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Summary

Travel demand is still poorly managed in Kigali city. The other researches that were done on traffic congestion in Kigali city aimed to regulate the supply side of the problem. However, this study aims to regulate the demand side of traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city where inflexibility of work schedules and land use design were presented as the main issues leading to traffic congestion. Most of the workers in Kigali city start and end their work at the same time which means that their departure time is fixed. Additionally, most workers do not change the location of their workplaces which means that their commuting distance is fixed. The inflexibility of work schedules in terms of where and when to start work in Kigali city increase the travel time of workers which worsens the level of service in the roads. Based on land use design of Kigali city, there is not enough mixed land use of workplaces with the residential area which attracts workers to work in other places particularly in the CBD rather than their residential areas. Connectivity is another cause of traffic congestion because the road width is small where the number of vehicles exceeds the capacity of roads during peak-period.

The main objective of this research is to provide knowledge that will be beneficial in regulating the demand side of traffic congestion in Kigali city by explaining how inflexible work schedules and land use design influence traffic congestion in terms of travel time and level of service. The study was mainly explanatory and used a mixed method where both quantitative and qualitative methods were used. The data was collected using questionnaires, semi-structured interviews, ArcGIS pro, and secondary data for triangulation.

The statistical results of the study did not show any strong correlation between the independent variables and the dependent variables because of the limited number of respondents that undermined the relationships and the questionnaire data collected represented peak-period only hence social-economic variables did not show any relationship with travel time as proved by other empirical studies. However, using the data from interviews, questionnaires, ArcGIS Pro and secondary data, the study shows that there is a significant relationship between inflexible work schedules, land use design and traffic congestion where departure time choice, commuting distance, land use mix, and connectivity has influenced significantly travel time and level of service. All the 3 roads under study are congested where Gisozi-CBD road is the most congested and Kicukiro-CBD road is the least congested.

This study supports the view that traffic congestion can not only be regulated by focussing on the supply side of traffic congestion but balancing both the demand and supply side of the problem. However, travel demand management that aims to reduce unnecessary trips is the pillar to achieve sustainable mobility which focuses on the movement of people rather than the movement of cars. It is recommended under this study that the transportation sector in Kigali collaborates with the Ministry of workers, Ministry of health, urban planners, and the other relevant sectors to alleviate traffic congestion and its impact in Kigali city. The study also recommended that the other empirical research that focuses on travel demand management can be conducted in Kigali city since there is a gap in the literature about the topic.

Keywords

Inflexible work schedules. Departure time choice. Commuting distance. Land use design. Land use mix. Connectivity. Traffic congestion. Travel time. Level of service. Travel demand management.

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Abbreviations

BRT	Bus Rapid Transit
CBD	Central Business District
E. U	European Union
GIS	Geographic Information System
IHS	Institute for Housing and Urban Development Studies
KCMP	Kigali City Master Plan
KG	Kigali Gasabo
KK	Kigali Kicukiro
LOS	Level of Service
MIFOTRA	Ministry of public service and labour
MININFRA	Ministry of Infrastructure
RTDA	Rwanda Transport Development Agency
SOV	Single Occupancy Vehicle
SPSS	Statistical Package for Social Science
SRI	Speed Reduction Index

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Chapter 1: Introduction

The chapter presents information on how land use design and inflexible work schedules influence traffic congestion on a global scale and in Kigali city particularly. It incorporates the background of the problem from the literature review. The chapter highlights also the problem statement and research objective. Moreover, the chapter designates the relevance of the study. In the end, this section outlines the main objectives, the main research question and sub-questions of the research.

1.1. Background information

Transport is the main sector that plays a significant role in the development of the country economically. For transport to become sustainable, it must ease mobility, accessibility, and above all being affordable (World Bank Group, 2018). Balancing the three pillars of sustainability in transport is a challenge where more attention is paid to the economic sustainability only. Daniel et al., (2010) discussed that transport contributes 13% of global greenhouse gases and 23% of CO_2 emissions globally. It is expected that the CO_2 emitted by the transport sector globally will increase by up to 53% by 2030. This is a challenge resulting from traffic congestion especially in cities experiencing rapid urbanization and population growth. Nowadays, 55% of people live in urban area which is expected to reach 68% in 2050 (John, 2019).

Traffic congestion persists to dominate as the major transport problems globally especially in developing cities which are experiencing rapid urbanization. According to Toan (2018) in relieving traffic congestion problem, even though much effort and resources have been devoted, they have been only a few successful cases. The main reason for this is the failure to manage the travel demand by balancing the demand and the supply side of the problem. Jain et al., (2012a) also added that more roads will not solve traffic congestion problem additionally, the Australian 2019 report shows that the number of rail and road projects in Melbourne and Sidney will not prevent traffic congestion to rise steeply.

In ancient times, traffic congestion solutions came from the supply side by increasing transportation facilities but nowadays strategies focus on managing the demand side (Monowar et al. , 2009). Travel demand management is a policy choice for solving traffic congestion and other transportation problems by regulating travel needs through restriction and regulation. Seattle Urban Mobility Plan, (2008) implied that Strategies adopted to manage travel demand includes parking management, carpooling, congestion pricing, land use management, urban land use design, and flexible working conditions.

Flexible work schedules like telecommuting and changing working locations came as a solution to subside inflexible work schedule which is a traditional way of working which does not allow workers to choose when and where to work (Fisher, 2017). Inflexible working conditions has shown many weaknesses where workers commuting distance and departure time to their job does not change. The empirical study done in Australia showed that 83% of workers are happy with flexible work schedules. The same study proved that number of daily travellers will be reduced to 41% if the workers will be able to work remotely 50% of their time (John, 2019). It was also proved empirically that workers with flexible work schedules can change their commuting distance and departure time choice more often than workers with inflexible work schedules (Fisher, 2017). By introducing policies like telecommuting and compressed workweek, productivity and worker morale will be increased significantly, additionally, traffic congestion will be eradicated in cities.

Another way of regulating travel demand is land use design. Land use management and urban design are some of the strategies that favour sustainable transport where E.U strongly advise compact city as an urban form to manage travel demand. Compactness advocates the development along with the existing urban infrastructure where activities like residential and jobs can exist in one proximity to one another (Jabareen, 2006a). Through compact cities, mixed land use of activities and connectivity of roads within the neighbourhood promote the use a non-motorized mode of transport like walking and cycling. On the other hand, most of the African cities are centrally planned from the colonial era till today where workers live in the suburb and other economic activities like offices, and shops in the city centre (Joseph, 2018). The separation of workplaces and residential area increase the commuting distance where it tends to be higher than in the mixed land use neighbourhoods.

A study conducted in Netherlands proved that without flexible working schedules traffic would be increased by 4% (van der Loop et al. , 2017). Additionally, another study conducted in Stockholm predicted that mixing land use and improving connectivity of roads will reduce the vehicle mile travelled by 10% which in turn will improve the level of service of Stockholm roads (Lundqvist, 2003). Number of studies proved it empirically that there is a positive correlation between land use design, inflexible work schedules and traffic congestion but it is necessary to assess socio-economic variables like level of income, gender and age because they can mediate these hypothesises (Daragay, 2003; Ferguson, 2016; Lundqvist, 2003). Therefore, it is found important in this research to understand how inflexible working conditions and land use design influence traffic congestion in Kigali city.

1.2. Problem Statement

Rwanda is a landlocked country at the heart of Africa where the nearest port is 1,400 km in Dar es salaam. The transport sector in Rwanda is comprised of Road transport, air transport, and lake transport. Rwanda does not have a rail transportation system. Road transport is the main type of urban transport for passengers and goods in the country with a road density of 0.53 km/km^2 (Ministry of Infrastructure, 2008). However, the sector is facing many problems that have been conquered over many years.

The main challenge of urban road transport in Rwanda is population growth and increase in private car ownership. Kigali city, the capital city located at the centre of the country is growing rapidly because of immigration and its economic growth (Leopold and Aloys, 2018). It is estimated that the population of Kigali city increase by 4% every year and it is unavoidable. Moreover, private car ownership in the city is increasing drastically (Jean Chrétien, 2017). This can be underscored by poor organization and integration of public transport in Kigali city where long queues of people waiting for buses become a daily challenge. This discourages people to use public transport where many decide to use motorcycles or buy their cars. In 2014, the Mayor of Kigali said that the long waiting queues of buses will be resolved at the end of the year, but even nowadays the never-ending queues are still there especially during rush hours (Observers, 2015).

The increase in entrepreneurship and development of Kigali city in different careers leads to availability of work where number of workers increase and their personal development increase in terms of income. That contributes a lot to single-car ownership because many workers find it easy to afford a car. Leopold and Aloys (2018) highlighted that workers in Kigali city contribute a lot to traffic congestion in the city because more than 70% of workers start working from 7:00 A.M- 8:00 A.M and end their work at 5: 00 P.M. This applies to government, private, Banking and commercial workers. the majority of workers work from Monday to Friday except for shopping centres that sometimes open at the weekend. Additionally, because many people start

and end their work at the same time, traffic congestion is inevitable during peak period or rush hour.

According to Janssen, (2017) separation of workplaces and residential area increase commuting distance of workers who commute every day at the same time and went to the same place every day. This issue of higher commuting distance can be better explained by both inflexible working schedules and lack of mixed land use plan in Kigali city which does not allows workers to change when and where to work. Kigali city hosts the most administrative functions in Rwanda where the city is considered as centrally planned which means that workers moved in the city centre and out of the city centre at the same time.

To reduce traffic congestion during peak period in Kigali city, Jean Chrétien (2017) said that there is a need to relocate activities from Kigali city centre to the other parts of the city or the country because of the concentration of all activities at the same place. Vincent (2019) highlighted that more than 90% of commuters in the city move to the city centre for jobs, education, recreation, and shopping. Leopold and Aloys (2018) mentioned that there is a very serious problem of traffic congestion in Kigali city because there is no policy to rectify that issue yet which means that there is no mixed land use policy that allow the integration of residential area and workplace in the same neighbourhood.

The other challenge identified by researchers is that the majority of paved roads in Kigali city are in poor conditions because of poor maintenance hence need rehabilitation. Kigali city has over 1000 Km of roads where only 153 Km are paved roads. This implies that 85% of the roads in Kigali city are not in conditions to boost the economic condition of the country (Jean Chrétien, 2017). One of the examples is Nyabugogo-Gatsata road that was planned to be expanded by 2 double lanes network, but the project only added pedestrian's walkway and some other repair. The road was supposed to reduce traffic congestion in that area, but traders still complain that the road does not meet their daily practices (Dan, 2017). This indicates that there is connectivity problem in Kigali city where roads are not in good physical conditions and the roads width and length are not enough to cope with the number of vehicles using the roads.

