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School of Transportation Sciences

Master of Transportation Sciences

Master's thesis

Promoting cycling in Kigali City: evaluating the current offer and suggesting new options for residents and visitors

Marie louise Mizero

Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences, specialization Transport Policy and Planning

SUPERVISOR :

Prof. dr. Elke HERMANS

MENTOR :

De heer Roeland PAUL

2021

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PREFACE

This master thesis has the purpose of applying the knowledge learned during the master program of transportation sciences at Hasselt University. The topic of "Promoting cycling in Kigali city: Evaluating the current offer and suggesting new options for residents and visitors" has come in mind after understanding the importance of cycling while much attention has been given to the car users in the design of the transport system. As a student at the University of Hasselt, I gained a lot of knowledge and techniques that improved my abilities as a transport researcher. Since the cycling culture in developing nations has been documented as the lowest on the planet, this work aims to contribute to this topic.

ACKNOWLEDGMENT

First, I would like to thank the almighty God for being always on my side, keeping me healthy and strong to carry out the research.

This master thesis was promoted by Professor. Dr. Elke Hermans and Roeland Paul and is the final part to achieve the master's degree in Transportation Sciences, Transport Policy, and Planning at Hasselt University, Belgium.

I could not complete this thesis if it were not for my Professors' enormous support and valuable advice. Dr. Elke Hermans and Roeland Paul guide me and help me shape this thesis's overall concept. I have to say thank you to them both for all the support and inspiration that they gave me through the entire thesis.

Finally, my thanks also go to my classmates, family and especially to all the respondents for their willingness to contribute to the success of the thesis by giving their precious time and valuable information during the fieldwork.

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LIST OF ABBREVIATIONS

EU: European Union

UN: United Nation

RNP: Rwanda National Police

NRF: National Road Fund

RTA: Road Traffic Accidents

RDB: Rwanda Development Board

RTDA: Rwanda Transport Development Agency

RURA: Rwanda Utilities Regulatory Authority

SPSS: Statistical Package for Social Science

G3D: Gasabo 3D

IMT: Individual motorized Transport

NMT: Non-motorized transport

PT: Public transport

0. ABSTRACT

Cycling as a mode of transportation in urban areas has numerous benefits for cyclists and society: it is a low-cost, low-polluting, health-improving mode of transportation. In light of these advantages, many cities worldwide are enacting policies to encourage cycling. In Kigali, however, bicycle use is limited, but there are efforts to promote cycling. By means of literature review ,a structured questionnaire and interview , Kigali residents and visitors evaluated the suitability of the city for cycling, the existing infrastructure, appropriate education, and behaviour of cyclists and drivers, perceived problems and obstacles, and perceptions of ongoing changes in the bicycle transportation system in Kigali in this study and stakeholders evaluate the cycling situation, challenges , implemented countermeasures, long term plan to promote cycling . More than half of the 130 respondents believe that bicycles are a cost-effective mode of transportation. The state should encourage bicycle use by subsidizing bicycle acquisition. Although many people recognize the benefits of cycling, it is primarily considered a recreational activity. 43.75% of the residents and 58.82% of visitors evaluated the city's cycling facilities as poor. The main perceived barriers are the city's lack of good cycling infrastructure and a sense of insecurity associated with driver behaviour.

Bicycling is a mode of urban transportation influenced significantly by land use. According to the literature review, land-use plans have a significant impact on the efficiency and attractiveness of urban cycling networks .In line with this discovery, many of the interviewees mentioned the influence of land-use policies of cycling network developments, such as generally prioritizing cyclists in city infrastructure and guidelines , furthermore infrastructure is the key for encouraging people for a certain transportation mode, and further, that infrastructure itself is highly influenced by land-use policies.

In conclusion, our research identifies both the opportunities and challenges associated with developing a better cycle transportation system in Kigali city, implying the need for a variety of policies ranging from infrastructure improvements and comprehensive transportation system planning to improving driving culture to support cyclists' sense of security.

Keywords: Active transport, Land use, Barriers to cycling, Urban cycling, Cyclist perception, Infrastructural changes

1. INTRODUCTION

Cycling has become a popular and important mode of daily transportation in many cities around the world in recent years (Buehler & Pucher, 2012). As a result, many national and local governments now promote cycling as a means of achieving a more sustainable transportation system by reducing negative environmental impacts of transportation (for example, greenhouse gas emissions for climate change mitigation) and improving the quality of life and health in their cities (Banister, 2011;European Commission, 2011). Some cities have a lot of experience planning bicycle infrastructure, while others have very little. As a result, bicycle infrastructure planning has evolved in different cities to varying degrees (Hull & Holleran, 2014). Cycling promotes health through physical activity, takes up little space, and is cost-effective, both for the direct user and in terms of public infrastructure costs.

The governments should take it as their responsibility to promote and invest in active transport. The health benefits assessment of cycling can help local decision-makers to move towards sustainable modes of transports in the city. Increasing potential awareness of the health benefits of regular cycling can encourage more people to use active transport as part of daily activities (Arsenio & Ribeiro, 2015).

Bicycles for Africa (BfA) has taken on the task of encouraging Africans to ride bicycles to promote social and economic development. Their stated mission is to "deliver high-quality bikes tailored to people's needs".It's a shift in the international community's attitude toward non-motorized transportation, coinciding with Bicycles for Africa's efforts to actively promote the distribution of bicycles

The poor's daily trip problems appear to be becoming increasingly difficult in Sub-Saharan Africa's large cities. Most of the population has no choice but to use public transportation or walk because they cannot afford or cope with the costs of operating a motor vehicle. For city dwellers, public transportation is costly, and providing a suitable service in rapidly expanding urban areas is becoming increasingly difficult due to a lack of investment. As a result, poor city dwellers walk most of their journeys even for long distances. In this context, the bicycle may be a viable option for assisting underprivileged urban residents in their daily mobility. It is less expensive than motorized transportation, but it is also faster and easier to do than walking, bicycles are generally used more in rural areas than in African cities. The low distribution of bicycles in African cities is due to various factors. Road safety issues and the difficulty of maneuvering in four-wheeled traffic are frequently mentioned, and the purchase price is too high for those with low incomes and savings potential. (Räber, 2014).

This thesis aims to identify the current situation of cycling in Kigali city. The study focused on promoting cycling, then it proposes appropriate measures to promote cycling for residents and visitors of Kigali.

1.1. Description of the study area

Rwanda is a country in East Africa, has a land area of 26,338 km^2 and with 12.6 million and a population density of 230 people per km^2. Rwanda has made significant economic progress, raising its gross domestic product from $ 753 million in 1994 to $ 7.89 billion in 2014 (Patel, et al., 2016).

This research was conducted in Kigali city, focusing on the road users mainly located in Kigali city (one of the country's five provinces) and visitors from outside Kigali.

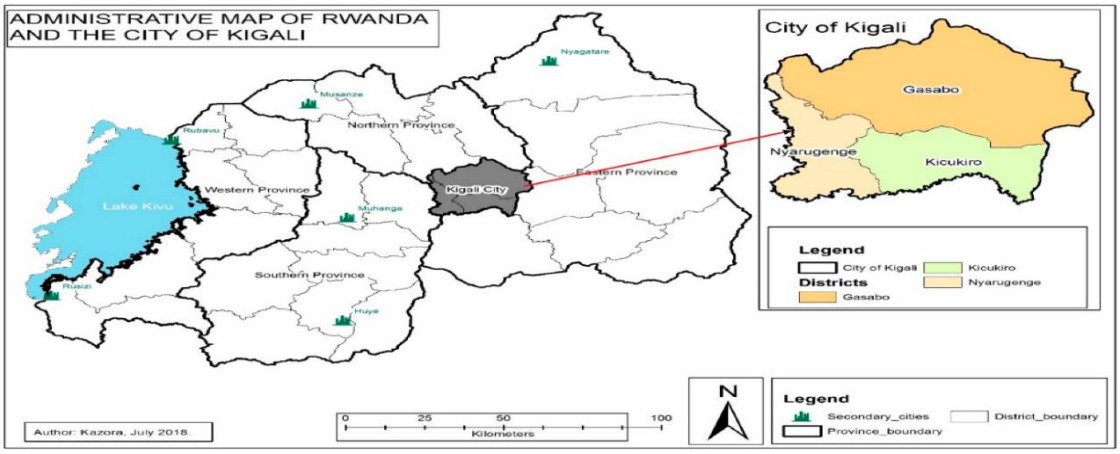

FIGURE 1 Administrative map of City of Kigali *(Kazora & Mourad, 2018)***.**

1.1.1. Background of study area

Kigali was established as Rwanda's administrative center in 1907, and it quickly grew into a major commercial center due to its central location. When Rwanda gained independence in 1962, it became the country's capital, and it has since become the country's major economic, cultural, and transportation hub (Ellison, Ang, & Nugroho, 2013).

Kigali has a tropical climate, with the lowest temperature being 15.73 degrees Celsius and the highest temperature being 26.89 degrees Celsius. The average annual precipitation is 950.9 mm; throughout the year, it rains. Slopes are generally steep, and most roads traverse along contours to ascend the slopes (Nduwayezu, Sliuzas, & Kuffer, 2016).

- **Physical characteristics**

a. Land Use

Kigali city is divided into three districts: Gasabo, Kicukiro, and Nyarugenge, with over 1.5 million people and covers an area of 730 kilometers, with a population density of 1806 per kilometer square (Kigalicity, 2018) , Land use in Kigali is officially grouped into two—urban and rural usages. Urban land use comprises 12.1% (88.40 km^2) of the total land area, while the remaining 87.9% (642.60 km2) is predominantly rural (Nduwayezu, 2015).

b. Topographic characteristics

Kigali is located at a high elevation, sprawling across four ridges and valleys, with an average elevation ranging from 1335 m to 2050 m above sea level. Kigali's terrain is an undulating landscape of steep hills punctuated by narrow elongated wetland basins that snake through the hilly, steep terrain, with an elevation variation of 715 m from highest to lowest points. Topography and steep terrain are the most

limiting natural constraints for infrastructure development in Kigali due to the city's varied elevation (OZ, EDAW, Tech, & ERA, 2007).

- **Demographic characteristics**

Kigali has a very young population, with 53.4 % of the population aged 14–35 years old, far higher than the national average (39.6%) (NISR, 2014).

- **Socio-economic characteristic**

Kigali is Rwanda's economic center, accounting for roughly 41% of the country's GDP (worldbank, 2017). In 2017, Kigali's GDP per capita was around $2,865, compared to a national average of $772 that year. The economy is primarily service-based. Promotion of Rwanda as a tourist and business destination is a key component of the government's economic development strategy. The number of visitors in Rwanda was reported at 1.7 million in 2018 (Shehadi, 2020), according to the World Bank collection of development indicators.

1.1.2. Transport modes in Kigali city

Passengers in Kigali rely on road-based modes of public transportation, including buses, minibuses, motor-bike taxis (Moto taxis), private cars, and walking. Moto-taxis is unique to Rwanda and other African cities because it is flexible, fast, and cheap. Still, they are also dangerous compared to other modes of public transportation (Zyl, Swanepoel , & Bari, 2014). There is lack of data regarding the number of bicycles as cycling is negligible in the country.

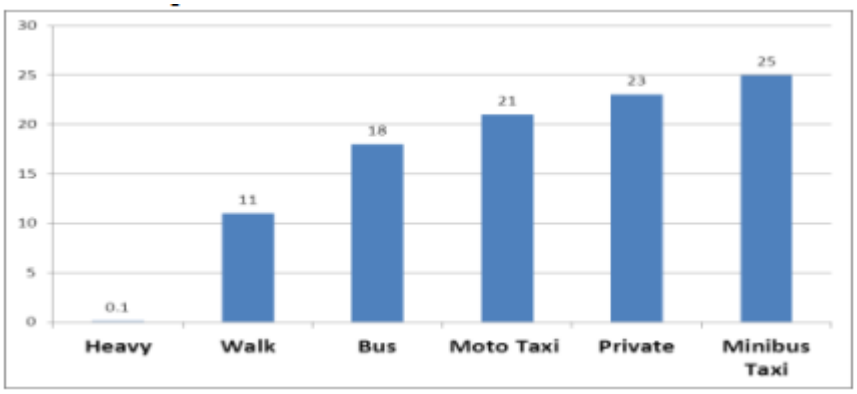

FIGURE 2 Transport mode share in Kigali city. Source: *(Zyl, Swanepoel , & Bari, 2014)*

Traffic congestion in Rwanda increases yearly due to the exponential growth of private cars and motor vehicles. Currently, Rwanda has 221,000 registered vehicles consisting of 52% motorcycles and 38% passenger vehicles of which at least 30,000 are in Kigali (Jitendra & Bower, 2020).

1.1.3. Cycling as a mode of transport in Kigali city

The Rwanda Development Board (RDB) has been working with the cycling federation to streamline activities and promote cycling tourism. Cycling events and initiatives influence tourists to stay longer and spend more money (Diana, Janene, & Michelle, 2020).

In collaboration with GURARIDE Rwanda, the City of Kigali has launched a campaign to promote non-motorized transport as a resource-efficient mode of transportation that is environmentally friendly, improves citizens' health, and is safe for users. Gura Universal Link GURARIDE Rwanda is now installing modern green mobility ridesharing docking stations across two networks as part of this

partnership (City Center and Gisimenti- Kimironko corridors). Each station has at least five bike racks (Writer, 2021).

1.2. Problem statement

Urbanization is taking place all over the world (Nkurunziza, 2013), and "cities in developing countries and emerging economies are growing by the hour. However, advancements in their transportation systems are falling behind" (Renjifo, 2016); the importance of transportation in urban areas is critical to meet the rising levels of travel demand. Resolving transportation issues has become a significant challenge for governments in developing countries.

The research conducted by Khisty, (2003) shows that transportation has been based on individual motorized Transport (I.M.T.), despite the truth that non-motorized transport (N.M.T.) and public transport (P.T.) represent a significant proportion of all journeys in urban areas and offer viable alternatives to most motorized trip especially in rural areas (Nkurunziza, 2013). The road cross-sections are not standardized; therefore, many of the roads in Kigali do not have separate pedestrian and cycle paths. In addition, there is a limited cycling network in the city.The cyclists's safety is jeopardized because of this.

One of Kigali's transportation infrastructure problems has been identified as a lack of protected sidewalks for pedestrians and cycle paths for cyclists (Minifra, 2012). Kigali currently has a few stretches of road with formal pedestrian walkways. Poor road markings and unsignalized intersections also harm pedestrian and cyclist safety. There are few cyclist underpass or overpass constructions in the entire country (Litman, 2018).

Rwanda has put in a lot of effort to organize transportation, including Kigali. The rise of car ownership is one of Kigali's most pressing challenges. In cities with limited public transportation options, the car often becomes the only mode of transportation used daily. According to Kigali household surveys, the number of vehicles is increasing rapidly (almost 12% per year) (Jitendra & Bower, 2020) . There is currently an issue of congestion at the existing bus terminals in Kigali City. If vehicular traffic is not well managed, Kigali will experience major traffic congestion in 2025, making it difficult and costly to resolve (Mbereyaho, Dushimimana, & Nzapfakumunsi , 2018).

Furthermore, the topography makes it difficult to build new roads, and the city lacks adequate land to widen existing roads easily. The road gradient for cycle paths should not be greater than 5% (Niyonsenga, 2012). Establishing a comprehensive and continuous cycling network on Kigali's hilly terrain will be difficult. The city is built on ridges and valleys, and traversing these may be difficult for bicycles, especially if not well integrated with public transport.

The costs of building new transportation infrastructure will rise over time, and cycling infrastructure requires significant investment to support better transit initiatives. Because Rwanda is a developing country, it may require additional funding for transportation projects.

Air pollution is also an issue in Kigali City. The shift to motorized vehicles has boosted greenhouse gas emissions, with the transportation industry being one of the primary sources of air pollution (Mbereyaho, Dushimimana, & Nzapfakumunsi , 2018). By providing pedestrian and bicycle corridors, the city can become less dependent on motorized transportation.

As a result, the transportation master plan should actively promote public transportation and non-motorized transportation as a viable alternative.

1.3. Objectives

The main objective of this research is to evaluate the cycling situation in Kigali city and identify cycling factors that promote cycling. The study focuses on assessing new suggestions for road users to support cycling in Kigali.

Specific objectives

1. To identify how cycling policy contributes to sustainable transport in Kigali city.
2. To identify the current cycling use in Kigali city
3. To analyze the characteristics that influence residents' and visitors' choice for a bicycle
4. To assess how land use and other factors affect cycling
5. To formulate recommendations to increase the usage of cycling in Kigali

1.4. Research questions

This study responds to the following research question:

How may cycling be an opportunity to contribute to a more sustainable city? The case of Kigali, Rwanda

This research question is divided into these sub-questions:

1. How cycling policy contributes to sustainable transport in a city?
2. What is the current cycling use in Kigali?
3. What are the relative characteristics that influence people's choice of trips, particularly cycle trips?
4. How do land-use planning and other factors affect the development of cycling?
5. Which actions can be taken to increase the usage of cycling in Kigali?

1.5. Justification of the Study

A review of cycling studies reveals that the potential for cycling in developing cities such as Kigali, where private cars and moto taxis account for a significant portion of trips, has received little attention. The study looks into the factors that encourage people to cycle in cities. This research will add to the body of knowledge and literature on cycling. The study will provide information and support to decision-makers on the potential for implementing some innovative solutions that will increase cycling acceptance in African cities, particularly Kigali. It will also provide data for further research into the possibilities of using new mobility services to improve the current public and private transportation systems, as well as change a city's cycling culture.

1.6. Significance of the Study

This master thesis will:

- Provide a treasure trove of data regarding promoting cycling
- Have a positive contribution to cycling research by encouraging policymakers to improve cycling conditions in Kigali or across the country.
- Create a foundation for future in-depth cycling research.

1.7. Methodological Framework

The methodology framework depicted in Figure 3 will be used to answer the research question. As a result, the work is divided into three sections. The first section's main task is to conduct a literature review. The second phase is data collection, which will include preparation and analysis among residents and visitors. Therefore, the survey questionnaires will be distributed randomly by using online platforms.

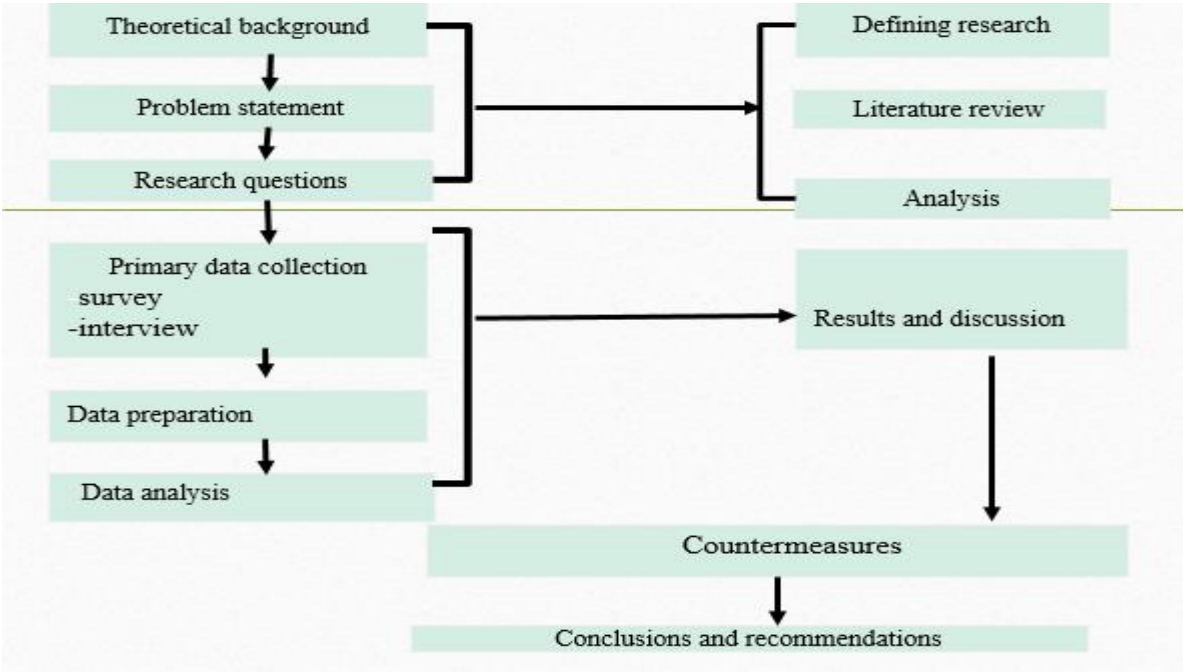

FIGURE 3 Overview of the research methodology

1.8. Study Assumptions

This research makes the following assumptions:

- The randomly selected sample of residents is representative of the entire city
- The randomly selected sample of visitors from different districts is representative of the entire City
- A structured online interview/survey is the most effective way to collect accurate data.
- Finding the current cycling use in Kigali are the best way forward to promote cycling and an opportunity to contribute to a more sustainable city.

1.9. Limitations of the study

The following limitations can be stated:

- Lack of research based scientific information regarding cycling in Rwanda
- The respondents may not cooperate in data collection
- The respondents may give answers that make them look good (social desirability)
- The existing data may not provide the required information

2. LITERATURE REVIEW

This chapter deals with scholars' views concerning the research objectives. This part of the literature successively discusses the trends of non-motorised transport around the world, cycling as smart and green mode of transportation, benefits of cycling, the health economic assessment tool (HEAT) for cycling and walking, factors to promote cycling, soft measures to promote cycling, the Es for promoting cycling, barriers of cycling, cyclists facilities, investing in cycling challenges to effective policymaking at a national level, the link between cycling and other modes and the future of cycling.

2.1. Trends of non-motorised transport

Walking and cycling make up a different % of daily trips in different countries. In car-oriented countries like Australia, Canada, and the United States, about one-tenth of daily trips are made on foot or bike. Walking or cycling accounts for more than half of all daily trips in the Netherlands. Most European countries fall somewhere in the middle, with active travel accounting for 25% to 35% of daily trips. The comparability of walking and cycling statistics is limited due to differences in national travel surveys. Nonetheless, active transportation rates in Europe are at least twice as high as in North America and Australia. (Buehler & Pucher, 2012).

In the early 1970s, active travel in Denmark, Germany, and the Netherlands was roughly comparable, at around 40 to 50%. Still, surveys show that active travel in Denmark, Germany, and the Netherlands is nearly twice that of France and the United Kingdom. More car-restrictive policies, combined with various measures to encourage walking and cycling, have resulted in smaller declines in active transportation in Denmark, Germany, and the Netherlands since the 1970s (Buehler & Pucher, 2011).

Because the national travel survey methodology changed in 2001, increasing the walk mode share by capturing previously unreported walk trips, it's difficult to gauge walking and cycling trends in the United States. The United States Census Bureau, using a consistent methodology, reports a significant drop in workers walking or cycling to work, from 7.9% in 1970 to 3.5% in 2009 (Buehler R. , 2012).

In Denmark, Germany, and the Netherlands, cyclists make up nearly every segment of society. Women make up about one-fourth of all bike trips in the United States, Canada, and the United Kingdom; women make up about half of bike trips in Denmark, Germany, and the Netherlands and cycling is gender-neutral, but men dominate it in the United States, Canada, and the United Kingdom. On the other hand, women's walking trips show little variation across countries. Walking and cycling levels vary significantly by age, but the variation is much smaller in some countries than in others.

In Denmark, Germany, and the Netherlands, the combined share of walking and cycling trips increases with age. Walking and cycling account for roughly half of all trips taken by the elderly compared to one-fifth of trips taken by the elderly in the United Kingdom and one-tenth of trips taken by the elderly in the United States. The disparities in cycling rates between countries are startling. Cycling accounts for 23% of trips taken by the elderly in the Netherlands, 15% in Denmark, and 10% in Germany, but only 1% in the United Kingdom and 0.5 % in the United States. (Buehler & Pucher, 2011)

Compared to other Asian and European countries, Africa has a very low percentage of bicycles in its transportation modes. Only about 4% of Nairobi residents ride bicycles to work, even though 47 % of

residents walk to work. In Dar es Salaam, cycling accounted for only 3% of all trips, increasing to 5% in 2007. (Pendakur V. S., 2005).

In some European cities, such as Copenhagen or Amsterdam, cyclists now account for more than 60% of all road users (Makarova, Shubenkova, Mavrin, & Boyko, 2017) . In contrast to developed countries, most African countries appear to prioritize investment in transportation facilities and policies for the minority who can afford motorized transportation over the needs of non-motorized transport users. For example, only 10% of African countries (such as Nigeria, Kenya, Ghana, Uganda, and Tanzania) have developed policies to promote non-motorized transportation compared to 64% in Europe (FiA, 2016) .

There have been some efforts and initiatives in Africa to promote cycling, but they are insufficient. Cycling is promoted at the University of Nairobi, for example, through a bike-sharing program (LAB, 2020). One bicycle purchased in Ghana is donated to a student in a rural community through the Ghana Bamboo Bikes Initiative (Whiting, 2020) . In Nigeria, university students use AwaBike, an android-based bicycle-sharing application, to search for available bicycles, make payments, unlock bicycles, and lock them after use (Kanife, 2019).

The challenges of non-motorized transport in Africa, particularly in Sub-Saharan Africa, leave a lot to be desired. The needs of cyclists and pedestrians are frequently overlooked, putting them in danger. They account for a sizable proportion of traffic accident victims. More than half of Tanzania's capital, Dar es Salaam, uses non-motorized transportation. Still, there is some apprehension about riding bicycles in the city because of the risk of road accidents caused by speeding motorized traffic (Pendakur S. V., 2005). According to a study conducted by Damasere-Derry & Bawa, (2018) in three northern Ghanaian cities, 58 % of all cyclist injuries and fatalities were due to no apparent fault on the cyclists' part. According to the authors, 64% of fatal cyclist accident victims were not at fault in their crashes. These findings highlight the vulnerability of cyclists in the majority of developing countries.

Cycling and walking are the most common modes of non-motorized transportation in developing countries, with walking being the most common mode of transportation in most cities. Cycling, which is the subject of this research, also meets the mobility needs of cities in Europe and developing countries, particularly in Asia. However, recent trends in some Asian cities have seen a decline in cycling due to rising economic levels and associated motorization and changing social perceptions that view cycling as a poor person's mode of transportation (Tiwari, 2008). But, due to transport and land-use policies that favor non-motorized and public transportation facilities, bicycle ownership, and use are high in developed countries, particularly the Netherlands, Denmark, and Germany (Choudhary, Joshi, & Singh, 2018).

