular (less than three times a week)	83.2	79.2	85.5
Regular (three times a week or more)	16.0	20.2	4.8
<hr/>			

n=636	31.30%	47.90%	20.80%
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A brief profile of each cluster is discussed below; the analysis includes cycling patterns for the different zones in the city.

Cluster 1: informal workers with children

This cluster is composed mostly of couples with children who regularly use the bike to commute to informal jobs. It has a relatively large share of male respondents (78%) and consequently a smaller share of women (22%). The average age (32 years) is higher than the sample average (23 years). The dominant type of household in this cluster is couples with children (88.9%), a category that represents only 25.8% of the sample respondents. Regarding employment status, there is a larger share of informal workers (52.5% versus 24.7% in the sample). This cluster has the highest proportion of university graduates (16%), and thus a higher average income and vehicle ownership. Consequently, a smaller proportion have secondary education certificates than the global sample (46.9% versus 63.2%). Some 54.9% of the respondents belong to the medium-income wage group. Regarding vehicle ownership, 57.4% of the respondents own a bicycle and only 16.7% own no mode of transport. Most of the individuals in the cluster (68.6%) have access to one or more bicycles.

To understand the travel patterns for Cluster 1, it is worth analysing the intra- and inter-zone trip distribution (Table 12). The intensity of O-D pairs of cycling trips is shown in Figure 29.

Table 12: % of cycling trips by informal workers with children (n=642 trips)

O-D pairs	Cycling purpose*			Departure period*	
	Formal jobs	Informal jobs		Peak hours	Off-peak hours
	Work/school	Selling/as a bicycle-taxi	Other		
Z1-Z1	4%	1%	1%	2%	6%
Z1-Z2	5%	9%	3%	5%	7%
Z1-Z3	0%	1%	1%	0%	1%
Z2-Z2	11%	33%	5%	17%	43%
Z2-Z3	6%	7%	3%	5%	7%
Z3-Z3	2%	6%	2%	0%	6%

*Differences in the percentage of trips between “cycling purpose” and “departure period” are due to missing data in the sample

Only 6% of all cycling trips take place within the CBD, and the average travel distance is 1.46 km (SD=0.73 km). This lower share of cycling trips within Z1 can be justified by the fact that it concentrates the majority of high-income individuals (Lall et al., 2017), who have higher car ownership. (Pochet et al., 1999) found that cycling utility in SSA cities declines as income rises. Work/school (4%) is the primary cycling purpose. The highest trip intensity is towards commercial/service areas. Roads within Z1 are paved, well-lit and well-connected, which is critical for ensuring a safe and comfortable cycling environment. However, due to the fast-moving motorized traffic and the lack of bike lanes, cyclists are exposed to road accidents. Studies in SSA cities indicate that despite the low traffic volume, late afternoon and evening are dangerous times for cycling due to bad driver behaviour, as drunk driving is the main cause of accidents (Verster et al., 2018).

Most of the cycling trips from Z2 are oriented towards Z1 (17%). Selling/as a cycle-taxi (9%), followed by work/school (5%) are the primary cycling purposes. The most frequent O-D pairs are observed between poor residential areas (Z2) and commercial/service areas (Z1). On average they travel about 2.19 km (SD=1.19 km). This is the classic cycling pattern in most SSA cities. Most young unemployed men must live near the city centre if they hope to cycle daily to the inner city to find decent jobs (Lall et al., 2017). Many informal workers cycle to earn their livelihood, and therefore have no specific destination and are less influenced by road quality. They often use a bicycle as a mobile carrying platform to sell in the streets and for uses as a cycle-taxi. Most of the trips take place at off-peak hours (7%), when the low-traffic volume makes cycling safer and encourages the use of bicycle-taxis, particularly among women. However, African women sit side-saddle on bicycle-taxis, which poses a serious safety risk. Cyclists at peak-hours (5%) are mostly street vendors, since the high rate of motorized traffic means more potential customers, particularly at the afternoon peak when people return home.

Figure 29: Most frequent O-D pairs of cycling trips by informal workers with children

49% of cycling trips take place within Z2: 33% for selling/as a bicycle-taxi, 11% for work/school and 5% for other purposes. The high share of trips for selling is justified by

the fact that the city periphery concentrates most of the low-income individuals and a vast network of informal markets (Lall et al., 2017; UN-Habitat, 2011). On average they travel 2.30 km (SD=1.28 km). The most frequent O-D pairs correspond to neighbourhoods with larger informal markets and bus terminals. At peak hours, the concentration of trucks, buses, motorcycles, handcarts and pedestrians makes cycling impracticable in many road sections. For street sellers, finding a favourable place for selling is very challenging, so they must start out early in the morning. This may explain why 43% of the cycling trips within Z2 occur in the off-peak period. Most commuters in Z2 are captive cyclists, which means that the bicycle is the only available alternative since many roads in Z2 are not accessible by car due to the dense unplanned informal settlements, with narrow and disconnected roads.

The average travel distance between Z2-Z3 is about 6.05 km (SD=2.25 km), which is far higher than the cluster average of 3.11 km (SD= 2.17 km); a possible explanation is that selling/as a bicycle-taxi (11%) is the main cycling purpose. Mutiso et al., (2011) underline that bicycle-taxi fares are dependent on trip length, so bicycle-taxi drivers prefer long trips to maximize their revenues. Z3 is basically an agricultural area, and the roads connecting this zone are often wide, unpaved and lacking basic cycling facilities such as street lights. It has low traffic volume which makes cycling safer, although it is uncomfortable due to the unpaved road surface, particularly for bicycle-taxi operators who regularly carry passengers and/or heavy loads. Bicycle-taxi drivers are often physically fit young men ((Mutiso et al., 2011), which ensures a faster connection and also protection for late afternoon and evening commuters, highlighting the fact that bicycle-taxis not only provide door-to-door transport but also play an important security role for more vulnerable individuals.

Cluster 2: short-distance students

This cluster is composed mostly of students in single-parent households with children who regularly cycle to their workplace or school. This cluster has a large share of male respondents (70%). The average age is 20 years (similar to the global sample, which is 23 years). This is a very common household type in most SSA cities, probably due to low average life expectancy and polygamy (UNFPA, 2016). Most have only a secondary education (74.6%), which influences their average income. Most households' (55.2%) income is below the minimum wage. Vehicle ownership and the number of bicycles available in the household are similar to Cluster 1. Table 13 breaks down all Cluster 2 trips according to cycling purpose and travel behaviour (departure time).

Table 13: % of cycling trips by short-distance students (n=766 trips)

O-D pairs	Cycling purpose*			Departure period*	
	Formal jobs	Informal jobs	Other	Peak hours	Off-peak hours
	Work/school	Selling/as a bicycle-taxi			
Z1-Z1	7%	2%	2%	3%	5%
Z1-Z2	4%	1%	2%	4%	7%
Z1-Z3	2%	1%	0%	1%	1%
Z2-Z2	39%	12%	9%	20%	45%
Z2-Z3	6%	4%	1%	3%	5%
Z3-Z3	4%	3%	1%	1%	5%

**Differences in the percentage of trips between "cycling purpose" and "departure period" are due to missing data in the sample*

Figure 30 shows that most trips between Z1-Z2 are commuting to work/school (4%), other purposes (2%) and selling/as a bicycle-taxi (1%). The average travel distance is 1.80 km (SD=1.01 km). The lower school cycling share can be explained by the fact that a large proportion of parents do not encourage their children to cycle to school. Most secondary schools are located along the main roads where there is no cycling infrastructure, street signage or cycle crossings, which makes cycling to school unsafe. 7% of cycle trips are off-peak. This is likely because the majority of public schools in Mozambique open between 6:30 AM and 7 AM, somewhat before morning peak hours.

Cycling within Z2 covers short distances: the average cycling distance within Z2 is 1.15 km (SD=0.55 km), typically cycling to school (Emond et al., 2012). 39% of this cluster cycle to work/school, 12% for selling/as a bicycle-taxi and 9% for other purposes. The roads in the city periphery are often narrow and unpaved, making cycling safer due to a relative absence of motorized traffic. 45% of trips occur off-peak. These narrow roads afford shade, which is highly appreciated in summer, and probably explains the high cycling share within this zone. Cycling within Z2 allows parents to reduce their daily travel expenditure to school, thus increasing school attendance, which has a significant impact on reducing poverty. However, there are no proper parking facilities at school, which discourages cycling due to the fear of bicycle thieves.

Some 11% of cycling trips take place between Z2-Z3. 6% are for work/school, 4% for selling/as a bicycle-taxi and 1% for other purposes. The average cycling distance is 5.02 km (SD=3.83 km), which is substantially more than the sample average of 2.69 km (SD=2.25 km). A possible explanation is that suburban areas are remote and deprived of basic services such as education and health (UN-Habitat, 2011), so students must travel long distances in search of alternatives. Long daily distances affect the cycling decisions of poor households, who are forced to restrict their trips to the most essential purposes such as work, selling or farming. This discourages school attendance, which contributes to increasing poverty.

Figure 30: Most frequent O-D pairs of cycling trips by short-distance students

Cluster 3: occasional cyclists

This cluster is composed mostly of students who occasionally cycle to school or work. The average age is 19 years. Household composition, employment status, education level and income are similar to Cluster 2. The majority are single parents with children (96.3%), students (86.1%) and secondary level students (63.9%), with incomes below the minimum wage (65.7%). This cluster has the largest share of female respondents (41%), which probably justifies the greater proportion of low-income households since many single-parent households in Mozambique are female-headed and most are poor. A glance at the structure of the urban Mozambican population shows that females represent 53.5% of the total population (INE, 2015).

Table 14: % of cycling trips by occasional cyclists (n=325 trips)

O-D pairs	Cycling purpose*			Departure period*	
	Formal jobs	Informal jobs	Other	Peak hours	Off-peak hours
	work/school	selling/as a bicycle-taxi			
Z1-Z1	0%	3%	2%	4%	5%
Z1-Z2	2%	4%	1%	5%	4%

Z1-Z3	0%	0,4%	0.4%	0%	1%
Z2-Z2	8%	36%	25%	34%	37%
Z2-Z3	3%	5%	4%	1%	4%
Z3-Z3	0%	3%	3%	6%	0%

**Differences in the percentage of trips between “cycling purpose” and “departure period” are due to missing data in the sample*

Table 14 shows that trips within the CBD (Z1-Z1) correspond to 5% of all trips. 3% are for selling/as a bicycle-taxi and 2% for other purposes. The average travel distance is 0.36 km (SD=0.06 km), below the cluster average of 2.84 km (SD=2.38 km). The lower share of cycling trips between Z1-Z1 can be explained by the fact that the inner core in most SSA cities is a high-income residential area, so few individuals cycle for their daily activities (Lall et al., 2017). This cycling pattern can be seen in Figure 5, where a higher cycling intensity is observed between O-D pairs connecting to large informal markets. Roads connecting market places in Z1 are often paved and are congested at peak hours when the main intersections are occupied by street vendors, which narrows the streets. This contributes to road disputes between different transport modes and makes cycling unsafe. According to (Garrard et al., 2008), women often avoid cycling in such conditions and tend to cycle off-peak.

Cycling trips between Z1-Z2 represent 7% of all trips: 4% for selling, 2% for work/school and 1% for other purposes. The average travel distance is 1.97 km (SD=1.25 km). (Oakil et al., 2016) report that cycling intensity is higher if the primary purpose is utilitarian and the commuting distance shorter. Some researchers (Felkner et al., 2016) have stated that road quality in SSA cities declines rapidly beyond the inner city, making cycling unsafe due to the lack of bike lanes. Women are often the most penalized because many cannot endure the hardships of such trips, and so become passive cyclists (bicycle-taxi passengers), while others avoid cycling altogether. This prevents their participation in economic activities and ties them to poverty.

Figure 31: Most frequent O-D pairs of cycling trips by occasional cyclists

Figure 33 illustrates that the highest number of bicycle trips (69%) take place inside the city periphery (Z2-Z2). Cycling for other purposes (25%) has particularly high relevance. The average travel distance is 1.60 km (SD=1.07 km). Such relatively long cycling distances for non-utilitarian trips may reveal typical occasional cycling characteristics (Heesch et al., 2015). The primary cycling purpose is selling (36%) and most trips are off-peak. According to (Bryceson, Mbari, et al., 2003; Lall et al., 2017), the city periphery (Z2) often concentrates the majority of informal job opportunities, and therefore attracts this type of cycling trips. This cluster also has a larger share of female respondents. Some authors report that most women in SSA cities are dedicated to domestic activities and to activities in the informal economy, such as selling in local markets or working on family farms (Kes et al., 2006; Wodon & Blackden, 2006). The quality of the roads in Z2 is poor and they lack most facilities; they tend to be narrow, uneven, unpaved and disconnected, with no street lights or drainage. This kind of road network deters car trips and encourages cycling by day, particularly during the hours of sunlight since buildings offer protection from the sun. However, cycling through these streets is unsafe by night or in the long tropical rainy season, inducing a shift to the main roads, which cyclists must share with fast-moving automobiles and dense traffic, thus exposing them to the risk of accidents.

6.5. CONCLUSIONS

This study identifies and profiles clusters of cycling commuters in the city of Quelimane based on socio-demographic and cycling-use variables. The O-D matrix shows their cycling patterns. Cycling commuters were clustered into three groups according to three socio-demographic and attitudinal variables: household composition, employment status and cycling frequency to work/school. The clusters identified are *informal workers with children*, *short-distance students* and *occasional cyclists*. Their cycling patterns were spatially visualized using GIS. Selling and bicycle-taxi are the main cycling purpose, highlighting that the bicycle is used as a work tool.

Table 15: overall percentage of cycling trips per travel purpose and distance (n=1733)

Clusters	Cycling purpose (%)				Distance (km)			
	work/ school	selling/ bicycle-taxi	Other	Total	<2	2-5	>5	Total
C1- Informal workers with children	13	21	7	41	15	19	7	44
C2-Short- distance students	29	12	9	50	20	14	5	39
C3-Occasional cyclists	1	5	3	9	10	7	3	20
Total	43	38	19	100	45	40	15	100

Table 15 presents a summary of cycling trips per travel purpose and distance. The majority of trips are regular to work (either formal or informal) and to study. Also, students use their bicycle for informal activities as selling things and transporting persons. Trip distances are up to 5km long, which can explain why most trips are within Z2, where half of the population lives and cover their daily activities. Individual from cluster 1 (41% of total) cycle to sell/bicycle-taxi (21%) as major activity. About 19% cycle medium distances (2-5 km). In Cluster 2, 29% cycle to school, covering less than 2 km. Occasional cyclists often cycle to sell/ bicycle-taxi, and half cycle short distances, less than 2km.

When comparing these findings with Figures 31-33, a high cycling intensity can be observed within Z2, which hosts most people and many informal activities. However, the bike patterns contrast with other types of cities where trips to work and shop have the CBD as the main destination (Cervero, 2000, 2013). The reasons for this could be the following: i) The urban layout influences cyclists' behaviour. Cycling in SSA cities is mostly for poor, while wealthier people own cars and make trips to CBD where roads are paved and most formal jobs and retail activities are located. ii) Lack of public transport. For the poor majority, the bicycle is the only available mode of transport and it is also used as an informal taxi. iii) Poor road conditions beyond the city-periphery (Z2) that makes it inaccessible by car and thus safer for cycling.

On the other hand, the results shown in Tables 12-14 indicate that attitudes towards cycling are basically influenced by individual social roles, so individuals in larger households and low-income employees cycle more frequently. This is consistent with other studies in the field (Boumans et al., 2005; Pucher et al., 2003; Zhao, Nielsen, et al.,

2018). The O-D pairs enabled us to assess the cycling patterns for the different clusters. In Cluster 1 and 3, the main cycling purpose is to transport goods to sell in local markets. On average, the respondents' cycle short-medium distances. This is consistent with (Bryceson, Mbari, et al., 2003), who consider these cycling patterns to be linked to informal jobs in the city periphery associated with selling goods in nearby markets. In Cluster 2, the primary purpose is cycling to school. This was expected since the dense informal settlements and narrow streets offer a safe cycling environment (Mbari et al., 2003; UN-Habitat, 2011), which encourages parents to allow their children to cycle to school. Nevertheless, the described patterns should be complemented by more advanced modelling approaches to identify the causal relationships among cycling patterns and the built environment.