Inflexible work schedules and land use design in Kigali city has contributed to the lower level of service in Kigali city where in the research conducted by Vincent (2019) shown that Kigali city roads are classified as level of service E where there is unstable vehicle flow. The delay survey in Kigali city roads is equal to 58 seconds per vehicle. Moreover, the absence of land use mix where residential areas and workplaces are separated increase commuting distance which automatically increased travel time from residential area to workplaces. However, travel time of commuters is influenced by other social economic factors because the time spent by someone who use public transport and travel time spent by someone who has his/her own car or who can afford to use private transport (motorcycle and uber) is not equal even if the destination may be the same (Ferguson, 2016). Consequently, socio-economic factors influence the departure time choice of the commuter because public transport commuters tend to start their journey early than private car owner.

From the above problem stated, there is a need to address the demand side of traffic congestion in Kigali city by regulating and reducing travel behaviour. Many researchers like (Frank, 2006; Meerkerk, 2015; Omondi, 2018; van der Loop et al. , 2017) studied how land use design influence traffic congestion or how inflexible work schedules influence traffic congestion. However, there is a need to identify the gap on how inflexible work schedules and land use design together influence traffic congestion. Inflexible work schedules are better explained together with land use design concepts because mixed land use and connectivity emphasize better commuting distance and departure time choice of commuters which in turn influence positively or negatively traffic congestion. This will boost the understanding of sustainable

planning and integration of working places and residential areas through making work schedules flexible or mixing land use which will improve wellbeing of city dwellers in terms of social, economic and environmental aspects.

1.3. Relevance of the research topic

Kigali city, as the fastest growing city in Africa, needs innovative measures to regulate the transport sector. The sector faces challenges which affect the city development and liveability.

As for theoretical relevance, first of all this is the first study in Rwanda that explains how inflexible work schedules and land use design influence traffic congestion. This study fills a unique gap in literature especially in sub-Saharan Africa. However, there is no empirical researches in other countries that combined both inflexible work schedules and land use design as the variables contributing to traffic congestion. All the literatures presented one variable as the main cause of traffic congestion. Secondly, previous studies have shown that inadequate public transport is the major cause of traffic congestion in Kigali city and suggests different solutions including upgrading roads, proposing aerial cable cars and use of electric cars (Leopold and Aloys, 2018). Almost all the proposed measures of traffic congestion want to regulate the supply side of the problem which is not cost effective. In this study, land use design and inflexible work schedules aim to explain the demand side of traffic congestion which can be regulated with no extra cost. Lastly, the finding of this study will be helpful to transport sector, health sector, workers sector and planning sector in Kigali city. This will create a collaboration between those sectors in future planning of secondary cities.

As for societal or practical relevance, this research addresses a need for effective transport which is well managed. Therefore, by resolving the traffic congestion problem they will be a need for mixing land use and introducing flexible work schedules. Besides they will be a need to integrate workplaces and residential area in the society which can increase productivity and social welfare. Within this study, recommendations can be made to the transport sector, health sector, urban planners, decision makers, and the Ministry of workers in Rwanda through improving Kigali city liveability or through developing secondary cities which are new developing cities. Apart from this, the study will provide empirical literature for the next studies by adopting land use design and inflexible work schedules variables that has not yet studied together or by using the other travel demand management variables in explaining traffic congestion issues in developing cities.

1.4. Research objective

This study aims to provide knowledge that will be beneficial in regulating the demand side of traffic congestion in Kigali city by explaining how inflexible work schedules and land use design influence traffic congestion (travel time and level of service) on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads.

1.5. Main research question and sub-questions

1.5.1. Main research question

How do inflexible work schedules and land-use design influence traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city?

- Independent variable inflexible work schedules are composed by departure time choice and commuting distance as sub-variables.
- Independent variable land use design is composed by composed by connectivity and land use mix as sub-variables.

- Dependent variable traffic congestion is composed by travel time and level of service as sub-variables.

1.5.2. Sub-questions

1. What is the situation of traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city?
2. How do the inflexible work schedules influence traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city?
3. How does land use design influence traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city?

Chapter 2: Literature review/theory

2.1. State of the art of theories/ concepts of the study

2.1.1. Introduction

This chapter uses concepts and theories to explain the background of the problem discussed in chapter 1. The leading theories discussed were rooted in the main variables of the research question. The chapter introduces the first independent variable which is the inflexible work schedules and its possible theories. The second independent variable which is land use design is explained by using the urban form concept. Additionally, the chapter explains traffic congestion as the dependent variable and its sub-variables, together with empirical studies showing the link between inflexible work schedules and traffic congestion and the link between land use design and traffic congestion. Moreover, the relationship between the independent variables and traffic congestion is explained. Lastly, the chapter provides a conceptual framework of the research formulated based on theories, concepts and empirical studies.

2.1.2. Inflexible work schedules

A fixed work schedule or inflexible work schedule is a situation where employees start and end their work at the same time and place designed by their companies. Normally working hours are 40 per week where the work starts at 8:00 or 9:00 A.M and ends at 5:00 or 6:00 P.M from Monday to Friday (Golden, 2009). This traditional fixed working arrangement has caused many environmental issues like traffic congestion and social concerns where worker morale declined. However, the new flexible work schedule was proposed as a solution to reduce traffic congestion issues, improve morale of workers and change urban structure planning (Yu et al., 2019). The Researcher on a flexible work schedule stated that an employee must be treated as an adult as long as the job is done (Omondi, 2018).

Flexible working hours allow employees to work in shifts which reduce the number of workers going and coming from work during peak hours (Hirshfield, 2019). According to Omondi, (2018) flexible working schedules are observed as the ones that allow the employees to choose when to work and the place where the job should be done outside the temporal workplace. However, Kossek and Michel (2011) explained flexible working schedules as the situation that allow the employees to choose the time, place, shifts and number of hours they want to work.

Based on the above definitions, flexible work schedules occur in many forms. Some of them are categorized based on the meaning of flexible working schedules. Considering the flexibility in when the work occurs, they are flexitime and compressed workweek form. Based on where to perform work there are telework and split locations. Considering the fact to reduce workload and working in shifts, flexible working schedules can be found in job sharing and part-time job forms. Lastly, concerning employment breaks and time off, part-year work and short and long term levees are among the forms (Kossek and Michel, 2011).

They are several theoretical emerging perspectives of flexible working schedules. One of them is border theory that was developed by Clark in 2000. The theory is based on the idea that work and family make two different spheres that impose a burden on one another. The author mentions that they are physical, psychological or temporal borders between home and workplace. However, individuals are motivated by accomplishing their works as well as close relationships and happy families (Fisher, 2017). The second theory among many others is signalling theory. This theory has been used to explain how flexible work schedules can lead to employee's wellbeing by allowing them to participate in personal development activities. According to Omondi (2018) flexible work schedules can lead to positive perceptions that can permit the employee to cope with work-family engagement.

It was proven by scholars that flexible working schedules are associated with improvement of organizational performance, personal positive developments and better air conditions in cities (Kossek and Michel, 2011). However, both business managers and employees should work together to create a favourable work schedule (Hirshfield, 2019). Inflexible working schedules that do not allow people to choose when and where to work have proven as the environmental, economic and social hinder of sustainability. In the Kigali city context, departure time and commuting distance are going to be considered as the sub-variables of inflexible work schedules that contribute to traffic congestion.

2.1.2.1. Departure time choice

In the Urban transportation context, commuter trips departure time plays an important role in forecasting Peak hour and provide a basis for future policymaking (Bhat, 1998). The choice of departure time received increasing attention by analyst as it determines variation in congestion level during the peak period (Cheng et al., 2013)

According to Saleh and Farrell (2005) departure time decisions are related to the management of the demand-side measures of traffic congestion like flexible work hours and traffic control, especially during peak hours. Understanding the correlation between departure time and traffic congestion is important to the design and evaluation of coping measures during peak period congestion (Mahmassani and Chang, 1986). However, considering the factors that affect departure choice is very necessary.

Individual departure time choice does not only influence by work by also by other personal activities. Some of the factors influencing departure choice discussed by scholars include marital status and family obligation, income, travel cost, occupation, travel time and flexibility of work schedule. Recent research has shown that flexibility of work schedule is the crucial factor that determines departure time choice for work. It was found that workers with inflexible work schedules do not change their departure time choice and when the changes are made, they are slighter compared with flexible workers (Saleh and Farrell, 2005).

To reach their destinies, different workers adjust their departure time choices to avoid traffic congestion and congestion charging which is now increasingly being implemented in many cities (Noland and Small, 2006). However, it was found important to include departure time choice in this study because in Kigali city, more than 70% of workers start from 8:00 A.M and end their work at 5: 00 P.M. This means that their departure time choice and commuting distance are fixed (Leopold and Aloys, 2018).

2.1.2.2. Commuting distance

Commuting distance from home to work is part of almost everyone's life every day. The way a commuter use to reach the workplace may affect the state she/he starts the work in (Wolday et al., 2019). Extremely congested roads will impact the journey of the employees through delay and tardiness where Traffic congestion is the popular excuse for workers every day. A depressing consequence of daily life is the result of traffic congestion and tardiness workers go through every day that tends to worsen the productivity at work (Rahman et al., 2014).

Table 1. Commuting distance with respect to travel mode

Commuting distance	Travel mode
>1Km	Walking
1-5Km	Cycling
5-10Km	Bus/Paratransit
>10Km	Cars

Source:(Rahman et al., 2014).

In table 1 Above, it is evident that the longer the distance, the more people adapt motorized transport. Recent research about "an empirical study on the relationship between commuting distance and job satisfaction" in the Netherlands concluded that there is a negative relationship between the two because there is a need to explore the other possibilities that contribute to job satisfaction. He added that there is an opportunity for the firm to offer a flexible hour schedule to improve job satisfaction. Additionally Janssen (2017) stated that employees that have a flexible schedule are more satisfied with their jobs than the ones with fixed schedules. Moreover, for Rahman et al, (2014) to resolve the dissatisfaction of long commuting employees, a flexible working policy like telework, Neighbourhood work centre, split location, and others was advised to the companies.

To understand better the relationship between workplace, residential place and commuting distance, the urban spatial structure model is the core (Simpson, 1987). Accurate forecast of residential and workplace patterns benefits transportation planning and land use development policies. One of the principles that show the relationship between the workplace and the residential place was build based on the job search model and the human capital migrants model states that workers prefer to work near their residential place. This is preferred considering the factors like the cost of travel and time that can be wasted in traffic congestion. By contrast, the modal developed by Simpson in 1980 shows that the skill's level of resident's influences workplace decision location especially, low skilled residents.