2.2. Cycling as smart and green mode of transportation

Walking and cycling can help achieve sustainable transportation goals by creating healthier and more sustainable communities while reducing traffic and pollution. Cities are generally confronted with congestion, air and noise pollution, and road accidents. Before deciding which cycle policies or initiatives to implement in a region, it's critical to consider the city's real problems and how cycling-related measures can help resolve these challenges (Handy, Van Wee, & Kroesen, 2014). Cycling networks and other cycling-related policies are often adopted to raise cycling levels by encouraging people to move from different modes of transportation. While the immediate and most straightforward to quantify the effect of cycle interventions is a modal shift, typically, the indirect impacts or "co-benefits" resolve cities' problems. Cycle networks and related measures should be incorporated to recognize essential quality design criteria for cycle infrastructure and networks as a link to accomplish a modal shift and the associated co-benefits (safety, directness, coherence, attractiveness, and comfort).

To better understand the significance of cycling as a sustainable mode of transportation, a brief definition is required. The European Commission's definition is widely used: "Sustainable development stands for meeting the needs of current generations without jeopardizing future generations' ability to meet their own needs." (European Commission, 2014) Given that mobility is the foundation for people to meet their needs (existential, social, etc.) by allowing them to carry out activities related to these needs in different locations, transportation is critical for meeting people's needs.

Given that sustainability necessitates balancing a social dimension of mobility with economic and ecological aspects, cycling is a very sustainable mode of transportation. It allows people to travel in an affordable, healthy, safe, resource-efficient, and environmentally friendly manner. As a result, cycling plays an important role in the long-term development of cities and metropolitan areas.

Smart mobility and smart city concepts have recently emerged to limit the problems caused by urban population growth and find innovative solutions to meet this challenge (Chun & Lee, 2015). Academics, public and private companies, and urban planners are increasingly focusing on the bicycle as a mode of transportation to improve the urban transportation system (Börjesson & Eliasson, 2012), on the other hand, cannot be considered smart unless it is also sustainable (Jeekel, 2017). Moving smartly requires efficient public transportation, a network of safe and continuous bike lanes, and interchange parking to avoid city congestion (Garau, Masala, & Francesco Pinna).

2.3. Benefits of Cycling

Cycling has many benefits (Bardi, Mantecchini, Grasso, Paganelli, & Malandri, 2019). Encouragement of its use could thus help achieve the global goals of sustainable transportation and environmental protection. Cycling has indeed great benefits and can help a society to develop. The major advantages are mainly associated with the environmental, health, economic and social impact. All benefits will be briefly discussed below.

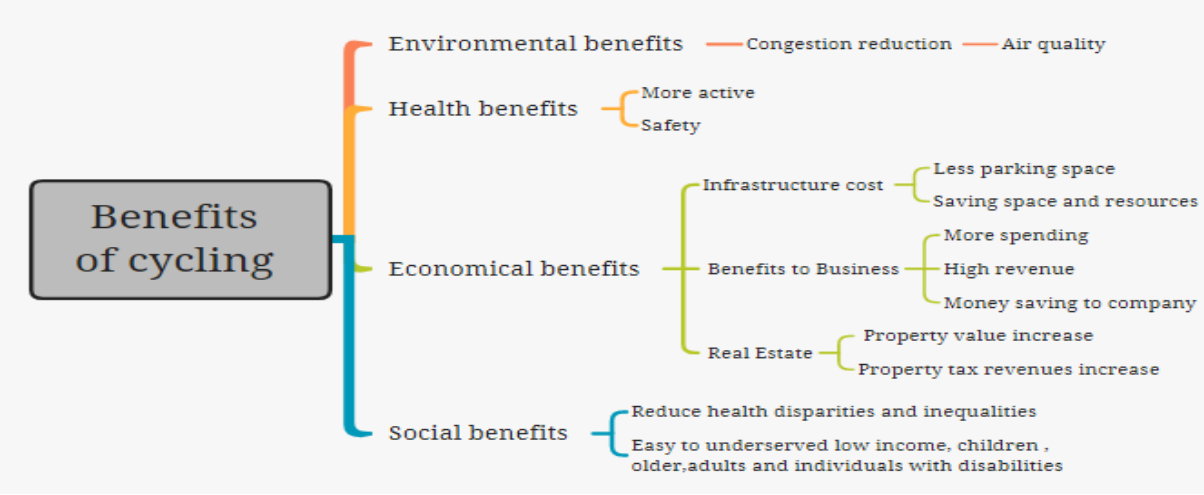

FIGURE 4 Summary of cycling benefits

Source: Own processing based on Literature Review

2.3.1. Environmental benefits

Although biking has numerous health benefits, the impact of transportation-related biking on environmental outcomes is noteworthy. Short-distance motor vehicle trips use the least fuel and produce

the most pollution per kilometer compared to long-distance trips. Cycling could potentially replace these trips. Cycling is the most environmentally friendly mode of transportation. The bicycle emits no pollutants into the environment and is virtually silent. Several studies have found that replacing short car trips with bicycle trips can reduce CO2 emissions from traffic. Reduced car travel would help to reduce ozone depletion, the greenhouse effect, photochemical smog, acid rain, and noise pollution (TRT, 2010).

i Pollution and air quality

Poor air quality and air pollution have been linked to various chronic diseases, including respiratory conditions, CVD, lung cancer, lower quality of life, and premature death (Brunekreef, Beelen, & Hoek, 2009;Pelucchi, et al., 2009;Chen, Goldberg, & Villeneuve, 2008). Furthermore, air pollution has been linked to higher healthcare costs and increased absenteeism at work and school (Pascal M, 2013; Broome, et al., 2015).

Automobiles are the primary mode of transportation for most daily trips in the United States, as they are in many other countries. Most of these vehicles use fossil fuels and contribute to air pollution; a gallon (3.89 L) of regular gasoline or diesel produces between 17 and 22 pounds (7.71–9.97 kg) of carbon, which is released into the atmosphere (Bopp, Sims, & Piatkowski, 2019). Even a small shift in automobiles to bicycles or walking could reduce gasoline consumption, affecting demand and prices. Furthermore, because many of the trips that biking could replace are short or distant (less than 5 km), a mode shift would result in even more pollution reductions when automobiles are not fully warmed up and functioning efficiently (Melissa, Dangaia, & Daniel, 2018).

ii Congestion and traffic

Vehicle traffic congestion imposes a significant time burden on people worldwide. In the United States, it was estimated in 2014 that congestion caused Americans living in urban areas to travel an additional 6.9 billion hours and consume an additional 3.1 billion gallons of fuel, a problem that has gotten significantly worse in the last 30 years (Schrank, Eisele, Lomax, & Bak, 2015). The environment is impacted by shifting travel patterns from automobiles to biking.

2.3.2. Health benefits

Cycling regularly has significant health benefits and can thus help reduce health-care costs for society. Cycling has the same health benefits as other forms of exercise and motion. 4h of cycling per week, or approximately 10 km per day, which is the equivalent of a daily cycle trip to and from work for many people, is an adequate level of exercise. Cycling benefits personal health by improving fitness and providing an enjoyable, convenient, and cost-effective exercise and recreation. When evaluating the health benefits of cycling, it is critical to consider the risks associated with riding a bike (Pospischil & Mailer, 2014).

Employees who cycle to work have 1.3 fewer sick days than those who do not. However, when comparing the growth of the population in Innsbruck from 2002 to 2011, as well as bicycle accidents according to modal split, it can be stated that despite a 6% increase in population and an increase in daily cycling journeys (2002 – 13% to 2011 – 23%), there has been a decrease in the number of accidents (figure 5). More cyclists in daily traffic are more visible to other road users, demonstrating that bicycles' traffic accidents decrease as the number of cyclists participating in traffic increases. Another reason for Innsbruck's high bicycle usage could be the city's young population. In the age group 21 to 30 years, 80% have permanent access to a bike, whereas only 24% always have access to a car.

More cyclists in daily traffic are more visible to other road users, demonstrating that the risk of traffic accidents involving bicycles decreases as the number of cyclists participating in traffic increases. (Pospischil & Mailer, 2014).

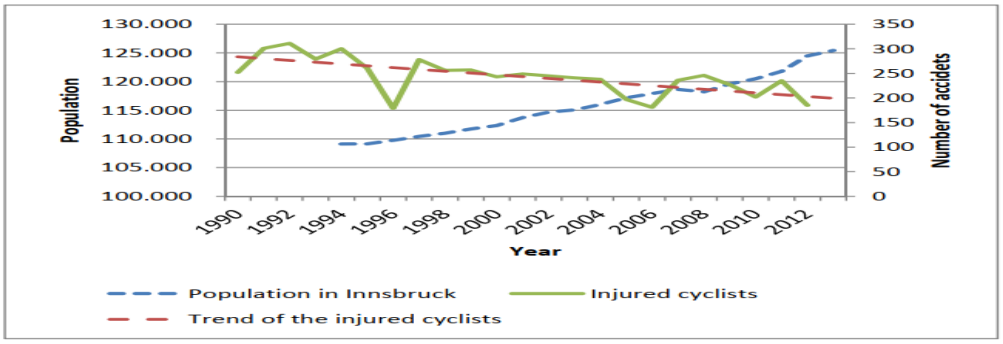

FIGURE 5 Population in Innsbruck and accidents including cyclists *(Pospischil & Mailer, 2014)*

Cycling regularly will also improve people's health. For example, a person who previously did not engage in any physical activity but now cycles 30 minutes per day regularly can reduce his/her risk of a heart attack by 50% (Motavalli, 2012). Cycling can help improve heart health. people who cycle to work have significant health benefits, such as improved cardiovascular functioning. Cycling commuters have a 52% lower risk of dying from cardiovascular disease and a 46% lower risk of developing the condition (Celis-Morales, et al., 2017).

According to (Chavarrias, 2019) cycling appears to be an effective way to lose body fat and mass. If you want to lose weight, you must eat a healthy diet and exercise regularly. Cycling can aid weight loss by increasing metabolic rate, muscle building, and fat burning. It's also adaptable to tailor the length and intensity of your workout to your specific needs. It can also provide independent transportation for those who do not have cars, especially children.

2.3.3. Economic benefits

Aside from the health and environmental benefits of biking for transportation, there are numerous other positive outcomes and associated infrastructure, policies, and programs to support biking. Direct costs (healthcare savings, time saved, and recreational benefits) and indirect costs (real estate values, biker spending, fuel savings, jobs created, and return on infrastructure investment) can all be calculated, (Bopp, et al., 2017).

The primary goal of calculating the economic benefits of biking is to provide data to decision-makers and community officials to aid in urban/transportation planning and resource allocation for infrastructure development and maintenance. Often, community transportation decisions are made without considering cost–benefit analyses for active travel and are solely based on automobile travel modes (Lawrence , 2004).

Some studies have looked at how biking affects a region. In Copenhagen, 1.4 million km were cycled per weekday in 2016, which is an increase from 1.34 million km in 2014. The city estimates that each kilometer traveled by bicycle results in a net gain of 1.20 DKK (USD 0.21/mile), whereas driving results in a loss of 0.69 DKK (USD 0.12/mile) per kilometer due to savings in public sector investment (e.g., infrastructure) and private economic sector activity (Kabell, 2016).

- **Infrastructure Cost–Benefit Analysis**

Communities frequently invest in infrastructure and support to encourage biking, which results in additional benefits such as lower healthcare costs, improved air quality, increased revenue for local businesses, and increases in real estate values. The benefits of infrastructure investment are frequently difficult to quantify; a review by (Cavill, Kahlmeier, Rutter, Racioppi, & Oja, 2008) noted a lack of well-designed studies to recognize the positive outcomes associated with investment fully, and many studies combine walking and biking.

Cycling parking takes up far less space than parking a car, 10 bicycles can be parked in the same space as one car. The space consumption of a parked bicycle has been calculated to be only 8% of that of a car (Paraskevi, Thomas, Stilianos, & Georgios, 2018). Which is especially advantageous when most cars are parked for 23 hours a day and parking near amenities like train stations or shopping malls is notoriously scarce. Cycling is the quickest and most flexible mode of 'door to door' travel for short distances, especially in congested cities. A typical car park is more expensive to construct than a bicycle stands to manufacture and install (Dekoster & Schollaert, 2010).

A cycle path requires less than half the width of a road in the inner city, is more environmentally friendly, and is more acceptable for the townscape. Cycling contributes to sustainable transportation by saving space and resources. The space required to transport one person by bike is only one-tenth of the space used per person in a private car on average (Pospischil & Mailer, 2014).

The European Community has developed a strong interest in the subject. According to the European Commission's green paper, more funds should be allocated to adequate bicycle infrastructure. The EU has continued to promote cycling initiatives through the annual European Mobility Week and Important co-financed projects, such as BYPAD and SPICYCLE, have also aided many cities in implementing bicycle sharing programs, providing cycling infrastructure, and promoting cycling (European commission,2021).

- **Benefits to Business**

Several studies have found that customers who arrive by bike visit commercial areas more frequently than other modes of transportation and often spend more, resulting in higher spending during a given time (Kelly, et al., 2013).

People who walk or bike to a commercial area spend more money per month than those who drive to the area. The removal of on-street parking is often thought to have a negative impact on business. Still, studies show that adding facilities like bicycle racks and lanes can boost economic activity while also providing a buffer from moving traffic that benefits pedestrians and bicyclist activity. Finally, bettering bicycle and pedestrian infrastructure may positively impact property values. Homes near bike paths have been found to sell for more money, and areas promoting walkability and attracting pedestrians have higher rents, revenues, and resale values.

Private companies that encourage their employees to ride bicycles save money because they are healthier and do not get sick as often as those who do not. Furthermore, private businesses will benefit because they will have to provide fewer parking spaces for their employees on their premises. Improvements for cyclists can become an important part of a public relations campaign. They could also be used as part of larger campaigns, particularly for businesses that rely on large crowds (e.g., cinemas and shopping malls). A cycle-friendly environment can also benefit retail establishments. Although cyclists do not spend as much money per shopping trip as car drivers, they spend more on average than car drivers because they shop more frequently. For example, cyclists spend 10% more

money than car drivers in Regensburg per year and make twice as many shopping trips (CIVITAS, 2010).

- **Real Estate**

Communities that invest in biking infrastructure expect significant regional benefits, ranging from reduced traffic or congestion to expanded opportunities for leisure time. (Railyards, 2017) discovered that the additional benefit of these investments is that they frequently increase property values for owners, which benefits communities by increasing property tax revenues. These returns on investment frequently help offset or completely pay for infrastructure and assist with upkeep and maintenance (CIVITAS, 2010).

2.3.4. Social benefits

When discussing the health benefits of cycling, it is important to remember that health does not only refer to physical health. Health can also be defined in terms of psychological health, such as happiness and a sense of community. Cycling can serve as a bridge for bonding and making new friends, increasing the social satisfaction of people's lives (Silvennoinen, 2017).

By expanding the network of available paths and improving road crossings, biking provides travel options for those who may be unable to travel by other modes (e.g., underserved, low-income, children, older adults, and individuals with disabilities). This increase in mobility leads to greater social inclusion. Furthermore, bicycling may be an effective way to reduce or eliminate health disparities and inequalities (Bopp, Sims, & Piatkowski, 2019).

More bicyclists mean a shift in overall travel behavior, resulting in fewer cars on the road during rush hour and fewer car–car and car–bicyclist collisions. As described in the following paragraphs, this also means slower traffic and less danger for those above potentially vulnerable populations. Biking rates that are higher can help communities gain support and momentum to invest in bike-friendly infrastructure and policies in the future (Macmillan, et al., 2014).

2.4. Health economic assessment tool (HEAT) for cycling and walking

Active transportation is frequently undervalued because it is difficult to quantify. People who walk or cycle have a low social status in many countries. Fitness, public health benefits of active transportation, enjoyment of walking and cycling, and improved mobility options for non-drivers are often overlooked or undervalued by planners. The health benefits of active transportation are not considered in the economic evaluation of transportation policies and projects (Fishman, Garrard, Ker, & Litman, 2011). Therefore, transportation planners ignore the benefits of active transportation. Any assessment that fails to recognize the benefits of active transportation undervalues the community's value of active transportation programs.

To address this problem, it was important to develop practical tools for a more comprehensive evaluation of active transport benefits, including public fitness and health benefits. WHO developed HEAT tools to facilitate evidence-based decision-making with the aim of creating economic arguments to advocate investment in transport policies that promote active transport (Kahlmeier, et al., 2014).HEAT enables economic assessment of the health benefits of walking or cycling by estimating a value for the reduced mortality that results from specified amounts of walking or cycling at the population level. The tool can be used when planning new cycling or walking infrastructures to calculate the economic value of the

10 reduced mortality when compared to past and/or current levels of cycling and walking. Furthermore, it can aid in developing more comprehensive economic appraisals and provides input for assessing the health impact of these new infrastructures (Pérez, et al., 2017).

2.5. Factors to promote cycling

Travel-related infrastructure, end-of-trip facilities, transit integration, promotional and other programs, bicycle access, and regulations are possible cycling promotion strategies (Pucher J. , Buehler, Bassett, & Dannenberg, 2010). Policymakers can benefit from guidance on which of the potential strategies is most likely to increase cycling and to what extent. In general, research can help provide such guidance in two ways. First, cross-sectional studies that compare people or places can identify key factors associated with higher levels of transportation cycling. Training programs, for example, could make sense if the bicycling ability is a significant factor. Second, studies comparing cycling before and after implementing strategies assess their effectiveness, which communities can use to improve or expand their strategies, or that other community can use to justify their adoption of these strategies. Such research is especially important for new strategies developed through trial and error. A policy approach based on evidence can help avoid squandering limited resources and failures that undermine public support.

The number of studies examining key factors associated with transportation cycling has increased rapidly in recent years, paralleling cities' interest in increasing transportation cycling.

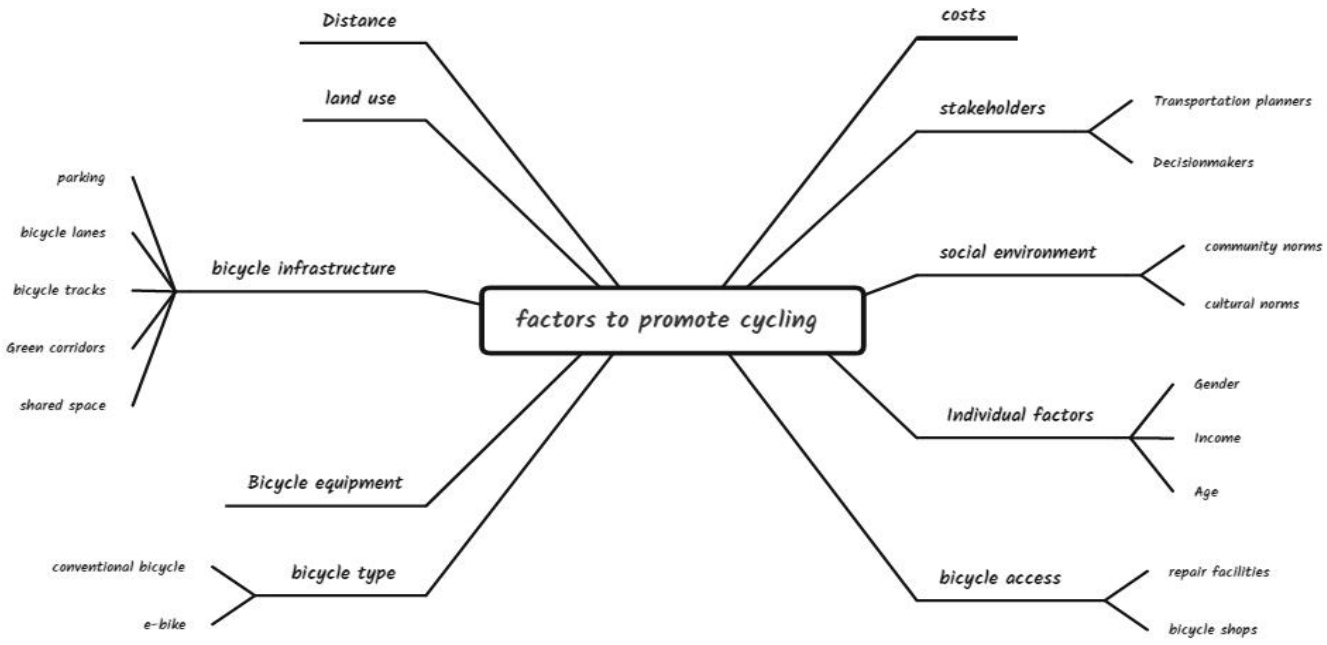

FIGURE 6 Summary of strategies to promote cycling

Source: Own processing based on Literature Review

2.5.1. Distance

Distance is one of the most consistent factors that has emerged from existing research: longer distances to work or other destinations make cycling less likely likely (Handy & Xing, 2011;Buehler & Pucher,

2012); (Heinen, Maat, & Wee, 2013). Distances reflect land use patterns, including the density of development and land use mixing, sometimes measured instead of distances. A possibility that has yet to be investigated is whether the effect of distance is nonlinear. For example, distance on cycling may be positive over short distances because longer distances mean more exercise. Given physical exertion limits, each additional distance increment may have a larger negative effect on cycling than other modes over longer distances (Handy, Van Wee, & Kroesen, 2014).

2.5.2. Bicycle infrastructure

Many studies also show that the availability of bicycle infrastructure is associated with increased cycling for transportation. These studies frequently measure infrastructure in miles of bicycle lanes or bicycle facilities, while some include parking and other worksite facilities (Heinen, Maat, & Wee, 2013). The bicycle is an essential and strategic mode of transportation in an urban area. In cities, bicycle infrastructure includes bike lanes with specific pavement, bike tracks, green corridors, shared spaces, cycling policies, campaigns, and cyclist-friendly traffic restrictions (Marchettini, Brebbia, Pulselli, & Bastianoni, 2014).

Cycling infrastructure is a problem that should not be tackled alone. Infrastructure development is a part of a more extensive set of policies that deal with urban planning and public political awareness. Cycling infrastructure takes space away from cars, which impacts traffic flow. Thus, the policies of promoting cycling belong to the broader approach of restricting cars and decreasing speeds. Since it is not feasible to build cycling infrastructure across the city, a cycling policy might be focused on strategies and implementations to alter low-speed neighbourhoods. In this situation, the bicycle is the key transport mode.

Municipal governments around the world are increasingly promoting bicycling as a mode of transportation to help alleviate traffic congestion, reduce pollution, and promote active lifestyles (Keall, 2015) , However, in many North American cities, the lack of cycling facilities, such as painted bicycle lanes and on-street but physically separated cycle tracks, is a major deterrent to population-level bicycling adoption (Pucher, Buehler, & Seinen, 2011) As a result, many municipalities in the United States and Canada have adopted policies to encourage bicycling. They have invested in building cycling facilities (Buehler & Pucher, 2012)

2.5.3. Bicycle access

Cycling requires having access to a bicycle, and studies show strong links between bicycle ownership and bicycle use (Buehler & Pucher, 2012). Bike-sharing (also known as cycle-hire) programs have expanded access to bicycles without requiring ownership (Susan A. Shaheen, 2012). Studies of these programs tend to focus on who uses them and for what purposes, but some have attempted to quantify their impact on overall cycling levels (John, Dill, & Handy, 2010).

Access to other types of infrastructure, such as bicycle shops, repair facilities, or air pumps, has not been considered. Aggregate studies focus on general availability rather than specific trips along the route. Route choice studies provide evidence on various types of facilities (e.g., bike lanes vs. paths vs. cycle tracks). However, it is important to note that these studies generally measure the preferences of existing cyclists rather than their ability to entice new cyclists (Broach, Dill, & Gliebe, 2012).

2.5.4. Bicycle type (Potential of electric bikes)

Electric-assist bicycles (e-bikes) are bicycles that "have a small electric motor that provides pedal assistance and allows riders to accelerate, climb hills, and overcome wind resistance more easily than manually powered bikes" and are "similar in geometry to human-powered bicycles." (MacArthur & Kobel, 2014).

E-bikes are a more competitive alternative to the private car because they are faster than mechanical bikes, allowing for longer distance cycling. They also make cycling in hilly terrain and with heavy loads easier. E-bikes, particularly in densely populated urban areas with numerous intersections, assist cyclists who must restart their journey after waiting at stop signs and traffic lights. Seniors and long-distance commuters appear to be the most likely customers for E-bikes. Overall, e-bikes are a promising technology for lowering external transportation costs, such as traffic noise and pollution (Jochem, Doll, & Fichtner, 2016). E-bikes may also help increase accessibility for people who are unable or unwilling to use traditional bicycles (e.g., elderly cyclists and people with physical limitations) (Jones, Harms, & Heinen, 2016).

The Netherlands and Belgium experts emphasized the growing popularity of e-bikes among all age groups and for various trip purposes. E-bikes, to some extent, replace mechanical cycling, but they also open new markets that did not previously exist, putting people on bikes who had never cycled before.

Furthermore, studies show that E-bikes use far less energy, costs, traffic noise and emit far less pollution than motorcycles and cars, contributing to overall transportation sustainability (Wolf & Seebauer, 2014; Jochem, Doll, & Fichtner, 2016). Despite the growing popularity of e-bikes in recent years, there has yet to be a study investigating how cyclists and e-bikers differ in route choice behavior and perception of the routes they choose. Understanding the differences in usage between bikes and e-bikes may lead to the adaptation of existing bike trail networks and influence the planning of new bike trails and urban transportation policies (Rose, 2012).

Conventional bicycling provides health benefits through physical activity (Götschi, Garrard, & Giles-Corti, 2016), which outweigh the risks of air pollution and traffic crashes from a public health standpoint (Mueller, et al., 2015). Similarly, because e-biking is an active mode, positive health effects from physical activity can be expected; however, net impacts may differ from traditional bicycling due to lower intensity of activity and potentially different travel patterns.

According to (Heinen, Maat, & Wee, 2013), numerous factors influence whether people use bicycles for utilitarian trips. As a mode of urban transportation, cycling has many advantages, but it is only suitable for moderately athletic people who live in flat areas. In hilly areas and for people with limited physical endurance, riding a bike for utilitarian purposes is unattractive. Cycling becomes more accessible to a wider audience and a viable mode of urban transportation, even in hilly areas, thanks to pedal-assisted e-bikes (DeMaio, 2009;Parkes, Marsden, Shaheen, & Cohen, 2013;Shaheen, Guzman, & Zuang, 2010).

According to the European Commission's White Paper on Transport (European commission, 2011), by 2050, only electric vehicles will be circulating in cities, with the use of conventionally fueled vehicles halved by 2030. Until 2030 and 2050, transportation-related greenhouse gas emissions are expected to be reduced by 20% and 70%, respectively (for 2008 levels). Electric bikes (e-bikes) may contribute to decarbonisation if the ambitions and goals are met.

Several key factors contributed to the significant market growth of electric two-wheelers (e-bikes and low-speed scooters) in China, including rapid urbanization, poor air quality, and traffic problems, which led to strong regulatory support for these vehicles, as well as the deterioration of bus transportation services and advances in battery technology (Weiner, Ogden, Sperling, & Burke, 2008).

According to an online survey conducted in North America by MacArthur, Dill, & Person, (2014), e-bike owners feel safer than riding a conventional bike. (Haustein & Moller, 2016), several factors, such as cycling infrastructure, cycling norms and behavior, and existing regulations, can explain the risk differences of e-bike riding in each country context. Astegiano, Tampère, & Beckx, (2015) discovered that in the Belgian city of Ghent, e-bikes are widely used for commuting, while cars are preferred for occasional trips that occur no more than once per week. Furthermore, the same study discovered that the problems associated with traditional bikes and e-bikes were similar and were related to pavement conditions and road markings.