Overall, this study highlights two main contributions. First, cycling intensity is rather low between the CBD and the city-periphery, because of the rather differences among those areas in terms of road quality, access to cars and location of activities for people with different income levels (Cervero, 2000, 2013). In Quelimane, most cycle trips take place in the city periphery (Z2), while most of the car trips are located in CBD (Z1). The second contribution is that the use of bike as taxi is affected by variables related to business models, rather than by variables of distances to destinations. For this reason, bicycle-taxi operators are more likely to cycle longer distances than the rest of the population to increase their revenues. That can alert about the risk to exclusively consider the linear relationship between travel distance and cycling choice in the context of SSA cities.

Based on those important aspects, transportation strategies should, therefore, be targeted to each type of traveller (here defined as clusters of cyclists). Due to the differences observed, very few lessons from studies in other socio-economic contexts can be applied to SSA. There is a clear need for mobility data for planning in SSA cities to serve as a basis for decision-making organised in a systemic way. This paper has generated the databases for the city of Quelimane, which allows the design of efficient policies aimed at producing a positive impact on mobility patterns.

The results show that despite the similarities in attitudes to cycling among the clusters, commuters behave according to the characteristics of the urban fabric in which they live, work, shop, and enjoy their leisure. Mapping cyclists' travel patterns for specific zones is crucial to define the geographical areas where customized policies can be implemented. For instance, most Cluster 1 commuters cycle regularly as a way to perform informal jobs, and Cluster 2 commuters to go to school. Most of these two clusters are located in the city-periphery. Cycling policies should be designed to reduce travel time, particularly when connecting residential zones with large market areas. Efficient safety measures are also required particularly on the main crossings to schools, and safe bicycle parking in schools to reduce bicycle theft and make cycling to school more attractive.

From a societal point of view, cycling offers immense commuting benefits in SSA cities; however, little is known about cyclist profiles. In order to develop precise policies that encourage cycling, further studies should consider attitudinal variables in identifying homogenous groups of commuter cyclists. This should precisely reveal different needs for different groups of commuter cyclists, with the goal of implementing the best possible solutions tailored to each profile.

7

**ATTITUDINAL
CYCLING SEGMENTS**

7. BICYCLE COMMUTING IN QUELIMANE: AN ATTITUDINAL MARKET SEGMENTATION ANALYSIS

7. 1. INTRODUCTION

Over the last years, most of the sub-Saharan African (SSA) cities have grown rapidly at an average rate of 4.5% (Sietchiping et al., 2012), and such growth is not always accomplished with transport infrastructure provision. Cities are becoming more disconnected and characterized by slow and costly commuting (Lall et al., 2017). This affects mobility capability, particularly to the low-income population, mostly located in the city periphery (UN-Habitat, 2006). Households spend nearly 8% of their monthly income on transportation expenses due to being highly dependent on the expensive and inefficient privately operated public transport (Kumar et al., 2008). This situation reduces the capabilities of participating actively in economic activities and accessing basic urban services, hence widening the social gap and reinforcing social segregation (Cervero, 2013; Goswami & Lall, 2016). It is therefore essential to make daily trips cheaper and more affordable for the urban population, and for this reason, a bicycle is seen as an alternative.

Cycling is widely recognized as an active mode of transport, sustainable and effective for urban trips (Biernat et al., 2018; Massink et al., 2011; Štastná et al., 2018). Moreover, cycling makes commuting cheap and affordable thereby increasing social cohesion (Gatersleben et al., 2007). Additionally in SSA, cycling offers easy access to decent jobs (most of them located in the CBD), health services, enables the creation of flexible jobs and helps in carrying heavy loads for short or medium distances at considerable low costs (Cervero, 2000; Mbara et al., 2003; Mutiso et al., 2011; Wallrapp et al., 2008). Despite all the above benefits, cycling has remained unrecognized as an urban transport mode (Nkurunziza, Zuidgeest, Brussel, et al., 2012; Nkurunziza, Zuidgeest, & Van Maarseveen, 2012). For example in Maputo, Mozambique, cycling modal share was estimated at 1.2% in 2014, whereas the mode share for personal motorized vehicles was 12.0%, public transport at 42.1%, and that for walking at around 44.7% (JICA, 2014; Kumar et al., 2008; Lall et al., 2017; Pochet et al., 1999; UN-Habitat, 2006, 2011). One key challenge to overcome these low cycling trends is the accurate assessment of existing cycling market segments so that policy-makers can effectively target promotional initiatives and prioritize projects that meet their specific needs.

Recently, in response to the widespread issues of air pollution and traffic congestion in many African cities, researchers have started to promote pro-cycling initiatives such as traffic calming measures and traffic signals at road junctions (Acheampong, 2017). Other studies have looked at improving road safety by adapting road networks in favour of cycling (Pochet & Cusset, 1999), while Sietchiping et al., (2012) suggest adding safe cycling paths in the effort to reducing motorized traffic. However, existing literature offers incomplete information on identifying who are the potential cyclists in medium-sized SSA cities, and how they can be motivated to more cycling. The only little available literature is dominated by studies that identify potential cyclists based on stages of behaviour change (Nkurunziza et al., 2012), and by socioeconomic and travel behaviour characteristics (Kruger et al., 2016; Nkurunziza et al., 2012; Pochet et al., 1999; Sahabana, 2010), and yet usually limited to large African cities. The identified segments

from these studies cannot explain a medium-sized SSA city cycling context since people in medium-sized cities tend to cycle more than those in larger cities (Acheampong et al., 2018; Howe & Bryceson, 2000).

This chapter aims to use an attitude-based segmentation to identify the existing cycling commuting segments and explore the relationship between attitude and cycling behaviour with a focus on the medium-sized city of Quelimane, Mozambique. These segments shall be based on a series of latent factors, obtained from attitudinal variables collected in the study area. The rest of the chapter is structured as follows: Section 7.2 is a literature review on cycling market segmentation. Section 7.3 talks about the methodology used. Section 7.4 presents and discusses the results. The last section presents the conclusion and provides remarks for further research.

7.2. LITERATURE REVIEW

The relevance of market segmentation when investigating travel behaviour has been widely discussed by the academia (Badoe & Miller, 1998; Elgar et al., 2004; Gatersleben et al., 2007; Nkurunziza, Zuidgeest, & Van Maarseveen, 2012). In travel demand studies, segmentation is often based on two approaches. The first approach is based on socio-economic variables such as age, gender, and income (Anable, 2005; Bergstrom & Magnusson, 2003; Heinen et al., 2010; Xing et al., 2010). These studies have found that socio-economic based segmentation may oversimplify the structure of the market. The second approach is based on the attitude towards behaviour (Beirão & Sarsfield Cabral, 2007; Feitelson & Cohen-Blankshtain, 2018; Liedtke & Schepperle, 2004; Nkurunziza, Zuidgeest, & Van Maarseveen, 2012). These studies have identified homogeneous segments based on attitudinal variables.

From previous studies for example, Nkurunziza et al., (2012) use the stage of behaviour change to segment commuters in Dar es Salaam (Tanzania). Six attitudinal segments were obtained. These segments served to identify policies and initiatives that could be adopted for each of the cycling sub-market to change towards more cycling behaviour. Li et al., (2013) used the attitudinal market segmentation approach to identify potential bicycle commuter market segments. Four attitudinal factors were used to identify six market segments. This study demonstrated that improving cycling infrastructure and increasing propaganda and education toward environmental protection can promote bicycle usage in each market segment. Anable, (2005) segmented commuters into six distinct psychographic groups where their current mode choice behaviour and reactions were presented. Their study has demonstrated that segmentation based on simple behavioural or socioeconomic variables could oversimplify the structure of the obtained segments. Based on findings from these studies, attitude-based market segmentation has demonstrated merit in identifying the main factors influencing cycling behaviour.

While few travel market segmentation studies exist in African cities and in particular for cycling, these studies mainly focus on large cities (Bechstein, 2010; Nkurunziza et al., 2012), and thus cannot be transferred to a medium-sized SSA city context. They can tell little in explaining who are the cyclists in a medium-sized city, due to likely cycling perception differences influenced by different urban contexts. For instance, when studying the informal transportation system in medium-sized SSA cities, many studies found that the importance associated with cycling perception is strongly influenced by the economic and social benefits it can provide (Bryceson, Mbari, et al., 2003; Mbari et

al., 2003; Moyo, 2013; Mutiso et al., 2011; Wallrapp et al., 2008). From these studies, it is shown that individuals cycle more if bicycles can contribute to their livelihood or reduced travel costs. Moreover, Heinen et al. (2011) when estimating cycling use models, found that the importance aggregated to cycling perception depends on the cycling frequency and travel distance. Their findings revealed that cycling perception decreases with the increase in travel distance. While most of these studies reveal the relationship between attitude, intention, and behaviour, and which may vary depending on the urban context, they tell little about how different people in the target audience should be reached with varying bicycle use promotional policies and strategies. Therefore, a systematic segmentation approach to identify homogeneous cycling market segments is still lacking in empirical research especially for a medium-sized Sub-Saharan African city setting.

For some studies that used attitudinal segmentation approach, intuitively divided the sample according to the factors determined by the researcher (Heinen, Maat, & Wee, 2011; Vandenbulcke, Thomas, de Geus, Degraeuwe, Torfs, Meeusen, & Panis, 2009). In such a case, the segmentation was based on the researcher's perception which may not accurately reveal the existing segments. Other studies used the same approach and employed an analytical procedure that automatically identified traveller segments by dealing simultaneously with different levels of factors influencing mode choice behaviour such as attitude towards the mode, physical and environmental factors (Badoe et al., 1998; Li et al., 2013; Shiftan et al., 2008). This enabled the identification of the role each factor plays in determining the attitude towards bicycle use. These studies helped to uncover the relationship between these factors and bicycle use and guided the development of better travel demand market segments.

Although different market segmentation approaches have been employed in travel behaviour studies, relatively little research has gone into bicycle use, and especially there have been very few attempts to identify distinct bicycles use market segments based on attitudinal factors. The differences between categories of people that travel by bicycle are not commonly considered in empirical research especially in a SSA city context, while this information is essential for effective bicycle use promotion.

The aim of this chapter is, therefore, to identify and characterize distinct attitudinal bicycle use market segments using structural equation modelling and the TwoStep clustering method. This helps to uncover the relationship between bicycle use and attitude in a medium-sized African city setting which often receives little attention in research.

7.3. METHODOLOGY

Data source

From July to December 2017, 1085 regular commuters in Quelimane were interviewed (64% male, average age= 25.73 years, SD= 11.36) using an online survey and face-to-face interview survey. For the online survey, 1284 cards containing individual access code to the questionnaire were randomly distributed in 3 university campuses and 4 commercial areas. A face-to-face interview survey was administered to 535 individuals not having regular access to the internet. This survey was conducted in larger markets (formal and informal), in the main streets and bicycle-taxi corridors. It is believed that in

these places one can find individuals with different socio-economic backgrounds, travel behaviour, and bicycling attitude.

The questionnaire was divided basically into 3 main sections as follows.

- i) The first section captured respondents' travel behaviour. According to Ajzen (1993) behaviour is an observed attitude. Therefore, respondents were asked to indicate their frequent transport mode for daily activities and their average cycling time. Responses were coded as follows: Walking =1, bicycle=2 and motorized modes (Motorcycle, three wheels' motorcycle and car) = 3. The average cycling time was coded as 1= <10min; 2= between 10min-20min; 3= between 20min-30min and 4= >30min.
- ii) The second section contained 24 questions (or statements) regarding the attitude towards cycling. In this study, attitude indicates the psychological perception of cycling or cycling-related factors. The attitudinal statements were carefully formulated in the questionnaire to reflect the commuter attitude that potentially impacts bicycle choice. These attitudes are related to cycling choice in several previous studies (Iwińska et al., 2018). Respondents used the Likert scale ranging from 1(low influence), 4 (moderate influence) and 7 (high influence) to indicate the extent to which they are influenced or not influenced by the 24 attitudinal questions (statements) of the questionnaire (see details in Table 16).
- iii) The third section of the questionnaire covers the standard list of socio-demographic variables: age, gender, income, education, employment status, household composition, and vehicle ownership (see details in Table 17).

From 1284 cards delivered only 521 answered the questionnaire. Adding to the face-to-face interview survey, a total of 1085 responses were collected with 903 well-completed (completion rate of 83.22%). The average questionnaire completion time was 26 minutes. Nearly 69.31% of the respondents were male and 30.69% female. The summary of the statistics of valid samples is presented in Table 17.

Table 16: List of attitudinal questions and descriptive statistics

Questions	Content	Average influence	SD
Q1	Your daily travel distance	4.40	2.10
Q2	Frequent disrespect to speed limits	3.92	1.83
Q3	Lack of street signalization	4.23	1.90
Q4	Discomfort caused by uneven pavement	4.10	1.93
Q5	Increasing rates of road accidents	2.71	1.68
Q6	Mixed road traffic composition	3.74	1.74
Q7	Poor street lighting	4.35	1.99
Q8	Road encroachment caused by street vendors	3.87	1.78
Q9	Not enough tree canopy shade along the streets	3.93	1.86
Q10	The absence of a convenient place to shower and change clothes	3.16	1.81
Q11	The absence of a convenient bicycle parking	2.96	1.77

Q12	Bicycling for bicycle-taxi services	2.26	2.02
Q13	Bicycling to sell goods in the street	2.68	2.05
Q14	Bicycling to carry loads in the street	2.15	1.86
Q15	Your time availability	3.47	1.93
Q16	Prevalence of bicycle theft	3.12	1.84
Q17	Rain	2.57	1.67
Q18	Heat	2.80	1.76
Q19	Risk of accidents or fall	3.04	1.61
Q20	Bicycling health benefits	3.94	1.88
Q21	Bicycling flexibility	4.30	1.68
Q22	Bicycling comfort	3.92	1.72
Q23	Bicycling cost if compared to other means of transport	4.07	1.84
Q24	Your cycling pleasure	4.89	1.73

Table 17: Characteristics socio-economics of the respondents

Socio-economic characteristics	% in the sample (n=903)
Gender	
Male	69.31
Age	
Young (<35 years old)	83.82
Adult (35-55 years old)	12.72
Elderly (>55 years old)	3.46
Average monthly income (1000 Mts $\approx$ 14 €)	
<3642Mts	51.10
>3642 to <25000Mts	46.81
>25000Mts	2.09
Education	
Other levels	5.84
Primary	24.01
Secondary	59.69
University	10.46
Employment	
Unemployed	13.66
Informal job	31.06
Formal job	55.29
Household composition	
Single parents with children	57.32
One-person household	3.46
Couple without children	6.48
Couple with children	32.73
Vehicle ownership	
None	33.88
Only bicycle	43.79
Bicycle and motorized modes	15.03
Only motorized modes	7.29

The attitude-based segmentation approach

To perform the attitudinal market segmentation of bicycle commuters, many steps were followed. In the first step, latent factors were extracted from a series of attitudinal questions using factor analysis. This is the initial step of the process and the outputs were used as input to the Structural Equation Modelling (SEM). In the second step, SEM was conducted to estimate simultaneously the association between attitudinal questions and latent factors, and between the latent factors. This helps to identify the main drivers for cycling choice. The respondent score in each significant latent factor was used for the attitudinal segmentation. In the third step, TwoStep cluster analysis was performed to group travels into homogenous attitudinal segments, which enables us to understand the specific characteristics of each segment towards cycling. This will assist in defining strategies to increase cycling use, targeted to each segment. The overall attitudinal market segmentation scheme is presented in Figure 32. This methodological structure is similar to used by Li et al., (2013) however, our biggest difference is that we have included in the analysis attitudinal factors that influence the use of bikes for commercial purposes, which is a specific cycling feature of medium-sized SSA cities.