However, not all workplaces should be located in the city centre. Works that serve the community like schools, hospitals, grocery stores should be located in the neighbourhoods because the numbers of visitors or users are much higher than the employees that work there (Wolday et al., 2019). It is evident from recent research that there is a correlation between traffic congestion and commuting distance from the residential location to the workplace location. However, commuting distance can be reduced through flexible work schedules. This will not only enable the use of non-motorized transport like biking and walking in cities, but it will also contribute to workers' satisfaction.

2.1.3. Land use design

The term land use has been mentioned without providing its meaning. Van Wee and Meurs, (2003) defined land use design as physical and functional characteristics of place result from human activities based on land use regulation of a certain area for effective use of resources . Physical characteristics often called urban design include built-up areas and layout of streets, whereas functional characteristics refer to human activities on the environment. Similarly, Srinivasan, (2000) land use is composed of forms and functions. Forms include physical infrastructure and buildings while functions include activities like residing, traveling, shopping, etc. According to Dempsey et al., (2009) land use simply means using the environment to perform different activities.

Land use design or planning can be simply explained by the urban form of the city. The urban form simply means the physical characteristics of the city or spatial configuration of fixed elements (Dempsey et al., 2009). However, Simpson (1987) stated that urban form comprises physical features and non-physical features including density, land use, transport infrastructure, building type, etc. The four main urban forms discussed by Jabareen, (2006b) include transit-oriented developments, compact city, urban containment, and eco-cities. Modern urban planning technology often involves mixed land use buildings and intensification of activities because they promote sustainable transport that is the reason why E.U strongly recommends compact cities.

Theories of urban form have shown the relationship between transport demand and where people have to live. The 20th century Burgess's concentric theory describes a city where

everyone has to move in the CBD with the industrial zone around followed by residential area according to income level. Additionally, Hoyt's sector theory developed in 1939 was the same but allowed some development alongside the transportation axis. Multi nuclei theory of urban growth was approved by Hans and Ullman in 1945 where the city can have several nodes that act as regional centres instead of having one CBD. Decentralization of employment triggered the notion of polycentric centres that was reinforced in the 1980s by urban economic theory (Srinivasan, 2000). However, the significance of urban form choice on sustainability and mobility is not always clear. Additionally, Snellen (2000) concluded in her research on Netherland case study that it has hardly proven empirically the relationship between urban form and travel behaviour.

To assess the relationship between land-use design and transportation, it is necessary to know spatial characteristic measures of those variables. Diversity of measures like density, connectivity, street network, shape, accessibility, land use mix among other indicators was proposed by different researchers. The proposed measures were focused on both physical and functional characteristics of land use design (Srinivasan, 2000). Considering developing city design, Kigali city is centrally planned and has only one CBD where many people moved in during the daytime and move out in the evening. Moreover, by looking at the conditions of the main roads that connect residential areas and the CBD, the relationship between land use design and traffic congestion can be measured by street connectivity from the residential area to commuters' destinations and land use mix.

2.1.3.1. Connectivity

Theories of urban form have inspired planners and designers to develop good neighbourhoods. The impact of neighbourhood design on transport has gained the attention of many scholars. By comparing new urban neighbourhoods with traditional neighbourhoods, Authors Stangl and Guinn, (2011) placed connectivity and street layout as the essential aspects of neighbourhood design. According to Badland et al., (2008) defined streets connectivity as the potential variable that affects transport-related physical activities behaviour. Additionally, Saelens et al., (2003) mentioned that connectivity can simplify physical activities like walking and cycling that are essential for health. Moreover, connectivity is the directness or ease of movement from one place to another (Srinivasan, 2000).

There is no accepted standard to measure the connectivity of streets. Connectivity measures assess the ease of moving from one place to another and the integration of links between street segments (Srinivasan, 2000). A partial list that was developed in planning includes block density, street density, block area, block perimeter among many others. The Proposed spatial configuration of street connectivity includes orthogonal and non-orthogonal, radial, hybrids, to mention a few.

However, the urban connectivity of streets depends on its hierarchy (Lamíquiz and López-Domínguez, 2015). In Rwanda, roads are classified into 4 categories: National roads that link Rwanda with the neighbouring countries, districts and city of Kigali Roads that connect urban area, districts and Kigali city roads that connect rural area, and specific Roads constructed for private sector's activities (Ministry of Infrastructure, 2012).

According to Lamíquiz and López-Domínguez (2015), there is a high correlation between street network factors and the percentage of walking people in Madrid, Spain. Connectivity factor had more correlation with walking trips than the other popular factors like density and land use mix. It is evident from the literature that street connectivity can improve or worsen transport sustainability. Additionally, considering land use design, connectivity in terms of roads/ streets physical conditions is one of the factors that can influence the choice of motorized and non-motorized transport (Saelens et al., 2003). Approaches like sustainable cities, sustainable

transport, smart growth, and new urbanism have developed to react to the traffic congestion problem, improving air quality and the overall quality of life. Transportation, planning and health researchers need to work together to promote liveable cities.

2.1.3.2. Land use mix

The concept of land use mix that recently plays a central role in urban planning has shown to be an influential factor of travel behaviour like commuting distance and modal choice (Kevin Manaugh Tyler Kreider, 2013). In recent decades mixing complementary land use has proven to improve quality of life at the neighbourhood level and health outcome (Badland et al., 2008). Additionally, increased pedestrian and cycling in neighbourhoods reduce air pollution, traffic congestion and improve liveability and sense of place in cities. For these reasons, municipal planning and transportation agencies focus on promoting walkable neighbourhoods instead of using cars (Frank, 2006).

According to Saelens et al., (2003) land use mix is the integration of physical spaces like shopping, residential, offices and human activities within a given area. According to Health space and places, (2009) mixed land use enables the co-located different land-uses like a commercial, industrial and residential to integrate in a way that promotes non-motorized transport. However, Meerkerk (2015) defined mixed land use using 3 conceptual levels. The first level concerned primarily mixing within the same building. The second level involved mixing compatible functional mix and social mix. The last level involved mixing incompatible activities within the same neighbourhood as industries, residential, commercial and public parks. The Second level of land use mix is compatible with the research question of this thesis.

Recent researchers proposed that sustainable neighbourhoods should have workplaces, education, commercial and recreation together with comfortable transport connections that promote walking and cycling (Health space and places, 2009). The fact that the concept of mixed land use promotes less travel distance and fewer trips makes mix land use at the top of the solution of urban problems like congestion and crime (Meerkerk, 2015).

2.1.4. Traffic congestion

To begin addressing the traffic congestion phenomenon, the term must be defined first. There is no universally acknowledged meaning of traffic congestion. Toan (2019) categorized congestion into a recurring situation where the demand exceeds the supply during peak period and non-recurring situation where congestion is caused by the incident. In this paper, congestion is defined as a recurring situation.

Different scholars defined traffic congestion in different ways even though there is no universally agreed definition of it. Traffic congestion simply means that the road capacity is not enough to cope with vehicles trying to use it (Kumarage, 2004). The scholar added that congestion is caused by the single equation of balancing between the two parameters side named demand and supply. According to Ministry of Economic Planning & Budget (2013) agreed with traffic congestion as the condition when the designed road capacity surpasses the traffic as the result of rapid motorization. But Downs, 2004 defined traffic congestion “as the state when the speed at which the vehicle is moving at is below the designed capacity of the highway which results in delay”.

The impacts of traffic congestion are enormous and harm the sustainability of cities. The socio-economic impacts of traffic congestion include time wasted, increase in operating cost and excess emissions (Ministry of Economic Planning & Budget, 2013). However, Kumarage (2004) categorized the impacts of traffic congestion into 4 categories. The first one is economic growth impact where congestion increase transportation price in terms of productive time and fuel wastage. Secondly, traffic congestion affects the quality of life where many people had

become vulnerable to respiratory diseases like asthma. Additionally, traffic congestion deteriorates environmental quality through air and noise pollution. Lastly, traffic congestion leads to ant-social behaviour especially among drivers due to the frustration of slow-moving.

According to Rao (2012) and Ministry of Economic Planning & Budget, (2013), two factors that cause congestion include "micro-level" factors and "macro-level factors". Micro-level factors are those that are related to traffic on the road whereas macro-level factors are related to the overall use of the road. Congestion is produced at the road (micro-level) and driven at the macro-level. However, Toan (2019) argued that congestion is caused by the inequality between demand and supply-side where the urban area cannot keep pace with the growth of travel demand. The author suggested that long term and short-term strategies to alleviate traffic congestion can be related to both supply and demand side of the problem.

A variety of features has been recommended to quantify traffic congestion. Congestion measures can be assessed using criteria like clarity, simplicity, include travel time, describe the magnitude of congestion, relates to public transport congestion and allow comparison between metropolitan areas (Aftabuzzaman, 2007; Moran, 2011).

Traffic measures are categorized into basic measures, ratio measures, level of service, and indices (Aftabuzzaman, 2007). According to Moran (2011) traffic congestion indicators can be divided into "point-related measurements like vehicle count and flow, temporal/speed indicators like travel time and delay, and spatial indicators like queue length and density". For other scholars, they are no categories of congestion indicators where some indicators include roadway level of service, travel time index, congestion cost per capita, commute duration, etc.

Moran (2011) stated that point related measurements like speed, delay, travel time and level of service lead other measurements of traffic congestion although there is no single measurement that can address every traffic congestion challenge. This study focused travel time and level of service because the study conducted in Kigali city about traffic mitigation measures stated that travel time or delay during peak period is 57.8 seconds per vehicle in the main roads connecting residential areas to the CBD (Vincent, 2019). Using the same study, level of service was considered because the increase in road infrastructure is very low compared to the increase in population. This means that the capacity of the roads exceeds its volume during the peak period in Kigali city.

2.1.4.1. Travel time

In the urban context, congestion is the action of declining speed which directly leads to fuel consumption, greenhouse gas emission, an increase in maintenance cost, and loss of time (Lomax et al. , 1997). Direct measurement of congestion depends on the ratio of the peak period to off-peak period travel time. By comparing the speed experienced under peak period with the off-peak period operating conditions, the magnitude of congestion can be delivered (Mohan and Ramachandra, 2012).

Travel time and delay were defined as the basis of congestion measurement influenced by speed by Lomax in (1997). According to (Mohan and Ramachandra, 2012) unaccepted congestion is travel time or delay that overdoes agreed-upon norms like geographical location or transportation facilities. The scholar using U.S.A census data discussed that unaccepted congestion is when more than 10% of the population can use more than 60 minutes to commute to work or "if less than half of the population can commute to work in less than 20 minutes". Additionally, an empirical study conducted in India by (Saw et al., 2016) stated that very high congestion is when the perceived or estimated travel time by the traveller is more than 41 minutes.