Fyhri & Fearnley (2015) used a sample of 66 randomly selected participants (test users) in their study and discovered that e-bikers increased their cycling (number of trips and distance travelled) in comparison to the control group for both commuting and leisure trips. Female cyclists experienced greater e-bike impacts in the number of trips (increase) than male cyclists.

The growing popularity of motorized bicycles, particularly 'e-bikes, has spawned several studies looking into who is buying them, why they are buying them, and what types of travel they are used for (Jennifer & Geoffrey, 2012).

2.5.5. Bicycle equipment

Lovejoy & Handy, (2012) described the role of bicycle equipment, including bicycles themselves, bicycle attachments (pumps, lock, helmets, bags, etc). Cycling equipment may significantly impact the feasibility, comfort, convenience, and safety, thus affecting an individual's decision to cycle.

2.5.6. Costs

While general studies of travel behavior consistently show that cost is a significant factor, few studies have examined the relationship between cost and cycling. Cycling is, of course, almost free, except the initial bicycle purchase and some ongoing maintenance costs. However, evidence suggests that the cost of alternative modes, such as parking fees and tolls, as well as financial incentives like free parking or subsidized transit passes, have an impact on cycling by making the alternatives more or less appealing (Buehler & Pucher, 2012; Handy & Xing, 2011)

2.5.7. Individual factors

Studies show that socio-demographic characteristics, such as gender, income, and age, strongly link to cycling. Furthermore, studies show that cycling ability is a significant predictor of who cycles and how often they cycle (Handy & Xing, 2011; Dill & Voros, 2007; Gatersleben & Appleton, 2007, Li, Wang, Yang, & A Ragland, 2013; Titze S;Stronegger, Janschitz, & Oja, 2008).

- **Gender**

Previous research has suggested significant differences in cycling rates between males and females across countries. Females cycle as often as males in the Netherlands, Germany, and Denmark (Ton, Duives, Cats, Hoogendoorn-Lanser, & Hoogendoorn, 2018). However, women have been found to

withdraw from cycling in countries where gender is significant to cycling (e.g., the United States, Canada, the United Kingdom, and developing countries) due to the perceived danger of riding in motorized traffic and in other cases where cultural barriers tend to masculinize women cyclists, (Buehler & Pucher, 2012, Acheampong & Siiba, 2018). Quarshie, (2004) ,his study conducted in Accra, males own more property than females. He claimed, however, that the females rode their bicycles for short distance errands rather than for work or school, as the males did. Emond, Tang, & Handy, (2009) using a binary logistic regression approach, they sought to understand how gender influences riding a bicycle in the United States. Gender and certain individual, social, and environmental factors significantly impacted bicycling behavior. The situation is similar in many parts of Africa, including Ghana's Tamale metropolis. Angie, (2017) shows that in many parts of Africa, such as rural Ghana, it is rare to see a woman cycling, says the author. According to a study co-authored by Professor Gina Porter on Ghana, this is due to male attitudes toward women cycling and many women simply do not have the time to learn to ride bicycles on top of their chores. Cycling policies fail due to their inability to address cultural issues concerning women. A disregard for cultural and social issues concerning cycling impedes its growth and results in policy failure.

- **Income**

Cycling rates are similar across income classes in developed countries like Denmark and the Netherlands. However, in most developing countries, income is important for people's decision to cycle. Bicycles are unaffordable luxuries to middle-income earners in some developing countries and towns that rely solely on foot for transportation. In contrast, bicycle users in other developing countries dislike cycling due to its association with poverty, low-tech, and a lack of innovation (Tiwari, 2008). Good policies like lowering bicycle prices, incorporating cycle infrastructure into city planning, and enforcing motor vehicle restrictions, have led to Denmark being named one of the safest and most pleasant countries to walk or cycle in (UN Environment, 2016).

- **Age**

Age has been identified as a factor in both the rate and the decision to cycle. Although children and adolescents have the highest cycling rates in almost every country, the elderly in the Netherlands, Denmark, and Germany cycle nearly as much (Buehler & Pucher, 2012). Acheampong & Siiba, (2018) mention that, people in the Tamale Metropolis shifted to motorized modes like motorcycles in their later years of life to demonstrate improved living conditions or a lack of ability to ride. According to the World Bank's urban transport strategy review: cities on the move, nearly all secondary-school students in Vietnam ride bicycles to school, while motorcycles are rapidly displacing bicycles as a mode of transportation for those aged 25 to 35. According to Rahul & Verma, (2013) a logistic regression model, older people (over 50) have a 92% lower chance of riding a bicycle in Bangalore.

2.5.8. Social environment

Only a few studies have looked into the impact of the social environment on cycling so far. Titze S. , Stronegger, Janschitz, & Oja, (2008) encouraging or informing sharing among friends or family members are examples of social influences (Bartle, Avineri, & Chatterjee, 2013). Individual behavior may be influenced by larger community cultural norms (Bonham & Koth, 2010; Daley & Rissel, 2011, Steinbach, Green, Datta, & Edwards, 2011). If cycling is seen as a common mode of transportation, residents may be more likely to cycle themselves, reinforcing the community norm. Residents may be less inclined to cycle as a mode of transportation if cycling is viewed as a child's activity or a competitive sport.

2.5.9. Land use

Land use policy for residential and service locations could be a major factor in improving cycling conditions. The most important market for bicycles continues to be short trips. As a result, the bicycle is very popular in medium-sized (Milakis, Athanasopoulos, Vafeiadis, Vafeiadis, & Vlastos, 2012) and smaller cities (Tampakis, et al., 2013) all over the world.

2.5.10. Stakeholders

Involving people in transportation planning and decision-making is a great way to increase their desire to cycle, be more cautious when using existing infrastructure, express their opinions, and contribute actively to cycling networks. This decision will lead them to understand better the current situation and a greater willingness to collaborate with other stakeholders and the municipality (Milakis, Athanasopoulos, Vafeiadis, Vafeiadis, & Vlastos, 2012) . It also helps the city develop the best solutions for the specific context. Giving specific groups –student groups, neighbourhood groups or others – an active role in planning cycling infrastructure will be rewarded by a high willingness to contribute to and identification with the results. It also demonstrates the city's willingness to improve the local cycling conditions (Le Pira, Ignaccolo, Inturri, Pluchino, & Rapisarda, 2016).

Nonetheless, public participation in transportation planning is frequently viewed as a formal, mandatory phase of the decision-making process that serves no real purpose. Stakeholders and citizens must be involved at the start and throughout the planning process to achieve consensus, transparency, and sustainability (Le Pira, Inturri, Ignaccolo, & Pluchino, 2017).

2.6. Barriers of Cycling

Despite the benefits of cycling, it has indeed some barriers as well. The major barriers are mainly associated with parking facilities, distance, weather, safety, social status, health problems, security and topology. Some disadvantages will be briefly discussed below

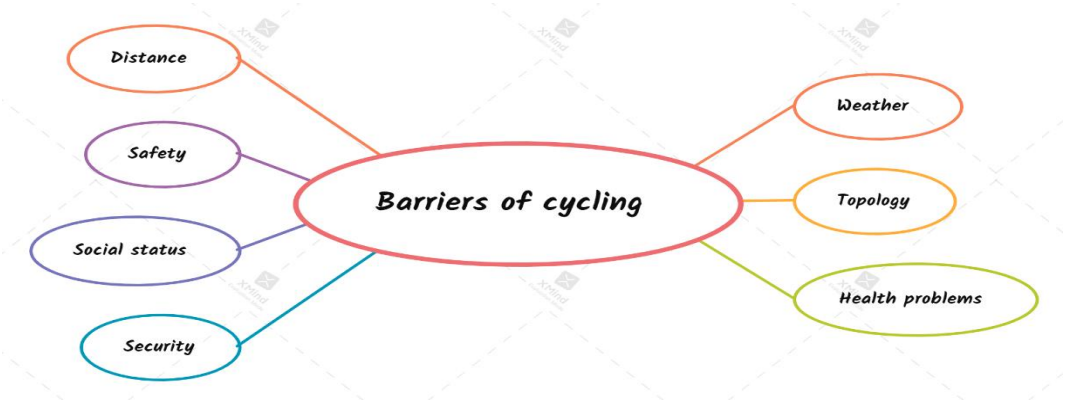

FIGURE 7 summary of cycling barriers

Source: Own processing based on Literature Review

2.6.1. Weather

Cyclists are more vulnerable to weather conditions than car drivers, so their decision to cycle is strong ly influenced by personal comfort. As mentioned in (Sabir, 201;Thomas, Jaarsma, & Tutert, 2013; Brandenburg, Matzarakis, & Arnberger, 2007;Saneinejad, Roorda, & Kennedy, 2012; Gebhart & Noland, 2014) personal comfort, and thus the impact of weather conditions on bicycle volume, varies by cyclist group (level of experience, age, gender), as well as trip motivation. Recreational cyclists are more susceptible to bad weather than commuting cyclists.

Females were more sensitive to weather conditions than males; about 70% of casual cyclists and only 30% of commuting cyclists confirmed that weather influences their riding decisions; about 90% of casual cyclists and 50% of commuting cyclists changed their bike riding day as a result of the weather; more commuting cyclists confirmed that weather influences their riding decisions; (almost 20% of cyclists changed their route as a results of weather) (Farhana, Geoffrey, & Christian, 2013).

The effect of temperature on bicycle volume was discovered to be non-linear (Miranda-Moreno & Nosal, 2011;Phung & Rose, 2007;Corcoran, Li, Rohde, Charles-Edwards, & Mateo-Babiano, 2014;Lewin, 2011; Gebhart & Noland, 2014).

When the temperature rises above a certain point, the volume of cyclists rises, but when the temperature rises above a certain point, the volume of cyclists decreases. Temperature had a negative effect on bicycle volume when it was higher than 28°C in (Miranda-Moreno & Nosal, 2011). When the temperature dropped below 15°C, Saneinejad, Roorda, & Kennedy, (2012) noticed that cyclists became more sensitive.

Phung & Rose, (2007) and Lewin, (2011) found that the ideal temperature for bicycling is 25°C, 28°C, and 32.2°C. According to research (Gebhart & Noland, 2014;Buehler & Pucher, 2012; (Meng, Zhang, Wong, & Au, 2016),the research has found that hourly bicycle volume is influenced by rainfall not only in that hour, but also in the previous three hours or the morning (Miranda-Moreno & Nosal, 2011; Gallop, Tse, & Zhao, 2012). It is beneficial for cyclists to be aware of weather forecasts for their journey. They can dress appropriately and travel by combining modes of transportation (e.g., train + bicycle, or bus + bicycle).

2.6.2. Topology infrastructure

The topography has a significant impact on bicycle use, with the maximum gradient appears to be more important than the average gradient (Menghini, Carrasco, Schüssler, & Axhausen, 2010). Nonetheless, some towns with challenging topography have a high modal share in favor of bicycles (Parki, Wardman, & Page, 2008). The urban form and urban design of spaces can directly impact cycle use; for example, dense urban development that mixes various activities and uses promotes cyclist mobility (Kemperman & Timmermans, 2009). We refer to these factors as urban form because they create more favorable conditions or a better environment for cycling.

2.6.3. Social Status

Cycling may be regarded as a child's activity or socially inappropriate for those who can afford a car. General socio-demographic characteristics of the users such as age or level of income yield different results in different studies (Dill & Voros, 2007; Pucher & Buehler, 2008). Other factors such as family size, car or bicycle availability directly relate to cycle use (Pinjari, Eluru, Bhat, Pendyala, & Spissu,

2008).A large family size or bicycle availability is associated positively with bicycle use instead of car availability. Other factors such as gender seem to be related more to cycling culture than bicycle use (Garrard, Rose, & Lo, 2008).

2.6.4. Health

Cyclists may inhale vehicle exhaust emissions. A research conducted by (Panis L. I., et al., 2010), found that cyclists inhale 400 to 900 times more particles than car passengers on the same route. The inhaled doses increased as the cycling trip lasted longer. Several studies have investigated cyclists' exposure to UFP (Ultrafine particles). Most of them took place in Europe, and exposure to larger particulate matter (i.e., PM2.5 and PM10) and other pollutants (e.g., black carbon, NO2, or noise) was frequently measured with UFP exposure. Some studies compared commuters' UFP exposure across similar routes using different modes of transportation (e.g., bus, car, or bicycle , (Okokon, et al., 2017; Ragettli, et al., 2013;Zuurbier, et al., 2010) whereas others analyzed only cyclists' exposure across different routes(Hankey & Marshall, 2015;Hatzopoulou, et al., 2013;Jarjour, et al., 2013;Peters, et al., 2014)

2.6.5. Security

When bicycle parking facilities are insufficient, there is a risk of theft or damage. Research conducted shows that New Yorkers are discouraged from riding bicycles due to a lack of bicycle parking. Lack of parking is the most important factor in people's decisions not to ride bicycles or to ride bicycles less frequently. Bicyclists may be hesitant to ride to public transportation or shop at local businesses because they are afraid of being robbed. According to some studies, the combination of facilities is critical. At schools, parking spaces were mostly found to affect cycling to school positively, but evidence is mixed. The lack of bicycle parking is often mentioned as a reason for not cycling to school (Mackie, 2010). In other studies, many respondents indicate that safer parking would encourage them to cycle to school more (Mandic, et al., 2017).

Piatkowski & Marshall (2015) found that increased concern about security and comfort, which includes bicycle parking, storage, and fear of theft, was associated with 0.37 lower odds of bicycle commuting (Piatkowski & Marshall, 2015), and (Titze S. , Stronegger, Janschitz, & Oja, 2007) found that students who were not concerned about bicycle theft were more than twice as likely to cycle to university regularly. The fear of bicycle theft can deter people from riding their bikes.

2.6.6. Safety

According to an Australian study, 0.29 crashes occur every 1000 km cycled (RG, et al., 2015) . In 2012, a Dutch study found that cyclists were involved in 31% of lethal traffic accidents and 59% of traffic accident victims treated in emergency rooms (Polinder, et al., 2016). Bicycle injuries that required hospitalization had a high mortality rate of 5.7% and a significantly high multi trauma rate of 41.0%. In a Dutch study of bicycle-related traumatic brain injuries, 4% of cyclists treated in the emergency room died in the hospital because of their multiple injuries (Scholten, Polinder,S, Pannemen, van Beeck, & Haa-gsma, 2015;Guerre, Sadiqi, Leenen, Oner, & Gaalen, 2018)

Police in the United Kingdom and the Netherlands document slightly more than 30% of crashes involving severely injured cyclists. The situation is much worse when reporting minor injuries: only 21% in the UK and almost none (4%) in the Netherlands (Wegman, Zhang, & Dijkstra, 2012). Fatal

crashes are an exception to the underreporting. This is due, at least in part, to the fact that the more severe the injury, the more likely it is to be caused by a collision with a motor vehicle, and thus the more likely it is to be documented by the police (Schepers, et al., 2014). When it comes to fatal crashes, the reporting level can be as high as 100% (U.K., Israel), but it can also be lower (86% in the Netherlands).

Safety concerns, both real and perceived, are frequently cited as a major impediment to the promotion of cycling as a mode of transportation. Crashing traffic conditions, driver behavior that ignores the cyclist's place on the road, and a lack of understanding of cyclists and individual car drivers about how to behave in shared traffic conditions make cyclists vulnerable when they interact with motorized transport on roadways (Pucher & Dijkstra, 2003).

In the United Kingdom, safety concerns are a major impediment to increased cycling. For example, parents are frequently unwilling to allow their children to cycle to school due to concerns about road safety (Alexandros, Y.T.Wang, & Cathy, 2019).

2.7. Es for promoting cycling

Generally, promoting cycling is achieved by combining the countermeasures from different perspectives. League of American Bicyclists and the Pedestrian and Bicycle Information Center recommend a multifaceted approach based on the five E's: Engineering, Education, Encouragement, Enforcement, and Evaluation & Planning (Vermont, 2018).

Education: Education involves giving people of all ages, abilities and socioeconomic status the skills and confidence to bicycle and walk. Educational programs provide the groundwork for communities/regions to begin supporting bicycling; they raise community awareness, promote safety, and often help inform motorists, bicyclists and pedestrians how to navigate the public right of way. Ensuring current and potential motorists, bicyclists and pedestrians understand and practice essential rules of the road is a crucial component of a safe transportation network.

Encouragement: To create a bicycle and pedestrian friendly community, programs and initiatives that encourage cycling and walking are essential. Providing maps, brochures, and travel guides is one way to promote and encourage cycling and walking. These materials will make cycling and walking more accessible and enjoyable. These steps can help both novice and advanced cyclists have better experiences. Another effective strategy is to emphasize the numerous advantages that cycling can provide.

Enforcement: Bicyclists, pedestrians, and motorists must all recognize and respect each other's rights on the road. User expectations are defined by rules and regulations, which reduce the risk of injury. To ensure public safety, law enforcement officers must understand these laws and regulations, know how to enforce them, and apply them fairly. Similarly, having more cops on bikes help better understand cyclists' problems. Promoting bicycling requires the involvement of law enforcement and the implementation of sound policies.

Evaluation: The ability of the region to track and measure travel behavior, safety, infrastructure condition, and project impact is critical to the planning process. The foundation of a great bicycling and walking community is a comprehensive bicycle and pedestrian plan, with dedicated funding and active support, and progress without it is difficult. Local governments and regional planners should survey non-cyclists and occasional walkers to see what changes can change their habits. Gathering and

analyzing data on bicycle and pedestrian crashes will aid planners in identifying problem areas within existing bicycle and pedestrian infrastructure so that improvements can be made quickly.

Engineering: Engineering is the process of making bicycle, pedestrian, and parking areas that are safe, accessible, and convenient. It also refers to the current bicycle and pedestrian infrastructure in a community. Engineering improvements that alter the built environment are critical components of a successful bicycle and pedestrian plan. Building a strong bicycle and pedestrian network will be critical to make these improvements cost-effective, comprehensive, and timely.

2.8. Measures to promote cycling

The main goal of soft measures is to reduce the impact of motorized traffic on residential and school districts in the inner city (Fietsberaad, 2010). This measure prioritizes cyclists by reducing travel time and distance in urban traffic. This is an excellent way to increase the appeal and competitiveness of cycling.

2.8.1. Road infrastructure and parking facilities

Investing in well-designed cycle path infrastructure promotes the potential growth of urban cycling. Many factors contribute to bicycle-friendly infrastructure, including the design of junctions, roundabouts, traffic lights, and the safety of bicycle lanes, including adequate signage.

The Dutch National Information and Technology Platform for Transport, Infrastructure, and Public Space (CROW) published the first version of a Design Manual for Bicycle Facilities in 1993, which detailed all the steps, from the decision to promote cycling to the actual physical implementation. It outlined the five most important requirements for bicycle-friendly infrastructure: improved traffic safety, directness (short, fast routes from origin to destination), comfort (good surfaces, generous space and little hindrance from other road users), and attractiveness (a pleasant, socially safe environment, without smell or noise nuisance) and cohesion (logical, cohesive routes).

The cycling network cannot be considered in isolation from other cycling facilities, such as parking areas: linked to public transportation; at home and work; in shops and shopping centers; in public offices and on streets.

The availability of safe and convenient parking is just as important for cyclists as for motorists. Still, it is frequently overlooked in the design and operation of stores, offices, schools, and other structures. Bicycle parking should be visible, easily accessible, simple, convenient, and spacious. Racks must support the entire bike (not just one wheel) and allow the user to lock the bike's frame and wheels with a cable or U-shaped lock. Parking should preferably be covered, well-lit, and visible to pedestrians and motor vehicles. Parking should also provide cycle services, especially for long-term parking, which requires more security and protection than short-term parking. Security cameras are typically installed in long-term parking facilities (Fietsberaad, 2009).

- **Opening one-way streets for car traffic to bicycle transit**

Opening one-way streets to bicycle transit is a popular way to promote urban cycling in many European cities. More than 358 one-way streets (64 kilometers of cycle paths) in Strasbourg now have two-way cycle lanes. In Belgium, similar measures have been implemented (in Brussels since 2005). Accidents in this mixed traffic circulation are decreasing year by year, according to experience. Bicyclists can avoid longer detours or dangerous roads with heavy vehicular traffic and high car speeds by using the

'limited one-way streets.' Because cyclists and motorists can see each other on a one-way street with limited traffic, visibility is improved. This means cyclists can avoid motorists' unexpected manoeuvres.

On the other hand, this measure is frequently criticized regarding cyclist safety. Cycle contraflows, as they are known in the United Kingdom, necessitate extensive road markings. Car speeds must be limited to 50 km/h, but no more than 30 km/h in most cases. Furthermore, the road must be wider than 3 m to ensure the safety of both cyclists and motorists. Finally, local governments must launch aggressive information campaigns to mitigate road rules.

- **Allowing bicycle transit in bus lanes**

Motorcycles, mopeds, scooters, and tricycles – but not those with sidecars – were allowed to travel in most red route bus lanes in London starting on January 5, 2009, for an 18-month trial. Cyclists and pedestrians' organizations have argued that this trial measure is dangerous. The Cycling London Campaign, a volunteer organization, has launched a monitoring campaign to expose motorists' dangerous behavior and document accidents. This will assist local governments in analyzing the most critical locations and determining whether this rule will be permanent.

Bus –bike lanes are a good way to promote cycling in congested cities with limited right-of-way because they don't require additional infrastructure and prioritize public transportation and cycling over other modes. Although there is no global standard design, guidelines and case studies in Europe, North America, and Australia agree that the design should reduce the likelihood of buses and cyclists colliding. Although the different mass and speed of bicyclists and buses make this bus-bike interaction probability dependent on local conditions, in general, a design that considers the cycling infrastructure inside the bus-bicycle lanes (designated lane, segregated lane, adjacent lane), the position of the cycling infrastructure along the bus lane (left or right side), and the width (wide to facilitate a safe overtaking, or narrow to avoid the overtaking) ensures bicyclist and bus safety and efficiency (Cazorla, 2017).

2.8.2. Safety

Cyclists are vulnerable to motor vehicles, and they may feel even more so when cycling conditions are poor due to a lack of cycle path infrastructure. The cyclists' subjective perception of the risk of being hit by a car. This perception could be based on personal experience with dangerous traffic situations or simply a subjective emotion. At intersections, cyclists must be visible to motorists and cyclists must be aware of cars. Bringing road users closer together is one way to increase their awareness of one another. Safe cyclists' facilities also create independence in selecting a transport mode as it becomes possible for more people including the elderly, children, families, and people with disability to travel themselves. This has necessitated significant investment in expanded and improved cycling infrastructure (TRT, 2010)

Several targeted initiatives have been developed to address these fears and their underlying safety issues: for example, Safe Routes to Schools is a package of practical and educational measures to encourage children to cycle and walk to school by improving safety throughout the journey. Reduced speeds and volumes, re-allocating road space, raising awareness of other road users, and sponsoring bicycle training/road safety campaigns are some of the measures being considered (ECMT, 2004)

When age and gender are considered, some interesting results emerge. Cycling, for example, can be safer than driving for young people (Wegman, Zhang, & Dijkstra, 2012) . Confounding factors, such as the age distribution of cyclists, can also make monitoring road safety performance indicators difficult. The rising share of older people in the pedal cycle traffic has explained some areas where cycling risk increases.

- **Reducing speed limit of cars to 30 km/h**

Many European cities reduce maximum car speeds to 30 km/h, although traffic flow rarely exceeds this in congested urban areas.

This measure aids in controlling vehicular traffic in residential and school districts and areas where a bicycle track is not available. Road humps or other barriers between cyclists and motorists, which require significant investment, become obsolete when car speeds are reduced. These traffic calming measures benefit cyclists and pedestrians in Freiburg, where 90% of residents live within a 30 km/h zone (TRT, 2010).

- **Allowing right-hand turns at red traffic lights for cyclists**

The city of Strasbourg has launched a pilot scheme that restricts right-hand turns to cyclists with dedicated traffic lights and who are permitted to turn right at red traffic lights (without committing an offense) while considering other road users (vehicles and pedestrians) who already have priority. This measure allows cyclists to cut down on their travel time by preventing them from stopping at red traffic lights when it isn't necessary (Haning, et al., 2016).

It is critical to reduce waiting for green traffic lights, particularly in the colder northern European countries. In 2007, a fascinating experiment was carried out in the Dutch province of Brabant, in the south (TRT, 2010). The idea behind this green light scheme was that cyclists would get a green light two or three times per cycle instead of just once in the rain, below 10 degrees Celsius, or with little car traffic. A rain sensor and a thermometer were connected to the traffic light system to determine weather conditions. The positive results of the experiment in Grave were decided to be implemented by provincial authorities, and many traffic lights will be modified in the coming years (Haning, et al., 2016).

2.8.3. Security

When bicycle parking facilities are insufficient, cyclists' main security concerns are fear of theft or damage and personal aggression when traveling at night. Local governments and police departments have implemented various measures; the most relevant examples come from cities in the Netherlands and Denmark (TRT, 2010)

- **Supervised parking**

In 1997, the city of Utrecht (population 270 000) established a funding system in which car parking fees are used to partially fund bicycle parking facilities, totaling EUR 750 000 per year. The costs of administration and security of bicycle parking facilities are covered by this fund, supplemented by other municipal budgets. Apeldoorn (population: 155 000) pays for the 2 800 free supervised bicycle parking spaces with revenue generated from car parking. Before introducing free supervised bicycle parking, 18% of supervised storage users said they traveled to the center by car or bus (Haning, et al., 2016).

- **Registered bicycles**

Bicycle theft has been structurally addressed by the ‘integrated bicycle theft prevention program' (2002-2006) in Amsterdam. The goal of this program was to monitor high-risk areas for bicycle theft and

break the chains of unregistered bicycles. The risk of bicycle theft in Amsterdam fell from 16% to 10% in just 5 years. The approach was expanded nationwide in 2007 with the National Bicycle Register at the Government Road Transport Agency, which keeps track of all bicycle thefts. This register has been open to the public since January 2008, and users can check whether a bicycle is registered as stolen by entering a frame or chip number (Haning, et al., 2016).

2.8.4. Intermodality

Many journeys are inaccessible by cycling or public transportation alone, as neither provides enough flexibility. In Northern Europe, public transportation systems and city planners increasingly recognize the importance of cycling as a feeder and distributor service for public transportation. There are a few key steps that could be taken to improve intermodality:

implementing bicycle sharing schemes; providing parking and service facilities at major transportation terminals in the city center (train stations, bus terminals, car parking areas, subway stations, and so on); allowing bicycles to be carried on commuter trains and providing bicycle racks on buses.