Figure 32: The attitudinal market segmentation scheme

Step 1: Factor analysis to explore commonalities between attitudinal questions

Factor analysis is used to determine the underlying factor structure that exists among the 24 attitudinal questions in the questionnaire and to identify latent factors. Then the principal component is used as the extraction method. This extraction method assumes that the sample used represents the entire population of interest. The rotation method used is Promax due to its capabilities of handling a large dataset (Field, 2013). The robustness of the result is tested through the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity. The obtained factors provide inputs for the model structure in the SEM. SPSS version 20 is used as a statistical tool.

Step 2: SEM to estimate the coefficients of latent factors

The objective of employing SEM in this study is to assess the coefficients of latent factors as a function of the attitudinal questions in the questionnaire. The model structure in the SEM is linear and is composed of 2 sub-models. The first sub-model considers the latent factors as dependent variables and the attitudinal questions in the questionnaire as independent variables. This measures the strength each attitudinal question has in explaining the latent factor. The second sub-model considers the latent factors reflecting perception towards cycling as dependent variables (target) and the latent factors reflecting the likelihood of cycling as independent variables. The structure of the SEM is presented in Figure 33. The SEM is constructed in SPSS AMOS. Path diagram is used to represent the relationship between attitudinal questions and attitudinal factors. Circle or ovals represent the latent variables while the rectangles represent the attitudinal questions. The single-headed arrows in the path diagram represent the causal effect between variables and the path coefficients or estimates. Only significant latent factor pairs, having estimate value > 0 were included in the cluster analysis. The SEM model has a chi-square (χ^2) = 926.89, Degree of freedom (Df) = 175, Probability level (P)=0.000. The Root Mean Square Error of Approximation (RMSEA) = 0.065, Pclose=0.000, within the 90% of confidence interval, less than recommended 0.08. The Comparative Fit Index (CFI) = 0.877, Incremental Fit Index (IFI) =0.878 are close to the ideal 0.9. Based on these criteria, the model fits the data properly and therefore, meets our statistical adequacy expectations.

Figure 33: SEM model structure

Step 3: Cycling market segments

Homogeneous cycling market segments are identified, which will form the basis for decision making in defining policies to persuade people to cycle. TwoStep clustering is chosen as the clustering method due to its algorithm capabilities to handle very large data sets either categorical or continuous and automatically allow to determine the optimum number of clusters (Martínez et al., 2006). The average score each latent factor received from the respondent is considered a continuous input variable. They are scaled as Low influence <4, Moderate influence = 4 and High influence > 4. The clustering criterion used is Akaike's Information Criterion (AIC) since it is found sensible to variables and provide the best possible solution. The average silhouette measure of cohesion and separation (segments consistency) is 0.4, which is statistically acceptable. The ratio of sizes between the largest cluster and smallest cluster is 2.63. Log-likelihood is used as a distance measure due to its capabilities to handle mixed-type variables and the number of segments is set to be determined automatically to maximize segment quality. This allowed exploring attitudinal differences between segments.

7.4. RESULTS AND DISCUSSION

To understand how cycling can be promoted in SSA cities, it is worth identifying potential attitudinal market segments and their influential variables. Such an approach requires the identification of latent variables explaining cycling attitude.

Identifying commuters' attitude using factor analysis

Table 18, shows how the attitudinal questions were grouped into 5-factor groups (latent factors). Factor group 1 is composed of 8 attitudinal questions related to respondents' concerns about the traffic and road infrastructure conditions. It reflects respondent sensitivity to comfort and stress caused by poor street pavements (0.81), lack of street signalization (0.77) and lack of street lights for night riders (0.76). This factor group is labelled as "*sensitivity to comfort and stress*". Factor group 2 is composed of 5 attitudinal questions reflecting respondent sensitivity to weather changes and safety such as heat (0.84), rain (0.76) and lack of safety, risk of accident or fall (0.62). This factor group is labelled "*sensitivity to weather changes and safety*". Factor group 3 is composed of 3 attitudinal questions showing bicycling commercial potentiality such as carrying loads in the street (0.90), for taxi-services (0.89) and selling goods in the street (0.73). This factor group was labelled "*need for the economy*", which indicated that respondents perceive cycling as an opportunity for livelihood or to reduce travel costs. Factor group 4 is composed of 4 attitudinal questions reflecting cycling advantages, such as flexibility (0.70), comfort (0.62) and low travel costs if compared to motorized modes (0.66). This factor group was labelled "*perception towards cycling*". Factor group 5 is composed of 2 attitudinal questions showing respondents' need for cycling facilities such as proper bicycle parking (0.79) and a place to shower and change clothes after cycling (0.75). This factor group was labelled "*willingness for cycling facilities*".

These factor groups count for 5.68% to 23.76% of the total variance in the data. The total variance explained is 54.89%. The goodness of fit indexes, KMO= 0.86, chi-square (χ^2) = 6998.85; degree of freedom (Df) = 276 and Sig=0.00, which is statistically acceptable.

Table 18: Factor loading and factor group influencing bicycling markets

Statistics

Latent factors and correspondent attitudinal questions	Loading coefficient	Mean	S.D	Sig <0.05
Factor 1: Sensitivity to comfort and stress				
Your daily travel distance	0.57	4.4	2.10	0.00
Frequent disrespect to speed limits	0.64	3.92	1.83	0.00
Lack of street signalization	0.77	4.23	1.90	0.00
Discomfort caused by uneven pavement	0.81	4.1	1.93	0.00
Mixed road traffic composition	0.65	3.74	1.74	0.00
Poor street lighting	0.76	4.35	1.99	0.00
Road encroachment caused by street vendors	0.61	3.87	1.78	0.00
Not enough tree canopy shade along the streets	0.61	3.93	1.86	0.00
Factor 2: Sensitivity to weather changes and safety				
Increasing rates of road accidents	0.55	2.71	1.68	0.00
Prevalence of bicycle theft	0.52	3.12	1.84	0.00
Rain	0.76	2.57	1.67	0.00
Heat	0.84	2.8	1.76	0.00
Risk of accidents or fall	0.62	3.04	1.61	0.00
Factor 3: Need for economy				
Bicycling for bicycle-taxi services	0.89	2.26	2.02	0.00
Bicycling to sell goods in the street	0.73	2.68	2.05	0.00
Bicycling to carry loads in the street	0.90	2.15	1.86	0.00
Factor 4: Perception towards cycling				
Bicycling flexibility	0.70	4.3	1.68	0.00
Bicycling comfort	0.62	3.92	1.72	0.00
Bicycling cost if compared to other means of transport	0.66	4.07	1.84	0.00
Your cycling pleasure	0.57	4.89	1.73	0.00
Factor 5: Willingness for cycling facilities				
The absence of a convenient place to shower and change clothes	0.75	3.16	1.81	0.00
The absence of a convenient bicycle parking	0.79	2.96	1.77	0.00

Estimating cycling adoption likelihood using SEM

Based on the factor groups identified in the factor analysis, the model measurement structure is presented in Figure 34 and summarized in Table 19. The structural model presented in Figure 34, shows that Q4 (0.75) and Q7 (0.75) have the strongest association with the latent factor 1 (Sensitivity to comfort and stress). This means that uneven pavement and lack of street lights are viewed by the commuters as the most influential for travel discomfort and stress. Q18 (0.73) has the highest correlation with the latent factor 2 (Sensitivity to weather changes and safety), which suggest that heat is perceived by the commuters as a relevant barrier for cycling. Q12 (0.90), is strongly associated with the latent factor 3 (need for the economy). This means that commuters perceive the opportunity for bicycle-taxi relevant to livelihood. Q10 (0.80) correlates positively with the latent factor 5 (willingness for cycling facilities). This means that cycling facilities

such as a place for shower and change clothes are seen by the commuters relevant for cycling. Q22 (0.40) has the highest association with latent factor 4 (perception towards cycling), which means that cycling comfort has an important influence on cycling perception. Overall, all the attitudinal variables have a positive relationship with the latent factors.

The latent factor sensitivity to comfort and stress is significant and strongly related (0.64) to the perception toward cycling. This shows that commuters commonly view cycling sensitivity to road conditions. The sensitivity to weather changes and safety indicates a positive weak relationship (0.08) to the perception toward cycling. This indicates that commuters view weather conditions and road safety issues less influential for cycling attitude. The need for the economy has a positive impact (0.37) on perception towards cycling. This may be due to bicycles being used for commercial purposes. Bicycles help in providing some income for the neediest families and also is a cheap travel alternative compared to other urban transport modes. The willingness for cycling facilities is positively related (0.36) to the perception towards cycling, which means that commuters view cycling facilities important for cycling. The estimates presented in Table 19, indicate that lack of proper road infrastructure such as uneven pavement, street signalization, and deficient street lighting has an important influence on cycling commuting in Quelimane.

Figure 34: SEM Model results

Table 19: Maximum likelihood parameter estimates for an identified SEM of cycling adoption intentions

Independent variable	Dependent variable	Estimate	SE	CR	Sig<0.05
Factor 1: Sensitivity to comfort and stress	Factor 4: Perception towards cycling	0.64	0.04	5.58	0.00
Factor 2: Sensitivity to weather changes and safety		0.07	0.03	1.10	0.27
Factor 3: Need for economy		0.37	0.02	4.86	0.00
Factor 5: Willingness for cycling facilities		0.35	0.03	3.81	0.00

Cycling market segments

This section identifies attitudinal cycling market segments using TwoStep cluster analysis based on latent factors derived from SEM. This helps to characterise the main drivers (motivators or barriers) to bicycle commuting in each market segment. From the identified 5 latent attitudinal factors (Table 20), 4 factors were selected to perform the cluster analysis. The selected latent factors are: perception towards cycling, sensitivity to comfort and stress, need for economy and willingness for cycling facilities. These four latent factors were selected for being positively associated and for having significant estimates in the SEM. Three attitudinal segments determined from cluster analysis are obtained and presented in Table 20. The summary of the attitudinal segment composition is presented as follows:

Demanding Cyclists: Individuals in this market segment represent 34.8% of the total sample. They exhibit a high perception towards cycling, indicating cycling advantages such as flexibility, comfort and low travel costs compared to motorized modes. They also indicate a high sensitivity to comfort and stress, raising concerns about traffic and road infrastructure conditions such as poor street pavements, lack of street junction signalization and lack of street lights for night riders. This segment is also characterised by a high willingness for cycling facilities, indicating the need for proper bicycle parking and a place to shower and change clothes after cycling. This segment however, exhibits a low need for the economy, implying a less need for bicycling commercial potentiality such as carrying loads on street, bicycle taxi-services, and selling goods on the street.

Cautious Cyclists: This is the largest segment with a share of 47.2% of the total sample. Individuals in this segment have a moderate perception towards cycling such as indicating flexibility, comfort and low transport costs as cycling advantages. The segment exhibits a moderate sensitivity to comfort and stress implying poor street pavements, lack of street junction signals and lack of street lighting. This segment is however, characterised by a low willingness for cycling facilities such as proper bicycle parking and a place to shower and change clothes, and indicate a much lower need for the economy such as carrying loads on street, bicycle taxi-services, and selling goods on the street.

Forced Cyclists: This segment is the smallest with a share of 18% of the sample. It is characterised by a high need for the economy, implying bicycling for commercial purposes such as carrying loads on street, bicycle taxi-services, and selling goods on the street. The segment has a moderate perception towards cycling such as indicating flexibility, comfort and low transport costs as cycling advantages. The individuals in this segment show moderate sensitivity to comfort and stress related to poor street pavements, lack of street junction signals and lack of street lighting. The segment is characterised by

the low willingness for cycling facilities such as proper bicycle parking and a place to shower and change clothes.

In short, individuals in the *Demanding Cyclists* segment have the highest positive attitude towards cycling. Most of the individuals exhibit moderate attitude towards cycling which is mainly influenced by the sensitivity to comfort and stress, especially for the *Cautious Cyclists* segment. The *Forced Cyclists* segment is mainly characterised by the need for economy.

Table 20: Market segments of cycling commuters

Latent factors	Influence score	Cycling market segments		
		Demanding cyclists (34.8%)	Cautious cyclists (47.2%)	Forced cyclists (18.0%)
Factor 4: Perception towards cycling	High	●(4.95)		
	Moderate		●(3.75)	●(4.37)
	Low			
Factor 1: Sensitivity to comfort and stress	High	●(5.12)		
	Moderate		●(3.45)	●(3.74)
	Low			
Factor 3: Need for economy	High			●(5.12)
	Moderate			
	Low	●(2.16)	●(1.38)	
Factor 5: Willingness for cycling facilities	High	●(4.54)		
	Moderate			
	Low		●(2.17)	●(2.55)

Table 21 presents the socio-economic and travel behaviour profiles of the various attitudinal market segments. This allows to identify and locate physically the individuals in the different segments.

Demanding cyclists

This segment is mainly dominated by men and most likely has more women than other segments and most of them having formal jobs. Its population is predominantly single parents with children mainly aged below 35 years with mainly secondary level education. The average income of the segment is between >3642 Mts to <25000Mts and most individuals own a bicycle and cycle frequently to their daily activities and in a distance that is likely within an average cycle commuting time of 20 minutes.

Cautious cyclists

This is a segment likely to be dominated by men and many of them with formal jobs. The segment population is mainly composed of single parents with children, most of them aged below 35 years and having secondary level education. Their income is most likely below 3642Mts and majority owning no vehicle while some own a bicycle. Majority of people in this segment walk frequently and others cycle commute to their daily activities within a distance that is likely to take between 20-30 minutes.

Forced cyclists

The majority of people in this segment are men and most likely with informal jobs. The segment is mostly dominated by couples with children and single parents with children

with many below 35 years and having secondary level education. The segment income is mainly below 3642Mts with the majority owning bicycles. Most of the population cycle frequently and travel longer distances with an average commuting time of more than 30 minutes.

Table 21: Socio-economic characteristics and travel behaviour of each attitudinal segment

Socio-economic characteristics	Cycling market segments		
	Demanding cyclists	Cautious cyclists	Forced cyclists
Gender			
% Male	61.95	67.98	87.65
Age			
% young (<35 years old)	81.59	86.87	80.25
% adult (35-55 years old)	15.87	10.50	12.35
% elderly (>55 years old)	2.54	2.63	7.41
Average monthly income (1000 Mts $\approx$ 14 €)			
% <3642Mts	29.52	63.57	59.88
% >3642 to <25000Mts	68.57	34.57	37.04
% >25000Mts	1.90	1.86	3.09
Education			
% Other levels	1.59	6.73	11.73
% Primary	21.27	25.29	25.93
% Secondary	68.25	57.31	49.38
% University	8.89	10.67	12.96
Employment			
% Unemployed	8.25	18.33	11.73
% Informal job	28.89	24.36	53.09
% Formal job	62.86	57.31	35.19
Household composition			
% Single parents with children	62.42	60.00	40.37
% One-person household	1.59	4.05	5.59
% Couple without children	6.37	6.43	6.83
% Couple with children	29.62	29.52	47.20
Vehicle ownership			
% None	23.97	45.24	10.53
% Only bicycle	50.79	33.64	72.37
Bicycle and motorized modes	20.50	11.60	11.84
Only motorized modes	4.73	9.51	5.26
Self-reported travel behaviour			
% Walking frequently	26.28	51.64	24.38
% Cycling frequently	66.67	39.72	65.00
% Using motorcycle or car frequently	7.05	8.64	10.63
Average commuting time	10min-20min	20min-30min	>30min

7.5. POLICY IMPLICATIONS

The objective of this section is to discuss how different segments may be persuaded to increased bicycle commuting. The findings have indicated that the identified segments are more heterogeneous between themselves and have homogenous characteristics within a specific segment. This information is critical to designing policies and promotional strategies targeted to each market segment.

Generally, individuals in the *Demanding Cyclists* segment express the most positive attitude towards cycling where they cite different cycling advantages and indicate a high need for cycling facilities. Most individuals in this segment cycle frequently to their daily activities and do so within a cycle-able distance. However, these frequent cyclists stand out to their frustration with no cycling facilities and cycle on poor road quality conditions. This makes cycling difficult in the city of Quelimane like in many other SSA cities. According to the results (Table 20), this segment is highly sensitive to comfort and stress and point to a high need for cycling facilities. This finding reveals that this segment may be motivated to increased cycling when improved traffic and good road infrastructure are provided, well signalized, and with street lighting. This finding is consistent with previous studies for instance Gatersleben et al., (2007) which reported that in an environment with little or no bicycle facilities, people with positive cycling attitude need support to determine and test a good cycle route. The findings also point out the high need for proper bicycle parking and a place to shower and change clothes after cycling. According to Pochet & Cusset (1999), bicycle parking problems such as theft must not be neglected and thus, guarded bicycle parking gives the users a feeling of security and make its use more practical. Therefore, to promote cycling to this segment, it would be useful for policymakers to consider these cited factors especially if they want to reach more women.