There is no congestion measurement comprehensively address all the challenge, however, travel time indicator like speed enables policymakers to decide as it guides on identifying the major issue (Dzintars, 2017). However, Jain et al., (2012b) have discussed that traffic congestion is expressed both in time and space through average vehicle speed. Additionally, comparing travel time in peak period and travel time in off-peak period can be used to quantify traffic congestion problem which can help to solve that issue within the state.

2.1.4.2. Level of service

The level of service (LOS) has been traditionally a popular measure of traffic congestion. The concept was adopted in 1985. Moran (2011) defined Level of service as "congestion delay intensity on a roadway or a particular intersection ranged from least congested (A) to most congested (F)". Level of service F is when the average vehicle speed is less than 24km/h, and the vehicle per capacity ration is greater than 100% (Ali and Kazemi, 2014; Qi et al., 2015).

Table 2. Evaluation of road level of service

Level of service	Average vehicle speed	Vehicle/ capacity ratio	Description
Level A	>48Km/h	60%	Free flow
Level B	>40Km/h	70%	Stable vehicle flow
Level C	>32Km/h	80%	Stable vehicle flow
Level D	>24km/h	90%	Less stable vehicle flow
Level E	= 24Km/h	100%	Unstable vehicle flow
Level F	<24Km/h	>100%	Forced flow

Source: (Ali and Kazemi, 2014; Qi et al., 2015)

Level of service is characterized by traffic flow such as vehicle compactness, average speed and intersection delay, volume to capacity ratio (Aftabuzzaman, 2007). By contrast Mohan and Ramachandra Rao (2012) explained some indices which work based on the level of services. Those include the roadway congestion index and lane mile index. The roadway congestion index was developed in 2005 by shrank and Lomax. It measures vehicle mile travelled per lane mile of freeways and it allows comparison between different metropolitan areas. Lane mile index was developed by Cottrell. It is obtained by using the indicator of average annual daily traffic volume per-hourly capacity.

Scholars agreed that the level of service indicator is comprehensive by non-technical audiences and field data collection for the indicator is very easy. However, many critical weaknesses of this method raised where Aftabuzzaman (2007) commented that the method only represents the selected congested area and it cannot be generalized to other areas. Additionally (Mohan and Ramachandra, 2012) commented that the use of LOS is sometimes confusing especially when the traffic congestion is at the edge of the road. Moreover, Moran (2011) added that once the congested level is reached, it is difficult to distinguish the levels of congestion.

Level of service can be used to measure the magnitude and the volume of traffic flow of selected roads by comparing peak and off-peak period speed which can help the municipality to make decisions about traffic congestion issues as it can be quantified trough level of service.

2.1.4.3. Linking inflexible work schedules and traffic congestion

Several researchers have tried to explain how traffic congestion and flexible work schedules are related. The empirical study done in the Netherlands using transportation data from 2000-2016 showed that without flexible working schedules traffic would be increased by 4%. The research proved that alternative departure choice reduced traffic during the peak period by 7%. Moreover, the commuting distance was reduced by 2% for public transport users (van der Loop et al. , 2017).

Another study done in the USA showed that telecommuting has shown positive results in reducing commuting distance and reduction in peak-period trips. The results also identified that fewer trips taken during peak periods contribute positively to the environment, social and economic aspects of the community (Lari, 2012).

In Omondi, (Omondi, 2018) findings, flexibility in work schedules means changing in when and where to work. Based on empirical studies, he concluded that the average commuting distance and departure time choice have a positive correlation with travel time and speed. Recent researches have shown that workers with flexible work schedules have a high chance to choose different departure time where they can work in different shifts and different workplace which can reduce the number of daily trips (Saleh and Farrell, 2005)

2.1.4.4. Linking land use design and traffic congestion

Recent researchers' attention was to prove how land use design and sustainable transport are related. Researches proved a need for collaboration between the health sector, planning sector, and transportation sector because sustainable transport improves air quality and liveability of cities (Frank, 2006). The concept of sustainability has emerged the need to know which urban form contributes to the use of non-motorized transport (Jabareen, 2006b).

Mixed land use concept was proved by many researchers like (Frank, 2006; Meerkerk, 2015) using empirical studies that it contributes to the sustainability of cities. All compatible activities being close to each other reduce the travel time and promote walking and cycling in neighbourhoods (Jabareen, 2006b). Centrally planned cities have seen as the urban forms that increase traffic congestion through increasing travel time and commuting distance (Meerkerk, 2015).

Another land use design factor that contributes to sustainable transport is connectivity. The ease of moving from one place to another has proven to reduce travel distance and time. road connectivity is one of the essential aspects of designing neighbourhoods (Stangl and Guinn, 2011). Physical conditions of the roads and number of intersections can either reduce or increase travel time. Same as land use mix, connectivity also can promote the use of non-motorized means of transport (Saelens et al., 2003). Neighbourhoods with integrated street networks have proven to have a low level of traffic congestion during the peak period.

2.1.4.5. Relationship between inflexible work schedules, land use design and traffic congestion

Travel demand management is the art of reducing the need to travel by changing travel behaviour and avoiding expansion of transportation patterns. The main reason to control travel needs is to reduce the traffic congestion problem in cities around the world. Some strategies suggested controlling travel behaviour include alternative/flexible work schedules and land use design policies which can promote the use of non-motorized transport (Ferguson, 2016).

However, the discussion of integrating land use and transport has been going on over the last decades because of increasing environmental issues in rapid urbanization cities. Land use mix was suggested by different researchers as the urban form that reduces travel distance, reduces stress, and conserves energy hence contributes more to the sustainability of cities (Daragay, 2003).

It has been suggested by researchers that mixing residential and workplace can reduce travel distance and time. The empirical research that was conducted in Washington DC proved that areas with mixed residential and workplaces are associated with shorter commuting distance and travel time (Daragay, 2003). Additionally (Parthasarathi et al., 2013) results concluded that land use characteristics play a significant role in travel behaviour. Another empirical study conducted in Stockholm proved that mixing residential areas with workplaces will reduce

vehicle Kilometre Traveled about 10% and improve the level of service (Lundqvist, 2003). The empirical research conducted in the Netherlands concluded that commuting distance and travel time have a positive correlation with connectivity and modal choice (Janssen, 2017) .

However, other empirical studies do not fully support the hypothesis that mixing land use and workplaces reduce travel distance and travel time. According to Daragay (2003) the quantitative proof that there is a correlation between mix-use (residential and workplace) does not explain the qualitative side factors. Additionally, socio-economic variables like income, gender, number of workers per household, and level of education also play a significant role in assessing whether land use mix influences travel behaviour (Lundqvist, 2003) . Furthermore, Ferguson (2016) mentioned that high-income earners adopt easily flexible working schedules than the lower-income earners. It can be concluded that mixing land use in an area where no one is educated or commute to work will not improve the sustainability of cities.

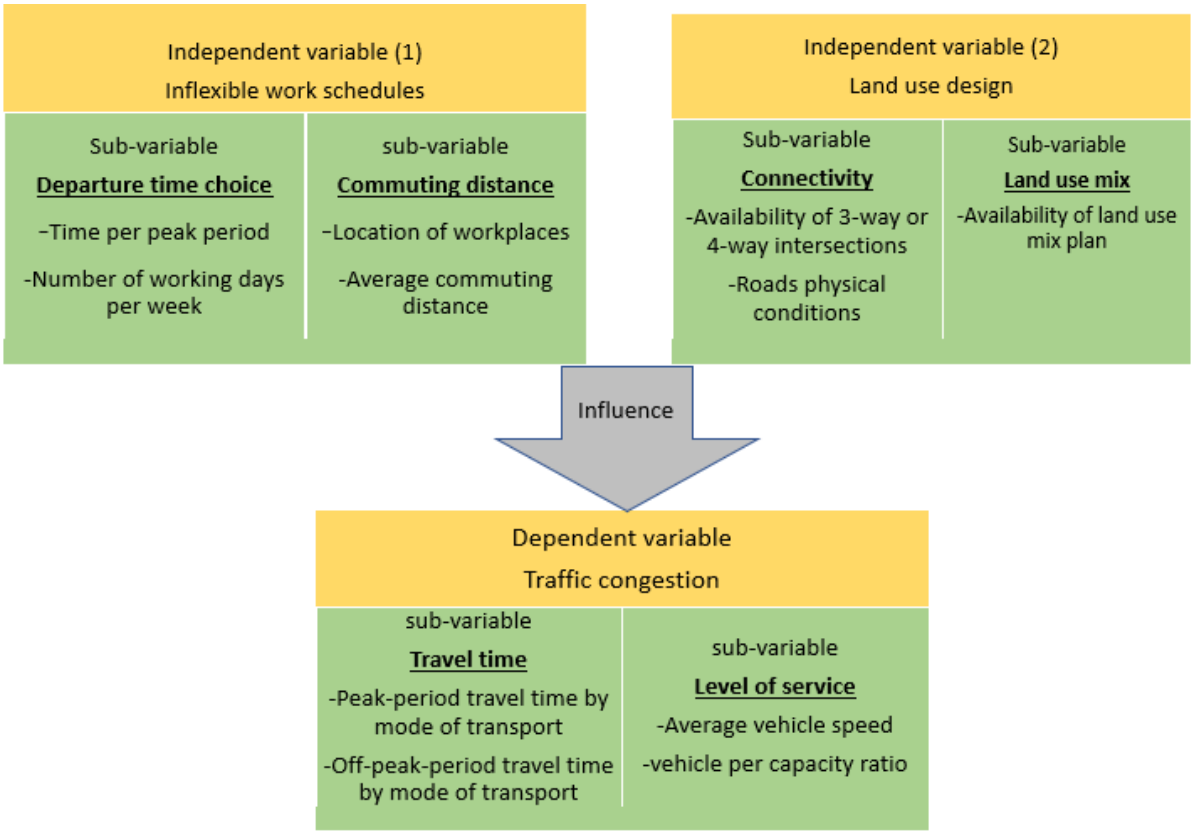
Traffic congestion supply solutions like increasing the number of roads and transportation facilities are necessary but not efficient for the city's economy and future land use developments. However, Policies supporting land use mix and flexible work schedules have been growing in the response of traffic congestion in cities. In centralized cities, People commute every day at the same time for work because residential and workplaces are scattered. Even if quantitative data proved that land use mix and connectivity can improve the environmental, social, and health status of cities, it is necessary to also consider the qualitative variables like education level, income, number of workers per household, sex, and age in these relationships.

From the literature review, it can be concluded that there is correlation between inflexible working schedules, land use design and traffic congestion. For example, it could be determined that departure time choice and commuting distance increase or reduce travel time, speed or level of service. In the same way, connectivity and land use mix can shape positively or negatively travel time and level of service. However, social economic factors like level of income, age, sex, education level and household type are important variables that contribute to traffic congestion.