Bicycle sharing is a popular way to encourage people to ride their bikes in cities. Bicycle sharing is being implemented in various ways and through various schemes in many cities, including some where attitudes toward cycling are negative. Apart from Dutch and Danish cities, Paris, Milan, Munich, Berlin, Seville, Lyon, Strasbourg, Brussels, and Barcelona are major European cities. The concept is simple: locate enough pick-up stations near the city's most appealing points (such as subway stations, railway stations, government offices, and commercial districts) to provide commuters with various transportation options to and from work.

To design integrated transportation networks that use all modes of transportation, it is critical to improving connections between cycling and public transportation. Providing better connections between these two modes can encourage more people to ride bicycles, reducing reliance on private vehicles. Development of parking facilities at railway stations and bus/tram stops, allowing public transport passengers to board with their bicycles, and renting bicycles at public transportation and railway stations improve the interface between cycling and public transportation. Given that in the Netherlands, for example, 35 % of all train users arrive at the station by bicycle, the potential effects of such measures on both cycling and public transportation modal share appear promising. (Midenet, 2018).

2.9. Investing in cycling

Many countries' planners and politicians want to increase the proportion of trips taken by bicycle. However, this is frequently difficult. A national target of doubling cycling by 2025 in England is likely to be missed: between 2001 and 2011, the proportion of commutes made by bike barely increased. One important factor is the continued underinvestment in cycling infrastructure compared to European leaders. (Aldred, Watson, Lovelace, & Woodcockd, 2019)

2.9.1. The need for investment in cycling

Cycling infrastructure of high quality can aid in the creation of transportation systems in which people can cycle without the risk and stress of mixing with motor traffic (Pucher & Buehler, 2008). Aldred, Elliott, Woodcock, & Goodman, (2017) discovered that people under-represented in UK cycling

statistics, particularly women and the elderly, prefer to cycle on infrastructure that is completely or partially separated from motor traffic.

Evidence is mounting that constructing such infrastructure along key desire lines can boost cycling rates (Panter, Heinen, Mackett, & Ogilvie, 2016). Compared to major road upgrades and high-speed rail, cycling infrastructure is inexpensive. However, it is more expensive than the more traditional British approach of encouraging, training, and promoting cycling (Golbuff & Aldred, 2011).

2.9.2. Barriers to investing in cycling

Barriers and opportunities may arise because of multi-level governance, which involves a wide range of geographical scales and includes public and private organizations (Butterfield & Low, 2017). There is a symbiotic relationship between larger structural processes and the actions of policy entrepreneurs (Bulkeley, 2010). Policy entrepreneurs may be required early on to 'kick-start' change. Still, they may then require the support of institutional processes and transnational networks to ensure that business-as-usual (BAU) does not resume. Even when there is a clear case for change with legally binding, challenging targets, entrenched BAU may persist. Bache, Reardon, Bartle, Marsden, & Flinders, (2015) describe how the UK's ambitious and legally binding carbon reduction targets have evolved into a symbolic meta-policy with little impact on local transportation policy and practice.

2.10. Barriers to implementing sustainable transport policy

Barriers are impediments to policy implementation that limit or even prevent it. Even though several countries are making progress in promoting cycling travel, challenges remain in planning and implementing cycling promotion policies (ECMT, 2004)

2.10.1. Financial Constraints

Several studies in the United Kingdom have looked at the obstacles to pro-cycling policy adoption and implementation, highlighting a lack of funding and leadership (Marije de Boer & Caprotti, 2017), so governments find it difficult to devote a significant portion of their budget. As a result, the amount spent on cycling is very limited. The development of public transportation facilities is always a higher priority for governments. On the other hand, some cycling policy measures, such as infrastructure development, necessitate significant financial resources. (Potwarka & Bakhsh, 2020)

The growing importance of cycling in Finland has not resulted in a significant increase in financial support for cycling. Most governmental and local budgets are based on existing and ongoing investments and outcomes. As a result, new policies, such as investments in cycling, have not significantly increased their share of public funds. There is a scarcity of data on the health and environmental effects of cycling (especially in terms of costs and benefits, including external ones) and precise statistical data that could be used to communicate the benefits of cycling to the public or track the implementation of cycling policies (Küster & Kolczyńska, 2020).

Although Nairobi City (Kenya) has taken the bold step to allocating at least 20% of its existing and future road construction budget to NMT and public transportation infrastructure and services, funding for NMT interventions is almost always a concern (UN Environment, 2016). The policy commits the government to developing and implementing a public transportation strategy so that walking and cycling become a preferred mode of transportation for residents, reducing reliance on the private car.

2.10.2. Political and Institutional Barriers

Cycling policies have many goals and involve stakeholders, including transportation ministries, other national governmental bodies, and regional and local governments. Policy planning and implementation can be skewed due to a lack of horizontal and vertical coordination. In addition, a lack of national commitment, which places sole responsibility for cycling policy with local governments, can result in a lack of motivation to promote cycling, in addition to the lack of political support, it is difficult to deal with private stakeholders' disagreements on road space redistribution. The cycling lanes next to private buildings need careful and time-consuming negotiation among stakeholders to agree on a plan (Aldred R. , 2012).

Latvia mentions the lack of a national coordination body for cycling policies. Tasks are not delegated to specific institutions or authorities. As a result, cycling advocacy has largely fallen to cycling organizations and enthusiasts (Holger, 2018). France claims that the lack of a strong national policy message on cycling and a lack of commitment from the central government to cycling issues has hampered the development of cycling in the country. When local communities solely drive cycling policy, efforts to improve cycling vary dramatically from region to region and city (J. Dekoster, 1998).

Local government capacity building was limited to raising awareness, training some municipal staff, and practical experience with performing spot interventions. The institutional setup for transportation in Rwanda is fragmented. It may become a liability in the long run, possibly due to lengthy approval and processing period's and bureaucratic red tape (Ellison, Ang, & Nugroho, 2013).

2.10.3. Physical barrier (lack of space)

Road space is a common barrier to developing cycling infrastructure in many cities, especially Europe, the planners nowadays have difficulty constructing and refurbishing the cycling infrastructure when most city areas are already built up. The street space is scarce, particularly in the inner-city areas with dense population (Wang, 2018).

Furthermore, many European cities, particularly inner cities, have a compact urban structure with limited street space. Implementing cycling infrastructure in a constrained space is difficult (Gerike & Jones, 2016). There is a higher national cycling modal share in Germany than in the UK; however, car lobby groups may have a stronger influence (Sheldrick, Evans, & Schliwa, 2017).

Malta claims that its roads are generally too narrow to allow bike lanes. The desire to create dedicated bus lanes runs into the same problem. The problem has not been solved in dense urban areas. Still, it is being addressed in other areas covered by Malta's Roads Master Plan by incorporating cycle paths when existing roads are renovated or new roads are built

2.10.4. Social and cultural Barriers

Public acceptance of policy measures is linked to social and cultural barriers. Hamburg's primary social and cultural barrier is that some people are hesitant to give up on-streetcar parking space to add new cycling infrastructure. Many people are accustomed to traveling by car, and some business owners believe that their customers would prefer to do so (Wang, 2018). Another public acceptance barrier is that many people are afraid to use the newly constructed on-road cycling lanes. One interviewee in

research conducted by Wang, (2018) stated that using on-road lanes is safer because drivers can see some cyclists turning left or right more clearly at intersections, rather than cyclists suddenly appearing at intersections. However, many cyclists prefer to ride in a pedestrian area rather than in the new lanes, despite the increased conflict with pedestrians.

2.10.5. Lack of Public Awareness

Although the advantages of cycling as a short-distance mode of transportation are becoming more widely recognized, cycling is still viewed as a sport, leisure, or children's activity in many countries.

In Rwanda, pedestrians and cyclists still walk on the carriageway due to convenience and lack of safety awareness also shows that car owners do not respect the pedestrian and cyclists domain by parking over walkways and cycleway (Ellison, Ang, & Nugroho, 2013).

2.11. Future of cycling

Cycling will become even more popular in the coming years because of recent innovations. Bike sharing has existed for decades, but it is now expanding at astounding rates. From the first large-scale automated system in Lyon, France (1500 bikes) in 2005, bike sharing has grown to 1286 systems worldwide as of May 2017, with a total of 3,415,750 bikes (Fishman E., 2016; Meddin, 2017). Bike sharing significantly increases bike availability, routing flexibility, and access to and from public transportation. Bike-sharing systems are constantly improving in technology, allowing for future integration into comprehensive mobility packages such as public transportation, car sharing, and Uber-like taxi services, which provide alternatives to the private car.

Although not as dramatic as the phenomenal growth of bike sharing and E-bikes, real-time information technology for cycling has been steadily improving, providing better guidance on optimal routes, parking locations, bike-sharing locations and availability, and public transportation stops (Pucher & Buehler, 2017)

Perhaps most encouraging for cycling's future is the documented shift in cultural attitudes and preferences toward less reliance on automobiles and increased demand for living in mixed-use, compact developments in or near city centers (Goodwin & van Dender, 2013). Many European and North American city centers have experienced a revival, owing to an influx of new residents in their 20s and 30s who are more willing than their parents to walk, bike, and ride public transportation. This cultural shift in locational and travel preferences is likely to foster additional growth in cycling.

3. METHODOLOGY

This chapter explains the methodology that was used to conduct the research. It is divided into two major sections, the first is concerned with the data collection process, and the second is concerned with data analysis and interpretation.

3.1. Primary Data Collection Process

The data collection method is the most crucial aspect of any research. This study used various methods to collect as many responses as possible from the main target groups regarding the promotion of cycling in Kigali. The steps taken in this regard are depicted in the diagram below.

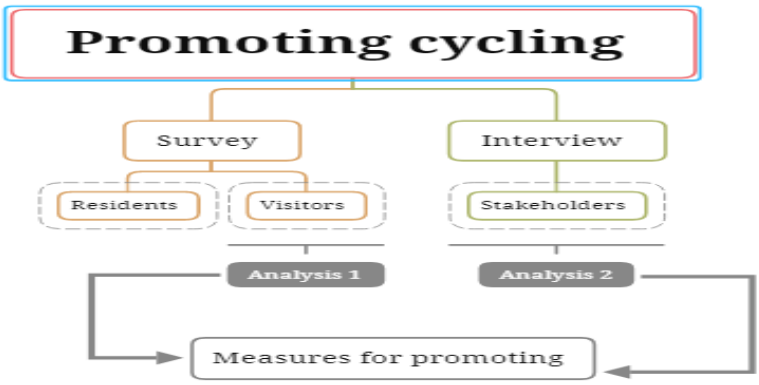

FIGURE 8 **Summarized methodological process**

Then a strategy for gathering information was planned. First, Hasselt University granted the research a permit, which aided in approaching all the institutions involved in this study. Indeed, after obtaining a Research Permit and all necessary permits to interview the stakeholders online, the survey was held online by Qualtics from February 27th January to March 20th , 2022.

3.1.1. Target group

The main target groups are inhabitants of the city and people coming as visitors. The participation was opened to all residents and visitors of the city to report on the current cycling situation in Kigali. The participants were inhabitants of the city, including students and workers and visitors of Kigali. This decision was made because the main users (residents) have the potential for cycling in the city. Moreover, this group is also supposed to have access to smartphones or computers, which can lessen their difficulties in data collection. For stakeholders were the targets to provide information on the problems they face while promoting cycling in the city.

These participants were recruited by contacting schools' representatives, commuters using car parks daily, tourism office/accommodation providers and motorcyclists' associations and spread the questionnaire on social media (Facebook, WhatsApp, and Instagram pages). The participants must be at least 18 years old due to legal constraints in Rwanda. Most of the questions were multiple-choice and rating scale questions, which allowed them to choose the best alternative in a defined list of options. Still, there were also some open-ended questions to express their opinions.

3.1.2. Online Survey tool

Survey research has an essential role in several fields when gathering primary data (Kotzab, 2005); using a survey as a strategy enables us to collect relevant data for the specific field the survey addresses. This is usually delivered using questionnaires that permit researchers to bring together standardized data that we can easily compare (Saunders et al., 2004).

The survey was conducted using a questionnaire to understand the importance of (promoting) cycling in Kigali. The survey was split into several parts. The first part gathered personal information on the survey participants. The second part contained the survey questions that deal with cycling for residents and visitors. The third part applied to the factors that could change a person's willingness to start cycling or cycle more. The last part concerned the policy measures.

The survey was conducted using a questionnaire elaborated in qualtrics. Overall survey time was estimated to be 10 minutes. The questionnaire survey was designed to be completed in less than 15 minutes to maximize response rates and limit respondents' boredom. Because many of the questions were closed, the average response time was around 10 minutes.

3.1.3. Interview

It was essential to interview local policymakers to understand how cycling regulations are implemented, interviews were conducted with RURA in charge of road performance, Kigali city in charge of defining bicycle policy goals and master plan;GURARIDE and kigali rides as public bike share companies, RNP in charge of road safety, RTDA in charge of control national road, NFR for road funding and B3D as road designer were also questioned. All questionnaires used during the current study can be found in annex 1.

3.2. Data Cleaning

Before beginning the analysis phase, the first step was to collect all the survey responses and organize them into an easy-to-manage file to ensure data quality. Because data collected directly from questionnaires may not be immediately usable for analysis, it must be cleaned, formatted, and corrected before being used. Furthermore, the most important variables that can aid in achieving the research objectives must be chosen.

3.3. Quantitative and qualitative method

Before describing the methodology, it's essential to define the difference between quantitative and qualitative methods to understand why a combination of the two has been chosen. Quantitative research focuses on numerical data that means it's variable-oriented. Thus, the linkage through multiple variables is analyzed empirically while qualitative research is case-oriented; according to this, some phenomena are described by examining why and how specific connection occurs.

Therefore, quantitative, and qualitative research has a significant difference. Punch (2014) recommends that combining both research methods is essential when analysing a specific phenomenon. Consequently, both methods' usage benefits academic research because various problems are linked with one method.

Quantitative data was helpful in the case of Kigali to provide primary data information about cycling networks and cycle users from a large set of respondents. The interview with relevant organisations represents the qualitative part. Their actions and ideas on how to further promote cycling are discussed.

3.4. Secondary data

Secondary data can give several opportunities for further developing the research through re-analysis and re-interpretation of the current study. Secondary data for promoting cycling were taken from various sources such as government publications, competitor websites, social media, Uhasselt library, journals, articles, Google trends, etc. These data are necessary because they can provide information on cycling, secondary data used for literature review in the previous chapter, previous surveys and interviews related to promoting cycling can help our analyses.

3.5. Statistical analyses

Statistical modelling, according to (Lee, et al., 2012) aids in the development and testing of theories through causal explanation, prediction, and description. Models can be used to interpret the behavior of variables using mathematical expressions. Furthermore, models with high explanatory power are assumed to have excellent predictive power. Therefore, descriptive statistics, visualisations in graphs, cross tabulation and hypothesis test will be implemented to achieve the objective in this research.

3.5.1. Test of Independence Chi-Square Test

The Chi square test is a statistical test, which measures the association between two categorical variables in this research (Garson, 2012).

4. DATA ANALYSIS

4.1. Descriptive statistics results

This chapter is about the analysis of responses collected through the questionnaire and interview, the results of the residents and visitors, and those of the stakeholders.

4.1.1. Descriptive analysis of respondents

After cleaning for erroneous or incomplete surveys, complete answers from the survey were obtained from 96 residents and 34 visitors. The graphs and tables presented below provide information about these respondents, different good practices, challenges or barriers, possible improvements and suggestions in terms of cycling in Kigali.

Table 1 lists the characteristics of respondents in general. There were 55(43.8%) male respondents while 72(56.3%) were females; with a mean age (respectively SD) of 29 years (4.204) (figure 9). With possible multiple answers, the respondents polled were living with their parents (28.46%), living with siblings (26.92%), married (24.62%), living alone (20.77%), living with children (20%), living with others (12.31%) and living with boyfriend or girlfriend (2.31%). Finally, the respondents' highest degree was mainly from university (85.4%), high school (10.8%), technical/college (3.8%), while primary and none education had no answers (0%).

TABLE 1 characteristics of respondents (n=130)

		Kigali	**Visitors(from different Rwanda districts)**	**Total**	**%**
Gender	Male	45	13	58	44.6
	Female	51	21	72	55.4
Age group	<=25 years	13	7	20	15.4
	26-35 years	79	25	104	80
	36+ years	4	2	6	4.6
Family composition		25	12		
	Parents			37	28.46
	Alone	24	3	27	20.77
	My husband or wife	24	8	32	24.62
	Children	15	11	26	20
	Siblings	29	6	35	26.92
	boyfriend or girlfriend	3	0	3	2.31
	Others	13	3	16	12.31
Education background		0	0		
	None			0	0
	Primary school	0	0	0	0
	Secondary school	7	7	14	10.8

	Kigali	Visitors(from different districts)	Rwanda	Total	%
Technical school/college	3	2		5	3.8
University level	86	25		111	85.4

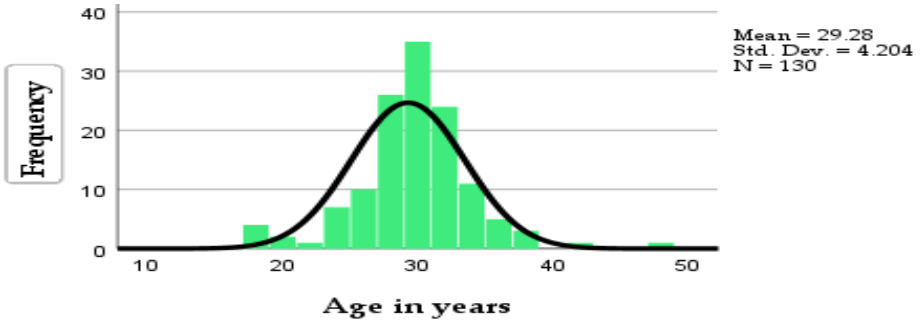

FIGURE 9 Average age of respondents (Residents and visitors)

4.1.2. Responses related to cycling behaviour

Respondents were asked how often they use a bicycle. Figures 10 and 11 represent the frequency of cycling for residents and visitors. 5% of the residents cycle daily. In comparison, 18% of visitors cyle daily, 8% of residents and 6 % of visitors cycle several times a week, 6% of residents and 15% of visitors cycle few times a week, 10% of residents and 9% of visitors cycle few times per month, 31% of residents and 20% of visitors cycle few times per year whereas 40 % of residents and 32% of visitors never cycle. By comparing visitors and residents, visitors use bicycles more than residents.

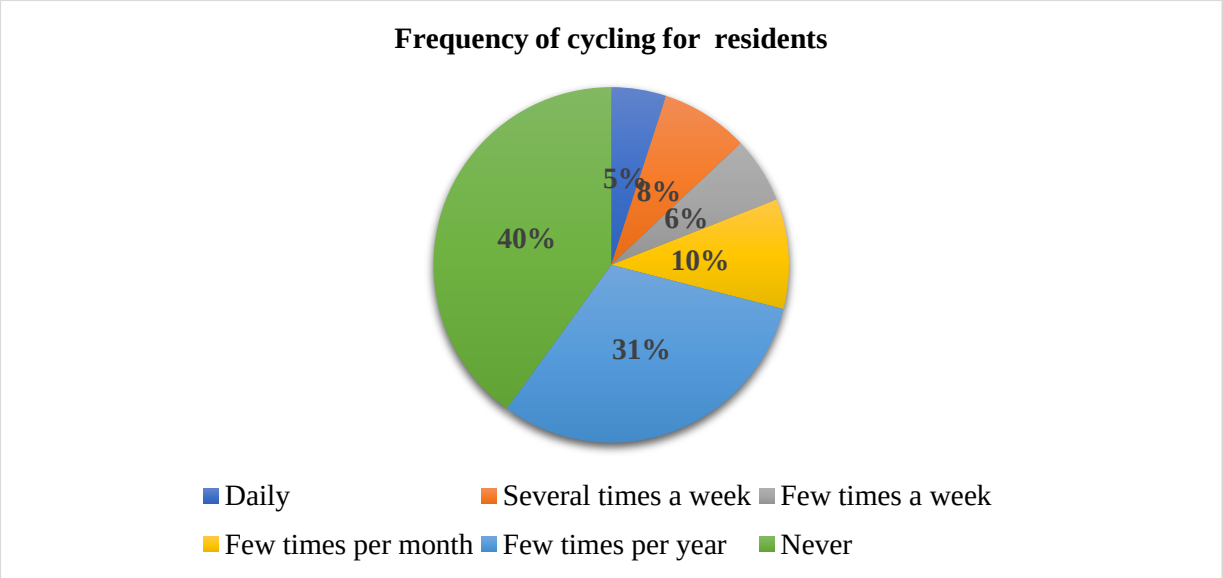

FIGURE 10 Frequency for residents (n=96)

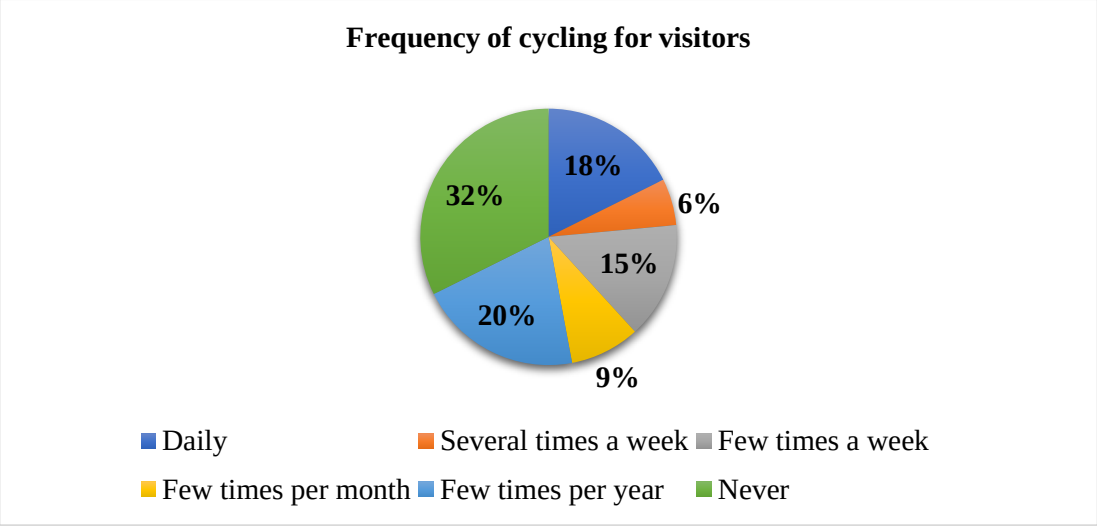

FIGURE 11 Cycling frequency for visitors (n=34)

To evaluate respondents' bicycle type preference, those who indicated to use a bicycle were asked to choose among different types; 10 bicycle types were presented: normal/ regular bike, female regular bike, tricycle, bike share, cargo ,e-bike, folding bike, hybrid bike, mountain bike, racing bike, and others (multiple answers were possible). Figure 12 illustrates the number of respondents and their corresponding bicycle type used by residents and visitors. The respondents mostly used regular bikes, mountain bikes, and bike share while e-bikes, folding, cargo hybrid and adaptive had the least answers.

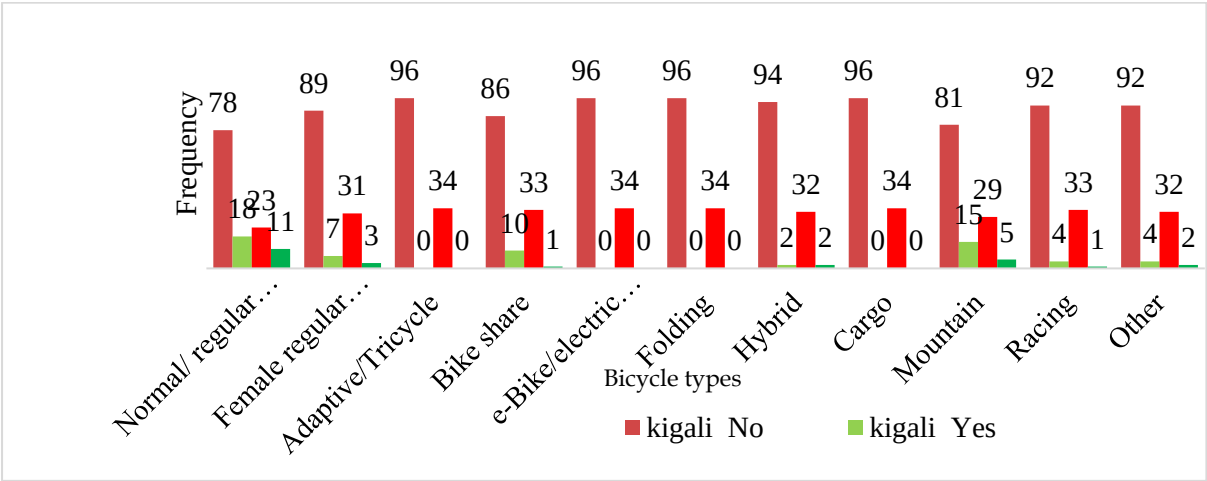

FIGURE 12 Bicycle types n=130

Next, respondents were asked the reasons of choosing a bicycle over other modes (with possible multiple answers). Figure13 shows the rationale cyclists have for their choice of transportation in connection to residential location. For visitors, the positive influences on physical health and condition are the primary rationale for choosing bike as a transportation alternative (36.1%) Interestingly, for the residents this motivation is primary only for 31.4%. In contrast, for residents the positive influences on affordability is the primary rationale for choosing bike as a transportation alternative (32.6%).From visitors , 22.2 % chose affordability as a primary reason for transportation. Moreover, 16.7% of the visitors choose cycling for environment reasons whereas residents the same motive accounts for 18.6%

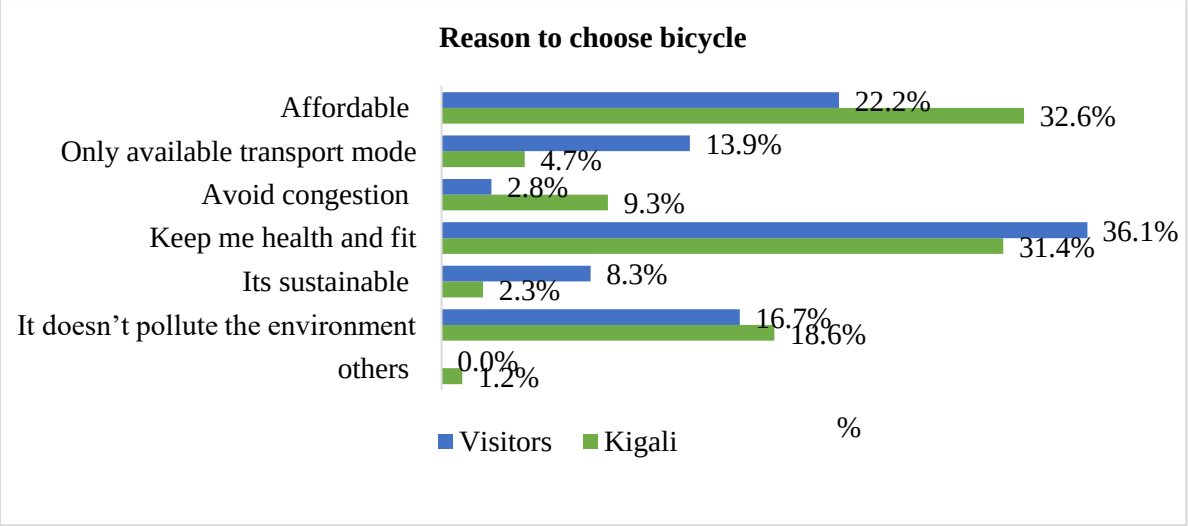

FIGURE 13 Reasons to choose bicycle (n=86 for residents and n=36 for visitors)

This question was directly followed by a multiple-choice question that asked the respondent about the purpose of the trip (multiple answers possible). Cycling to daily activity (work) is a little bit more common amongst residents (24.3%) than visitors (20.7%). Yet, residential location does not seem to influence those who cycle for communities facilities (17.1% for inner-city and 16.2% for visitors). However, the residents people tend to choose cycling as a transportation alternative for social destinations (15.9%) and running errands (14.6%) and for recreation facilities (14.6%) more than the visitors do (10.8% for running errands; and 13.5% for recreation facilities).