The *Cautious Cyclists* segment unveils a moderately positive attitude towards cycling and a moderate sensitivity to comfort and stress. Individuals in this segment also indicate a low need for cycling facilities and a much lower need for economy. This can be reasonable because most individuals in this segment do not own a vehicle and are low-income earners, who can not afford a bicycle. The findings (Table 21) indicate that this segment has a high dependency on walking. They walk longer distances to their daily activities than those cycling, hence justifying the revealed moderate and low cycling perception. This segment which is the majority share of the sampled population can be motivated to cycle by providing easy access to bicycles and spare parts. Bryceson et al., (2003) suggests that credit provision schemes can contribute positively to access and usage of bicycles to the urban poor. This requires government support in reducing bicycle prices to allow easy access of bicycles to the urban poor, and provide local policies and strategies that support bicycle commuting.

People in the *Forced Cyclists* segment reveal a high need for the economy where the choice for cycling is done purposely to generate income. This segment is composed of bicycle-taxi operators and mostly men who cycle regularly carrying passengers and goods despite poor traffic and road infrastructure conditions and inexistent cycling facilities. These people who are mainly low-income are highly motivated to cycle to generate some income for their daily living. This finding is consistent with several previous studies which showed that individuals cycle more if bicycles can contribute to their livelihood or reduced travel costs (Bryceson, Mbarara, et al., 2003; Mbarara et al., 2003; Moyo, 2013; Mutiso et al., 2011; Wallrapp et al., 2008). For the passengers, commuting with bicycle-taxi enables them to save some money which is used for other household expenses. Based on results (Table 20), this segment reveals moderate sensitivity to comfort and stress, thus these people can be motivated to keep cycling by providing improved traffic and good

road conditions, well signalized, and with street lighting. This requires an effort of the Government transportation agencies in making these measures effective. It would be relevant for the city to provide dedicated bicycle lanes that connect major markets and residential areas. This could provide comfort, safety and also minimize the physical effort needed to find potential passengers, thus increasing daily revenues and leading to a positive cycling attitude in this segment in particular and to the city in general.

7.6. CONCLUSION

This study applies attitudinal market segmentation for the analysis of bicycle commuting markets to target promotional strategies to attract more people to cycling. To better understand individual attitudes towards bicycle commuting, a face-to-face and an internet-based survey were conducted in the city of Quelimane, Mozambique. The factor analysis was used to identify latent attitudinal factors extracted from a series of attitudinal questions in the survey and SEM captured the interrelationship between them. TwoStep cluster analysis was used to group different bicycle commuters into several attitudinal market segments.

The result of this study revealed that attitudinal segmentation approach is useful in identifying preferences and attitudes that drive each cycling market and the policies and strategies that would be the most effective in targeting each market segment. In this study, three attitudinal market segments were identified by four selected latent factors which were: sensitivity to comfort and stress; perception towards cycling; the need for the economy; and willingness for cycling facilities. These segments exhibited different attitudinal characteristics related to barriers and motivations for increased bicycle commuting.

According to the market segmentation findings, the *Demanding Cyclists* with the most positive attitude towards cycling would be motivated to more cycling by providing proper cycling facilities and improved traffic and good road infrastructure, well signalized, and with street lighting. The *Cautious Cyclists* with moderate and low cycling attitude may be motivated to increased cycling by providing easy access to bicycles and spare parts through reduced bicycle prices. While the *Forced Cyclists* with a high need for the economy where regular cycling is purposely to generate income, may be motivated to increased cycling by providing improved traffic and good road conditions. Persuading people to cycle should be a continuous action, particularly in medium-sized SSA cities where residential and work locations are within cycle-able distances, and majority of the city population are low income with limited travel mode alternatives.

The results presented in this study is an attempt to identify cycling market segments and shed light on preferences and attitudes that drive distinct cycling market segments. The study provides a basis for policy-makers to plan and develop cycling promotional strategies that would be most effective for each attitudinal segment. Since cycling commuters' attitude is mainly measured by traffic and road infrastructure quality conditions, further research should explore the connection between each segment and daily cycling route choice. This information will help to get more insights into bicycle travel behaviour and gain a better understanding of targeted strategies for increased cycling.

8

CYCLISTS' ITINERARY

8. ANALYZING THE FACTORS INFLUENCING CYCLISTS' ITINERARY

8.1. INTRODUCTION

Cycling is a vital transport mode in most Sub-Saharan African (SSA) cities (Pochet & Cusset, 1999). It provides a means for commuting, flexible job opportunities such as bicycle-taxi, to carry loads (Mendiate et al., 2020; Mutiso et al., 2011), fast access to jobs and health facilities (Dorsey et al., 2008) and is a way for social integration (Nkurunziza, Zuidgeest, Brussel, et al., 2012). Increasing cycling may be relevant to reduce congestion and pollution issues in urban areas and encourage physical activities that may help in reducing obesity and cholesterol related problems (Gatersleben et al., 2007). However, the existing road infrastructures offer enormous challenges for cycling massification campaigns since it is presented disconnected, without road facilities and often unpaved (Lall et al., 2017). For instance, the average paved roads in most SSA cities are about 318m per 1000 population, while in developed countries it is about 1000m per 1000 population (Kumar et al., 2008). Moreover, the main intersections are usually occupied by street vendors (particularly during working hours) which contribute to road encroachment and disputes between motorized modes, cyclists and pedestrians (Pochet et al., 1999; Sietchiping et al., 2012). This makes cycling route choice difficult.

Assessing what cycling route variables are relevant for commuters is not purely the quickest route (Koh & Wong, 2013), the determinants for route choice range from weather conditions, route safety to comfort (Misra & Watkins, 2018; Zhu & Zhu, 2019). For instance (Winters, Teschke, et al., 2010), found that cyclists could take a long detour of up to 67% longer than the shortest route to use routes with acceptable facilities in an area. During day time, 75% of the cyclists prefer routes with tree cover (de Sousa et al., 2019). At night, cyclists often avoid dark routes, since it creates a sense of insecurity and an atmosphere for crime (Chandra et al., 2017). This indicates that the importance associated with each route variable changes according to commuter departure time (travel behaviour), showing that cycling route choice understanding is complex and requires deep studies. Such understandings are crucial for transport planners to build cycling-friendly cities.

Current understanding of cycling route choice often relies on commuter perception or revealed preferences (Broach et al., 2012; de Sousa et al., 2019; Emond et al., 2012; Kang et al., 2013; Winters & Teschke, 2010). In these studies, commuters were considered to have similar travel behaviour. These studies ignore that route choice is a dynamic decision and commuter significantly alter the importance given to a route attribute influenced by many factors, such as departure time and the built environment. Given the many unique circumstances that characterize cycling in many SSA cities, we argue that the inclusion of departure time and built environment into the route choice analysis is crucial in improving our understanding of route choice in the context of these cities. Specifically, the cities often have a very humid climate and harsh daytime sun and most streets lack tree cover. In the evening, most roads have minimal street lighting (Kumar et al., 2008) and there is a general noticeably declining public security (UN-Habitat, 2016). Additionally, the road infrastructure is concentrated near the inner-city, leaving the outer areas disconnected (Lall et al., 2017). This forces cyclists to adjust their cycling itinerary

depending on the departure time and urban zone. This suggests the need for empirical research to distinguishing which route attributes are important for the commuter with distinct travel behaviour. This research analyses the factors that affect cyclists' route choice by evaluating the importance each route attribute received from cyclists with different departure times. The results of this analysis will contribute to identify which route choice variable are perceived more consensually among different groups of cyclists. This may help in having a much accurate understanding of cyclist's itinerary in the context of SSA cities and help to improve initiatives to promote cycling.

This study uses some pre-identified attitudinal cycling market segments of Quelimane, Mozambique and develops a better understanding of the factors that may potentially influence cyclists' itinerary. Non-parametric tests are employed to explore and compare significant differences in the importance that each route choice variable received from individuals in different attitudinal cycling market segments and with different travel patterns. It is structured in four sections. Section 8.2 is a brief review of the literature on past route choice research. Section 8.3 is about the case study and the methods for the analysis. Section 8.4 presents the results. The last section presents the final discussion, conclusion, and reflection on the main research findings.

8.2. LITERATURE REVIEW

The importance of road attributes when investigating travel behaviour is well documented (Bryceson, Mbara, et al., 2003; de Sousa et al., 2019; Kang et al., 2013; Moyo et al., 2018; Sener et al., 2009; Winters & Teschke, 2010). Following the advice of previous studies in SSA cities, they highlight especially street surface quality, traffic accident rate, traffic volume, traffic speed, street signalization, street lighting, tree cover, presence of street vendors, trip length.

Studies by Segadilha et al., (2014); Winters & Teschke, (2010) consider cyclists to prefer street with smooth pavements because they minimize vibration, which creates discomfort. Other studies in the context of African cities, however, show that preferences for smooth pavements are tempered with the safety of such streets. Moyo et al. (2018) for instance reveals that during peak hours in Johannesburg (South Africa) cyclists opted for longer and even poorly paved roads to avoid fast-moving motor vehicle traffic in the paved main roads. Fishman, (2016) found that daytime cyclists deviate from their most direct routes to ride on traffic-calmed streets. For Wood et al., (2013), night riders behave differently. Due to poor visibility, cyclists consider irregular pavement to contribute to road accidents. Road accidents involving cyclists are becoming a major health issue in SSA cities (Damsere-Derry et al., 2017). For example, in Malawi, 16% of the people who died in transport-related crashes in 2016 were cyclists (WHO, 2019). Moyo et al., (2018) claim that during the day, most cycling-related accidents occur in busy inner-city roads since most roads allow different types of transport modes moving at different speeds. For (Lall et al., 2017), due to narrow and irregular roads in the city periphery, car access is limited making cycling in these urban zones safer by day. Verster et al., (2018) consider that for safety reasons, night-riders in South African cities prefer busy roads. However, they become vulnerable to road accidents. Additionally, they reported late afternoon and evening to be dangerous hours in South African roads. They point to speeding, which they associate with drink-driving, as the main cause of accidents. A study conducted

among adults living in five urban regions across Europe concluded that routes with a speed limit of about 30km/h were preferable rather than 50km/h or more (Mertens et al., 2017). Such perception is difficult in most SSA cities since few streets have a speed limit imposed on them (Kumar et al., 2008). A well-signalized road makes traffic undoubtedly safer and attractive for cycling. Moyo et al., (2018) found that due to lack of enough car parking space motorists in Johannesburg (South Africa) deliberately do not respect the existing street signalizations. There are often incidents where car drivers park on sidewalks, obstructing cycling and pedestrian path. The relevance of street lighting and tree cover on cycling route choice varies per cycling period. For de Sousa et al., (2019), day time cyclists prefer dense tree-covered roads to avoid heat and to be less exposed to pollutants. However, night cyclists have preferences for uncovered paths and lighting.

While the above-mentioned road attributes are more consensual in the literature, the influence of road encroachment is subject to different understandings (Cervero, 2000; Mutiso et al., 2011; Sietchiping et al., 2012). Some cyclists find the presence of street vendors in the main intersection to reduce the available road section turning the main intersection into “disputed terrains” between different transport modes, often resulting in accidents and fatalities (Pochet et al., 1999; Sietchiping et al., 2012). Our understanding, particularly for those cycling in the afternoon, is that street vendors provide a faster last-minute shopping opportunity since most families do not have food refrigerators mechanisms. Mutiso et al., (2011) report that bicycle-taxi operators often station themselves around the nodes with street vendors especially during the peak-hours in order to take advantage of the pool of shoppers whom they can ferry to different destinations.

The above discussion motivates the focus of the paper, which is to contribute to the existing knowledge about cycling in SSA cities. However, the importance given to this route attributes depends on many factors, particularly on the departure time, built environment characteristics (Mertens et al., 2017; Winters, Brauer, et al., 2010; Winters, Teschke, et al., 2010) and cycling experience (Muñoz et al., 2013). To identify whether the importance given to route choice variables differ based on the individual departure time, a non-parametric test is used. In that, some variables are more prominent in influencing cycling itinerary than others. Hence, the results of this study contribute to an improved understanding of the role various attributes have on cycling route choice and provide strong empirical evidence in assisting to effectively direct financial resources special targeted to those routes attributes relevant for most cyclists in SSA cities.

8.3. RESEARCH METHODOLOGY

Data collection

The study examines a broad array of route attributes that influence route choice. The data used in this analysis come from a survey conducted among 901 daily commuters in the city of Quelimane in the year 2017. Two sampling approaches were used. First was the internet-based survey and the second was a face-to-face survey. To identify which survey approach was appropriate, the respondents were first asked if they have internet access. Those who confirmed were given an invitation card with individual access code. This enabled them to fill out the online questionnaire from any mobile device. A total of 1284 invitation cards were delivered. On the other hand, a face to face survey was conducted

on respondents who did not have internet access by research assistants who were recruited from a local university. Mobile devices were used to introduce the respondent's answers to the online questionnaire. 535 individuals have been interviewed.

The questionnaire was carefully designed to reflect the main bicycling route choice variables as presented in several previous studies (Bryceson, Mbara, et al., 2003; de Sousa et al., 2019; Kang et al., 2013; Moyo et al., 2018; Winters & Teschke, 2010). It was divided into two main sections. The first section contained questions to measure commuter perception toward the cycling route attributes and their subsequent travel behaviour. Respondents used a Likert scale ranging from 1 (extremely not at all important); 2 (not at all important); 3 (not important); 4 (somewhat important), 5 (important), 6 (very important) and 7 (extremely important) to indicate the extent to which they perceive the importance of the 9 route choice variables when bicycle commuting. The question was formulated as follows: How important is the "*street pavement condition*" when bicycle commuting. The remaining content of the attitudinal questions is presented in Table 22. The second section of the questionnaire gathered data about respondents' travel behaviour and travel patterns. Regarding travel behaviour, respondents were asked to indicate their departure time for the previous day's trip. Responses were coded as AM for those that departed before 12 PM and for PM for those that departed after 12 PM. Regarding travel partners, respondents were asked to describe their previous days cycling itinerary by indicating the origin and destination (O-D) of each trip. The O-D pairs were aggregated according to the urban zone the trip took place. Those trips that had the inner city as origin and destination were coded as Z1-Z1. Trips that had the city periphery or sub-urban area as origin and destination were coded as Z23-Z23. Trips that took place between the inner-city and city-periphery or sub-urban area were coded as Z1-Z23. Trips that had the city-periphery and the sub-urban area as origin or destination were coded as Z2-Z3.

Analysis

The overall analytical procedure to identify the most influential route choice variables involved two main steps, namely, descriptive statistics and non-parametric tests. Details are given in Figure 35 and described as follows.