2.2. Conceptual framework

The conceptual framework presented in figure 1 is prepared using the variables from signalling theory and urban form concept which influence traffic congestion. The choice of the variable from signalling theory is justified by fisher (2017) because inflexible work schedules that do not allow workers to choose where and when to start work lower workers' productivity and increase traffic congestion. Additionally, the choice of the variable from urban form theory is justified by Jabareen (2006b) where the author discussed that land use design can promote or hinder sustainable transport. Traffic congestion is considered as the dependent variable whereas inflexible work schedules and land use design are independent variables. Traffic congestion of this research is described under two sub-variables which are travel time and level of service. Inflexible work schedules are designated under departure time choice and commuting distance as sub-variables whereas land use design is described under connectivity and land use mix as sub-variables.

Figure 1. Conceptual framework



Chapter 3: Research design, methods and limitations

The chapter begins with revised research questions. The methodology and research strategy used to answer the research questions are explained. Additionally, the chapter gives a brief description of sample size selection of study area, validity, and reliability of the research, and data analysis techniques. Moreover, the operationalization of variables and concepts are done by defining the variables and sub-variables. Relevant indicators on each sub-variable are presented in operationalisation table. Finally, the challenges and limitations of the study design are presented.

3.1. Revised research questions

After revising the literature review, the main research questions and sub-questions were revised as follow:

Main research question

How do inflexible work schedules and land-use design influence traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city?

- Independent variable inflexible work schedules are composed by departure time choice and commuting distance as sub-variables.
- Independent variable land use design is composed by composed by connectivity and land use mix as sub-variables.
- Dependent variable traffic congestion is composed by level of service and travel time as sub-variables.

Sub-questions

1. What is the situation of traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city?
2. How do the inflexible work schedules influence traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city?
3. How does land use design influence traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city?

3.2. Description of the research design and Methods

3.2.1. Research strategy

After identifying measurable indicators of variables, the next step is to choose which strategy to be used for data collection. 3 main aspects that define a suitable research strategy include research objective whether it requires in-depth information or general information, the use of primary data source or secondary data source and whether the data will be collected on the field or using desk research, and lastly researcher's preference about qualitative analysis, quantitative analysis, and mixed methods analysis (Baxter and Jack, 2008).

The research type is explanatory because this study aims to explain how inflexible work schedules and land use design influence traffic congestion in Kigali city. It aims at providing in-depth information about how these independent variables influence traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city. Thus, data has to be collected on a small number of units not the whole Kigali city.

Based on the above information, a case study strategy was adopted to collect new data. This choice was made based on 2 factors: Case studies "are intended to be intensive studies, which

is defined as an in-depth study of a few units with multiple variables" (Van Thiel, 2014,p.86). To understand the interaction between specific contexts and phenomena, it is suitable to use the case study strategy. Additionally, this study focuses on a small number of units (3 main roads and 3 neighbourhoods in Kigali city) and a large number of variables.

3.2.2. Research Method

Different researchers mix quantitative and qualitative information to explain how land use design and inflexible work schedules influence traffic congestion because it was proven empirically that quantitative correlation between those variables is not enough to explain these hypotheses (Daragay, 2003; Ferguson, 2016; Lundqvist, 2003). In this research mixed method was adopted where both quantitative and qualitative data was collected.

Quantitative data was collected using closed-ended questionnaires and open source data of geographic information systems, using ArcGIS pro while qualitative data was collected through semi-structured interviews and closed-ended questionnaires. The triangulation with information obtained from questionnaires and interviews was possible since ArcGIS and secondary data was used in certain features.

Qualitative data was collected through questionnaires and semi-structured interviews with selected professionals who work in planning, transport, and ministry of workers in Kigali city. The interview questions were formulated based on the indicators selected on each variable and the research questions of this study. Interviewing professionals who are in charge of transport, workers, and urban planning in Kigali city was useful because more knowledge was gained to support information from questionnaires, secondary data and spatial analysis.

3.2.3. Data collection instruments

Different data collection instruments were used to collect primary data that will be used to answer research questions. Instruments were selected based on the indicators from the operationalization table.

Using ArcGIS software, Kernel density was performed to find the availability of 4-way and 3-way intersections of each road. Using the open street maps, Physical characteristics of the roads were obtained. Additionally, using Kigali city master plan, information about land use mix indicators like presence of shops, hospitals, schools, and offices within residential area were collected. Moreover, distance and off-peak period travel time and from one place to another were obtained using secondary data source which is Google maps.

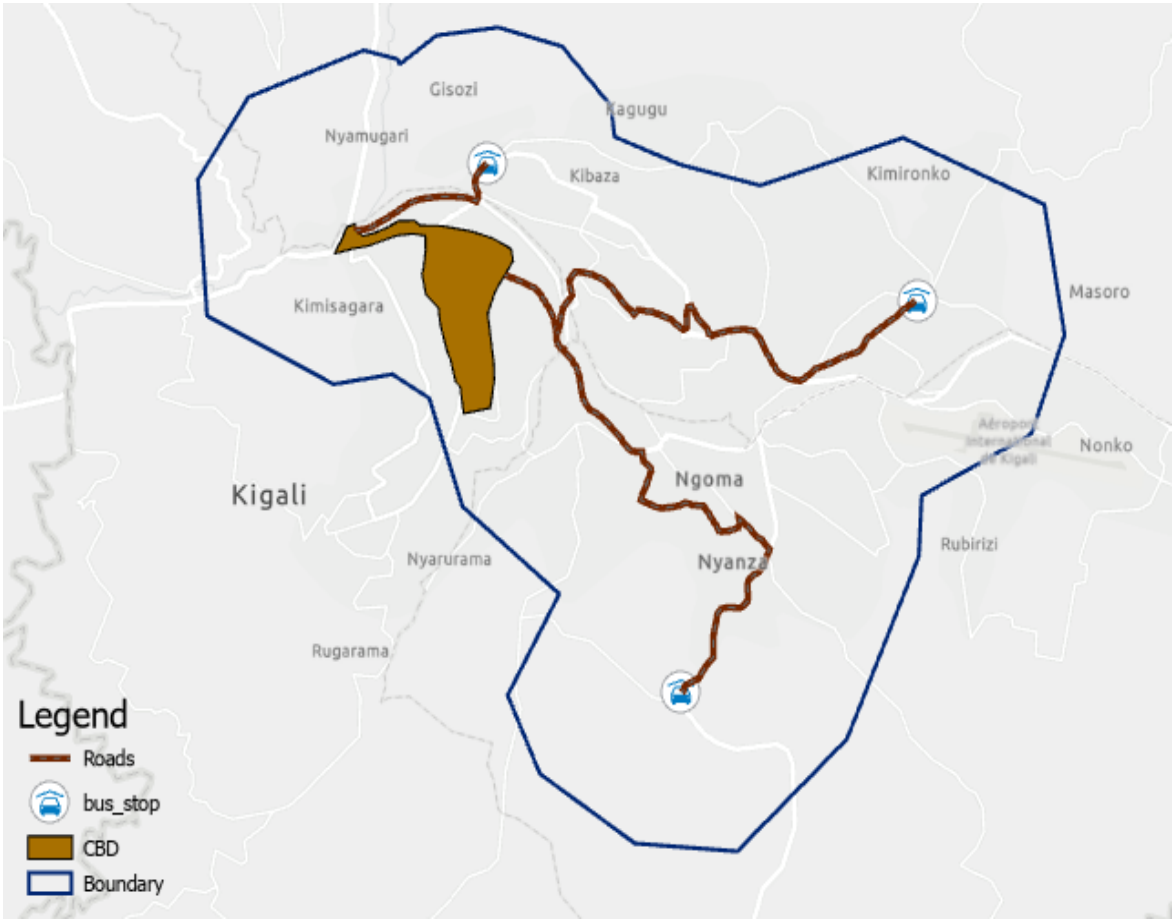
Closed ended questionnaires was used to collect data from 3 neighbourhoods that connect the 3 selected roads in Kigali city to the CBD. Door to door method was used to get information from workers who live in Kimironko, Gatenga and Gisozi neighbourhoods. Online digital questionnaires formed using Qualtrics survey was used where responses were recorded automatically on my project platform. Respondents was selected using stratified random sampling where the 3rd house from each street was selected. The data collected was classified as nominal and ordinal data where SPSS software was used to analyse quantitative data. A copy of questionnaires can be found in Annex 1.

Finally, online-based semi-structured interviews was conducted using zoom and skype. People from various profiles were selected to crosscut different answers. Open ended questions were used for a variety of respondents from MININFRA (Ministry of infrastructure), urban planners, civil engineers, Ministry of public service and labour (MIFOTRA) as well as academics. Interview questions were developed to gain insight into the relationship between land use design, inflexible work schedules and traffic congestion in Kigali city. A copy of interview questions can be found in Annex 2. Atlas ti was used to organize and analyse qualitative data that was collected.

3.2.4. Study area, sample size, and selection

The study area was delineated using ArcGIS Pro. The 3 main roads were digitized and the buffer of 2 km on each road was applied by assuming that the approximate respondents' geographical home location of the 3 road users live within 2 km of those roads.

Figure 2: Study area



Key informants in Kigali city that were interviewed were selected using snowball sampling. For grounded theories (statistics solution, 2015) suggested that the sample size for interviews can vary from 10-50. Based on the time and resource limitations for this research, 16 respondents were selected. Organizations in charge of workers, planning and road infrastructures in Kigali city was selected using purposive sampling, but snowball sampling was used to find relevant respondents within the organization.

The population of the selected study area is composed of different Neighbourhoods from Gasabo, Kicukiro and Nyarugenge districts. Using the data for population census done in 2012 the total population of the selected area is 456,163 (National Institute of statistics of Rwanda, 2015). Stratified sampling was used to improve sample representativeness based on the highest populated sector connected to each road within the study area. Stratified sampling is a probability sampling done by the researcher based on specific characteristics or features of interest (Van Thiel, 2014). With respect to populated Neighbourhoods on each road kimironko, Gatenga and Gisozi were selected and the total population of the neighbourhoods is 150,489 (National Institute of statistics of Rwanda, 2015).

The sample size is determined using formula $n= (z^2*p*q)/d^2$

where n is the sample size, z = 1.96 at standard level of 95%, p is the percentage of picking a choice which is equal to 0.5, q is equal to 1-p and d is the sample error which is 5%.