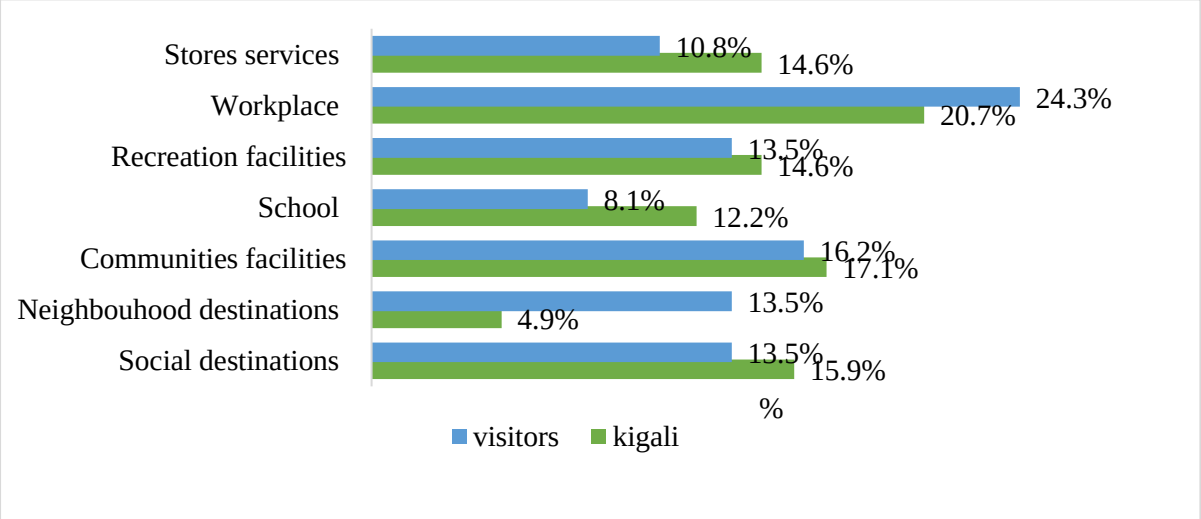

FIGURE 14 Purpose of the cycling trip (n=119)

Figure 15 and 16 visualises the connection between respondents travel time and residential location.

The respondents who indicated to use a bicycle (n=81) were asked the approximate time taken to ride a bicycle from origin to destination per month. A clear trend is that the residents and visitors cycle shorter time, 79% and 61% respectively cycle less than 15h per month. 14 % of the residents and 13% of visitors take 16-30 h while 7% of residents and 26% of visitors ride more than 31 hours per month.

Thus, the largest difference of the cycled time between the residents and visitors are quite logically, that visitors bike many hours per month than residents.

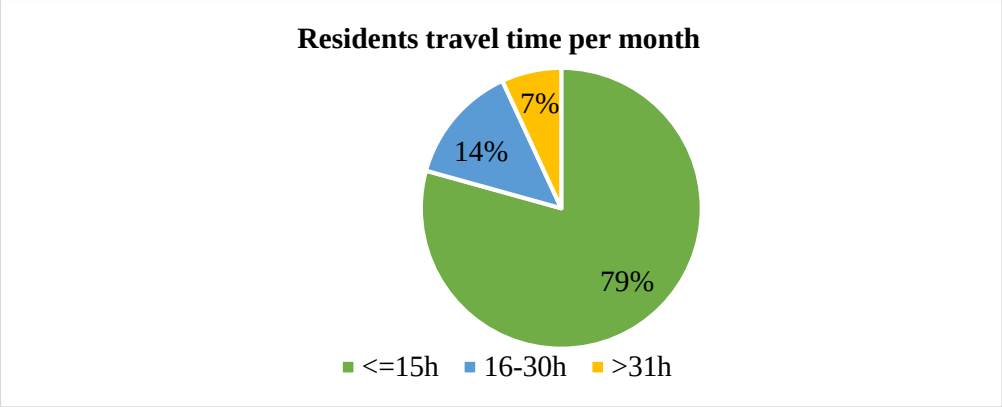

FIGURE 15 Residents travel time (n=58)

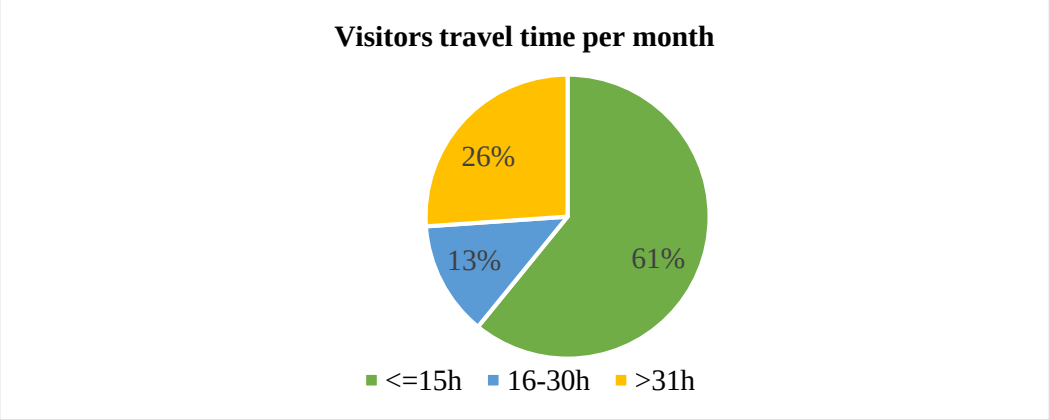

FIGURE 16 Visitors Travel time with (n=23)

The respondents were then asked about bike lane use and lane type preferences. Both residents and visitors cycle mostly on and off the street.

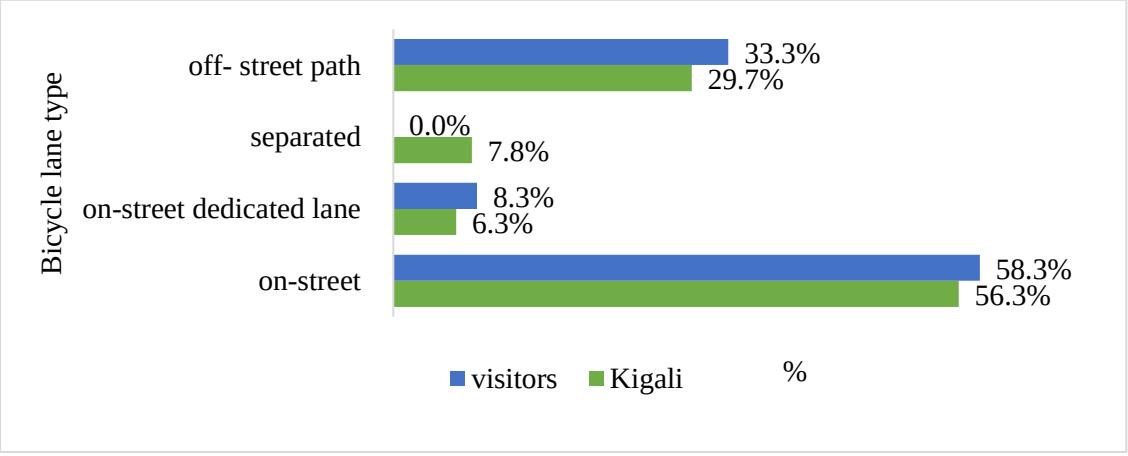

FIGURE 17 The use of bicycle lanes type (n=81)

Respondents who indicated to use a bicycle were asked to choose their bicycle lane preference (on-street, buffered, separated and boulevard. They preferred both separated bike lanes and bike boulevards because bikes and cars do not have to share the same lane, which creates safety. Only few respondents prefer to ride on –street and in buffered lanes.

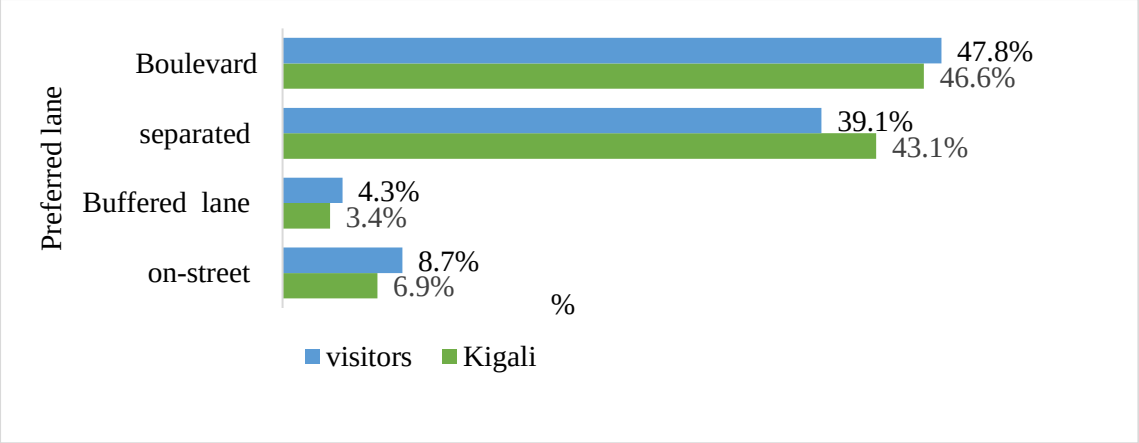

FIGURE 18 Bicycle Lane types preference (n=81)

Next, the respondents were asked to categorise themselves into different transportation bicyclists (i.e., their comfort level using available cycling facilities). 4/10 of the respondents (42.31%) are enthused and confident but prefer separate facilities, 26.15% are concerned with cycling, and 17.69% aren't interested in cycling. The remaining 13.85% are strong and fearless, as shown below. The concern was related to the safety as they prefer to use separate facilities.

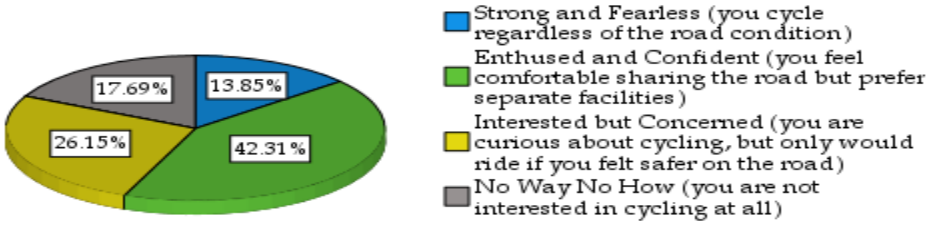

FIGURE 19 Comfort level of using available cycling facilities (n=130)

4.1.3. Challenges Faced by Cyclists

The respondents were asked about their challenges as cyclists. Poor road condition was viewed as a significant challenge to ride a bicycle by both residents (37.2%) and visitors (54.1%). Most participants agreed that the lanes are in poor condition, poorly connected in the network with 25.7% and 21.6%(residents and visitors. Moreover perceived unsafety due to careless behavior and lack of regard for cyclists was viewed as a challenge by 25.7% of the surveyed residents and 18.9% of the surveyed visitors. Poor image of community for cyclists and other such as ignoring them weren't dominant challenges.

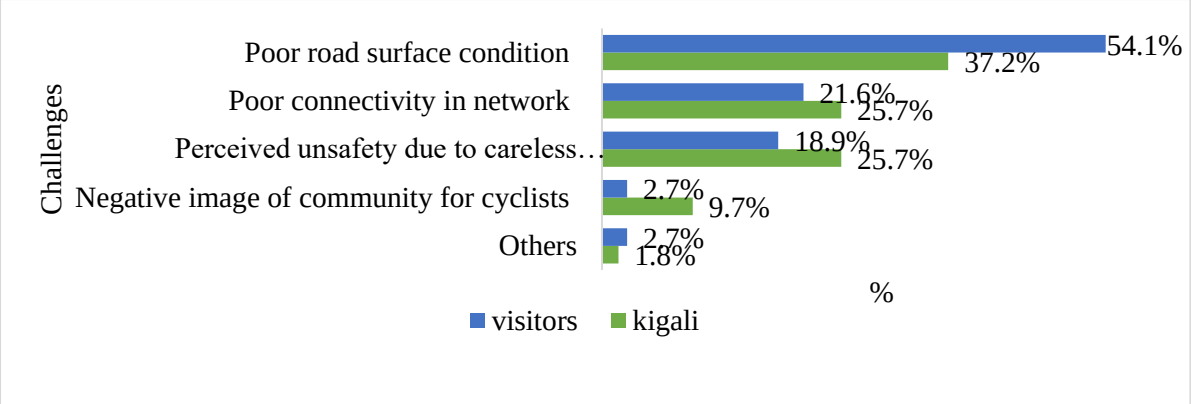

FIGURE 20 Cyclist challenges (n=109)

Respondents who cycle few times a week, per month, per year and who never cycle were asked yes or no questions about different factors as to why they don't cycle more frequently.

Most residents named being quite unexperienced (n=71), personal safety concern (n=70) visually unappealing surrounding (n=68) no bike (n=67). At the same time, more visitors mentioned unsafe intersections (n=22), heavy traffic and personal safety (n=19) as top obstacles for not cycling more frequently.

Personal safety concern is related to unsafe intersections. Intersections or junctions significantly impact the road network in various aspects such as safety, capacity, mobility, and operation cost (Xi, ZhaoCheng, WenBo, ZhanQiu, & JunFeng, 2013). Kigali intersections have two main common problems: lack of markings or signs and traffic lights; Absence of markings and signals increase conflicts between the traffic and the problem with priority raises among road users. The cyclists suffer more as they are required to wait until a gap is available, and in some cases, they may misjudge the length of the gap which can cause a road crash and lead to personal safety concern.

At the same time, heavy automobile traffic (56.9%), destinations too far away (53.4%), being unexperienced (56.9%), unsure about the route and lack of time were barriers for most respondents not to cycle more often. According to the study, a large share of respondents (48.6%) thought the cycling paths in the study area were poor, and 51.4% indicated there were no lanes.

Bicycle parking systems (racks, stands) and storage facilities (lockers, cycle centers) are a variety of facilities that allow cyclists to park their bicycles in a safe, convenient, and orderly manner. As a result, they contribute to a well-organized public space and make cycling more appealing (DfT, 1997). Kigali city has not many bicycle parking provided, 43.1% of the respondents saw this as a serious issue of why they didn't ride bicycles more frequently same as lack of worksite amenities.Unsafe intersection, travel with children, and too many stops and too much to carry were also described by half of residents and visitors as not as perceived barriers to cycle more frequently.

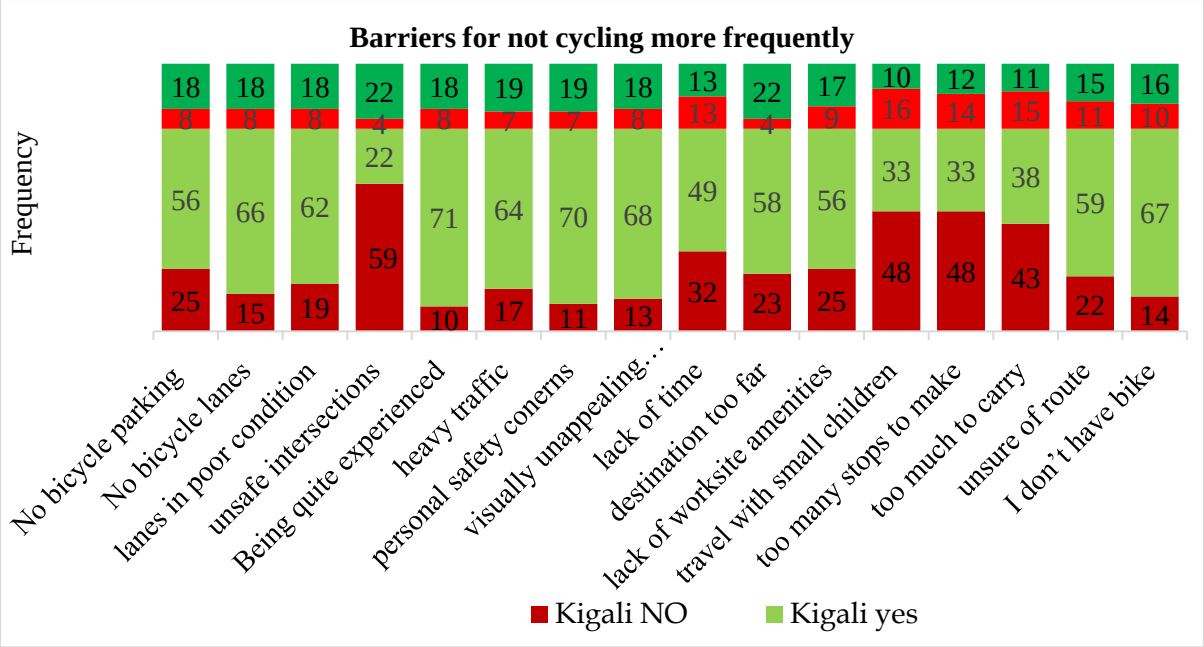

FIGURE 21 Barriers for not cycling more frequently (n=81 for residents and n=26 for visitors)

In the following question, respondents were asked about factors that would make them shift from bicycle to motorized transport. The six most significant factors of Figure 22 have been looked at in relation to residential area. The major reasons for people's decision to shift to another mode does not differ greatly between residents and visitors. Amidst the visitors, 19.8% other mode travel fast, long distance and enable carrying luggage, the residents the same reason is given by 17.5%,17.1% and 16.9%. Similarly, residents 17.9% name safety to be a key hinder, and visitors 18.5%. However, within the residents 16.3% of people prefer other modes of transportation at times when they are able to afford another mode, while in the visitors the same reason was given by 17.9%. What is interesting about these data is that people had no bike available 14.2% of residents, while in the visitors this only accounts for 4.3%

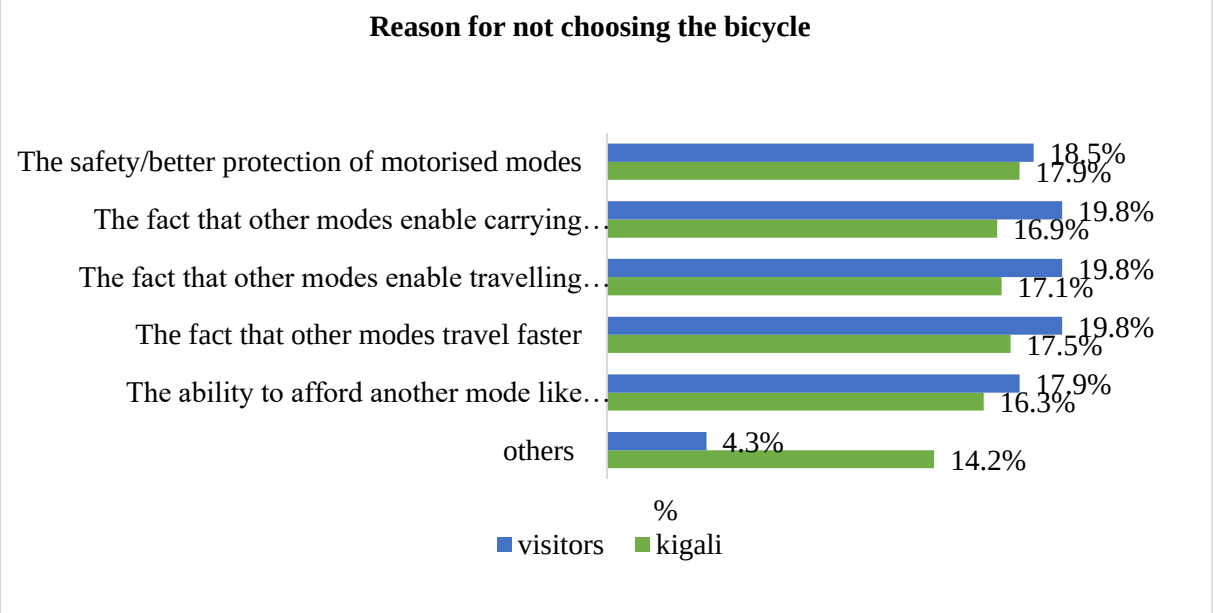

FIGURE 22 Reasons to shift to motorised modes (n=130)

Next, respondents were asked to answer a five-scale question from 1 (Not at all Important) to 5 (Very Important) to indicate how each negative factor would cause them to stop or decrease their cycling. The results showed that with 30.8%, the respondents indicated rain as a negative factor because riding in the rain increases the chances of getting wet, making you more susceptible to becoming cold. The rain was also viewed as a problem, particularly when dressing appropriately for professional situations at work, personal health condition with 27.7% such as being sweaty and tired for work, were viewed as a problem and hills with 26.9% were ranked top three as very important (5) by respondents as negative factors that can influence people to reduce cycling in Kigali city.

The results show that the respondents scored rain, hot weather, cold weather, hills, and environmental factors as moderately important reasons to shift to motorised modes, followed by slightly important and personal health condition as not at all important.

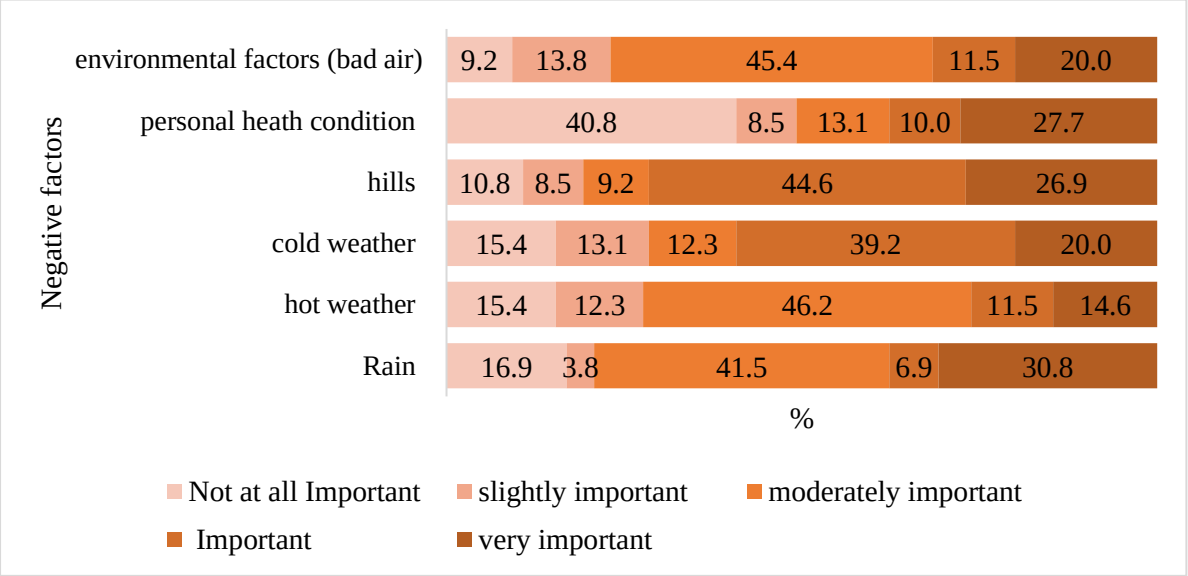

FIGURE 23 Negative factors that would cause you to stop or decrease your cycling (n=81)

4.1.4. Factors that could change a person's willingness to start cycling or cycle more

In the questions on transportation safety and road conditions, respondents were asked to rank the importance of 6 potential factors they may encounter on a scale from 1 to 5 (with 5 being the most important and 1 being the least). Almost all of the responses averaged high scores especially the roadsurface in good condition (65.4%), lighting (50.8%),more aware drivers (50%), reduced traffic speeds (48.46%) and fewer vehicles with 47.69% were scored as very important. In comparison, police presence was classified as not at all important with 46.9%.

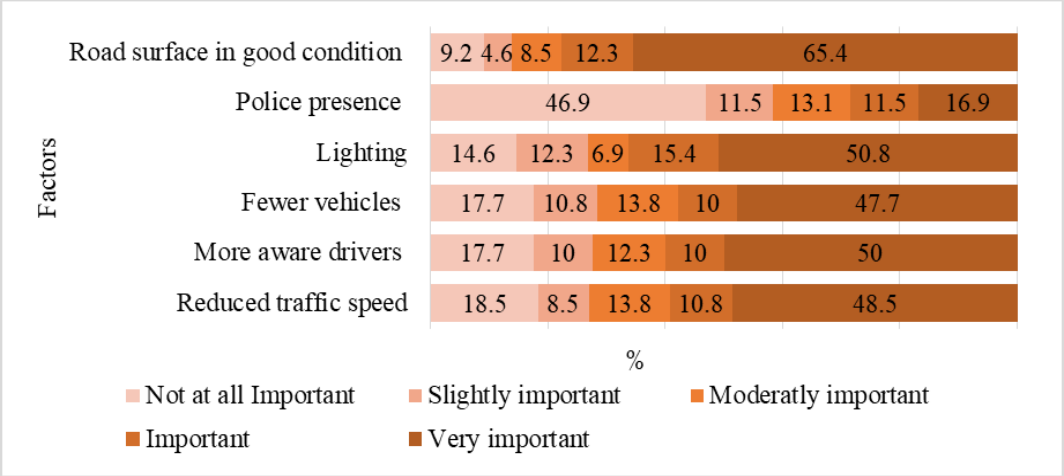

FIGURE 24 Transportation Road condition factors that would increase cycling n=130

Questions about transportation cultural and encouragement programs comprised a significant area of interest in the survey. It was categorised in 7 sub questions (how community, school/university, workplace embrace cycling, cycling cultural acceptance, a place to refresh up, change clothing and shower and financial incentives). Seven options were available to be ranked on a scale of 1 to 5

The two most influential categories were a place to change clothing and shower after arriving (52.3%) and a place to freshen up with 50.8% of the respondents who ranked them as very important, followed by important, culture acceptance as moderately important, school and workplace that embrace cycling as slightly important and community that embraces cycling as not at all important with 48.5%.