Figure 35: Methodological procedure to identify variables influencing cyclists itinerary

a) Descriptive statistics

As a preliminary analysis and to better understand the variation on the importance of each cycling route attribute, a broad array of cycling route attributes were examined in relation to each cycling attitudinal segment (Demanding cyclists, cautious cyclists, and forced cyclists). An extensive list of these attributes was compiled from several previous studies (Bryceson, Mbara, et al., 2003; de Sousa et al., 2019; Kang et al., 2013; Moyo et al., 2018; Winters & Teschke, 2010). SPSS version 20 was used to generate the database as well as a statistical tool. Descriptive statistics, frequencies were employed to explore the score importance of each cycling route choice attribute per each cycling attitudinal segment. The result of this analysis is presented in Figure 36.

b) Non-parametric test

To identify whether the importance given to a route choice variables differ based on the individual departure time and travel pattern, a non-parametric test Kruskal-Wallis test was performed. It is a non-parametric test and enables a comparison of significant differences between two or more independent samples (Field, 2013). Each cycling route choice variable was considered as test variables. For each cycling attitudinal segments, the cyclists' travel behaviour (departure time) and travel patterns (cycling zones) were

considered as grouping variables. Two departure time groups were despite. AM for individuals that depart before 12PM while PM for those departing after 12PM. From the travel patterns, 2 pairs of cyclist groups were observed based on the built environment characteristics of the city. (i) Z1-Z1, for those cycling within the planned areas (inner city) and Z23-Z23 those cycling within the unplanned area (city periphery or suburban area). (ii) Z1-Z23 for those cycling between the planned areas (inner city) and unplanned areas (city periphery or sub-urban area). Z2-Z3, for those cycling between the unplanned areas (city periphery and sub-urban area). This comparison is vitally important for transport planners in SSA cities since the quality of the road infrastructures is different per urban zone (Lall et al., 2017) and this has an enormous influence on individuals' importance perception of the cycling route choice variables. Thus in each attitudinal cycling segment, the analysis testes the following null hypotheses:

- *There are no differences in the importance perception of the cycling route choice variables between individuals who depart in the morning (AM) and the afternoon (PM).*
- *There are no differences in the importance perception of the cycling route choice variables between individuals cycling within the planned area (Z1-Z1) and the unplanned areas (Z23-Z23).*
- *There are no differences in the importance perception of the cycling route choice variables between individuals cycling between the planned areas and unplanned areas (Z1-Z23) and those cycling between unplanned areas (Z2-Z3).*

In interpreting the Kruskal-Wallis test result, two key statistics are of interest as discussed in (Field, 2013). The first is the mean rank score of each group- Departure time (AM, PM) and travel patterns (Z1-Z1, Z23-Z23, Z1-Z23 and Z2-Z3). Since Kruskal-Wallis is a test based on ranked scores from lowest to highest, the group with the lowest mean rank score is the group with the greatest number of lower scores and the highest mean rank have the greatest number of high score within it. The second key statistic is the Chi-Square and the statistical significance of the test (P-Value <0.05). This indicates whether the observed differences between the groups are significantly small, moderated, or large. Following (Field, 2013), the effect of 0.5 is considered a large effect and considered in this study. The result of the Kruskal-Wallis test is presented in tables 22-25.

8.4. EMPIRICAL RESULTS

The score importance of each cycling route attribute

From Figure 36, two main issues can be highlighted. First, respondents are consensual on the following: 26.9% of Demanding cyclists, 39.7% of Cautious cyclists and 33.3% of Forced cyclists when choosing a cycling route, they are consensual that the street signalization is extremely important. Similar perceptions have 25.2% of Demanding cycling, 37.4% of Caution cyclists and 25.3% of Forced cycling on the quality of the pavement of the street. Street lighting was also considered extremely important by 24.3% of Demanding cyclists, 37.6% of Cautious cyclists and 34.0% of Forced cyclists. Moreover, the lack of street tree cover was cited as extremely important by 22.9% of Demanding cyclists, 30.3% Cautious cyclists and 30.2% Forced cyclists.

Secondly, respondents were not consensual on the following route choice variables. The average rate of road accidents was cited by 19.3% of Demanding cyclists as somewhat important when defining a cycling itinerary, 26.4% of Cautious cyclists perceive it as not at all important while 17.9% of Forced cyclists consider extremely important. Similarly, the long route distance was perceived differently by cyclists. 20.9% of Demanding cyclists consider important, 27.3% of Cautious cyclists reported as very important while 26.5% of Forced cyclists reported as not important.

Figure 36: Score the importance of each cycling route attribute per attitudinal segments

Comparing the importance each cycling route choice variables received based on individuals' travel behaviour and travel patterns.

Having explored how cyclists in different attitudinal segments perceive the importance given to each route choice variable, the analysis proceeds to examine whether there is any statistical difference between respondents with different travel behaviour and with different cycling patterns, for each route choice variable the Kruskal-Wallis test is used. Firstly, the perception of each route choice variable is examined between those cycling in the morning (AM) and those cycling in the afternoon (PM). Since the built environment characteristics of the city show that the quality of the road infrastructures declines with the distance to the inner city (Lall et al., 2017), it is highly convenient to understand how people cycling frequently between specific urban zones perceive the importance of each route choice variable. Therefore, next the analysis differentiates the route choice importance perception among those cycling between different urban zones.

Comparing the importance each route choice variable received from individuals who depart in the morning (AM) and the afternoon (PM).

The results presented in Table 22 show the Kruskal-Wallis test comparing the significant differences in the importance that each route choice variable received from the AM and PM Demanding, Cautious and Forced cyclists. The analysis tests the null hypothesis that there are no statistical differences in the perception of the route choice variables between those departing in the morning and the afternoon. The results show that for Demanding cyclists the null hypothesis is valid, there are no significant perception differences between AM and PM demoing cyclists.

For Cautious cyclists, the results show that 33.33% of the route choice variables present a significant difference in the importance that each route choice variable received. These

variables are street surface quality ($\chi^2=6.096$), average daily traffic volume ($\chi^2=4.654$) and the average number of road accidents ($\chi^2=7.751$). The importance perception for these variables ranges from not important (Mean=3.01, SD=1.764), important (Mean=4.65, SD=1.563) to very important (Mean=5.57, SD=1.568) respectively. PM Cautious cyclists (263.24) had a higher mean rank on the route choice variable the average number of road accidents. This means that when defining a bike itinerary PM cyclists perceive the average number of road accidents less important than AM cyclists (212.44).

Forced cyclists, the analysis reveals that 11.11% of all the route choice variables present a significant important perception between AM and PM cyclists. This variable is long route distance ($\chi^2=3.994$). This variable was perceived as important (Mean=4.73, SD=1.698). AM forced cyclists (84.09) have a high mean rank than PM forced cyclists (64.20).

Table 22: Significant importance differences each route choice variable received from individuals who depart in the morning (AM) and in the afternoon (PM)

Route choice variables	Kruskal- Wallis Test		
	Demanding cyclists	Cautious cyclists	Forced cyclists
	(AM) - (PM)		
Fast traffic speed	1.066	1.224	0.088
Lack street signalisation	1.912	0.024	2.572
Poor route pavement quality	0.730	6.096*	0.439
Average number of road accidents	0.254	7.751*	0.642
Average daily traffic volume	0.665	4.654*	0.003
Street lighting	0.069	1.115	0.126
Lack of tree cover alongside the road	0.208	0.010	0.042
Presence of street vendors on the main intersections	1.638	0.642	0.248
Long route distance	0.316	1.691	3.994*
<i>N</i>	300	436	162

*p-value <0.05

Comparing the importance each route choice variable received from individuals cycling within the planned area (Z1-Z1) and within the unplanned areas (Z23-Z23)

Table 23 tests the null hypothesis that there no significant differences in the importance each route choice variables received from individuals cycling within the inner city and those cycling within the city periphery or sub-urban area. The analysis showed that Demanding cyclists perceived 11.11% of the route choice variables significantly different. Among the cycling route choice variables, the lack of tree cover along the roads ($\chi^2=6.603$) was reported statically different between those cycling the planned areas and within the unplanned areas. This variable was reported important (Mean=4.73, SD=1.931). The higher mean rank is observed for those cycling within unplanned areas (118.93) than those cycling within the planned area (73.80).

For Cautious cyclists, the results show that the null hypothesis is valid, there are no significant perception differences between those cycling within the planned areas and those cycling within unplanned areas.

11.11% of all the route choice variables are considered significantly different by Forced cyclists. This variable is long route distance ($\chi^2=4.170$) and was perceived as important (Mean=4.78, SD=1.692). The mean rank indicates that those cycling within the unplanned areas (60.46) perceive this variable more importance than those cycling within the planned area (32.00).

Table 23: Significant importance differences each route choice variable received from individuals who cycle within the planned area (Z1-Z1) and those cycling within the unplanned area (Z23-Z23)

Route choice variables	Kruskal- Wallis Test		
	Demanding cyclists	Cautious cyclists	Forced cyclists
	(Z1-Z1) - (Z23-Z23)		
Average traffic speed	0.851	0.377	0.684
Street signalisation	0.583	0.778	0.089
Route surface quality	0.713	0.615	0.257
The average number of road accidents	0.560	1.689	0.482
Average daily traffic volume	0.486	1.747	0.621
Street lighting	0.283	0.971	1.074
Lack of tree cover alongside the road	6.603*	0.100	0.250
Presence of street vendors on the main intersections	0.001	0.003	0.102
Long route distance	0.066	0.164	4.170*
<i>N</i>	234	372	117

*p-value <0.05

Comparing the importance each route choice variable received from individuals cycling between planned area and unplanned areas (Z1-Z23) and those cycling between unplanned areas (Z2-Z3)

The last level of the analysis is to test the hypothesis that there no significant differences in the perception of the cycling route choice variables between individuals cycling between the planned areas and unplanned areas (Z1-Z23) and those cycling between unplanned areas (Z2-Z3), Table 24. For the Demanding cyclists, the Kruskal-Wallis indicates that 11.11% of the route choice variables present significant differences between those cycling between the Z1-Z23 and Z2-Z3. The variable is the average number of road accidents ($\chi^2=3.887$). It was considered as somewhat important (Mean=3.83, SD=2.209). The mean rank indicates that those cycling between the Z1-Z23 present the highest score (38.69) that those cycling between Z2-Z3 (29.43).

When defining a cycling itinerary, Cautious cyclists consider 11.11% of the variables significantly different between those cycling between Z1-Z2 and Z2-Z3. The variable is

the average traffic speed ($\chi^2=5.430$). The variable was considered important (Mean =5.08, SD=1.884). In addition, the mean rank indicates that the highest importance score was given by those cycling between Z2-Z3 (36.71) than those cycling between Z1-Z23 (26.29).

Similarly to the other attitudinal segments, Forced cyclists perceive 11.11% of the route choice variables differently between those cycling between Z1-Z23 and Z2-Z3. The variable is long route distance ($\chi^2=7.913$). The variable was considered important (Mean=4.61, SD=1.728). The mean rank shows that those cycling between Z2-Z3 give high importance (26.15) compared to those cycling between Z1-Z23 (14.68).

Table 24: Significant importance differences each route choice variable received from individuals who cycle between planned and unplanned area (Z1-Z2) and those cycling between the unplanned area (Z2-Z3)

Route choice variables	Kruskal- Wallis Test		
	Demanding cyclists	Cautious cyclists	Forced cyclists
	(Z1-Z23) - (Z2-Z3)		
Average traffic speed	0.039	5.430*	0.63
Street signalisation	0.600	1.108	2.052
Route surface quality	0.391	0.882	0.616
Average number of road accidents	3.887*	0.848	3.388
Average daily traffic volume	0.187	0.169	0.057
Street lighting	0.023	0.214	0.705
Lack of tree cover alongside the road	0.003	0.219	2.566
Presence of street vendors on the main intersections	0.500	0.917	3.422
Long route distance	2.130	0.284	7.913*
N	66	62	44

*p-value <0.05

8.5. DISCUSSIONS AND POLICY IMPLICATIONS

This study aims to get an insight into variables influencing route itinerary for cyclists in different attitudinal segments (Demanding cyclists, Cautious cyclists, and Forced cyclists), with different travel behaviour (departure time AM and PM) and different travel patterns (cycling in the planned area and unplanned area). The empirical data was collected by means of an internet-based survey and face-to-face survey on regular commuters in Quelimane, Mozambique. We expected that depending on the departure time and the built environment in which the trip takes place, cyclists would perceive the route choice variables differently. To explore this, a non-parametric test Kruskal-Wallis was conducted to compare the significant differences in the importance that the 9 route choice variables received from different cyclists. The study also explores the level of importance perception within each attitudinal segment. Overall, cyclists are more consensual that street signalization, the quality of street pavement, street lighting, and

street tree cover extremely important when defining a cycling itinerary. This conclusion is based on Figure 36. This is consistent with previous studies in SSA cities that found bicycling daily in SSA cities is hard due to the lack of reasonable road infrastructures, that can provide comfort and safety (Kumar et al., 2008; Moyo et al., 2018). With this information, the significant importance difference each route choice variable received per attitudinal segment was first evaluated based on departure time and further based on travel patterns (Tables 22-24).

Overall Demanding cyclists when choosing a bike route do not present significant differences between AM and PM cyclists. People in this segment tend to bicycle frequently to formal jobs because they do not have suitable transport alternates. Most own only a bicycle. Muñoz et al., (2013) consider that cycling frequency decreases the perception of cycling barriers. This means that frequent bicyclists perform the action allocating minimal attention to the existing barriers. Regarding travel patterns, those cycling within unplanned areas perceive lack of street cover along the roads as important. This is as expected, based on Lall et al., (2017); Kumar et al., (2008) most SSA cities have ignored the presence of non-motorized modes like cycling, therefore, the road quality is poor, missing links and basic facilities for cycling such as trees along the roads particularly in the periphery. According to de Sousa et al., (2019), tree cover provides comfort, particularly when cycling in a hot climate. Those cycling frequently between the inner-city and unplanned areas perceive the actual rate of road accidents somewhat important. This is consistent with Moyo et al., (2018) who found that in Johannesburg (South Africa) most cycling-related accidents occur in busy inner-city roads since many roads allow different types of transport.

The higher difference between Cautious cyclists departing at AM and PM is in the perception of the route choice variable number of road accidents. People who depart in the afternoon consider this variable not important. This is as expected since people in this attitudinal segment pedal less and, therefore are less exposed to the road traffic. Additionally, this could justify the similar importance given to all route choice variables by those who cycle within the planned areas or unplanned areas. People cycling between the unplanned areas consider important the average traffic speed. According to UN-Habitat, (2016), in the SSA cities, there is poor connectivity between these zones. This is linked to Quelimane, only 2 main roads are connecting the city periphery to the suburban area, these roads often present busy and fast-moving motorized traffic, unsafe for cycling. This could probably justify this perception.

In addition, we found that Forced cyclists to perceive the long route distance significantly different regardless of the travel behaviour or travel patterns. This is obvious since people in this segment cycle for livelihood. The bicycle-taxi fare as based on the travel distance (Mbara et al., 2003; Mendieta et al., 2020; Mutiso et al., 2011). Linking with Quelimane, it is found that in the morning there is an enormous demand for this service and, at that time bicycle-taxi operators often increase the cost per distance travelled. Those who cycle in the unplanned area also considers the route distance important. Bicycle-taxi service is crucial in the city periphery as it enables an easy connection in the narrow and irregular road network that characterizes these zones, therefore long distances mean increased revenues. Those who cycle between the planned area and the unplanned area also consider route distance as important. Associating this with Quelimane it could be justified since

most formal workers travel daily to the inner city. The lack of public transport is a business opportunity for bicycle-taxi operators who find the long distances and increased demand for potential passengers very profitable.

The need to promote cycling for commuting in Quelimane is a national ambition, recognized for becoming one of the first African cities to join the Transport Decarbonisation Alliance (TDA, 2019), setting an ambitious target to meet zero net emission of the transport sector to achieve the 2050 targets of the Paris agreement. The present study, besides pointing out to a huge step forward in highlighting major cycling route choice challenges in Quelimane, also points out how to be addressed to remove barriers for cycling promotion. Based on our findings, cyclists are more consensual that street signalization, the quality of street pavement, street lighting and street tree cover is extremely important when defining a cycling itinerary. Since there is a limited road investment in Quelimane, there is a risk that people will stop cycling. Improvements in the road quality by increasing the street signalization, the quality of road surface, providing street lighting and street tree cover are some of the practical ways to remove the general cycling route choice barriers.