The total number of sample size is 384, but because of time limitation and current COVID 19 challenge, only 150 questionnaires were expected to be conducted. The sample size selected for questionnaires was divided equally among the 3 selected Neighbourhood. Equal number of 50 questionnaires were expected to be responded in Kimironko, Gatenga, and Gisozi. The selection of respondents was done using the following steps:

a. In each neighbourhood, household respondents were selected using stratified random sampling.
b. Each neighbourhood was divided into 3 or 4 strata based on the number of main streets identified using Google map in each neighbourhood.
c. Kimironko neighbourhood has 4 main streets (KG11 Ave, KG15 Ave, KG17 Ave, and KG19 Ave) where equal number of respondents was selected on each street. This means that 13 houses were selected on each street by using the selection interval of 3 where every third house of the street was selected.
d. Gatenga neighbourhood has 3 main streets (KK 6 Ave, KK 30 Ave and KK 34 Ave) where equal number of respondents was selected on each street. This implies that 17 houses were selected on each street by using the selection interval of 3.
e. Gisozi neighbourhood has 3 main streets (KG 14 Ave, KG 33 Ave and KG 774 Ave). Equally,17 houses were selected on each street by selecting every third house. Street names were adapted from Google map.

Table 3 shows the total number of expected responses and the number of collected responses for questionnaires whereas table 4 shows the number of expected responses and the number of collected responses for interviews.

Table 3. Number of expected responses and collected responses for questionnaires

Roads	**Neighbourhoods**	**Population Size**	**Population percentage**	**Number of expected responses**	**Number of collected responses**
Kimironko-CBD	Kimironko	57,846	33.3%	50	55
Nyanza Kicukiro- CBD	Gatenga	48,640	33.3%	50	55
Gisozi-CBD	Gisozi	44,003	33.3%	50	51
Total		**150,489**	**100%**	**150**	**161**

Table 4: Number of expected responses and collected responses for interviews

Organization	**Number of expected responses**	**Number of collected responses**
Academics	4	4
District civil engineer	3	3
District urban planner	3	2
MININFRA	3	1
MIFOTRA	3	1
Total	**16**	**11**

3.2.5. Validity and Reliability

3.2.5.1. Validity

There are 2 basic types of validity namely internal and external validity. Internal validity relates to how the study measured what it was intended to measure. It looks at the extent to which the indicators were measured whereas external validity refers to the ability to generalize the findings from the research (Ritchie, 2014). The process starts with the operationalization of indicators into measurable units and the selection of research instruments (Van Thiel, 2014).

The research insured validity by forming questions for interviews and questionnaires based on the operationalization of variables from the literature review into indicators. Triangulation of data source from different backgrounds of respondents and different instruments like questionnaires, interviews, ArcGIS, and secondary data ensured that data was valid. Additionally, questions for questionnaires and interviews were pre-tested before gathering official data to ensure that the questions will be understood by the respondents to avoid ambiguity.

3.2.5.2. Reliability

Reliability was defined as the precision and accuracy of the measurement methods (Van Thiel, 2014). Reliability in this study was ensured by measuring different indicators on the same variable. Additionally, this research used questionnaires, software supported analysis and interviews as the standardized measurements for primary data collection. Moreover, to ensure that the results of the research are reliable, the study used both primary and secondary source data.

3.2.6 Data analysis techniques

This section explains how the collected data was organized, analysed and presented. To organize the qualitative data collected from interviews and questionnaires coding was done by using a computer program for qualitative data analysis known as Atlas ti. The codes were assigned from the operationalization of indicators to see how information was repeated by respondents. The code simply means a summary of the main indicators of variables (Van Thiel, 2014). Some additional codes can be created based on the new information provided by respondents. Both inductive and deductive coding was used. Interview respondents were named from R1 to R10. The data from questionnaires was organised automatically since Qualtrics survey was used to digitize questions. The data was cleaned by indicating the missing value especially for multiple responses and assigning the right level of measurement to each indicator before being analysed. However, data from ArcGIS software was organized in inbuild attribute tables of the software.

To analyse quantitative data, statistical analysis like descriptive and inferential analysis was used. Descriptive analysis used is correlation analysis whereas inferential analysis as mean T-test and ordinal regression analysis. The tool proposed for this analysis is SPSS. Since the indicators asked in questionnaires are categorized into ordinal and nominal, it was possible to determine the association and relationship between land use design, inflexible land schedules and traffic congestion using ordinal logistic regression analysis and Spearman's correlation. To ensure the reliability of statistical data, Cronbach α test was performed. To analyse qualitative data co-occurrence table, queries and network analysis were used through atlas ti to find the relationship between different indicators.

ArcGIS Pro was used to perform Kernel density in order to find the availability of 3 or 4-way intersections. Additionally, the software was used to classify the physical conditions of roads under this study. The data was organized following the variable and sub-variable order provided in the operationalization table. For each sub-variable, interview data of all indicators were presented first in a table with the frequency showing how many respondents repeated a response.

Then the explanation of interview findings of each indicator was provided by comparing and contrasting with the data from questionnaires, ArcGIS and secondary data. Questionnaire data were presented as graphs and charts whereas ArcGIS data were presented as maps.

3.3. Operationalization: Variables, indicators

Operationalization is an important step in research where theories and concepts are transmitted into empirical research. Theoretical concepts can be translated into entities that can be transformed into measurable units in real-world through operationalization (Van Thiel, 2014). In this section, the operationalization of variables and indicators was done by defining the key variables and sub-variables. The definitions were captured from literature review and indicators of each variable are presented in the operationalization table below.

3.3.1. Definition of Theories/ concepts

Signalling theory: This theory has been used to explain how flexible work schedules can lead to employee's wellbeing by allowing them to participate in personal development activities. The theory explains how flexible work schedules can lead to positive perceptions that can permit the employee to cope with work-family engagement (Omondi, 2018).

Urban form: The urban form simply means the physical characteristics of the city or spatial configuration of fixed elements including physical features and non-physical features like density, land use, transport infrastructure, and building type (Dempsey et al., 2009; Jabareen, 2006b).

3.3.2. Definitions of variables and sub-variables.

3.3.2.1. Inflexible work schedules (independent variable 1)

A fixed work schedule or inflexible work schedule is a situation where employees start and end their work at the same time and place designed by their companies. Inflexible working schedules is the situation that does not allow the employees to choose the time, place, shifts and number of hours they want to work. (Golden, 2009; Kossek and Michel, 2011). The sub-variables for inflexible work schedules include departure time choice and commuting distance.

Departure time choice (sub-variable 1): defined as preferred time to start a trip (Bhat, 1998; Cheng et al., 2013).

Commuting distance: (sub-variable 2): defined as distance traveled from one place to another (Wolday et al., 2019).

3.3.2.2. Land use design (independent variable 2)

Land use design is physical and functional characteristics of place result from human activities based on land use regulation of a certain area for effective use of resources (Srinivasan, 2000; Van Wee and Meurs, 2003). Land use mix and connectivity were used as sub-variables.

Connectivity (sub-indicators 1) is defined as ease of moving from one place to another and the integration of links between street segments (Srinivasan, 2000).

Land use mix (sub-indicator 2) is defined as the integration of physical spaces like shopping, residential, offices and physical space within a given area (Saelens et al., 2003).

3.3.1.3. Traffic congestion (dependent variable)

In this study, traffic congestion simply means that the road capacity is not enough to cope with vehicles trying to use it. Traffic congestion was defined as a recurring situation, where road demand exceed supply during peak period (Kumarage, 2004). This variable has 2 sub-variables namely level of service and travel time.

Level of service (sub-variable 1): level of service is defined as "congestion delay intensity on a roadway or a particular intersection ranged from least congested (A) to most congested (F)" (Moran, 2011).

Travel time (sub-variable 2): defined as the time spent to move from one place to another which is expressed in distance and speed (Lomax et al., 1997).

1.3.2. Operationalization table

The table 6 below summarises the transformation of theories, variables and sub-variables defined above into measurable indicators.

Table 5. Operationalization table

Theory/ concepts	Variables	Sub-variable (s)	Indicator (s)	Scale	Data source	Data type	Collection Method	Units of measurement
Signalling Theory	**Inflexible work schedules** **(independent variable 1)**	**Departure time choice**	Time/ Peak Period (before peak period, during peak period, after peak period)	Interval	Road users, Literature, MIFOTRA, RTDA	Quantitative and qualitative	Questionnaire, interview, secondary data	Minutes
			Number of working days per week	Ordinal	Road users, Literature, MIFOTRA, Academics	Quantitative and qualitative	Questionnaire, interview, secondary data	Quantity per week
			Availability of alternative work schedules	-	MIFOTRA, Road users, Literature	Qualitative and quantitative	Interview, Questionnaire, secondary data	percentage
		Commuting distance	Location of workplaces	-	Road users, MIFOTRA, RTDA, urban planners, civil engineers	Quantitative and qualitative	Questionnaire and interview	Km
			Average commuting distance	Nominal	Google maps	Quantitative	Secondary data	Km
Urban Form	**Land use design** **(Independent variable 2)**	**Connectivity**	Availability of 4-way intersection and 3-way intersection.	Nominal	ArcGIS Pro, Urban planners, civil engineers, academics and RTDA	Qualitative and quantitative	Interview and software supported analysis	Quantity per area
			Roads physical conditions	Ordinal	Road users, RTDA, civil engineer, academics, ArcGIS Pro	Quantitative and qualitative	Questionnaire, interview and software supported analysis	Likert scale (perception).
		Land use mix	Availability of land use mix plan	-	Urban planners, civil engineers, Kigali city master plan	Qualitative and quantitative	Questionnaire, secondary data and interview	Likert scale (availability)

-	**Traffic congestion** **(dependent variable)**	**Travel time**	-Peak period travel time by mode of transport	Interval and ordinal	Road users, RTDA	Quantitative, qualitative	Questionnaire, interview	Minutes and Likert scale perception
			-Off-peak hour travel time by mode of transport	Nominal	Google maps	quantitative	Secondary data	Minutes
		Level of service	-Average vehicle speed (distance/time)	Nominal	Road users, Google maps, RTDA	Quantitative and qualitative	Interviews and questionnaire	Km/h
			Vehicle per capacity ratio	Nominal	Literature	Quantitative and qualitative	Secondary data	Percentage

3.4. Challenges and limitations

3.4.1. Challenges

This study experienced several challenges. Questionnaires data was corrected during COVID 19 periods I did not find a way to correct my data as expected because of travel limitations. Besides sample size is another limitation where only 161 responses were collected instead of 384 because people were supposed to social distance themselves. It was difficult to reach the respondents because my assistant used door to door data collection method. The responses collected mainly represent peak period situation as workers were the target group. Another limitation was no responses from interviewees because many claimed that they were not at their workplaces and they cannot help me with any information. Notwithstanding the above, this study is a case study. Only working trips for the 3 main roads were considered and a limited number of indicators were used. The results from this study cannot be generalized in any other road of Kigali city. Lastly, the data collection period of this research was fixed that is why time limitation did not allow us to look for more interviewees or questionnaire respondents.