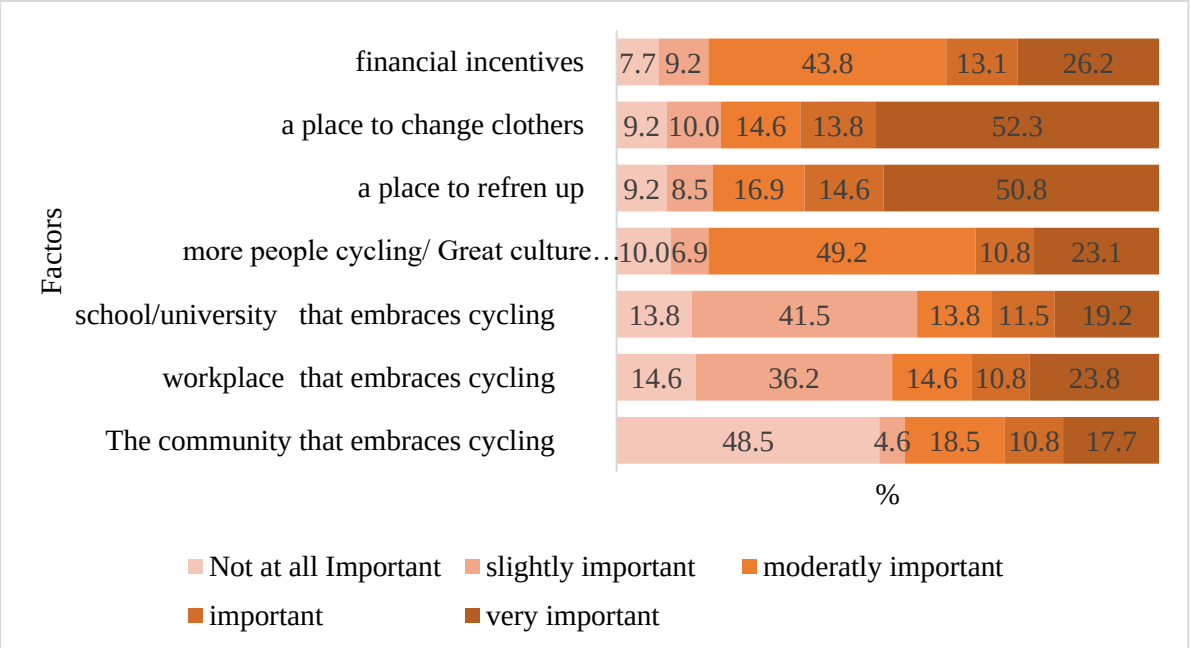

FIGURE 25 Cultural and encouragement programs that would cause to start or increase cycling (n=130)

In the following question, the respondents were asked to answer a five-scale question (not important to very important) about transportation facility factors that could increase cycling frequency. The category with the highest significant response as very important were bike paths connecting to the station and safer places to cycle with 60.8%, followed by convenient parking (56.9%), better connectivity (56.2%)

and elimination of dangerous locations (53.1%). Compared with other factors, bicycle routes with wayfinding signs were chosen as important with 43.1%.

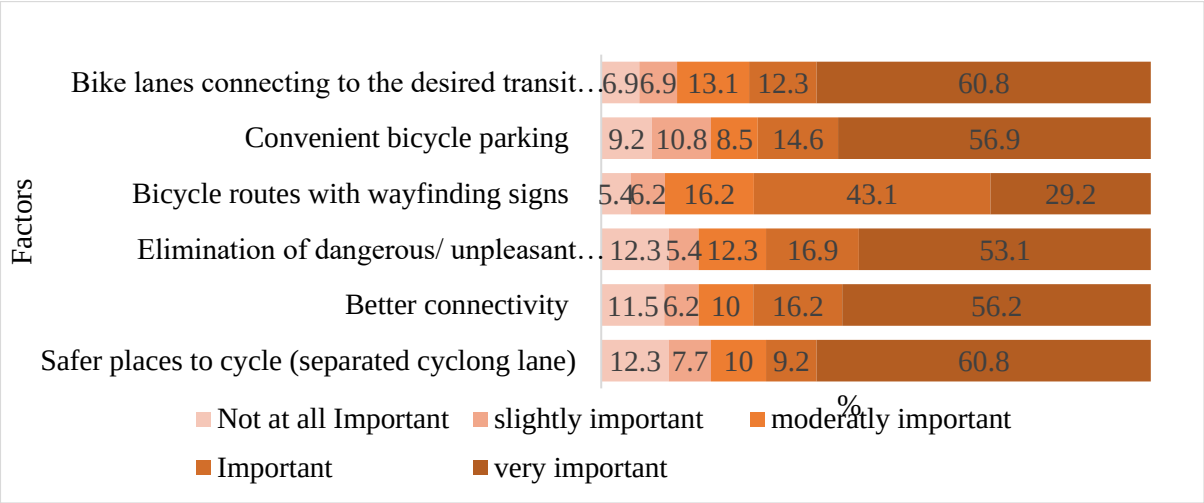

FIGURE 26 Transportation facility factors that would increase cycling (n=130)

Respondents were asked to answer a five-scale Likert question (not important to very important) about the improvements factors that would support cycling in Kigali. So, according to the respondents separated bike lanes (60.8%), secure bicycle parking, more bike lanes and worksite amenities (52.3%), good maintenance of sidewalk, bike lanes, bike routes/ greenways (51.5%), provision of tunnels to avoid hilly sections and better street lighting (50.8%) and more signed bike routes (49.23%) were the top statements with the highest score on very important. Safe intersection (60.8%), improved connection between sideways and bikeways (54.6%), enforcement for road users (53.1%), map (50.8%), provision of e-bike (46.2%) and a bicycle app (44.6%) were top factors scored as important.

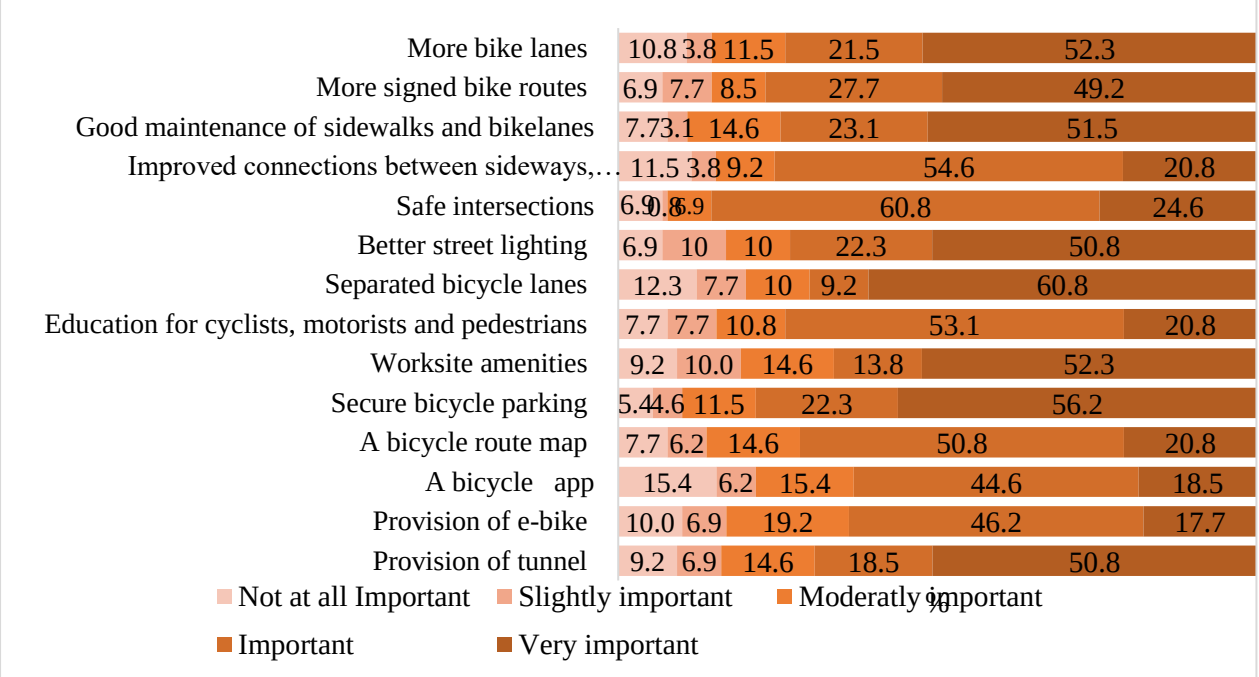

FIGURE 27 Improvement factors to support cycling in Kigali (n=130)

Another improvement factor that could increase cycling in Kigali is traffic education at school. According to the respondents, figure 28 represents the current situation of traffic education in Kigali. 48% of the respondents mentioned to not have (had) traffic education at school, 45% have traffic education on transit use and cycling and the remaining 7% aren't sure (figure 28).

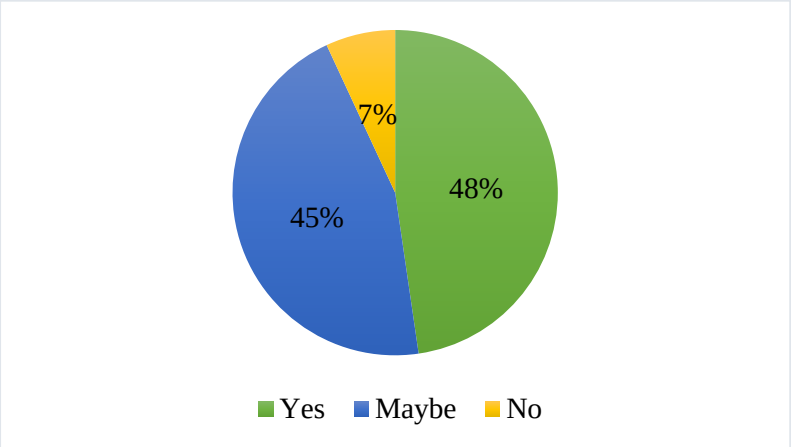

FIGURE 28 Mobility traffic education at school (n=130)

In the following question, respondents were asked about mobility education for school-age children (under 12 years). Multiple answers were possible. Only 35.38% have school age children and few of them mentioned that they received mobility education on walking (28.26%), transit use (8.7%), driving (36.96%) and cycling (43.48%).

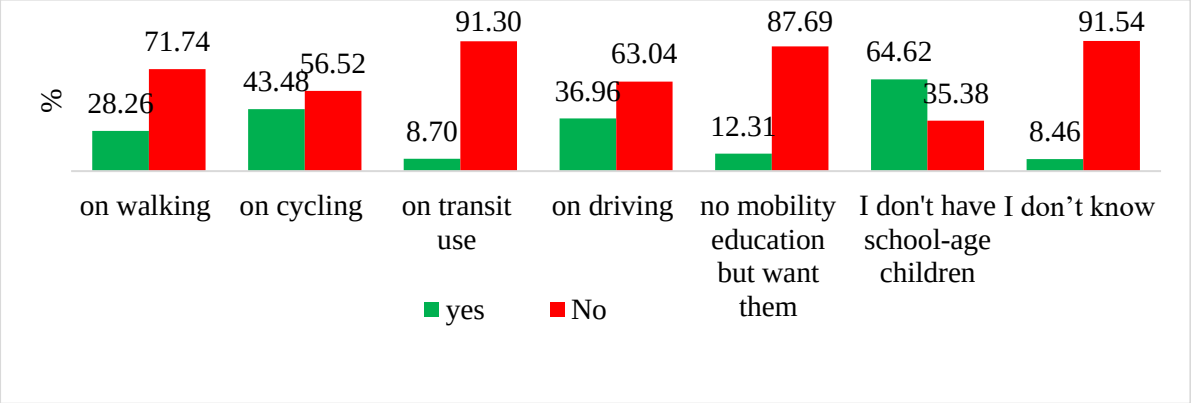

FIGURE 29 Mobility education for school age children (under 12 years) (n=130)

4.2. Cross tabulation results and hypothesis testing

Cross tabulation is a technique to evaluate the connection among various variables quantitatively. It indicates how links shift from one grouping variable to another. It is often applied in analysis to discover relationships, trends, and likelihoods inside raw data.

The goal of the study was to examine and test the hypotheses outlined; in this section, we describe the frequency use of bicycle vs location, vs age group, vs gender, vs level of education, vs self-categorisation of cyclists, vs barriers of cyclists and vs different destinations.

4.2.1. Results of the frequency use of bicycle vs location of the respondents

Figure 30 shows the frequency % use of bicycles and the location of respondents.

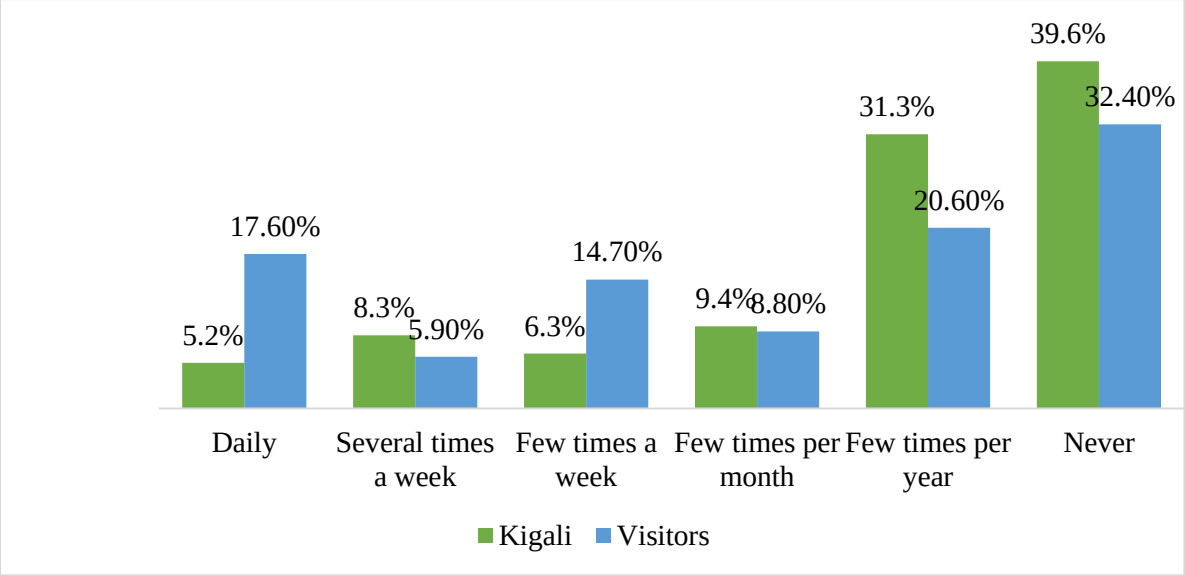

FIGURE 30 Results of the frequency use of bicycle vs location of the respondents

The following are formulated hypothesis to test of significant difference of frequency use of bicycles and location (residents and visitors):

H0: frequency use of bicycle is independent to the respondents who reside in and out of Kigali

H1: frequency use of bicycle is not independent to the respondents who reside in and out of Kigali

TABLE 2 Chi-Square Tests of significant difference of frequency use bicycles and location (residents and visitors)

				Monte Carlo Sig. (2-sided)		
					95% Confidence Interval	
	Value	df	Asymptotic Significance (2-sided)	Significance	Lower Bound	Upper Bound
Pearson Chi-Square	24.919[a]	15	.051	.048[b]	.044	.052
Likelihood Ratio	26.328	15	.035	.073[b]	.068	.078
Fisher-Freeman-Halton Exact Test	22.905			.060[b]	.055	.065
N of Valid Cases	130					

Note: since 16 cells (66.7%) have expected count less than 5. The Monte Carlo estimate of 0.055 for the exact p value is based on 10,000 random samples from the reference set, using a starting seed of 112562564. Exact Tests also computes a 95% confidence interval for the exact p value. This confidence interval is (0.055, 0.065) is greater than α=0.05), which means the null hypothesis is accepted and concludes that the frequency use of cycling isn't associated with location (Kigali and out of Kigali).

4.2.2. Results of the frequency use of bicycle vs age group

Figure 31 shows the results of age groups (<=25, 26-35 and 36+) and their correspondent frequency % use of bicycle.

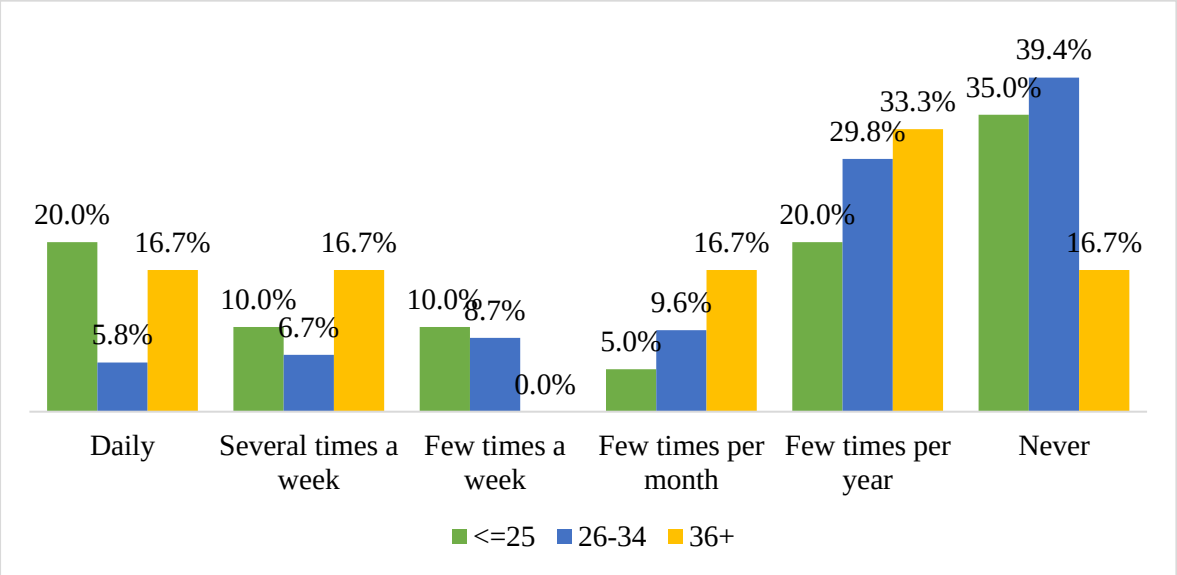

FIGURE 31 Results of the frequency use of bicycle vs Age group

The following are formulated hypothesis to test of significant difference of frequency use of bicycles and age group:

H0: frequency use of bicycle is independent to age group

H1: frequency use of bicycle is not independent to age group

The study tested the difference between cycling frequency and age group (<=25, 26-35 and 36+year) at $\alpha = 0.05$. The study found the following value of p as shown in the table below.

TABLE 3 Chi-Square Tests of Significant Difference between frequency use of bike and age group

	Value	Df	Asymptotic Significance (2- sided)	Exact Sig. (2-sided)
Pearson Chi-Square	8.183[a]	10	.611	.616
Likelihood Ratio	7.899	10	.639	.775
Fisher-Freeman-Halton Exact Test	9.167			.406
N of Valid Cases	130			

Note: a. 10 cells (55.6%) have expected count less than 5. in this case Fisher-Freeman-Halton Exact value was selected to conclude the test of independence.

From the table above, the p-value=0.406, is greater than α=0.05 (α is the test's level of significance), which means the null hypothesis is accepted and concludes that there is no significant difference in age group (<=25, 26-35 and 36+year) associated with often riding bicycles. Those who are under 25 and 36+ years seems to have higher cycling frequency than 26-35 years old.

4.2.3. Results of the frequency use of bicycle vs gender

Figure 32 shows the results of gender and their correspondent frequency % use of bicycle.

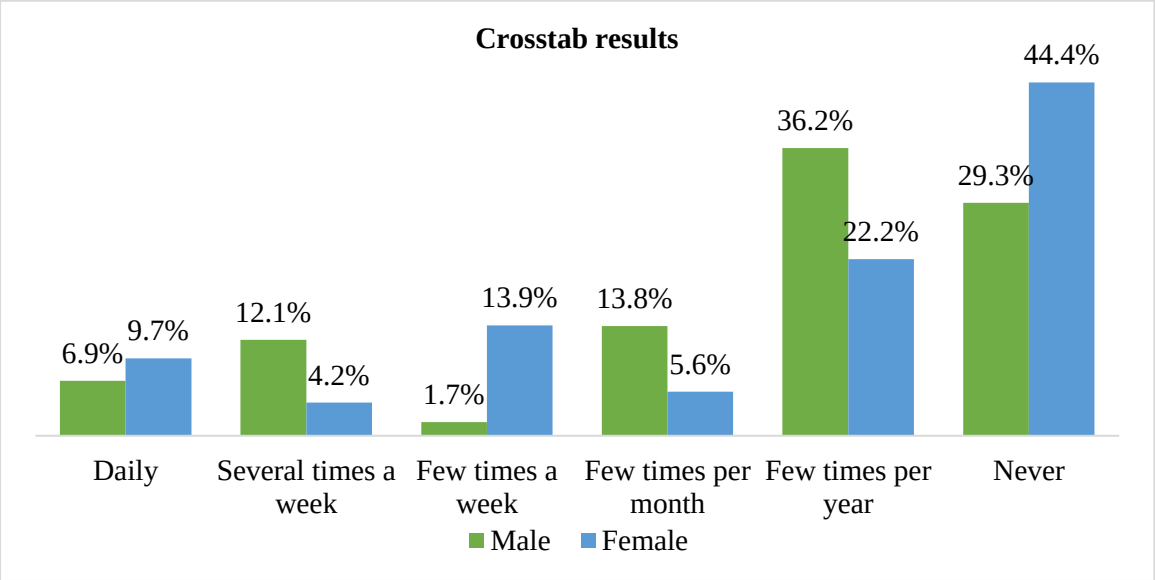

FIGURE 32 Results of the frequency use of bicycle vs gender

A test of independence Chi-Square was conducted to test if there is a significant association between gender and frequency of cycling.

The following are formulated hypothesis:

H0: frequency use of bicycle is independent to gender

H1: frequency use of bicycle is not independent to gender

TABLE 4 Chi-Square Tests of Significant Difference between frequency use of bike and gender

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	15.050[a]	5	.010	.008
Likelihood Ratio	16.214	5	.006	.010
Fisher-Freeman-Halton Exact Test	15.037			.009
N of Valid Cases	130			

Note: Since 3 cells (25%) have expected count less than 5. The minimum expected count is 4.46; fisher-freeman-halton Exact Test value was selected to conclude the test of independence.
From the table above, the p-value=0.009 is less than α=0.05 (α is the test's level of significance), which means the null hypothesis is rejected and concludes that cycling is associated with gender. The female seem to have a higher bicycle frequency than male.

4.2.4. Results of the frequency use of bicycle vs level of education

Figure 33 is a result of a crosstab in which cycling frequency and education are considered in relation to each other. It shows that most of the all-year cyclists have a grad shows the levels of education and their correspondent frequency use of bicycle.

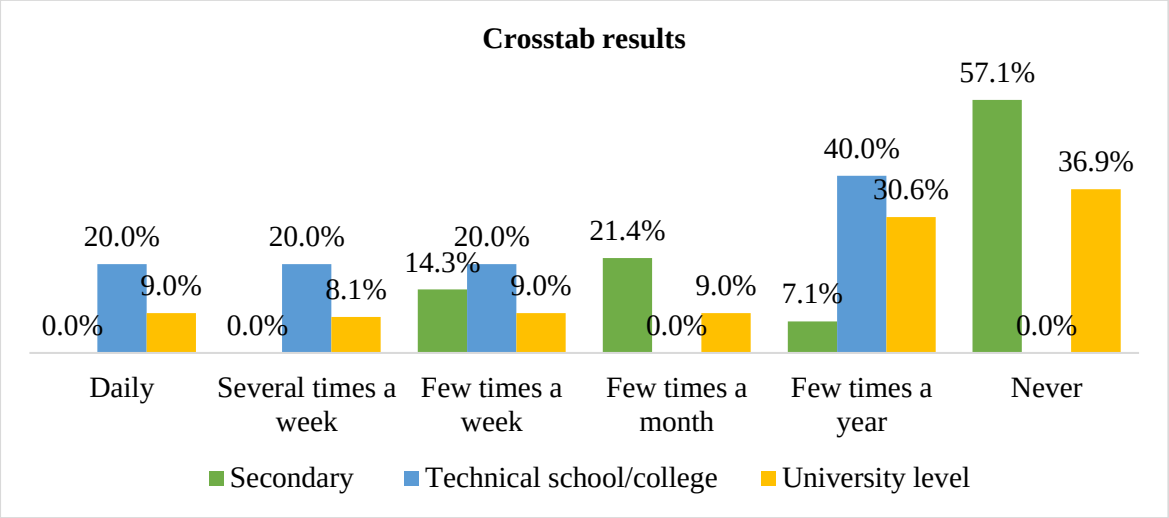

FIGURE 33 Results of the frequency use of bicycle vs level of education

The following are formulated hypothesis to test if there is a significant association between level of education and frequency of cycling:

H0: frequency use of bicycle is independent to level of education

H1: frequency use of bicycle is not independent to level of education

TABLE 5 Chi-Square Tests of significant difference of frequency use bicycles and level of education

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	14.481[a]	10	0.152	0.142
Likelihood Ratio	18.388	10	0.049	0.049
Fisher-Freeman-Halton Exact Test	15.086			0.043

N of Valid Cases	130

Note: 11 cells (61.1%) have an expected count of less than 5. The minimum expected count is .38. The minimum expected count is .38. Fisher-freeman-halton Exact Test value was selected to conclude the test of independence.

From the table above, the p-value=0.043 which is less than α=0.05 (α is the test's level of significance), which means the null hypothesis is rejected and concludes that the frequency use of cycling is associated with level of education. Those who have technical school level seem to have a higher bicycle frequency than others as from daily to few times a week have a higher %. Interestingly, for non-cyclists, the largest educational background group is secondary school with 57.1%. Those with a university level consists of 36.9% of the non-cyclist, and 0% of the non-cyclists have technical school level.

4.2.5. Results of cycling frequency and self-categorisation of cyclists

Figure 34 shows the results of self-categorisation of cyclists and their correspondent frequency use of bicycle.