People in Demanding cyclist segment who cycle frequently within the unplanned area perceive the lack of street tree cover as important. Most roads in the city-periphery do not present tree cover. To promote cycling there is a need to increase the density of street trees especially on the bicycle corridors connecting the larger informal markets. Additionally, those cycling between the inner city and the city-periphery or sub-urban area perceive the increased road accident somewhat important. Since most roads connecting these areas allow different types of transports, initiatives to increase cycling should focus on increasing road safety by providing separated lanes dedicated to cycling. It is also interesting to highlight that Cautious cyclists, biking between the city periphery and suburban areas consider the traffic speed as important. There is limited connectivity between these areas, therefore when travelling between these zones cyclists often use the busy main roads. To promote cycling between unplanned areas it is crucial to provide more alternative roads that connect these zones. These additional routes can facilitate a safer connection between agricultural areas and large informal markets. In addition, on main roads, traffic calming measures should be promoted, such as increasing road signalization and speed limitation. Forced cyclists regardless of travel behaviour and travel patterns perceive the long cycling distances important since it increases their profits. It is convenient to regulate this sector, to shift from informal to the formal transport system. This should include the definition of bicycle-taxi routes, stops, and fares. This will allow friendly interaction between bicycle-taxi operators and passengers.

This study shows the merit of using non-parametric tests to compare and explore the perception of route choice variables in contexts where people have few route choices. Lack of cycling route alternatives can affect cyclists' route attributes evaluation and generate unrealistic perceptions, since the stated preference may not reflect the underlying utility structure as it claims. Non-parametric tests help not only to identify the main perception differences but also where the differences are. Given that travel propose could establish differences when defining cycling itinerary and thus the perception of the route choice variables, it would be useful for further studies to capture the differences across

individuals cycling to utility and non-utility purposes and explore how this could influence route choice.

9

CONCLUSIONS

9. CONCLUSIONS AND FUTURE RESEARCH

9.1. OVERVIEW OF THE RESULTS

This section provides an overview of the key findings by answering the research questions addressed. This also brings the added value of this research

Chapter 1, discusses on cycle committing factors reported in the early scientific literature. To address this, literature identifying groups of commuter cyclists in SSA cities are explored and compared to literature in other urban contexts. This enabled identify key similarities and differences. Factors influencing cycling were divided into socio-economic factors, built environmental factors, natural environmental factors, and attitudinal factors. While the current literature points to socio-economic factors not clearly explaining the cycling choice, In SSA cities due to lack of public transport, road safety, and cultural habits, cycling is often for the poor man. The built environmental factors have enormous influence in both cycling decisions and route choice. Tree cover, road encroachment caused by the presence of street vendors, street lighting is strongly linked to cycling route choice particularly in peak hour and in the evening. Was found that in both SSA cities and in other urban contexts street lighting is perceived as crucial cycling motivators. In regard to travel distance, conventional literature points to an increase in travel distance negatively influence cycling choice. In SSA cities, its different, bicycle-taxi operators tax their services based on the travel distance. The natural environment factor, Temperature has little effect on cycling choice in SSA cities since its constant throughout the year. The rain influences route choice since most roads have poor drainage heavy rain mean flooded roads which are unsuitable for cycling. Street tree cover was found in both contexts relevant to cycling route choice. The attitudinal factors have an enormous influence on cycling choice and use. Conventional literature cites the environmental importance of cycling, its health-improving to be the main factor for cycling choice. Studies in SSA cities point the possibilities of cycling for the taxi, carry loads and use as a mobile selling platform in streets to be most linked for cycling in SSA cities.

From the literature review, several conclusions were drawn and served as empirical support to the definition of research objectives and research methods, discussed from chapters 2-5.

Chapter 6 focuses on investigating who are the cyclists in an SSA context based on socio-economic variables and answer the following research objective.

- *ROI: To identify who are the cyclists, their main socioeconomic characteristics, residential location, and travel patterns*

This chapter investigates the existing cycling groups based on socio-economic factors and cycling use factors. Since previous studies that the socio-economic characteristics such as income, age, and residential location strongly influence cycling use in an SSA city it was expected that grouping based on these factors could enable having heterogeneous groups of cyclists. The result of Twostep cluster analysis identified 3 groups of cyclists which are informal workers with children, short distance students, and occasional cyclists.

The clusters were based on household composition, employment status, and cycling frequency to work/school. The cluster of informal workers is composed of a couple with children who cycle frequently to informal jobs. Most trips take place within the city periphery followed between the city periphery and the inner city. They often cycle long distances. The second cluster is composed mainly of students in single parents' household and often cycle to formal jobs, such as workplace and school. They cycle frequently but often for a short distance. The third cluster is composed of students who cycle occasionally to workplaces or schools. This cluster shares many socio-economic similarities with cluster 2. However, they often cycle within the city periphery and between the city periphery and suburban areas. Formal work and for other purposes are the main cycling purposes.

The result suggests that mainly 3 groups of commuter cyclists and residential location play an important role in the cycling choice and use, however the cluster present many similarities. Most intense cycling takes place within the city periphery since this area has limited access to cars and has a concentration of informal jobs. These findings were not expected in early cycling studies and can serve as an empirical basis for developing more targeted policies to encourage cycling in SSA cities. Although the study findings provided a clear understanding of commuter cyclists, recommendations were made to attempt clustering based on attitudinal variables,

Chapter 7 focuses on investigating the existing attitudinal cycling markets and they answer the following research objective.

- *RO2: To explore the existing attitudinal cycling segments and their main cycling drivers*

This chapter addresses to identify the existing attitudinal market segments in a medium-sized SSA city. It is assumed that attitudinal variables could provide a better insight into existing cycling segments. This is investigated by the use of factor analysis to identify the underlying structure among the factors and SEM to identify the correlation between them. Twostep cluster analysis was used to identify and profile the attitudinal market segments. The result identified 3 attitudinal market segments which are Demanding cyclists, Cautious cyclists, and Forced cyclists. Demanding cyclists have a high positive attitude towards cycling. It is mainly dominated by adults, having formal jobs, and is most likely to have more women than other segments. Its population bicycle frequently often between 10min-20min. Although this segment seems positive to bicycle the following reasons are pointed as cycling deterrents: the discomfort caused by uneven roads, lack of street signalization and deficient street lighting. Cautious cyclists have a lower attitude toward cycling. Their cycling attitude could be since this segment is composed mainly young, poor and not owning any vehicle. This is most likely to have more men than a woman. The population in this segment have a secondary education level, formal jobs and belong to the low-income group. Although the population in this segment commute relatively long distances (between 20min-30min), most rely on walking. They perceive cycling slightly flexible, cheaper than other transport modes and comfortable, however, most cannot afford to buy or maintain a bicycle. Forced cyclists, this segment is polarized between bicycle-taxi operators and bicycle taxi passengers. Bicycle taxi operators are basically, poor young men. In terms of travel behaviour, a larger population cycle

frequently. On average they travel a long time (more than 30min). Cycling in this group is perceived as a working tool, to transport passengers, carry loads and also to sell goods in the streets. For the passengers, the bicycle reduces daily travel costs.

Chapter 8 focus to investigate what factors influence cyclists' itinerary based on their travel behaviour and travel patterns.

- *RO3: To identify factors influencing cyclists' itinerary*

This chapter addresses the factors that influence cycling route choice per different groups of cyclists (Demanding cyclists, Cautious cyclists and Forced cyclists). It is assumed that in SSA cities due to poor road infrastructures and a general lack of public safety cycling commuters will change their route depending on the departure time and travel patterns. This is investigated by a non-parametric test Kruskal-Wallis test that compares the significant differences that 9 route choice variables received from different cyclists (Demanding cyclists, Cautious cyclists and Forced cyclists). These attitudinal segments were identified in the previous chapter (Chapter 7).

The result indicates that overall, cyclists are consensual that street signalization, the quality of street pavement, street lighting, and street tree cover extremely important when defining a cycling itinerary. Demanding cyclists when choosing a bike route does not present significant differences between AM and PM cyclists. Regarding travel patterns, those cycling within unplanned areas perceives lack of street cover along the roads as important. Those cycling frequently between planned areas and unplanned areas periphery perceive the actual rate of road accidents somewhat important. Cautious cyclists departing in the afternoon considers the number of road accidents not important. Those cycling within the planned area and the unplanned area perceive most of the route choice variables insignificantly different. Those cycling between the unplanned areas consider the average traffic volume important. Forced cyclists perceive the route distance significantly different regardless of the departure time or travel patterns. Such information is crucial to identify which variables are more influential for route choice and how they are perceived in each attitudinal cycling segment.

These results allow us to answer the main research objective.

- *RO 0: To identify socio-economic, locational and attitudinal factors influencing cycling use and cyclists' itinerary*

The study took into consideration that factors influencing cycling in a medium SSA city are rather different from the larger city or western cities. Two research gaps were investigated in the literature. First, who are the cyclists and second what factors influence their cycling decision and cycling patterns. To explain who are the cyclists in medium SSA cities we tested different grouping approaches. First, considering early literature in SSA cities that cites cycling is for the poor, we attempted to group cyclists based on socio-economic variables and cycling use variables. Three clusters of commuter cyclists were identified (Informal workers with children, Short-distance students and occasional cyclists). Since the obtained groups do not reveal heterogeneities, we considered segmentation based on attitudinal variables. This segmentation approach allowed to uncover three major cycling attitudinal segments in a medium SSA city. Demanding cyclists, Cautious cyclists, and Forced cyclists. This helped to identify which factors

influence the cycling decision. Secondly, to complete the characterization of the attitudinal cycling markets, the non-parametric test was conducted. It was hypothesized that due to the urban form that concentrates most infrastructures in the inner city, hot weather, and a general lack of public safety in SSA cities, route choice depends on the departure time and travel patterns.

Two main conclusions can be depicted in this study. First, the research found that although cycling in SSA cities has been considered for the poor, socio-economic factors can't help in explaining the existing cycling groups. It is observed that due to the lack of public transport bicycle-taxi is used by many including those having a high-income. Therefore, it is difficult to predict cycling use based on socio-economic factors. Secondly, differently for many cycling studies, most cycling trips take place within the city periphery. Since the road network in this urban zone is irregular, cyclists' route choice is hard to predict.

This thesis provides strong pieces of evidence that different groups of cyclists are influenced by different factors. Demanding cyclists and Forced cyclists make most of their trips by bicycle while de Cautious cyclists see walking as the main commuting mode and they often commute long distances. Regarding route choice, Demanding cyclists and Forced cyclists, perceive most of the route choice variables insignificantly different while Cautious cyclists consider most of the route choice variables influential.

9.2. ACHIEVEMENT OF THE RESEARCH OBJECTIVES

This section presents several interesting issues that require further discussion. The generality of our process of data collection and the effect of socio-economic variable and attitudinal variables on cycling choice is also presented.

Three issues arise as a result of the data collection process and the qualitative data obtained in the field. First, the online data collection is an effective approach and allows respondents to quietly answer the questionnaire, however, in SSA cities only 60% of the population has access to the internet (USAID, 2016), therefore this approach is not inclusive. The use of face-to-face interviews is seen effective for this context therefore it can be easily transferred to other similar cities.

In chapter 6, the exploration of cycling groups based on socio-economic variables brought to light that although cycling in SSA cities is pointed for the poor, it is difficult to use socio-economic factors for grouping. Due to lack of public transport, a bicycle-taxi is a popular public transport mode, therefore, people with different socio-economic backgrounds experience cycling as passengers.

For route choice, the study has demonstrated that the street signalization, the quality of street pavement, street lighting, and street tree cover as extremely important when defining a cycling itinerary. This research compared the commuters that have different departure time and travel patterns. Chapter 8 provides pieces of evidence that cycling route choice is a dynamic decision and some individuals take a route choice decision based on the departure time and travel patterns. This raises the question if these findings can be generalized. It is seen that it can be generalized for SSA cities but not for cities in other urban contexts that present a suitable climate for cycling, general public safety and there no noticeable differences in the quality of road infrastructures per urban zone.

The last issue is assessing the generality of our findings in other contexts. The case study is Quelimane, and it has an above-average cycling share. However, smaller cities in Mozambique have quite similar urban form and infrastructure quality. Therefore, generalizing our findings to all the cities is hard, there must be topographic and cultural differences that could influence its cycling acceptability. However, this study leaves the impression of the existing groups of cyclists in these cities and key factors influencing cycling use and cyclists' itinerary which are largely consistent across small SSA cities.

9.3. POLICY IMPLICATION

Most governments not only the Mozambican aim to increase cycling for urban trips. This section reflects on transferring the results of the analysis into policy initiatives to promote cycling use. First, the initiatives regarding cycling promotion in each cycling segment are presented. Then several ideas not directly derived for the empirical analysis are discussed.

The decision to cycle in each cycling segment

This study revealed that factors influencing cycling are different per cycling group. This is relevant when defining initiatives to encouraging cycling as different segments are motivated differently. Policies to encourage people to cycle in SSA cities can be possibly summarized in 5 different ways (Figure 37).

Figure 37: Summary of policies to promote cycling in SSA cities

- a) From occasional demanding cyclists to frequent demand cyclists. People in this segment is highly sensitive to comfort and stress and point to a high need for cycling facilities. They can be encouraged to cycle more frequently basically by reducing traffic and providing good road infrastructure, paved, well signaled, with street lighting and tree cover particularly for those biking within the unplanned urban zones

- b) From occasional cautious cyclists to frequent cautious cyclists. These people often rely on walking for daily commuting. They perceive cycling moderately. Initiatives for behaviour change should be focused on providing easy access to bicycles and spare parts. Additionally, for those cycling between the city-periphery and the sub-urban area, initiatives for traffic calming are relevant.
- c) From occasionally forced cyclists to frequent bicycle taxi passengers. People in this segment are divided into bicycle taxi operators and passengers. Bicycle taxi operators are mainly by providing dedicated bicycle lanes that connect major markets and residential areas. This could provide comfort, safety and also minimize the physical effort needed to find potential passengers. To attract occasional into frequent bicycle taxi passenger initiatives should focus on the safety and provision of a reliable taxation system that enables passengers to pay the right amount for the trip.

Since this research has revealed that bicycle taxi is a mean of public transport, this means that people from all the segments can experience these services. Therefore, examples of possible initiatives can be depicted as follows.

- d) From occasional demanding cyclists to frequent bicycle-taxi passengers, possible initiatives could be focused on reducing passenger's stress and increasing the comfort of this service. Ideas could be focused on the creation of dedicated bicycle taxi routes that avoid interfering with the other transport modes. In addition, there is a need to introduce a rear seat much comfortable, with a cover that could provide passenger protection against the sun and rain.
- e) From occasional cautious cyclists to frequent bicycle-taxi passengers, possible initiatives could be focused on making the taxation very predictable. Since people in the caution segments really on walking since most cannot afford a bicycle. Therefore, to attract them to experience bicycle taxi as passengers its important that bicycle-taxi fee is attractive. This could be by reinforcing supervision and taxation.

9.4. RESEARCH RECOMMENDATIONS

Based on this study, this section presents four recommendations for further research.

First, this thesis focuses especially on identifying who are the cyclists and what key factors influence cycling. When attempting to identify groups of cyclists based on socio-economic factors, it was revealed that most cycling trips take place within the city periphery. However, the extent to which the urban form in medium SSA cities influences cycling choice is still limited. It seems essential to investigate the interrelation between these factors which could guide policymakers in such a context.

Second, after identifying the cluster of commuters based on attitudinal factors and cycling use factors it was found that they do not present heterogeneous cycling attitudes therefore attitudinal market segmentation was conducted. It was clear that although the segment of

forced cyclists has a small share its has a much wider impact on the overall cycling behaviour in the city. Further study is recommended to identify who are the bicycle-taxi operators and passengers and what are their real motivators for using this service.

Third, this thesis has focused on a limited extent of the effects of road-related factors on cycling route choice. It is without a doubt that the quality of the road infrastructure plays an important role in the cycling route choice. Moreover, it was assumed that cycling route choice behaviour could change depending on the departure time. Further study is recommended to uncover what exactly time interval is critical for route choice change. This would offer policymakers practical inputs to plan for proper bicycle facilities.

Finally, additional research is necessary to test the effectiveness of the proposed possible measures presented in this section, particularly those that aim to induce behaviour change of occasional demanding cyclists and occasional cautious cyclists to experience cycling as passengers. It would be advisable and would provide a complete picture of the existing cycling promotional initiatives for each cycling segment.