3.4.2. Limitations

The study area is located in Rwanda, precisely, Kigali the capital city. The study focuses only on 3 primary roads connecting residential areas and CBD. Those roads include Kimironko- CBD, Nyanza, kicukiro- CBD, and Gisozi- CBD and residential areas that were considered are limited to Kimironko, Gatenga and Gisozi neighbourhoods. Additionally, only working trips from the three neighbourhoods was considered. Data collection for the study was both Qualitative and quantitative data and both primary and secondary data source were used.

The study aims to explain how inflexible work schedules and land use design influence traffic congestion in Kigali city. Inflexible work schedules and land use design are independent variables, whereas traffic congestion is the dependent variable. Inflexible work schedules are limited to commuting distance and departure time choice sub-variables. Additionally, land use design is limited to land use mix and connectivity. Furthermore, traffic congestion sub-variables include travel time and level of service only. The results from this case study cannot be generalized since the findings only focuses on Kimironko- CBD, Nyanza, kicukiro- CBD, and Gisozi- CBD roads situation.

Chapter 4: Presentation of data and analysis

4.1. Introduction

This chapter presents the research findings gathered through the methods explained in the research analysis in chapter 3. The chapter begins with the description of the case narrating the unit of the study and the characteristics of interviews and questionnaire respondents. Then the findings are presented following the order of variables and sub-variables together with their indicators as in chapter 3, where data from interviews, questionnaires, and ArcGIS pro is analysed. Finally, the chapter presents statistical results summarized and discussed following the conceptual framework and theoretical review of the study.

4.2. Description of the case

This research is based on traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city. Those roads are the primary roads connecting residential area to the city centre in the capital city of Rwanda. They are known as the most congested roads in Kigali city compared to the other roads as they connect the most populated neighbourhoods and the CBD. Many researchers like (Jean Chrétien, 2017; Vincent, 2019) stated that the main causes of traffic congestion in Kigali city include land use planning of the city where some proposed that there is a need to relocate activities in the other districts of the country or the other parts of the city not in the city centre. Additionally, working trips was proven to be at the top of the other purpose of moving from one place to another. Different researchers proposed different solutions to reduce traffic congestion in the city but most of all were supply oriented solutions. Some of the solutions proposed include upgrading roads as well as improving public transport by bringing BRT lines in the city or bringing aerial cable cars.

From the time that traffic congestion emerged, the city authorities are trying to improve road connectivity and mobility in different parts of the city but also the more the roads become better, the more people are encouraged to buy their cars. There is a drastic increase in car ownership nowadays in Kigali city because the city is developing, and the worker's income is also increasing due to an increase in entrepreneurship. From this circle, it is hard to say that traffic congestion will be resolved by upgrading roads because even the country's topography does not make it easy as Rwanda is named "a thousand hills country". It is in this view that the research was undertaken to investigate how inflexible work schedules and land use design influence traffic congestion on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city using interviews, questionnaires, and ArcGIS Pro as data collection methods.

4.3. Respondent's characteristics

Interviews

To select the organizations, purposive sampling was used where organizations in charge of transportation, workers, and land use in Kigali city were selected. Lectures from universities were also selected and summarized as Academics. Snowball sampling was applied to select interviewees or key informants within organizations and universities. Selecting interviewee from different backgrounds was to allow to gain more insight about the subject under study. The final list of interviewed respondents is comprised of 4 Academics, 3 district civil engineers, 2 district urban planners, 1 from MININFRA (Ministry of Infrastructure), and 1 from MIFOTRA (Ministry of Labour) which make the total of 11 respondents as shown in Table 6.

Table 6: Interview respondents' distribution

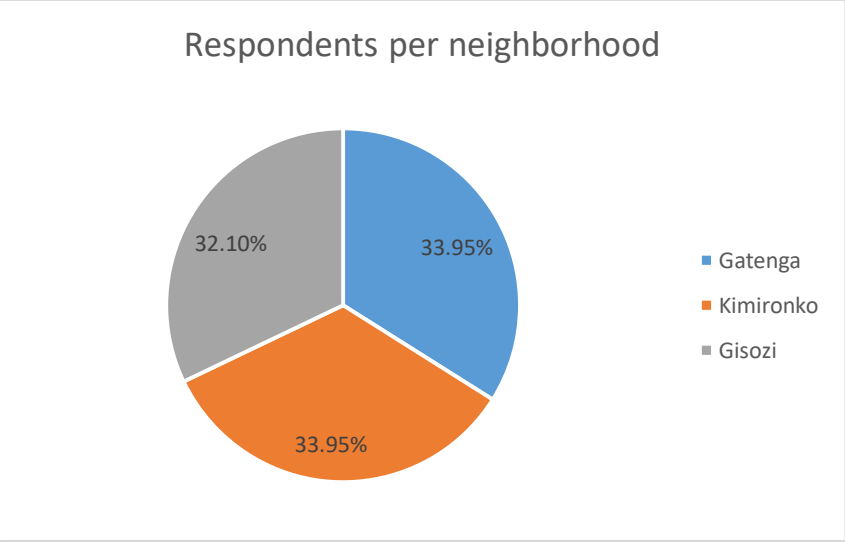
Organizations	Number
Academics	4
District civil engineer	3
District urban planner	2
MININFRA	1
MIFOTRA	1

Total number of respondents=11

Questionnaires

Questionnaires were applied to collect data from workers who use Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city. The sample size of questionnaires was based on the total number of populations of the 3 most populated neighbourhoods under study area which connect each road to the CBD. The neighbourhoods selected are Gatenga, kimironko, and Gisozi. The total population is 150,489 and the sample size drawn from stratified sampling is 161. In Gisozi neighbourhood 51 responses were collected, in both Kimironko and Gatenga neighbourhoods 55 responses were collected. The summary of the percentage of collected responses in each neighbourhood is shown in figure 3.

Figure 3: Distribution of questionnaire respondents per neighbourhood



Total number of respondents= 161

4.4. Presentation and analysis of data for variables and sub-variables

This section is presented in line with the variables and sub-variables as well as indicators following the order of the operationalization table in chapter 3 and the conceptual framework in chapter 2. The analysis of each variable and sub-variable will start with the findings from interview responses. The responses from interviews were named from R1 to R11 based on the codes generated from Atlas ti. Additionally, responses from questionnaires were compared and contrasted from interview findings. Moreover, maps and data from ArcGIS Pro were used where necessary to support findings from both interviews and questionnaires. Lastly, secondary data gathered was used for the purpose of triangulation. A description of the outcome from the above-

mentioned sources was presented at the end of each variable where the sub-variables were analysed separately.

4.4.1. Inflexible work schedules

This variable has 5 indicators clustered in 2 sub-variables namely departure time choice and commuting distance. Each sub-variable was analysed separately following the order of presenting data from interviews of all indicators first then each indicator was analysed by comparing findings from questionnaires, and secondary data findings where necessary.

4.4.1.1. Departure time choice

3 indicators were used to know when workers go to work and to estimate peak period hours on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city. Table 7 summarizes the interview response on the departure time choice of workers.

Table 7: Summary of interview responses on departure time choice

Sub-variable	Indicators	Summary of Interview responses	Frequencies
Departure time choice	Time per peak period	Traffic congestion starts from 6 A.M-9 A.M in the morning because most workers start work at 7 A.M or 8 A.M.	7**
		Traffic congestion starts from 5 A.M-8 A.M in the morning because most workers start their journey early in the morning.	4**
		Traffic congestion starts from 5 P.M-8 P.M in the evening because most workers close work at 5	6**
		Traffic congestion starts from 6 P.M-9 P.M in the evening as many workers start moving from 5:30 after closing work at 5	5**
	Number of working days per week	Most workers work from Monday to Friday means 5 days in a week	6**
		Public workers work from Monday to Friday, but private workers work 6 days in a week.	5**
	Availability of alternative work schedules	In Rwanda in general there is no telecommuting or any other form of working in another environment apart from your office for public workers.	1*
		Only private or business owners have the choice to change the time they start or end their business in Kigali city. It is not common for government or civil servant workers unless your job requires you to work on the field.	1*

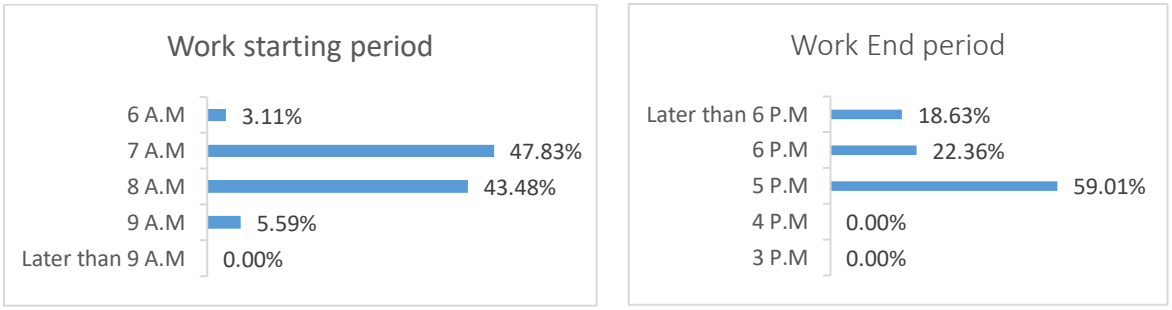
*Total number of respondents =1

**Total number of respondents=11

Time per peak period

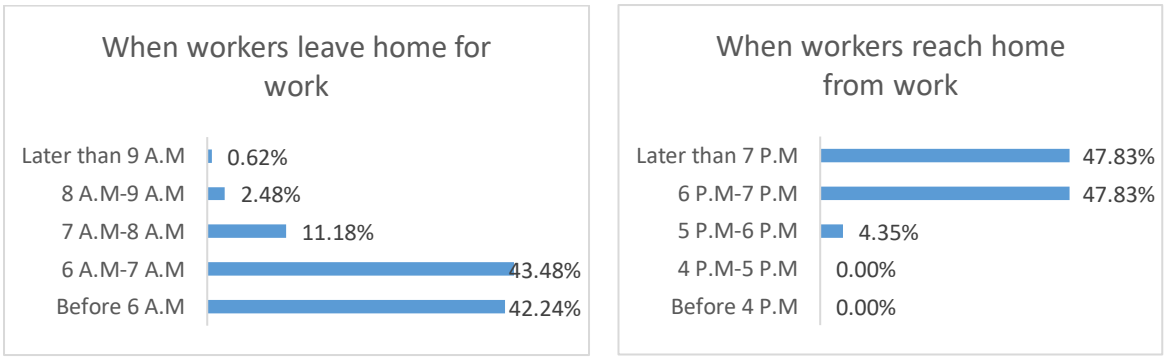
Based on 7/11 interviews, traffic congestion starts from 6 A.M up to 9 A.M because most workers start their job from 7 A.M. However, the other 4/11 interviews mentioned that workers prefer to start their journey early at 5 A.M. R1 mentioned that many workers start moving early because they want to be at their working place early regardless of their starting period of the job. 6/11 interviews mentioned that workers start moving immediately after closing jobs whereas 5/11 stated that workers start going back home some minutes after closing jobs. Peak hours were also estimated in the survey as shown below in figure 4 where 47.83% of respondents start their work at 7 A.M and 43.48% of the respondents start their work at 8 A.M. 59.01% of workers end their work at 5 P.M.