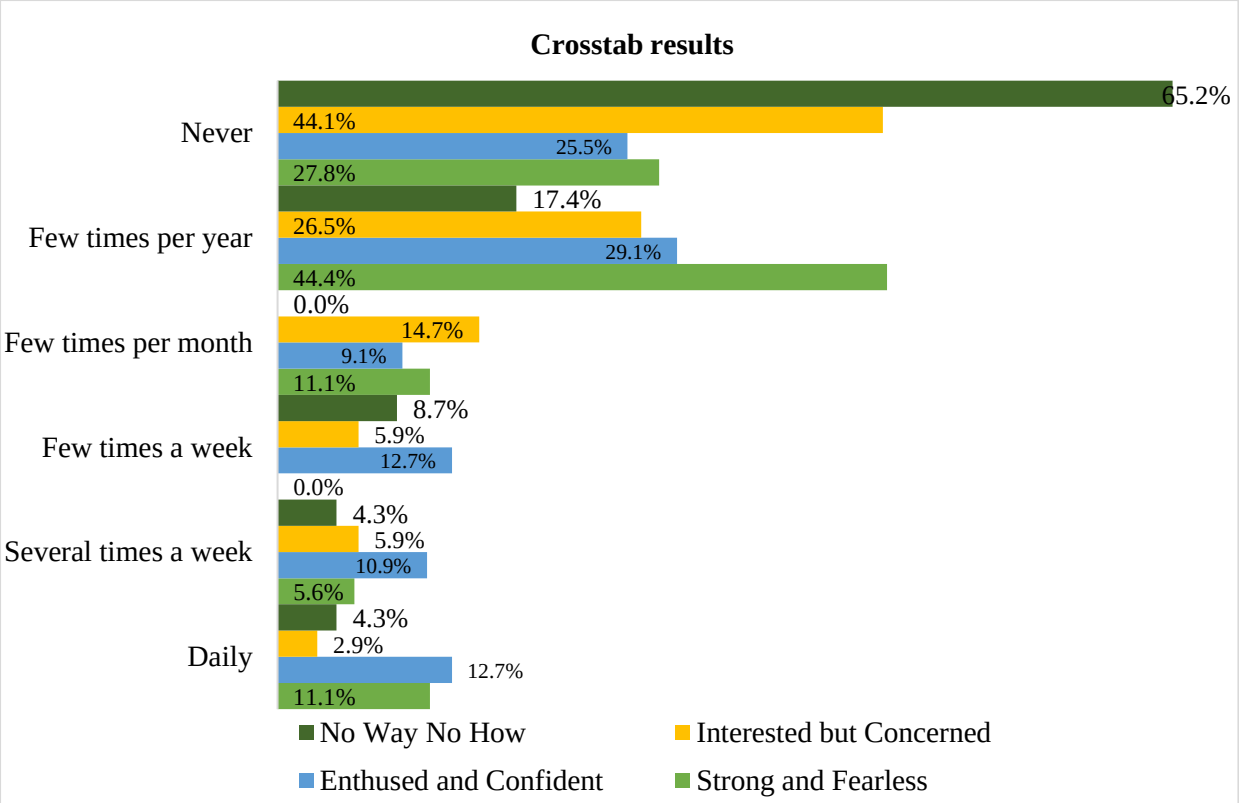

FIGURE 34 results of frequency use of bicycle and self-categorisation of cyclists

The following are formulated hypothesis to test if there is a significant association between self-categorisation of cyclists and frequency of cycling:

H0: frequency use of bicycle is independent to self-categorisation of cyclists

H1: frequency use of bicycle is not independent to self-categorisation of cyclists

TABLE 6 Chi-square test of significant difference between cycling frequency and self-categorisation of cyclists

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Monte Carlo Sig. (2-sided) Significance	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Pearson Chi-Square	20.926[a]	15	.139	.136[b]	.129	.143
Likelihood Ratio	24.014	15	.065	.117[b]	.111	.124
Fisher-Freeman-Halton Exact Test	19.197			.148[b]	.141	.155
N of Valid Cases	130					

15 cells (62.5%) have expected count less than 5. The Monte Carlo estimate of 0.148 for the exact p value is based on 10,000 random samples from the reference set, using a starting seed of 1314643744. Exact Tests also computes a 95% confidence interval for the exact p value. This confidence interval is (0.141, 0.155) is greater than α=0.05), which means the null hypothesis is accepted and concludes that the frequency use of cycling isn't associated with self-categorisation. The enthused and confident seems to have higher cycling frequency than others.

4.2.6. Results of cycling frequency and barriers faced cyclists

- **Results of cycling frequency and poor road surface condition**

Figure 35 shows the results of poor road surface condition and their correspondent frequency use of bicycle.

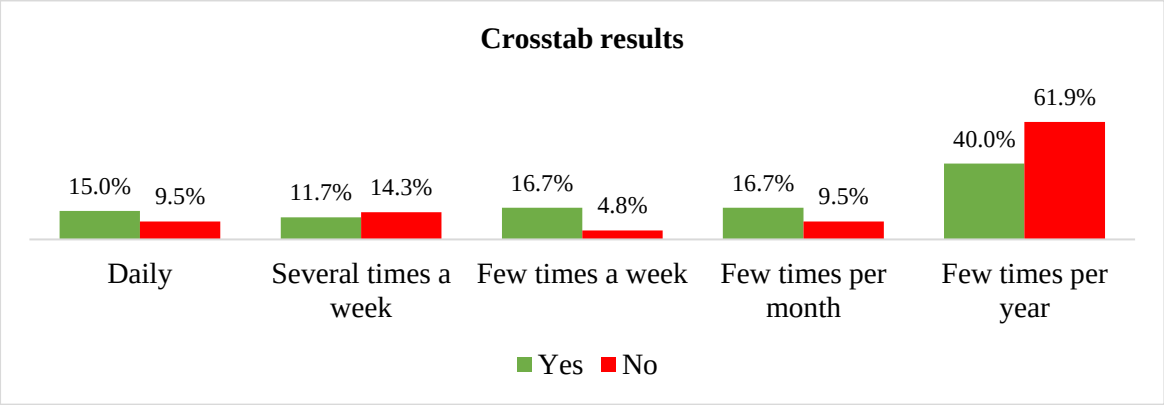

FIGURE 35 Results of the frequency use of bicycle vs poor road condition

The result shows a difference the respondents who cycle daily to few times per year regarding the statement, "poor road condition is cyclists challenge". Most of the respondents who cycle daily to few times per month agree with the statement while those who cycle few times per year disagree.

The following are formulated hypothesis to test if there is a significant association between poor road surface condition and frequency of cycling:

H0: frequency use of bicycle is independent to poor road surface condition

H1: frequency use of bicycle is not independent to poor road surface condition

The study tested the difference between cycling frequency and poor road surface condition at α = 0.05.

TABLE 7 Chi-Square Tests of significant difference between cycling frequency and poor road condition

	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	63.206[a]	5	<.001	<.001
Likelihood Ratio	75.093	5	<.001	<.001
Fisher-Freeman-Halton Exact Test	71.263		<.001	<.001
N of Valid Cases	130			

Note: since 1 cell (8.3%) has an expected count less than 5 a fisher-freeman-halton exact test value was selected to conclude the test of independence.

From the table above, the p-value<0.01 is less than α=0.05 (α is the test's level of significance), which means the null hypothesis is rejected and concludes that the frequency use of cycling is associated with poor road surface condition. So, we can say that respondents confirmed poor road condition as barrier faced.

- **Results of difference between cycling frequency and poor or inadequate connectivity in the bicycle network**

Figure 36 shows the results of poor road surface condition and their correspondent frequency use of bicycle.

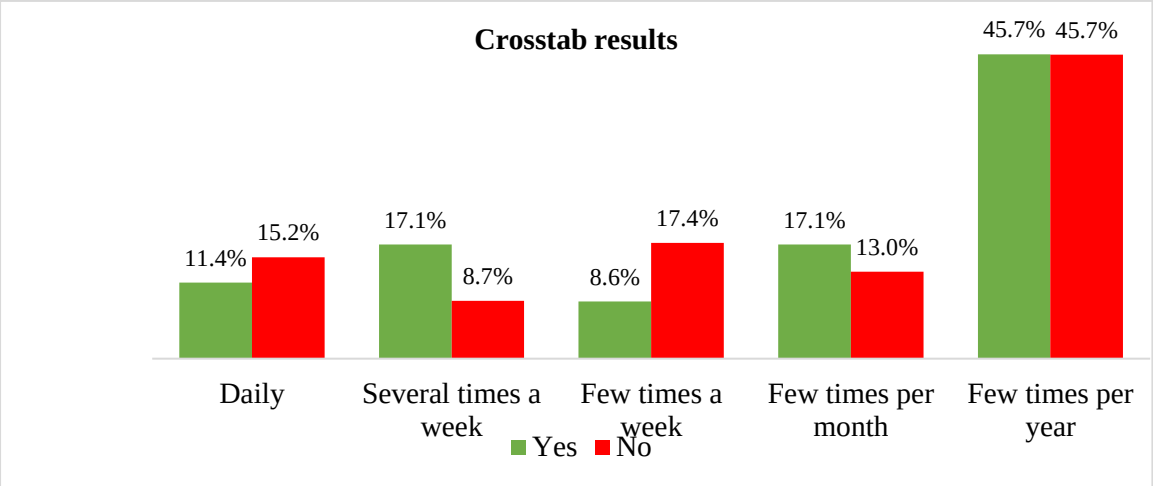

FIGURE 36 Results of cycling frequency vs Poor or inadequate connectivity in the bicycle network

The result shows a difference among the respondents who daily cycle to never regarding the statement, "Poor or inadequate connectivity is cyclists challenge". Some of the respondents who daily, few times a week disagree with the statement, but most respondents who cycle several times a week and few times

per month agree regarding this statement. Finally, the respondents who cycle few times per year, there is a balance between agree and disagree regarding the statement.
The following are formulated hypothesis:

H0: frequency use of bicycle is independent to Poor or inadequate connectivity in the bicycle network

H1: frequency use of bicycle is not independent to Poor or inadequate connectivity in the bicycle network

The study tested the difference between cycling frequency and Poor or inadequate connectivity in the bicycle network, tested at $\alpha = 0.05$.

TABLE 8 Chi-Square Tests of significant difference between cycling frequency and poor connectivity in bicycle network

	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	26.239[a]	5	<.001	<.001
Likelihood Ratio	30.553	5	<.001	<.001
Fisher-Freeman-Halton Exact Test	29.86			<.001
N of Valid Cases	130			

Note: 4 cells (33.3%) have expected count less than 5. Fisher-Freeman-Halton Exact Test value was selected to conclude the test of independence. From the table above, the P-value<0.01 is less than α=0.05 (α is the test's level of significance), which means the null hypothesis is rejected and concludes that the frequency use of cycling is associated with poor connectivity bicycle network. So, we can say that respondents who cycle daily and few times a week tend to disagree with the statement, but respondents who cycle several times a week and few times per month tend to agree the statement. Finally, the respondents who cycle few times per year has a balance between agree and disagree.

- **Results of difference between cycling frequency and Perceived unsafety due to careless behavior and lack of regard of drivers for cyclists.**

Figure 37 shows the results of Perceived unsafety due to careless behavior and lack of regard of drivers for cyclists and their correspondent frequency use of bicycle.

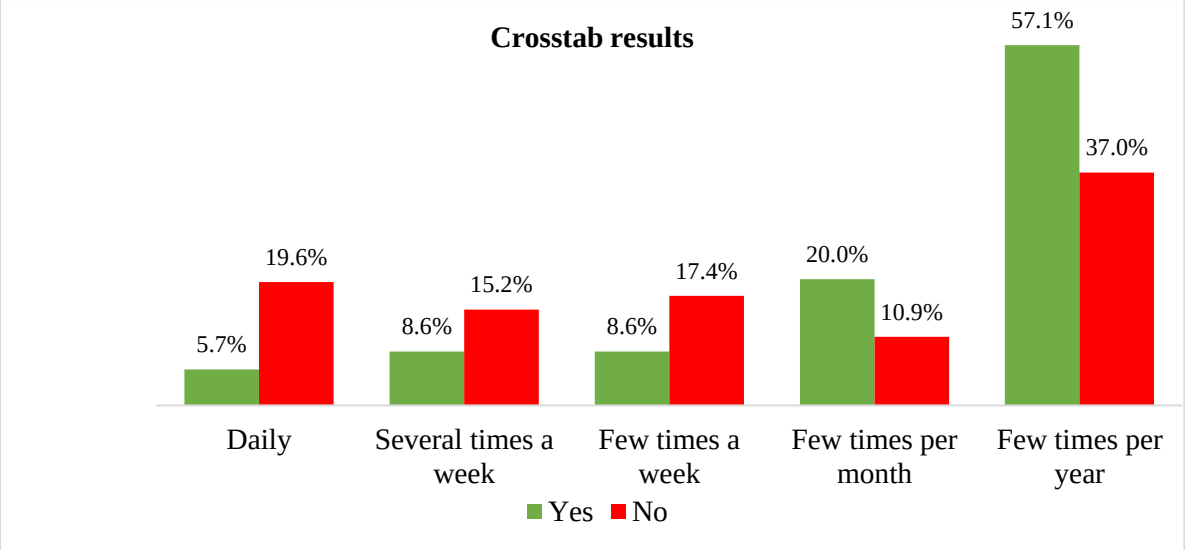

FIGURE 37 Results of cycling frequency vs Perceived unsafety due to careless behavior and lack of regard of drivers for cyclists

The result shows a difference between respondents who cycle daily to few times per year regarding the statement, "Perceived unsafety due to careless behavior and lack of regard of drivers for cyclists is a challenge". Most of the respondents who cycle daily to few times a week disagree with the statement, but most respondents who cycle few times per month and few times per year agree regarding this statement. So, we can say that respondents who cycle daily to few times a week tend to disagree with the statement, but respondents who cycle few times per month and few times per year tend to agree the statement.

The following are formulated hypothesis:

H0: frequency use of bicycle is independent to Perceived unsafety due to careless behavior and lack of regard of drivers for cyclists

H1: frequency use of bicycle is not independent Perceived unsafety due to careless behavior and lack of regard of drivers for cyclists.

TABLE 9 Chi-Square Tests of significant difference between cycling frequency vs Perceived unsafety

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	35.094[a]	5	<.001	<.001
Likelihood Ratio	40.754	5	<.001	<.001
Fisher-Freeman-Halton Exact Test	39.023			<.001
N of Valid Cases	130			

4 cells (33.3%) have expected count less than 5. Fisher-freeman-halton exact value was selected to conclude the test of independence. From the table above, the P-value<0.01 which is less than α=0.05 (α

is the test's level of significance), which means the null hypothesis is rejected and concludes that the frequency use of cycling is associated with Perceived unsafety due to careless behavior and lack of regard of drivers for cyclists.

4.2.7. Test of significant difference between cycling frequency and destinations

A test of independence Chi-Square was conducted to test if there is a significant association between cycling frequency and destinations

The following are formulated hypothesis:

H0: frequency use of bicycle is independent to destinations

H1: frequency use of bicycle is not independent to destinations

TABLE 10 Chi-square test of significant between cycling to work and frequency use of bicycle.

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	35.992[a]	5	<.001	<.001
Likelihood Ratio	40.511	5	<.001	<.001
Fisher-Freeman-Halton Exact Test	37.288			<.001
N of Valid Cases	130			

Note:4 cells (33.3%) have expected count less than 5. The minimum expected count is 2.00.

TABLE 11Chi-square test of significant between cycling to (stores and services) and frequency use of bicycle

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	18.041[a]	5	.003	.004
Likelihood Ratio	23.373	5	<.001	<.001
Fisher-Freeman-Halton Exact Test	19.472			<.001
N of Valid Cases	130			

Note: 5 cells (41.7%) have expected count less than 5. The minimum expected count is 1.23

TABLE 12Chi-square test of significant between cycling to school and frequency use of bicycle

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	16.977[a]	5	.005	.007
Likelihood Ratio	18.053	5	.003	.003

Fisher-Freeman-Halton Exact Test	16.860			.001
N of Valid Cases	130			

Note: 6 cells (50.0%) have expected count less than 5. The minimum expected count is 1.00

TABLE 13Chi-square test of significant between cycling to communities facilities and frequency use of bicycle

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	23.062[a]	5	<.001	<.001
Likelihood Ratio	26.836	5	<.001	<.001
Fisher-Freeman-Halton Exact Test	25.169			<.001
N of Valid Cases	130			

Note: 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.54.

TABLE 14Chi-square test of significant between cycling to recreational facilities and frequency use of bicycle

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	17.536[a]	5	.004	.005
Likelihood Ratio	23.724	5	<.001	<.001
Fisher-Freeman-Halton Exact Test	20.011			<.001
N of Valid Cases	130			

Note:5 cells (41.7%) have expected count less than 5. The minimum expected count is 1.31.

TABLE 15Chi-square test of significant between cycling to transit stops and frequency use of bicycle

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	10.391[a]	5	.065	.046
Likelihood Ratio	10.749	5	.057	.029
Fisher-Freeman-Halton Exact Test	7.728			.073
N of Valid Cases	130			

Note: 6 cells (50.0%) have expected count less than 5. The minimum expected count is .38.

TABLE 16Chi-square test of significant between cycling to social destination and frequency use of bicycle

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	15.759[a]	5	.008	.009
Likelihood Ratio	21.051	5	<.001	<.001
Fisher-Freeman-Halton Exact Test	19.228			<.001
N of Valid Cases	130			

Note: 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.38.

The table 12-16 shows cycling to different destinations (workplace, stores and services, school, community facilities, recreational facilities, social destination) were associated with the regularity of cycling in the study area. Fisher-Freeman-Halton Exact Test value was selected to conclude the test of independence. From the tables above, all the P-values (are less than $\alpha=0.05$ (α is the test's level of significance) which means the null hypothesis is rejected and concludes that cycling frequency is associated with cycling to destination.

However, this table does not alone tell the significance of these results. Therefore, figure 14 shows the significance of the means between the residents and visitors where cycling to work is slightly more common among residents (24.3%) and visitors (20.7%). On the other hand, it does not appear that residential location influences those who cycle to community facilities (17.1 % for residents and 16.2 % for visitors). Residents, however, prefer cycling as a mode of transportation for social destinations (15.9 %), errands (14.6%), and recreation facilities (14.6 %) more than visitors (10.8 % for running errands; and 13.5 % for recreation facilities and 13.5% for social destinations).

4.2.8. Recapitulation

Together the data presented in sub-chapter 4.2 provides an idea of how often residents and visitors use a bicycle. The results shows the percentage of cyclists per location, age group, gender, educational, and self-categorisation of cyclists, reasons to and not cycle, lane favourite and the barriers faced by cyclists.

By location, visitors bike many hours per month than residents, the visitors are more active.by education, the most active cyclists in Kigali possess either a technical school level, According to these data, and the non-cyclists by education also possess either a secondary degree. By age, those who are under 25 and 36+ years seems to have higher cycling frequency than 26-35 years. By gender, female has high frequency than male. There is no big difference on which lane they cycle most and their preference between residents and visitors, higher frequency for both ride on and off street lanes while they wish to ride on separated and boulevard lanes. By cyclists self-categorisation, Enthused and confident seems to have higher cycling frequency than others.

Due to this, the results also focuses on opening up the possible factors that may influence the respondent’s choice to choose the bicycle for transportation alternative and what hindered the inhabitants at times when they chose another alternative for transportation.

The factors which influence visitors for choosing the bicycle is physical health while for residents the positive influences on affordability is the primary rationale for choosing bike (figure13). The factors which hinders the residents to shift to another mode of transport from choosing the bicycle are many.

The most common reasons were safety, able to afford another mode, while for visitors are other mode travel fast, long distance and enable carrying luggage (figure b22).

However, the results show that not choosing the bicycle is not statistically connected to either of the independent variables, location or monthly distance time. To this point, the empirical results have delivered some clarity considering what personal factors influenced people's mobility choices in Kigali.

In addition, the results show that the purpose for the majority respondents and visitors is to commute to work, Moreover, the cyclists commute to community's services, social and leisure time activities on the bicycle, run errands, or view cycling as a work-out, the residents people tend to choose cycling as a transportation alternative for social destinations and running errands and for recreation facilities more than the visitors do.

However, the higher frequency challenges faced by residents and visitors are almost similar where poor road surface condition, poor connectivity in network and perceived unsafety due to careless behaviour and lack of regard of drivers for cyclists were highlighted.

Based on factors that would cause stop cycling, the respondents highlighted rain, hills, and personal health as top 3 another hand factor that would increase them to cycle based on road condition (road surface in good condition and lighting), culture (a place to change clothes and refreshen up), facilities (separated lane) and improvement (secured parking and tunnel) were ranked as most important.

4.3. Descriptive analysis of stakeholders

In Kigali, there is no independent regulatory authority for urban transport. In the process of transportation regulation, various institutions intervene. Because there is no systematic bicycle route planning based on a cycle of monitoring, planning, and implementing adjustments to the routes network, expansions to the routes network are incremental, with changes generally initiated by operators rather than by government authorities. In Kigali, the lack of a regulatory framework for transportation operation and management appears to be a barrier to the growth of bicycle transportation.

All transport planning stakeholders are needed to promote cycling in the City, including the non-governmental sectors. In this research, eight stakeholders have been consulted: Kigali city, GURARIDE, RTDA, Kigali rides, RURA, G3D, RNP, and NRF. The function of interviewees are described in table 24.

i. Kigali City

KCC is responsible for developing a master plan that includes, among other matters, the road and street system; the planning, programming, management, and supervision of maintenance works for the city of Kigali road network. In addition, the Districts and City of Kigali are also responsible of the development, operation and management of the transport system of the Districts and Kigali City respectively (KCC, 2022).

ii. RTDA, Rwanda Transport Development Agency

The core functional responsibility of RTDA is to plan, develop, manage and control the national road network, the airport infrastructure, inland waterways infrastructure and the railway initiatives (RTDA, 2020).

iii. GURARIDE

GURARIDE is a Rwanda-based green e-mobility public bike share (PBS) transport system company committed to the sustainability of micromobility in Africa (Kuhudzai, 2020).

iv. **RNP, Rwanda National Police**

RNP is responsible for ensuring road traffic and road safety regulation as part of its regulatory portfolio (RNP, 2018).

v. **NRF, National Road Fund**

The primary responsibilities of the National Road Fund are to collect, manage and disburse funds earmarked for road maintenance effectively (RTDA, 2020).

vi. Kigali rides

Kigali Rides help people make sports a part of their daily lives, especially cycling enthusiasts and others who want to exercise in a fun way. It is a community-based initiative that promotes cycling sports while also promoting NMT (non-motorized transportation) long-term (Iradukunda, 2020).

vii. **RURA, Rwanda Utilities Regulatory Agency**

Regarding the road transport, the key issues of RURA are to ensure that it is performing well, that the government regulatory policy toward it is appropriate and effective, that the environmental concerns are being duly addressed, and that benefits from investment in the improved road will be passed on to road users and responsive road transport services. It also handles matters specific to urban transport. It covers how to assess road transport performance and ways of tackling important issues affecting the development of trucking and passenger public transport services (RURA, 2022).

viii. G3D, Gasabo 3D

G3D is an engineering services company that includes engineering concept development, design, project management and implementation.

4.3.1. Current situation of cycling in Kigali

The stakeholders were asked to describe the current situation of cycling in Kigali. The E-Mobility Specialist of Kigali city and the Engineer from RURA reported lack and insufficient bicycle lanes. At the same time, the public transport inspector of RTDA mentioned that the construction of bicycle lanes is still in progress. The founder and CEO of Kigali rides reported that cycling was nowhere to be something popular in the city a few months back. Still, it changed so quickly people came to realize its benefits and adapted cycling to their sports routine with the help of CarFree day. The Country Project Coordinator of GURARIDE said there is a riding culture in Kigali, but more people need access to bicycles and supporting infrastructure for safe cycling. According to the Project Manager of G3D, Cycling is still considered as mean of exercises; only RNP and NRF representatives described cycling as bad and unsafe based on heavy traffic and unsafe intersection.

4.3.2. Main cycling challenges

Different stakeholders identified the main challenges of cycling in Kigali city in the following table 24.

TABLE 24 Main challenges of cycling in Kigali city identified by different stakeholders

Company/ institution	Position	Challenges
Kigali city	E-Mobility Specialist	Lack of enough cycling infrastructure as main challenge in Kigali

Company/ institution	Position	Challenges
GURARIDE	Country Project Coordinator	Very inadequate cycling lanes, poor access to bicycles,low public enlightenment on benefits of cycling and road safety as main challenge
Kigali rides	Founder and CEO	Cycling as transport: Safety Cycling as tourism: Topology Cycling as sport: None
RTDA	Public transport inspector	Lack of cycling infrastructures and Topography. It can be seen that initially roads in Kigali were built for cars, thus cycling in open traffic seems like a suicide mission. Traffic injuries and fatalities from vehicles travelling at high speeds, heavy traffic flow and a lack of separate lanes and paths are key reasons why so many people in Kigali don't cycle. Other minor factors include the topography and people being required to cycle for longer than they can
RNP	Representative	Lack of cycling infrastructure ie, currently, shared traffic lane is challenging for cycling
RURA	Senior Engineer	Heavy traffic is the main challenge
G3D	Project manager	Road Infrastructure does not promote cycling because of inadequate infrastructure, cyclists are extremely exposed to road accidents, people's mind-set that motor driving is the most suitable for commuting from one point to another
NRF	Representative	Insufficient paths for cycling

In the following question, the stakeholders were asked to talk about what their company did to promote cycling in Kigali and the results were summarised in table 25.

TABLE 17 what institution/ company does to promote cycling?

Company/ institution	What does your institution/ company do to promote cycling?
Kigali city	Awareness, development of cycling infrastructure, partnering with Private operators and NGOs to provide cycling services.
GURARIDE	➢ Public education and enlightenment ➢ Introduction of Public Bike Share ➢ Provision of free rides ➢ Provision of riding clinics for learners in collaboration with relevant stakeholders
Kigali rides	Make cycling a fun activity so that people will love cycling and then adapt it to their everyday life in the long run. Plan for tours, from someone who has not been riding for many years to some enthusiastic cyclist, meet up ride to the same destination, and bring up the good old memories of our childhood
RTDA	Provision of cycling infrastructures
RURA	Nothing

Company/ institution	What does your institution/ company do to promote cycling?
RNP	Joined the rest of the world to mark the 5th UN Global Road Safety Week as part of the drive to reverse one of the leading causes of death in the world
G3D	We cater to cycling ways while designing the urban roads
NRF	Funding new cycling lane projects

4.3.3. Implemented countermeasures

Despite all of the challenges mentioned above, many countermeasures have been put in place in Kigali to improve cyclists' comfort and safety by Kigali city, GURARIDE, RTDA, Kigali rides, RURA, G3D, RNP, and NRF; it is critical to recognize what has been accomplished and use it as a starting point for providing countermeasures.