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11. ANNEXES

11.1. SURVEY QUESTIONNAIRE (ENGLISH)

<p>Escuela Técnica Superior de Ingenieros de Caminos, Canales y Puertos</p>	<p>Ministério da Ciência e Tecnologia Ensino Superior e Técnico-Profissional</p>
WHAT ARE THE MOTIVATORS AND BARRIERS BEHIND CYCLING IN AFRICAN CITIES? CASE STUDY OF QUELIMANE_MOZAMBIQUE	
1. <u>WELLCOME!</u>	
<p><u>INTRODUCTION</u></p> <p>This survey is part of a research project ongoing at the E.T.S.I Caminos Canales y Puertos, Universidad Politecnica de Madrid and is sponsored by the Ministry of Higher Education, Science and Technology.</p> <p>The aim of this research is to understand the driving forces behind bicycling in Quelimane.</p> <p><u>Your collaboration is very important for the success of this research!</u></p> <p>This questionnaire will take you about 10min and by pressing "next" you can move to the next page. From the day you receive this card You have one week (7 days) to fill the form.</p> <p>Please note, by filling this form your personal information will remain confidential and collected data will be used only for statistical purposes.</p> <p>Questions, please contact us : classio.joao.mendiate@alumnos.upm.es</p>	

WHAT ARE THE MOTIVATORS AND BARRIERS BEHIND CYCLING IN AFRICAN CITIES?
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2. ACCESS NUMBER

* 1. Please insert your SURVEY NUMBER (This code is in your invitation card)

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3. YOU AND BICYCLE

This is the first section of the questionnaire, you will find questions about your relationship with the bicycle for intra-city trips. These questions refer to the USE OF THE BICYCLE IN GENERAL and bicycle route choice.

2. Do you have a driving license?

- ☐ Yes
☐ No

* 3. What are the modes of transport listed below that you have daily access?

- ☐ Bicycle
☐ Motorcycle
☐ Tricycle (Bajaj)
☐ Passenger car
☐ Pick up van
☐ Truck

4. How many bicycles do you have at your disposal?

* 5. How often do you go...

	Never	Once a year	Once a month	Once a week	Three days a week	Daily
...To the working place	☐	☐	☐	☐	☐	☐
...selling goods	☐	☐	☐	☐	☐	☐
...to the school/University	☐	☐	☐	☐	☐	☐
...shopping	☐	☐	☐	☐	☐	☐
...leisure	☐	☐	☐	☐	☐	☐
...visit family and friends	☐	☐	☐	☐	☐	☐
...sport	☐	☐	☐	☐	☐	☐
...night ride	☐	☐	☐	☐	☐	☐

* 6. What is your daily mode of transportation to...

	Walking	Bicycle	Motorcycle	Tricycle (Bajaj)	Private car	Public transport	N/C
... the working place	☐	☐	☐	☐	☐	☐	☐
...sell goods	☐	☐	☐	☐	☐	☐	☐
...the school/University	☐	☐	☐	☐	☐	☐	☐
...shopping	☐	☐	☐	☐	☐	☐	☐
...leisure	☐	☐	☐	☐	☐	☐	☐
...visit family and friends	☐	☐	☐	☐	☐	☐	☐
...sport	☐	☐	☐	☐	☐	☐	☐
...night ride	☐	☐	☐	☐	☐	☐	☐

* 7. In a typical day, what is your preferred travel time to your daily activities?

	Less than 10min	10min- 20min	20min- 30min	30min- 40min	40min- 50min	50min- 60min	More than 60min	N/C
To the working place	☐	☐	☐	☐	☐	☐	☐	☐
Selling goods	☐	☐	☐	☐	☐	☐	☐	☐
To the school/university	☐	☐	☐	☐	☐	☐	☐	☐
For shopping	☐	☐	☐	☐	☐	☐	☐	☐
Leisure	☐	☐	☐	☐	☐	☐	☐	☐
Visit family and friends	☐	☐	☐	☐	☐	☐	☐	☐
Sport	☐	☐	☐	☐	☐	☐	☐	☐
Night ride	☐	☐	☐	☐	☐	☐	☐	☐

* 8. Can you ride a bicycle?

- ☐ Yes
- ☐ No

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4. YOU AND BICYCLE

9. Which statement best describes your relationship to bicycle?

- ☐ I never really think about and not even consider cycling to my daily activity.
- ☐ I never used a bicycle but sometimes think about cycling to my daily activity.
- ☐ I rarely or sometimes cycle and seriously consider riding to my daily activity.
- ☐ I have fairly often cycled to my daily activity.
- ☐ I cycle regularly to my daily activity.
- ☐ I cycle daily and never consider to stop cycling.
- ☐ I no longer cycle to my daily activities.

10. What was the last time you rode a bicycle?

- ☐ Today
- ☐ Last 3 days
- ☐ Last week
- ☐ Last month
- ☐ More than a month ago
- ☐ A year ago
- ☐ None above

* 11. How often do you use a bicycle...

	Never	Once a year	Once a month	Once a week	Three days a week	Daily
...to the working place?	☐	☐	☐	☐	☐	☐
...to sell goods?	☐	☐	☐	☐	☐	☐
...to carry loads?	☐	☐	☐	☐	☐	☐
...for taxi-bicycle?	☐	☐	☐	☐	☐	☐
...to the school/ University?	☐	☐	☐	☐	☐	☐
...to visit family and friends?	☐	☐	☐	☐	☐	☐
...for shopping?	☐	☐	☐	☐	☐	☐
...for leisure?	☐	☐	☐	☐	☐	☐
...for sport?	☐	☐	☐	☐	☐	☐
...for night ride?	☐	☐	☐	☐	☐	☐

* 12. When riding a bicycle, how would you rate from 1-7 (low-high) the importance of...

	1(Low)	2	3	4	5	6	7(High)
...Allowed urban speed limits?	☐	☐	☐	☐	☐	☐	☐
... street signalisation/traffic lights?	☐	☐	☐	☐	☐	☐	☐
... street pavements condition?	☐	☐	☐	☐	☐	☐	☐
.... street accidents rate?	☐	☐	☐	☐	☐	☐	☐
... the current traffic volume?	☐	☐	☐	☐	☐	☐	☐
...street lighting for night ride?	☐	☐	☐	☐	☐	☐	☐
...roadside trees shade in your frequent travel route?	☐	☐	☐	☐	☐	☐	☐
...roadside activities on your frequent travel route?	☐	☐	☐	☐	☐	☐	☐
...your average travel time?	☐	☐	☐	☐	☐	☐	☐
What is your overall importance level of these road attributes for your bicycle trip?	☐	☐	☐	☐	☐	☐	☐

* 13. When riding a bicycle, how would you rate from 1-7 (low-high) your satisfaction level about...

	1(Low)	2	3	4	5	6	7(High)
... Allowed urban speed limits?	☐	☐	☐	☐	☐	☐	☐
... the existing street signalizations?	☐	☐	☐	☐	☐	☐	☐
... the existing street pavement condition?	☐	☐	☐	☐	☐	☐	☐
.... the current street accidents rate?	☐	☐	☐	☐	☐	☐	☐
... the current traffic volume in Quelimane?	☐	☐	☐	☐	☐	☐	☐
...the street lighting for night ride?	☐	☐	☐	☐	☐	☐	☐
...the roadside trees shade in your frequent travel route?	☐	☐	☐	☐	☐	☐	☐
...the roadside activities on your frequent travel route?	☐	☐	☐	☐	☐	☐	☐
...your average travel time?	☐	☐	☐	☐	☐	☐	☐
What is your overall satisfaction level of the road network system?	☐	☐	☐	☐	☐	☐	☐

* 14. When choosing a bicycle for your trip, how would you rate from 0-7 (low-high) the influence of...

	1(Low)	2	3	4	5	6	7(High)
...your daily travel distance?	☐	☐	☐	☐	☐	☐	☐
... Allowed urban speed limits?	☐	☐	☐	☐	☐	☐	☐
... the existing street signalizations?	☐	☐	☐	☐	☐	☐	☐
... the existing street pavement condition?	☐	☐	☐	☐	☐	☐	☐
.... the current street accidents rate?	☐	☐	☐	☐	☐	☐	☐
... the current traffic volume in Quelimane?	☐	☐	☐	☐	☐	☐	☐
...the street lighting for night ride?	☐	☐	☐	☐	☐	☐	☐

	1(Low)	2	3	4	5	6	7(High)
...the roadside activities on your frequent travel route?	☐	☐	☐	☐	☐	☐	☐
...the roadside trees shade in your frequent travel route?	☐	☐	☐	☐	☐	☐	☐
...the absence of a convenient place to shower and change clothes	☐	☐	☐	☐	☐	☐	☐
...the absence of a convenient bicycle parking	☐	☐	☐	☐	☐	☐	☐
...bicycle-taxi business opportunities in Quelimane?	☐	☐	☐	☐	☐	☐	☐
...The opportunity to use bicycle to sell goods in the street	☐	☐	☐	☐	☐	☐	☐
...the opportunity to carry loads in the street	☐	☐	☐	☐	☐	☐	☐
...your time availability?	☐	☐	☐	☐	☐	☐	☐
...bicycle theft?	☐	☐	☐	☐	☐	☐	☐
...rain?	☐	☐	☐	☐	☐	☐	☐
...heat?	☐	☐	☐	☐	☐	☐	☐
...risk of accidents or fall?	☐	☐	☐	☐	☐	☐	☐
...health benefits?	☐	☐	☐	☐	☐	☐	☐
...mode flexibility?	☐	☐	☐	☐	☐	☐	☐
...mode confort?	☐	☐	☐	☐	☐	☐	☐
...mode cost?	☐	☐	☐	☐	☐	☐	☐
...your pleasure to ride?	☐	☐	☐	☐	☐	☐	☐

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5. YOUR YESTERDAYS TRAVEL BEHAVIOUR

Here, you will be asked to describe your yesterday travel behavior and to indicate your trip origin, destination and arrival time at each destination.

* 15. From which neighborhood your trip started yesterday?

* 16. Bellow, it is presented the list of all the neighborhoods of Quelimane.

Based on your yesterday's trips can you please indicate those neighborhoods you have visited and its corresponding arrival time.

	Before	5AM	6AM	7AM	8AM	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM	5PM	6PM	7PM	After 8PM
17 de Setembro	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1 de Maio, A ou B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
24 de Julho	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
25 de Setembro	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3 de Fevereiro	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7 de Abril	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Acordos de Lusaka A ou B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Aeroporto	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bairro Novo	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bazar	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Brandao	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Chirangano	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Chuabo Dembe	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Coallane I ou A ou B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	Before	5AM	6AM	7AM	8AM	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM	5PM	6PM	7PM	After 8PM
Cololo		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Filipe Samuel Magala		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Floresta A ou B		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Gogone		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Icidua		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Inhangome		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ivagalane		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Janeiro		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kansa		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Liberdade		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manhaua A ou B		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mapiazua		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mborio		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Megano		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Micajune A ou B		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mirazane		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Morropue		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Namuinho		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Piloto		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Popular		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Saguar 1 ou 2		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sampene		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Samugue		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sangariveira		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Santagua		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sinacura		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Torrone Novo ou Velho		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

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6. SOCIODEMOGRAPHIC CHARACTERISTICS

This is the last section of this survey. Here, you will be asked to provide information about your socio-demographic characteristics.

Remember to submit this survey to be able to participate in the final prize, you can be the lucky winner of one of the four Samsung galaxy we are going to offer.

17. What is your birth-year?

18. Are you the head of your family?

☐ Yes

☐ No

19. Please let us know the gender and age of each person living in your household (including yourself) by completing the table below.

	Male	Female	Under 16 years of age	16-19	20-29	30-44	45-59	60 years of age and over
You	☐	☐	☐	☐	☐	☐	☐	☐
Spouse/Partner	☐	☐	☐	☐	☐	☐	☐	☐
Dependent Child 1	☐	☐	☐	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐	☐	☐	☐
Other adult 1	☐	☐	☐	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐	☐	☐	☐
Lodger 1	☐	☐	☐	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐	☐	☐	☐

20. How many people travel with you daily?

	Only 1	Between 1-5	Between 5-10	More than 10	N/A
Children	☐	☐	☐	☐	☐
Pregnant woman	☐	☐	☐	☐	☐
Elder peoples	☐	☐	☐	☐	☐
Handicapped	☐	☐	☐	☐	☐

21. What is your education level?

- ☐ No education
☐ Primary school
☐ Secondary school
☐ University

22. What is your employment status?

- ☐ Governmental
- ☐ Private sector
- ☐ Self employed
- ☐ Student
- ☐ Pensioner
- ☐ Unemployed

23. What is the household net income (In Mts per month)

- ☐ Bellow 3.642,00Mts
- ☐ Between 3643,00Mts-10.400,00Mts
- ☐ Between 10.401,00Mts- 25.000,00Mts
- ☐ Above 25.001,00Mts

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7. THANK YOU!

You have finished the survey!

Please stay tuned to "RADIO QUELIMANE FM 102" on September 25, 2017 to find out if your Survey number is the WINNER of the 2.000,00Mts Monthly Prize.

24. (Optional) If you wish to receive directly the results of this research, please write your email address

If you have any questions, please contact us at the following email address:
classio.joao.mendiate@alumnos.upm.es

THANK YOU FOR YOUR TIME!

11.2. SURVEY QUESTIONNAIRE (PORTUGUESE)

POLITÉCNICA "Ingeniamos el futuro"	Estado Español Superior de Ingenieros de Caminos, Canales y Puertos	Ministério da Ciência e Tecnologia Ensino Superior e Técnico-Profissional
IDENTIFICACAO DE VARIÁVEIS EXPLANATORIAS PARA O CICLISMO NA AFRICA SUB-SAHARIANA. CASO DE ESTUDO DE QUELIMANE_MOCAMBIQUE		
1. <u>BEM VINDO!</u>		
<p><u>INTRODUCAO</u></p> <p>Esta pesquisa faz parte do meu projecto de Doutoramento em curso na Universidade Politécnica de Madrid (Espanha) e é financiada pelo Ministério do Ensino Superior, Ciência e Tecnologia de Moçambique.</p> <p>Como podes constatar, a bicicleta é um dos modos de transporte mais importantes na cidade de Quelimane e a compreensão das motivacoes e barreiras por trás são vistos como bons indicadores para medir a sustentabilidade deste modo de transporte na nossa cidade. Esta é a principal razão pela qual estou conduzindo esta pesquisa e espero trazer novos conhecimentos científicos a este respeito.</p> <p>SUA COLABORAÇÃO É MUITO IMPORTANTE PARA O SUCESSO DESTA PESQUISA!</p> <p>Este questionário irá levá-lo cerca de 10min e, pressionando "NEXT", você pode passar para a próxima página. Desde o dia em que você recebe este cartão, você tem três dias para preencher o formulário.</p> <p>Por favor, note, preenchendo este formulário, suas informações pessoais permanecerão confidenciais e os dados coletados serão usados apenas para fins estatísticos.</p> <p>Perguntas ou duvidas, contacte nos através de: Telefone: 844093832 Email: classio.joao.mendiate@alumnos.upm.es</p>		

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2. CODIGO DE ACESSO

* 1. PORFAVOR INSIRA O CODIGO DE ACESSO QUE ESTA NO TEU CARTAO CONVITE

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3. TEU MODO DE TRANSPORTE COMUM

Esta é a primeira seção do questionário, você encontrará perguntas sobre seus modos de transporte e tempo de deslocação diário.

*** 2. Dos modos de transporte listados abaixo, quais são os que tens acesso diário? (Podes escolher mais de uma opção)**

- ☐ Bicicleta
- ☐ Motorizada
- ☐ Txopela
- ☐ Carro ligeiro
- ☐ Carinha de caixa aberta
- ☐ Camião
- ☐ Nenhum dos modos de transporte referidos acima

3. Quantas bicicletas você tem à sua disposição?

* 4. Com que frequência você se desloca...

	Diariamente	Trez vezes a semana	Uma vez por semana	Uma vez ao mes	Uma vez ao ano	Nunca
... Para vender productos no mercado ou na rua	☐	☐	☐	☐	☐	☐
...Para escola ou universidade	☐	☐	☐	☐	☐	☐
...Para fazer compras	☐	☐	☐	☐	☐	☐
...Para lazer	☐	☐	☐	☐	☐	☐
...Para visitar familiares ou amigos	☐	☐	☐	☐	☐	☐
...Para participar em actividades desportivas	☐	☐	☐	☐	☐	☐
... para outros propositos	☐	☐	☐	☐	☐	☐

* 5. Qual e o teu modo de transporte comum...