TABLE 26 Summary of implemented countermeasures for promoting cycling

Feature	Implemented measures
Public lighting	The City has 265 km of road network covered with public lighting, and the plan is to light the entire 350 km-network (tarmac and stone paved roads) and any new roads.
Cycle lanes	➢ Separate bicycle lanes on new roads (City Centre and Gisimenti-Kimironko) ➢ Elevated cycle lanes ➢ Promotion of NMT (Non-Motorized Transport) including cycling while undertaking the urban road design ➢ Planting trees to make paths comfortable ➢ Painting road edge lines and using studs to separate cycle lanes and to help the drivers keep driving in the carriageway
Intersections	➢ Using traffic police to control vehicles ➢ Traffic lights on some intersections with count down numbers to indicate the remaining time to pass or to keep waiting
Crossings	➢ Painted in red to increase their visibility ➢ Two vertical bars painted in white and red increase visibility and serve as an indication for people with disability ➢ Enforcement by traffic police for all road users
Campaigns	Kigali Rides offers many services including Bike Tours, every Sunday to promote cycling tourism and healthy lifestyles in Kigali.
Enforcement	➢ Installing speed governors in minibusses, buses, and all commercial vehicles to prevent them from exceeding 60 km/h was the most efficient solution for speed enforcement ➢ 24 hours a day, 7 days a week to enforce traffic rules by the traffic police (especially at intersections of Kigali city)
Bike share	➢ Introduction of Public Bike Share Scheme (Guraride has 100 bicycles at 12 docking stations) ➢ Free rides ➢ Riding clinics for learners and collaborating with relevant stakeholders

Feature	Implemented measures
Avoid bicycle theft	➢ Presence of docking station assistants ➢ Group lock of bikes on rack at the close of work

4.3.4. Proposed countermeasures to identified problems

Despite the implementation of the countermeasures mentioned above, the findings of this study indicate that there is still room for improvement in both infrastructure and road user behavior. The countermeasures presented in this study are primarily focused on infrastructure, additional research is required to clearly understand the factors that influence road users' intention to cycle. Focusing on infrastructure has numerous advantages because infrastructure can act as a deterrent to the performance of certain behaviors but also the major disadvantage that it requires a high investment.

The countermeasures were grouped in short-term (in 2-4 years) and long-term (≥ 4 years) by stakeholders.

There was no in-depth cost analysis for each countermeasure. Still, countermeasures that were expected to be expensive were not immediately classified in the short term. In addition, the countermeasures are based on current problems, they are primarily applicable to existing roads. When building new roads, these problems and others not identified in this study should be avoided.

TABLE 27 Proposed countermeasures from stakeholders on identified problems

Company/ institution	Feature	In short term	In long term
RTDA Kigali city	Infrastructure	➢ The designer should consider the cycling lane while designing and planning urban roads. ➢ More signed bike routes	➢ Increase cycling infrastructure ➢ Expansion of network of docking stations ➢ Support service providers and stimulate further close collaboration with relevant stakeholders ➢ Provision of a tunnel to avoid hilly sections
GURARIDE Kigali rides	Bike share scheme	➢ Introduction of subscription for bike sharing ➢ Flexible Payment Options ➢ Introduction of made in Rwanda bike	➢ integration of geofencing into the system and expansion of the geographical areas with access to the bike share ➢ integration of several popular payment platforms on the mobile app
Kigali city	Bicycle Parking	➢ Introduction of an integrated bike lock system	➢ GPS and Presence of docking station assistants.

5. DISCUSSION AND RECOMMENDATION

This research aimed to evaluate the cycling situation in Kigali city and identify cycling factors that can promote cycling. The survey was conducted with a sample size of 130 respondents and 19 stakeholders. This can be hardly be representative of Kigali city. Nevertheless, as demonstrated later in this section, the results from this survey and interview also support the conclusions drawn from our literature review and a set of recommendations to promote cycling.

5.1. Discussion

5.1.1. Socio demographics of respondents

According to the findings of this study, 5 % of respondents who reside in Kigali city cycle daily while 12% of respondents who reside out of Kigali cycle while 37.7% of respondents never cycle. Cycling frequency was associated with, gender, education background, travel to different destinations.

Based on the results of this study, 63% of respondents who cycle daily in Kigali were female and this presents a unique opportunity for cycling promotion in Kigali, as convincing women to cycle is often an important step in achieving healthy cycling rates in cities (Aldred, Elliott, Woodcock, & Goodman, 2017). Encouraging women and the adult population to cycle is one way to combat physical inactivity. gender and education level were the two most important socio-demographic variables influencing cycling behavior.

5.1.2. Motivation of cycling

Participants used their bicycles to improve fitness and health by means of exercises in this study. Based on this study, 36.1% of respondents who reside out of Kigali and 31.4% of respondents who reside in Kigali ride their bicycles to improve fitness. Shin, Kim, Lee, Park, & Jeong, (2013) support this conclusion in their report on Korea's Bicycle Transportation Policy. The perception of cycling to promote health was the most powerful motivator for cycling, this is consistent with many previous studies (Heinen, Wee, & Maat, 2010).We also discovered that 18.6% of respondents who cycle and reside in Kigali and 16.7% of visitors who cycle are more likely to believe that cycling will help reduce air pollution, implying that altruistic cycling beliefs may be a motivating factor to cycle in Kigali.

Another relevant factor is the importance of the built environment. To make Kigali a healthier city, city development policies and plans should consider the built environment and facilities that encourage people to cycle. Furthermore, typical geographical factors like mountains have an impact on cycling behavior. A systematic approach to urban planning is recommended to improve health and sustainability through active transportation, which promises to be a powerful strategy for long-term improvements in population health (Sallis, et al., 2016).According to a study conducted in Canada, the built environment and various spatial zones significantly impact healthy travel decisions (Winters, Brauer, Setton, & Teschke, 2010).

Making bicycling safer and more enjoyable may also help provide a travel mode option that is affordable for all socio-economic groups thus aiding social equity (Buehler & Dill, 2016).

5.1.3. Perceptions of cycling

Cycling in Kigali is not safe generally, enough bicycle signs and maintenance facilities around bike roads were enabling factors. At the same time, traffic on the bicycle roadside was a significant barrier to perceived safety with bicycle roads. A study from Poland also reported that the main perceived barriers to cycling were linked to feelings of insecurity related to drivers' behavior and road (Iwińska, Blicharska, Pierotti, Tainio, & Nazelle, 2018). Similarly, the perception of safety was found to hinder bicycling in many areas of Australia (Bauman, et al., 2008). From our results, Perceived unsafety due to careless behavior and lack of regard for cyclists was viewed as a challenge by 30.31% of the surveyed residents and 20.95% of the surveyed visitors.

5.1.4. Cycling Infrastructure

Numerous previous studies have argued that it is necessary to separate bicycle roads from pedestrian roads and vehicle roads. That related infrastructure should consider the matter when establishing new roads or redeveloping the urban area (Heesch, Sahlqvist, & Garrard, 2012;Dill J. , 2009;Krenn, Oja, & Titze, 2012).

Well-connected bike lanes separated from traffic and proper integration of cycling with public transportation are the most common features associated with higher levels of cycling (Damant-Sirois, Grimsrud, & El-Geneidy, 2014; Fishman, Washington, & Haworth, 2012; Gatersleben & Haddad, 2010; Pucher, Dill, & Handy, 2010; Margués, Hernández-Herrador, Calvo, & García-Cebrián, 2015). So, according to the respondents separated bike lanes count 60.8% as factor that would support the improvements of cycling in Kigali.

The sense of safety provided by good cycling infrastructure contributes to the promotion of cycling. The respondents choose safer places to cycle with 60.8% as very important factor to improve cycling in Kigali. Cities that have implemented infrastructure policies to promote citywide cycling have seen significant safety benefits as cycling volumes have increased over time (Viola, Roe, & Shin, 2010; WRI, 2013). This could be due to infrastructure providing a safe space for cycling and potentially increasing cycle awareness, normalizing the behavior, and increasing the number of cyclists, resulting in "safety in numbers" (Elvik & Bjørnskau, 2017).

The lack of shower facilities at work, a significant deterrent in other studies (Buehler R. , 2012), was no significant in our sample. According to the literature, the availability of bike parking facilities, on the other hand, increased the likelihood of being a cyclist (Heinen, Wee, & Maat, 2010 ; Braun, et al., 2016).In our sample convenient parking count 56.9% as the most important factors influence cycling. In this study, appropriate bicycle signs were also a significant enabling factor influence cycling.

The current study discovered that lack of bicycle roads was a significant barrier to cycle road. These findings are backed up by a study conducted in Poland, which found that the main perceived barrier to cycling in the city was a lack of good cycling infrastructure (Iwi´nska, Blicharska, Pierotti, Tainio, & de Nazelle, 2018). In an Australian study (Bauman, et al., 2008), a lack of bicycle-friendly design was a significant barrier to increased bicycle use similar to our analysis.

The lack of proper infrastructure for cyclists in Kigali is similar to that in other large cities such as Budapest, Hungary, and Sofia, Bulgaria, where cyclists highlighted the need for improvements in cycling infrastructure as a factor potentially encouraging more cycling within the City (Puhe & Schippl, 2014;Barnfield & Plyushteva, 2016). Similarly, one of the most important issues highlighted in a

cycling study in another large Polish city, Cracow, was infrastructure, where most people who cycle do so for utilitarian reasons.

5.2. Limitations

While this study collected more detailed information on bicycling behavior than any other studies found in the literature, there are still many limitations. One obvious limitation is that the study was only conducted in one region. As a result, the findings reflect the local characteristics, but they may be more difficult to generalize or compare to a larger group or other rural areas.

The study did not produce the expected results due to a low response rate and some respondents dropout during the survey. This can be explained by various factors, including the survey's length. Due to the time and effort required by respondents to complete the survey, longer surveys have lower response rates than shorter surveys. A longer survey is perceived as a burden by the respondent.

The results can now be skewed toward a specific target group, age group and education level (none and primary level). The study sample consists of residents and visitors with smartphones, tablets, or computers. As a result, some people didn't participate because of a lack of those materials and knowledge of how to complete the survey

All data collection was needed to be done online. It was difficult to meet online with stakeholders: The stakeholders appeared to have a variety of unscheduled responsibilities, making it difficult to set an exact time for the appointment.

Open-source information on Rwandan cycling statistics was insufficient to help the author understand the country's cycling situation.

5.3. Recommendations

For promoting cycling in Kigali and the African city context, the following recommendations are made considering the results of this thesis.

5.3.1. Recommendations for Planners

Bike lanes should be raised, separated, and made wider in the city. These are far more effective in encouraging cycling and improving safety than painted cycle lanes (also in terms of perceived safety).

To promote cycling in a city successfully, the planners should support a positive cycling culture among residents. The planners should develop initial design ideas for new or improved transportation infrastructure as an effective tool for making them feel more comfortable riding bicycles.

5.3.2. Recommendations for Policymakers

The national government should establish a basic policy framework for cycling that balances the interests of various policy objectives and that local governments can use as a policy context for cycling initiatives. Vertical and horizontal coordination between levels of government and different sectors (particularly health, environment, land use, and transportation) is critical. Cycling and walking should be fully integrated into transportation planning at all levels of government.

Significant investment is required, particularly in the development of proper cycling facilities. The national government's financial support can be extremely beneficial. The city should invest in cycling infrastructure to address cyclists safety concerns and perceptions of safety. This will necessitate the

creation of a network of segregated cycling lanes of high quality. Improved safety may encourage more people to ride bicycles, especially those who cycle less and never do so. A city should ensure that adequate cycling infrastructure is in place before or concurrently with the planning and design of a bike share scheme.

Bike parking should be visible and prominent for cyclists to find and discourage bike theft. Select racks that have at least two points of contact with the frame to ensure that bikes are securely locked and parking does not obstruct pedestrians. Furthermore, Portland encourages businesses to request or install bike parking on their property (PBOT, 2022).

Traffic light signaling should prioritize pedestrians and cyclists. This reduces the time people must wait to cross the road and aids cyclists in avoiding red lights (at speeds of around 20 km/h), a phenomenon known as the 'green wave.' Rain sensors have been installed at intersections in Kigali so that when it starts to rain, the traffic lights prioritize cyclists (Ben, 2016).

As other road users like motorcyclists, public transport users, have some bodies/institutions which follow their activities daily, it should be essential to include in governmental institutions like Ministry of infrastructure (MINIFRA), Rwanda Transport Development Agency (RTDA) or city of Kigali at least a person who will only be concerned with mobility and safety of cyclists daily. This person can be involved in the studies about road construction but focusing on the benefits of cyclists.

Provide bicycles for students: Bicycles have numerous advantages for students. As a result, active promotion of student bicycles should be undertaken, along with (quantity) discounts for families. Schools should also provide bicycles for students who have particularly long school commutes. Furthermore, workshops on fixing common bicycle problems can improve students' flexibility and safety on their school journey.

Polluting delivery vehicles in the city can be restricted by establishing Low or Zero Emission Zones. Because of these restrictions, businesses will be encouraged to test e-bike and cargo bike deliveries. Cities can provide financial incentives to these businesses to persuade them to switch.

To encourage and participate in promoting the growth of the tourism in Rwanda, the touristic centers may provide public bike scheme to experience a growth in cycling numbers, moreover, cycling may also influence visitors to cycle frequently as they can visit more stores frequently, resulting in higher weekly spending as they can travel to different area to complete a shopping trip.

5.3.3. Recommendations for further research

The following messages could offer a useful guide to those interested in offering their contribution to promote cycling in an urban area.

The author requests that researchers revisit this finding and determine whether additional bicycle facilities and existing infrastructure are required in Kigali to promote cycling.

Future research could develop models and analyze interview responses in other regions to see if the results of this dissertation are consistent in different geographic contexts. In addition, the survey was done in general. Future surveys could be done in employment centers, shopping districts, sports and entertainment zones, residential neighborhoods, or recreational areas to capture more complete bicycle travel data in other types of locations.

Overall, future studies should enrich and improve land-use factors, investigate dynamic influence of land use on bicycle usage, and extend study area to more specific cases in other cities.

Based on the findings of this study, leaders can learn how to make their cities safer and more accessible for bicyclists. The Kigali case study analysis also leaves room for future research into best practice policy financing improvements for local bicycling. Future research will focus on the accessibility needs of specific social groups such as unemployed people, the elderly, children, and the disabled.

6. CONCLUSION

Cycling as a mode of transportation plays an important role in transport of the city of Kigali. Cycling viewed as sustainable transportation system by the potential for significant environmental (greenhouse gas emissions for climate change mitigation), economic (job created, fuel saving,etc), health benefits (improving the quality of life) and social benefits (options for those who may be unable to travel by other modes) .

Traffic congestion in Rwanda increases yearly due to the exponential growth of private cars and motor vehicles therefore, this study has evaluated the current use cycling situation in Kigali city. There are no separate pedestrian and cycle paths on many of Kigali's roads. In addition, the city has a limited cycling network. The safety of cyclists is jeopardized as a result of this. Respondents and stakeholders identified the lack of adequate cycling infrastructure as the main challenge in Kigali.

Focusing on what factors were found to have significant influence on the decision to use bicycle as a mode of transport, the higher frequency of residents choose bicycle for keep them health whereas visitors choose bicycle is affordable. We found that 5 main factors might have been missing in Kigali: safety, a well-connected network, parking space, infrastructure and safe intersection. Concerned authorities should aim to maintain enabling factors while overcoming barriers to cycling and encouraging cycling behavior in Kigali. This study has identified the enabling factors that promote cycling in Kigali such as the availability of cycling lanes (separated lanes and boulevards), sufficiency of bicycle parking space, enough bicycle signs and maintenance facilities around bike roads.

Land use (residential area, commercial areas, and social infrastructure) can play a very important role in deciding the travel plan and affect people’s choices. It significantly influences bicycle usage in terms of frequency, time, and distance. As a result, the findings provide practical guidance for urban transportation planning. Better land use planning is a greater possibility of using more sustainable transport.

Cycling policy is influenced by three factors, the financial aspect, the regulatory or legal aspect, and the actor's role. These three aspects are interrelated. If there are no costs, then cycling facilities cannot be constructed. Likewise, if there are no clear rules, the funding cannot be allocated. The parties involved in cycling policy involve all actors, for example financing of infrastructure development can be submitted from the province to request funds from the national government. As Kigali city is highly willing to become a city of green transport; this research can significantly contribute to achieving this target. Providing safe and enforced infrastructure for cyclists will encourage many people in Kigali city to cycle rather than use motorised transport, which will reduce transport problems such as congestion, air pollution, and road accidents.

Some of the identified problems may not require a lot of knowledge resources to solve because the city has some areas where best practices [HE2] have been implemented (introduction of public bike share scheme, road painted in red to increase visibility and public lighting). It is only recommended that best practices be distributed throughout the city, as cyclist facilities and other relevant factors should be provided and maintained in all parts of the city to effectively promote and encourage people to cycle and improve cyclist safety and comfort.

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Appendices

Annex 1 Research Consent Form

Dear Participant,

My name is Mizero Marie Louise; I am a master's student in the Transportation Sciences program at the University of Hasselt in Belgium, specializing in policy and planning, and my email address is marielouise.mizero@student.uhasselt.be. You have been invited to take part in a study about cycling. This research aims to identify the current state of cycling in Kigali City, Rwanda, and determine how cycling can be promoted.

This research is intended to be informative, beneficial, and helpful in determining the applicable measures that could promote cycling usage for Kigali City residents and visitors.

Your voluntary participation in this research study is greatly appreciated. You have the option of not participating or withdrawing at any time. The information you provide is anonymous and will be kept strictly confidential. The study's findings could be published in an academic journal. This survey will take less than 10 minutes to complete.

Consent

I have read this consent form and have been allowed to ask questions. I give my consent to participate in this research study.

I agree to participate, yes □

No □

Date……/……/……

Annex 2. Questionnaires

Residents and visitors questionnaires

Section A : Personal information

1. If you live in Kigali, which district do you live in?
   i. Kicukiro
   ii. Gasabo
   iii. Nyarugenge
2. If you live out of Kigali (visitor), please mention which province and district you live in? ……
3. What is your gender?
   i. Male
   ii. Female
   iii. Other
4. How old are you? …….
5. Of which people does your household consist? (Multiple answers possible)
   i. Alone
   ii. my husband or wife
   iii. boyfriend or girlfriend
   iv. Parents
   v. Children
   vi. Siblings
   vii. Others
6. What is your highest educational background?
   i. None
   ii. Primary school
   iii. Secondary school
   iv. Technical school/college
   v. University level

Section B: the following questions deal with your cycling behavior

1. How often do you use a bicycle?

i. Daily

ii. Several times a week

iii. Few times a week

iv. Few times per month

v. Few times per year

vi. Never (skip Q2 to Q8)

2. If Q1 = I to v, what type(s) of bicycle do you use (check all that apply)?

i. Normal/ regular bike

ii. female bike

iii.Adaptive/Tricycle

iv. Bike share

v.Cargo

vi. e-Bike/electric bicycle

vii.Folding

viii.Hybrid

ix.Mountain

x. Racing

xi.Other

3. If Q1 = I to v, why do you choose a bicycle over other modes? (Multiple answers are possible)

i. It is affordable

ii. It is my only available means of transport

iii. It is a convenient mode in avoiding congestion

iv. It is a means of exercise to keep me healthy and fit

v. It does not pollute the environment

vi. It's sustainable

vii. Other (mention it below) ……

4. If Q1 = I to v, do you ever use a bicycle for transportation to/from any of the following Destinations (check all that apply)?

Workplace

Stores/services

School

Community facilities

Recreational facilities

Transit stops and stations

Social destinations

Other neighbourhood destinations (please indicate them) ……

5. If Q1 = I to v, approximately how many hours a month do you ride a bike? ……

6. Q1 = I to v, where do you cycle most of the time? (Please select the most appropriate answer)

i. On-street

ii. On-street in dedicated lane

iii.Separated bike lane

iv.Off street-side path

7. Q1 = I to v, If the following infrastructural options existed, where would you choose to cycle? (Check one)

i. On-street (in travel lane)

ii.Buffered bike lane

iii.Separated bike lane

iv.Off-street side path

v.Bike boulevard

8. If Q1 = I to v, what are your challenges as a cyclist? (multiple answers possible)

i. Poor road surface condition

ii. Poor or inadequate connectivity in the bicycle network

iii. Perceived unsafety due to careless behavior and lack of regard of drivers for cyclists

iv. Negative or poor image of the community for cyclists

v. Others ,……

9. If Q1 =iii to vi, how would you rate the following factors as to why you do not cycle more frequently?

Factors	Yes	No
i. No bicycle parking		
ii. No bike lanes		
iii. Bike lanes in poor condition		
iv. Unsafe intersections		
v. Being quite unexperienced		
vi. heavy automobile traffic		
vii. Personal safety concerns		
viii. Visually unappealing surroundings		
ix. Lack of time		
x. Destinations too far away		
xi. Lack of worksite amenities (e.g., showers)		
xii. Travel with small children		
xiii. Too many stops to make		
xiv. Too much to carry		
xv. Unsure of route		
xvi. I do not have a bike		

10. Which of the following factors would make you shift from bicycle to motorized transport?

Factors	Yes	No
i. The ability to afford another mode like motorbike/car		
ii. The fact that other modes enable travelling long distances without getting tired		
iii. The fact that other modes travel faster		
iv. The fact that other modes enable carrying luggage or more household members		

v. The safety/better protection of motorised modes

vi. Others

11. What general category of transportation bicyclist would you mainly place yourself in (i.e., your comfort level using available cycling facilities)?

i. Strong and Fearless (you cycle regardless of the road condition)

ii. Enthused and Confident (you feel comfortable sharing the road but prefer separate facilities)

iii. Interested but Concerned (you are curious about cycling, but only would ride if you felt safer on the road)

iv. No Way No How (you are not interested in cycling at all)

12. Should there be mobility education at school?

i. Yes

ii. No

13. If you have school-age children (under 12 years), have they or will they receive mobility education as part of their schooling? (Check all that apply)

i. Yes, on cycling

ii. Yes, on driving

iii. Yes, on transit use

iv. Yes, on walking

v. I don't know

vi. They don't receive mobility education and I want them to!

vii. I don't have school-age children

Section C: This section focuses on factors that could change a person's willingness to start cycling or cycle more. Select one of the answers from the scale (1 to 5).

14. Transportation safety and road conditions: On a scale from 1 (Not at all Important) to 5 (Very Important), please indicate how each of the following would cause you to start or increase your cyclin

Factors	**1**	**2**	**3**	**4**	**5**
Reduced traffic speeds					
More aware drivers					
Fewer vehicles					
Lighting					
Police presence					

the road surface in good condition					

15. Transportation facilities: On a scale from 1 (Not at all Important) to 5 (Very Important), please indicate how each of the following would cause you to start or increase your cycling

Factors	1	2	3	4	5
Safer places to cycle (e.g., a dedicated or separate cycling lane)					
Better connectivity/more direct routes (extended cycling network)					
Elimination of dangerous/unpleasant bottlenecks along the otherwise suitable routes					
Bicycle routes with wayfinding signs					
Convenient bicycle parking					
Bike lanes or bike paths connecting to the desired transit stop/station					

16. Transportation culture and encouragement programs: On a scale from 1 (Not at all Important) to 5 (Very Important), please indicate how each of the following would cause you to start or increase your cycling:

	1	2	3	4	5
The community that embraces cycling					
A workplace that embraces cycling					
School/university that embraces cycling					
More people cycling/greater cultural acceptance					
A place to freshen up a little after arriving by cycle					
A place to change clothing & shower after arriving by cycle					
Financial incentives					

17. Negative Factors: On a scale from 1 (Not at all Important) to 5 (Very Important), please indicate how each of the following would cause you to stop or decrease your cycling:

Factors	1	2	3	4	5
Rain					

Cold weather					
Hot weather					
Hills					
Personal health condition					

Environmental factors (e.g., bad air quality)

18. How important do you think the following improvements would support cycling in Kigali?

i. More bike lanes

a. Very important

b. Somewhat important

c. Not important

d. Not sure

ii. More signed bike routes

a. Very important

b. Somewhat important

c. Not important

d. Not sure

iii. Good maintenance of sidewalks, bike lanes, bike routes/greenways

a. Very important

b. Somewhat important

c. Not important

d. Not sure

iv. Improved connections between sidewalks, bikeways, and transit

a. Very important

b. Somewhat important

c. Not important

d. Not sure

v. Safe intersections for cyclists to cross roads

a. Very important

b. Somewhat important

c. Not important

d. Not sure

vi. Better street lighting
    a. Very important
    b. Somewhat important
    c. Not important
    d. Not sure
vii. Cycling lanes separated from vehicle traffic
    a. Very important
    b. Somewhat important
    c. Not important
    d. Not sure
viii. Education/enforcement for motorists, pedestrians, & bicyclists
    a. Very important
    b. Somewhat important
    c. Not important
    d. Not sure
ix. Worksite amenities (lockers, showers, dressing rooms)
    a. Very important
    b. Somewhat important
    c. Not important
    d. Not sure
x. Secure bicycle parking
    a. Very important
    b. Somewhat important
    c. Not important
    d. Not sure
xi. A bicycle route map
    a. Very important
    b. Somewhat important
    c. Not important
    d. Not sure
xii. A bicycle app

i. Very important

ii. Somewhat important

iii. Not important

iv. Not sure

xiii. Provision of e-bikes

a. Very important

b. Somewhat important

c. Not important

d. Not sure

xiv. Provision of a tunnel to avoid hilly sections

a. Very important

b. Somewhat important

c. Not important

d. Not sure

19. In case you have any additional suggestions or comments regarding the promotion of cycling in Kigali, please write it down here:

……

Thank you for your participation!

Stakeholders questionnaire

Section A: Personal information

1. What is your gender?
   i. Male
   ii. Female
   iii. Other
2. How old are you? ……
3. Do you live in Kigali? If yes, in which district do you live?

i. Kicukiro

ii. Gasabo

iii. Nyarugenge

4. If you live out of Kigali, please indicate which district you live in?

…….

5. What is your highest educational background?

i. None

ii. Primary school

iii. Secondary school

iv. Technical school/college

v. University level

Section B: General Questions

1. Institution name……

2. What is your position? ……

3. How would you describe the current cycling situation in Kigali?

……..

4. What, in your opinion, is the most common reason for people not cycling (more) in Kigali?

……..…….

5. What are the main cycling challenges in Kigali city? ……

6. What does your company do to promote cycling? …….

7. What countermeasures has your institution implemented in the last few years to increase cycling usage? ……..……

8. What are your short-term (2-4years) and long-term (>4years) plans for promoting cycling in Kigali?

……..

9. What is your opinion about the following suggestions/measures that could be taken?

i. Implementing (more) cycle lanes in different parts of the city

ii. invest more in maintenance

iii. address dangerous locations for cyclists

iv. Install more lightning

v. Install (more) racks to park bicycles

vi. Add (more) signals and markings for cycleways

vii. More efforts on mobility education

viii. Organise awareness campaigns and recreational activities addressing cultural taboos, such as the view that cycling is bad for women or is a transport mode only used by the poor

ix. Organise mass cycling trips where people can feel safer travelling in a group

x. Facilitate travel by providing information on safer and more convenient cycling routes

xi. Formulate policies that support the development of bicycle companies.

xii. Increase the supply, access, and affordability of bicycles.

10. Is your organisation/ company involved in bicycle rent (for visitors and/or inhabitants)?

i. Yes
ii. No

11. In case your organisation is involved in bicycle rent (for visitors and/or inhabitants), which measures do you take to avoid bicycle theft?

……..……

12. How do you handle the issue of bikes being damaged or stolen?

……..……

13. How much does it cost to rent a bicycle?

i. Per 30 min ……

ii. Per 1h…….

iii. Per day ……

iv. Per month …….

14. How many bikes are rented per month in your company? And do you have an idea about the profile of the renters?

15. ……..……

Thank you for your participation!