	Andar a pe	Bicideta	Motorizada	Txopela	Carro ligeiro	Carinha de caixa aberta	Camiao	Nao aplicavel
... Para ires ao local de trabalho	☐	☐	☐	☐	☐	☐	☐	☐
...Para ires vender no mercado ou na rua	☐	☐	☐	☐	☐	☐	☐	☐
...Para ires para a escola ou universidade	☐	☐	☐	☐	☐	☐	☐	☐
...Para fazer compras	☐	☐	☐	☐	☐	☐	☐	☐
...Para o lazer	☐	☐	☐	☐	☐	☐	☐	☐
...Para visitares amigos e familiares	☐	☐	☐	☐	☐	☐	☐	☐
...Para participares em actividades desportivas	☐	☐	☐	☐	☐	☐	☐	☐

* 6. Num dia normal, qual é o seu tempo de viagem habitual para suas atividades diárias?

	Menos de 10min	10min- 20min	20min- 30min	30min- 40min	40min- 50min	50min- 60min	Mais de 60min	Nao aplicavel
Para o local de trabalho	☐	☐	☐	☐	☐	☐	☐	☐
Para vender no mercado ou na rua	☐	☐	☐	☐	☐	☐	☐	☐
Para escola ou universidade	☐	☐	☐	☐	☐	☐	☐	☐
Para fazer compras	☐	☐	☐	☐	☐	☐	☐	☐
Para o lazer	☐	☐	☐	☐	☐	☐	☐	☐
Para visitar amigos ou familiares	☐	☐	☐	☐	☐	☐	☐	☐
Para participar em actividades desportivas	☐	☐	☐	☐	☐	☐	☐	☐

* 7. Sabes conduzir bicicleta?

- ☐ Sim
- ☐ Nao

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4. TU E A BICICLETA

Nesta secção iremos te perguntar sobre os atributos que te influenciam para o uso da bicicleta

* 8. Qual das afirmações abaixo melhor descrevem a sua relação com a bicicleta?

- ☐ Eu uso a bicicleta diariamente e nunca considere em parar usar a bicicleta para as minhas actividades diárias.
- ☐ Eu uso a bicicleta regularmente (pelo menos 3 vezes por semana) para as minhas actividades diárias.
- ☐ Eu uso a bicicleta razoavelmente (pelo menos uma vez por semana) para as minhas actividades diárias.
- ☐ Eu raramente uso a bicicleta, mas seriamente considero em usar para as minhas actividades diárias.
- ☐ Eu nunca uso a bicicleta mas as vezes penso em usar para as minhas actividades diárias.
- ☐ Eu nunca penso em usar a bicicleta e nem mesmo considero a possibilidade de usar a bicicleta para as minhas actividades.
- ☐ Eu já não uso a bicicleta para as minhas actividades diárias.

* 9. Qual foi a última vez que conduziu uma bicicleta?

- ☐ Hoje
- ☐ Nos últimos 3 dias
- ☐ Semana passada
- ☐ No mês passado
- ☐ Mais de um mês atrás
- ☐ A um ano atrás
- ☐ Nenhuma das opções acima referidas

* 10. Com que frequencia usas a bicicleta para as seguintes actividades...

	Diariamente	Trez dias por semana	Uma vez por semana	Uma vez por mes	Uma vez por ano	Nunca
...Para o local de trabalho?	☐	☐	☐	☐	☐	☐
...Para vender produtos no mercado ou na rua?	☐	☐	☐	☐	☐	☐
...Para carregar produtos de diferentes clientes?	☐	☐	☐	☐	☐	☐
...Para fazer taxi de bicicleta?	☐	☐	☐	☐	☐	☐
...Para ir a escola ou universidade?	☐	☐	☐	☐	☐	☐
...Para visitar amigos ou familiares?	☐	☐	☐	☐	☐	☐
...Para fazer compras?	☐	☐	☐	☐	☐	☐
...Para lazer?	☐	☐	☐	☐	☐	☐
...Para participar em actividades desportivas?	☐	☐	☐	☐	☐	☐

* 11. Que grau de influencia tem os atributos apresentados abaixo na escolha da bicicleta para a sua viagem urbana?

	1(Baixa influencia)	2	3	4	5	6	7(Alta influencia)
...Sua distancia de viagem diaria?	☐	☐	☐	☐	☐	☐	☐
... Os limites de velocidade permitido nas nossas estradas urbanas?	☐	☐	☐	☐	☐	☐	☐
... A sinalizacao das estradas/ semaforos?	☐	☐	☐	☐	☐	☐	☐
...As condicoes do pavimento das nossas estradas?	☐	☐	☐	☐	☐	☐	☐
... A taxa de acidentes rodoviaros nas nossas estradas urbanas?	☐	☐	☐	☐	☐	☐	☐
...O volume de carros nas estradas?	☐	☐	☐	☐	☐	☐	☐
...A iluminacao nas estradas em especial para os que pedalam de noite?	☐	☐	☐	☐	☐	☐	☐

	1(Baixa influencia)	2	3	4	5	6	7(Alta influencia)
...As actividades ao longo das estradas que usas com frequencia?	☐	☐	☐	☐	☐	☐	☐
...Sombra de arvores nas estradas que usas com frequencia?	☐	☐	☐	☐	☐	☐	☐
... A ausencia de um lugar conveniente para tomar banho e mudar de roupa depois de pedalar.	☐	☐	☐	☐	☐	☐	☐
...A ausencia de um conveniente parque de estacionamento de bicicletas	☐	☐	☐	☐	☐	☐	☐
...A oportunidade de fazer taxi de bicicleta?	☐	☐	☐	☐	☐	☐	☐
...A oportunidade de usar a bicicleta para vender produtos na estradas?	☐	☐	☐	☐	☐	☐	☐
...A oportunidade de carregar bens dos diferentes clientes que aparecem ao longo da via?	☐	☐	☐	☐	☐	☐	☐
...Teu tempo disponivel?	☐	☐	☐	☐	☐	☐	☐
...O risco de roubo de bicicletas?	☐	☐	☐	☐	☐	☐	☐
...A chuva?	☐	☐	☐	☐	☐	☐	☐
...O calor?	☐	☐	☐	☐	☐	☐	☐
...O risco de queda ou acidente?	☐	☐	☐	☐	☐	☐	☐
...Os beneficios para a saude?	☐	☐	☐	☐	☐	☐	☐
...A flexibilidade do modo?	☐	☐	☐	☐	☐	☐	☐
...O conforto deste modo de transporte?	☐	☐	☐	☐	☐	☐	☐
...O custo de usar este modo de transporte?	☐	☐	☐	☐	☐	☐	☐
...O seu prazer em conduzir a bicicleta?	☐	☐	☐	☐	☐	☐	☐

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5. TU E A BICICLETA

* 12. Quando conduzes bicicleta, que importancia das aos atributos assegurar?

	1(Baixa importancia)	2	3	4	5	6	7(Alta importancia)
...Os limites de velocidade permitido nas nossas estradas urbanas?	☐	☐	☐	☐	☐	☐	☐
... A sinalizacao das estradas/ semaforos?	☐	☐	☐	☐	☐	☐	☐
... As condicoes do pavimento das nossas estradas?	☐	☐	☐	☐	☐	☐	☐
.... A taxa de acidentes rodoviaros nas nossas estradas urbanas?	☐	☐	☐	☐	☐	☐	☐
... O volume de carros nas estradas?	☐	☐	☐	☐	☐	☐	☐
...A iluminacao nas estradas em especial para os que pedalam de noite?	☐	☐	☐	☐	☐	☐	☐
...Sombra de arvores nas estradas que usas com frequencia?	☐	☐	☐	☐	☐	☐	☐
...As actividades ao longo das estradas que usas com frequencia?	☐	☐	☐	☐	☐	☐	☐
...Tua media de tempo de viagem?	☐	☐	☐	☐	☐	☐	☐
Qual e o tua avaliacao geral da <u>importancia</u> destes atributos da estrada para a sua viagem de bicicleta?	☐	☐	☐	☐	☐	☐	☐

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6. TU E A BICICLETA

* 13. Quando conduzes bicicleta, qual é o teu grau dessatisfação com...

	1(Baixa satisfação)	2	3	4	5	6	7(Alta satisfação)
... Os limites de velocidade permitido nas nossas estradas urbanas?	☐	☐	☐	☐	☐	☐	☐
...A sinalização das estradas/ semáforos?	☐	☐	☐	☐	☐	☐	☐
... As condições do pavimento das nossas estradas?	☐	☐	☐	☐	☐	☐	☐
.... A taxa de acidentes rodoviários nas nossas estradas urbanas?	☐	☐	☐	☐	☐	☐	☐
...O volume de carros nas estradas?	☐	☐	☐	☐	☐	☐	☐
...A iluminação nas estradas em especial para os que pedalam de noite?	☐	☐	☐	☐	☐	☐	☐
...Sombra de árvores nas estradas que usas com frequência?	☐	☐	☐	☐	☐	☐	☐
...As actividades ao longo das estradas que usas com frequência?	☐	☐	☐	☐	☐	☐	☐
... Tua média de tempo de viagem?	☐	☐	☐	☐	☐	☐	☐
Qual é o tua avaliação geral da <u>satis</u> ficação dos atributos da estrada para a sua viagem de bicicleta	☐	☐	☐	☐	☐	☐	☐

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7. VIAGENS REALIZADAS ONTEM

Nesta secção, serás solicitado para descreveres as suas viagens realizadas ontem e igualmente serás solicitado para indicar a origem e os destinos.

* 14. De que bairro iniciou a sua viagem ontem?

* 15. Abaixo apresentamos a lista de todos bairros da cidade de Quelimane. Com base nas tuas viagens realizadas ontem, indique os bairros por onde passaste ou estiveste, indique também a correspondente hora de chegada em cada um dos bairros.

	Antes														Depois	
	das 5AM	6AM	7AM	8AM	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM	5PM	6PM	7PM	das 8PM
17 de Setembro	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1 de Maio, A ou B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
24 de Julho	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
25 de Setembro	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3 de Fevereiro	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7 de Abril	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Acordos de Lusaka A ou B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Aeroporto	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bairro Novo	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bazar	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Brandao	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Chirangano	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Chualo Dembe	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Coalane I ou A ou B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cololo	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	Antes das 5AM 6AM 7AM 8AM 9AM 10AM 11AM 12PM 1PM 2PM 3PM 4PM 5PM 6PM 7PM														Depois das 8PM
Filipe Samuel Magaia	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Floresta A ou B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Gogone	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Icidua	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Inhangome	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ivagalane	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Janeiro	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kansa	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Liberdade	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manhaua A ou B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mapiazua	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mborio	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Megano	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Micajune A ou B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mirazane	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Moropue	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Namuinho	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Piloto	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Popular	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Saguar 1 ou 2	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sampene	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Samugue	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sangariveira	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Santagua	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sinacura	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Torrone Novo ou Velho	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

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8. CARACTERÍSTICAS SOCIO DEMOGRÁFICAS

Esta é a última seção desta pesquisa. Aqui, você será solicitado a fornecer informações sobre suas características sócio-demográficas.

Lembre-se de enviar este inquerito para poder participar do sorteio, você pode ser o vencedor de um cheque de 2.000,00Mts.

* 16. Qual é o teu ano de nascimento?

17. Tu es o chefe da tua família?

☐ Sim

☐ Nao

* 18. Por favor, deixe nos saber o sexo e a idade de cada pessoa que vive em sua casa (incluindo você)

	Masculino	Femenino	Abaixo de 16 anos de idade	16-19	20-29	30-44	45-59	60 anos de idade ou acima
Tu/ voce	☐	☐	☐	☐	☐	☐	☐	☐
Parceiro/parceira	☐	☐	☐	☐	☐	☐	☐	☐
Crianças (dependentes)								
1	☐	☐	☐	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐	☐	☐	☐
Adultos 1	☐	☐	☐	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐	☐	☐	☐
Outros	☐	☐	☐	☐	☐	☐	☐	☐

19. Quantas Pessoas viajam contigo diariamente?

	Apenas 1	Entre 1-5	Entre 5-10	Mas de 10	Nao aplicavel
Crianças	☐	☐	☐	☐	☐
Mulher grávida	☐	☐	☐	☐	☐
Pessoas idosas	☐	☐	☐	☐	☐
Pessoas com deficiência física	☐	☐	☐	☐	☐

* 20. Qual é o seu nível de formação acadêmica?

- ☐ Nível primário
- ☐ Nível secundário
- ☐ Nível universitário
- ☐ Outros

21. Tens carta de condução?

- ☐ Sim
- ☐ Não

* 22. Qual é o teu status de emprego?

- ☐ Governamental
- ☐ Sector privado
- ☐ Auto emprego
- ☐ Emprego ocasional
- ☐ Estudante
- ☐ Pensionista
- ☐ Desempregado

* 23. Qual é o teu rendimento líquido mensal(Mts/mes)

- ☐ Abaixo de 3.642,00Mts
- ☐ Entre 3.643,00Mts-10.400,00Mts
- ☐ Entre 10.401,00Mts- 25.000,00Mts
- ☐ Entre 25.001,00Mts- 35.000,00Mts
- ☐ Acima de 35.000,01 Mts

IDENTIFICACAO DE VARIÁVEIS EXPLANATORIAS PARA O CICLISMO NA AFRICA SUB-SAHARIANA.
CASO DE ESTUDO DE QUELIMANE_MOCAMBIQUE

9. MUITO OBRIGADO

Você terminou a pesquisa!

Fique atento a "RADIO QUELIMANE FM" no dia 25 de setembro de 2017 para descobrir se o número da pesquisa é o VENCEDOR do Prêmio Mensal 2.000,00Mts.

24. Se tiveres alguns comentários ou observações, teremos todo agrado em recebê-los.

25. (Opcional) Se quiseres receber os resultados desta pesquisa por favor envie-nos o seu e-mail.

Questões, dúvidas, contacte-nos através do email:
classio.joao.mendate@alumnos.upm.es

MUITO OBRIGADO PELOS SEUS COMENTÁRIOS!

11.3. COMPILATION OF PHOTOGRAPHS

Road infrastructure challenges, job location, and type of cyclists

a) Road infrastructures

- Road pavement quality

Paved and well-maintained roads- Inner-city	The typical transition between the inner city and city-periphery

Unpaved roads - City periphery	Poorly maintained roadsides-City periphery

- Street Lighting

Fully lit streets- Inner- city

Not lit streets- Inner city

Fully lit streets- City periphery

Not lit streets- City periphery

- Street tree cover

Streets with tree cover- Inner city

Streets with no tree cover- Inner city

Streets with partial tree cover- Suburban area

Streets with no tree cover- City periphery

b) Job location (road encroachment)

- Informal markets along the main intersections

Clothes market along the roads- City periphery

Small groceries located on the walking and cycling paths- Inner city

Small groceries located on the walking and cycling paths- City periphery

Street vendors on walking and cycling path- City periphery

c) **Groups of cyclists**

- Ordinary cyclists (main bicycle corridors)

Avenue Julius Nyerere (City periphery)

Mercado do Lixo (City periphery)

Avenue Herois da libertacao Nacional–
Mercado central (Inner city)

Avenue Eduardo Mondlane (City
periphery)

- Livelihood cyclists
 - i) Bicycle-taxis operators and passengers

Bicycle-taxi operators carrying passengers – Inner-city	Bicyletaxi operator carrying a passenger- Suburban area
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Bicycle-taxi operators carrying passenger and loads- City periphery	a Typical bicycles used for taxi activities. It has a padded cushion fitted onto the rear seat.
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ii) Selling along the roads

Bicyclists selling palm thatch roof panels-
City periphery

Bicyclist selling vegetables and coconuts-
City periphery

Group of cyclists selling coconuts- Sub
urban area

iii) Carry loads

Bicycle loaded with beer and soft drink packaging- City periphery

Bicycle loaded with steel square pipes- City periphery

Bicycle loaded with bags of flour- Inner city

Bicycle loaded with empty gallons- Inner city