Figure 4: Survey results: start and end period of work for the entire study area



To know when workers start moving for work and when they reach home from work, survey data were collected to crosscut with the information from interview where 4/11 interviews mentioned that people start moving between 5 A.M and 6 A.M. R3 mentioned that the time people start moving for work differ where some leave at 8 A.M and others like private workers leave later at 10 A.M but many people close their work at the same time in Kigali city. As illustrated in figure 5, 42.24 % of workers start moving for their work before 6 A.M, whereas 43.48% start moving between 6 and 7 A.M. Additionally, the figure 5 shows that 95.66% of workers reach their home between 6 P.M and later than 7 P.M. The illustration in figure 5 below is for the entire study area for all 161 responses.

Figure 5: Survey results: when workers leave home for work and when workers reach home from work



A secondary data review on working hours in Rwanda and holidays stated that government workers start work from 7:00 A.M up to 5 P.M whereas the private sector starts their work at 8:00 A.M and ends their work at 5 P.M. both government and private sector have 1-hour lunch break. The source also added that banking hour is from 8:00 A.M up to 5 P.M and shopping hours are from 8:00 A.M up to 6:00 P.M (Fortune of Africa, 2014).

According to Article 49 of the labour code in Rwanda, employees are supposed to work 45 hours per week. This means from 7:00 A.M up to 5:00 P.M with 1-hour lunch break every Monday to Friday (Republic of Rwanda, 2009). The law states that the worker may work overtime based on mutual agreement between parties involved.

To sum up, in Rwanda almost all workers move in the peak period. Even if the starting period for the private and government sector differ, it is only one hour different which is not enough to say that we have flexibility in terms of choosing the departure time for work. The data from questionnaires were not analysed based on each neighbourhood because the labour law applies everywhere in the country and they are the same. Additionally, the analysis of the data per each Neighbourhood did not show any difference in responses. In the study conducted by Vincent (2019) on traffic congestion in Kigali city, 26. 24% of all the trips done in Kigali city is only for

work. That was the main factor among other reasons why people move from one place to another. Cheng et al., (2013) stated that by looking at the starting period and end period of work you can estimate peak period or rush hour in a certain place. The author also added that the departure time of commuters can also be used to estimate the time when the roads are busy. To sum up this indicator of time per peak period in Kigali city, it is evident that there is the inflexibility of work schedules in Kigali city because work schedules of workers are clustered in the same period which means that workers do not have the opportunity to work in shifts rather than the designed hours. Based on the findings from interviews, questionnaires and secondary data, rush hour or peak period on Kimironko- CBD, Nyanza Kicukiro- CBD, and Gisozi- CBD roads in Kigali city can be categorized from Monday to Friday as follow:

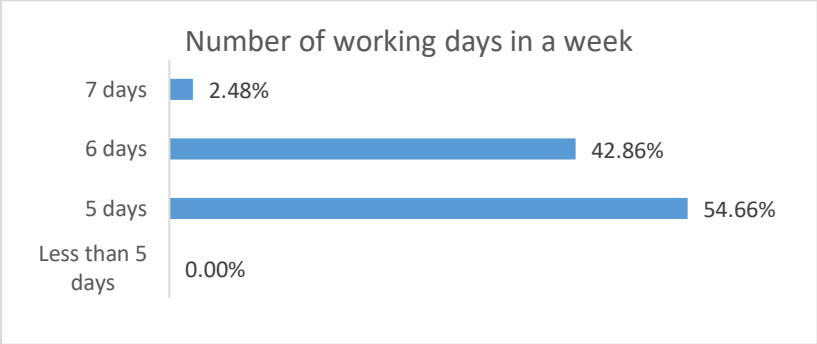
Table 8: Time per peak period in Kigali city

Time of the day	Peak period
Morning	6:00 A.M-9:00 A.M
Evening	5:00 P.M-9:00 P.M

Number of working days per week

From table 7, 6/11 respondents mentioned that number of working days is 5 in a week from Monday to Friday whereas 5/11 respondents said that private workers work up to 6 days in a week in Kigali city. The survey data collected for the entire study area shows that 54.66% of workers work 5 days whereas 42.86% of workers work 6 days a week as illustrated in the figure 6.

Figure 6: Survey results: Number of working days in a week



The number of working days per week goes hand in hand with the number of working hours per day. As mentioned above in the labour law, number of working days in Rwanda is 5 days in a week which can be increases based on mutual agreement between a worker and contractor. According to Fortune of Africa (2014) government sector workers and private sector workers work from Monday to Friday whereas banking and shopping days are 6 days from Monday to Saturday in Rwanda.

It is evident from the 3 sources used to answer this question which are interviews, questionnaires, and secondary data that working days in Rwanda are 5-6 days. Based on this finding, it is concluded that there is no flexibility in work schedules in terms of choosing to work few days because they are no workers who work less than 5 days a week in Rwanda. The findings are applied to all the 3 selected neighbourhood which are Kimironko, Gisozi, and Gatenga because working laws and conditions are applied everywhere in Rwanda with no exception.

Availability of Alternative work schedules

One respondent out of the 3 respondents that I intended to interview about the availability of alternative work schedules in Rwanda stated that in Rwanda telecommuting or working from home was not common until COVID 19. R11 also added that only private workers can change their start and end period of their work because public workers must follow labour laws that do not allow them to work from home or any other place which is not their office unless they are on the field. The table 9 summarizes the findings from questionnaires for the entire study area where workers were asked whether or not they change the start or end period of their work, whether they change the location of workplaces or whether they telecommute. The purpose of those questions was to know whether there is flexibility or not in the work schedules of Kigali city workers. The responses are grounded on the working conditions of workers before COVID 19.

Table 9: Survey Results: Questions on availability of alternative work schedules.

	Questions	**Summary of responses**	**Frequency**	**Percentage**
Flexibility in workplace location				
1	Do you change the location of workplace in a week?	Yes	27	16.77%
		No	134	83.3%
Flexibility in starting work				
2	Do you change the Start period of your work in a week?	Yes	32	19.87%
		No	129	80.13%
Flexibility in closing of work				
3	Do you change the end period of your work in a week?	Yes	31	19.25%
		No	130	80.75%
Telecommuting availability				
4	Do you telecommute (work from home) in a week?	Yes	152	94.41%
		No	9	5.59%

Total number of respondents=161

Yu et al., (2019) Stated that by introducing flexible work schedules, worker morale and productivity will be increased. John (2019) also mentioned that the number of daily commuters will be reduced by 41% if the workers will be able to work remotely 50% of their time. However, in Rwanda people who prefer telecommuting have been seen as lazy people or anti-social people (Opobo, 2015). Telecommuting in Rwanda is a bit common among the youth, but it is not popular even people can think that you are rude, or you do not want work if you say that you want to work from home or telecommute which is in line with what R11 said.

R11: "Before COVID that was not here. We used to commute to work! Telecommuting is not common especially in Africa, so Rwanda is not an exception. Even if you tell your worker like I want to work from home, he/she will think that you are rude, or you do not want to work at all".

However, telecommuting or any other form of having an alternative work schedule was confirmed in many countries as a success story that reduced traffic congestion in their cities. One of the valid examples is an empirical study done in the Netherlands using transportation data from 2000-2016 which showed that without flexible working schedules traffic would be increased by 4%. The same research proved that alternative departure choice reduced traffic during the peak period by 7%. (van der Loop et al. , 2017). This can be emphasized by what R11 mentioned as a moral reason Rwanda can study from COVID 19.

R11: "Another thing that can help is telecommuting because now in corona traffic has reduced! some workers are working from home. Now the situation is better. Suppose that we are 80 workers where I work and all of us have cars if 40 work from home means that something can be reduced on traffic. And generally, more cars moving 0n the road are the main cause of traffic! I think that can be a reason us Rwandan can learn from this period of COVID 19".

To summarize this part of the availability of alternative work schedules, it is obvious that workers do not have many alternatives in terms of choosing where to work or when to start or end work. Having the ability to change the location of your workplace does not mean that you are rude or anti-social as some people think. I agree with what R11 mentioned that we can learn from the experience we had in corona to fight traffic congestion in Kigali city. However, the analysis of the availability of work schedules in Kigali city only reflects on questionnaire data, secondary data, and 1 interview that was done instead of doing 3 interviews as it was intended. The analysis results also reflect all the 3 selected neighbourhoods because working conditions are the same in Rwanda and analysing each case alone on questionnaire responses did not prove any difference in answers.

4.4.1.2. Commuting distance

Two indicators were used on this sub-variable to know the location of workplaces in Kigali city and to know where workers from Gisozi, Gatenga, and Kimironko works. The first indicator is the location of workplaces whereas the second indicator is the average commuting distance that was computed using google maps to support findings from interviews and questionnaires about the location of workplaces. The table 10 below summarizes findings from interviews about the location of workplaces.

Table 10: Summary of Interview response on Location of workplaces in Kigali city

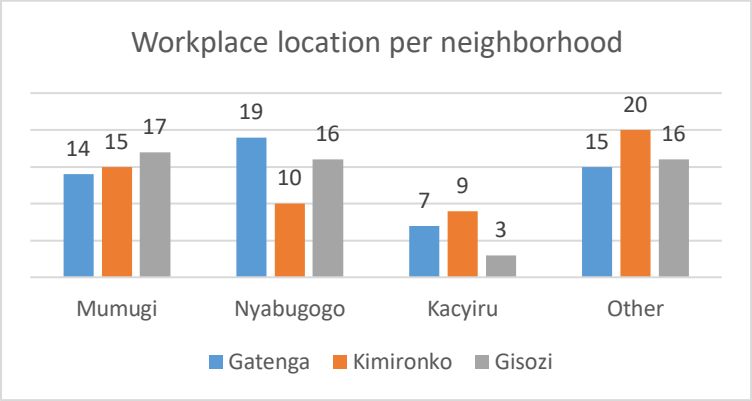
Sub-variable	Indicators	Summary of interview responses	Frequency
Commuting distance	Location of workplaces	Workplaces are located in the same place in Kigali city named CBD (Mumigi and Nyabugogo).	7
		Workplaces are located in different places of the city	4
		The distance between workplaces and residential area in Kigali city in general is not short.	10

Total number of respondents=11

Location of workplaces

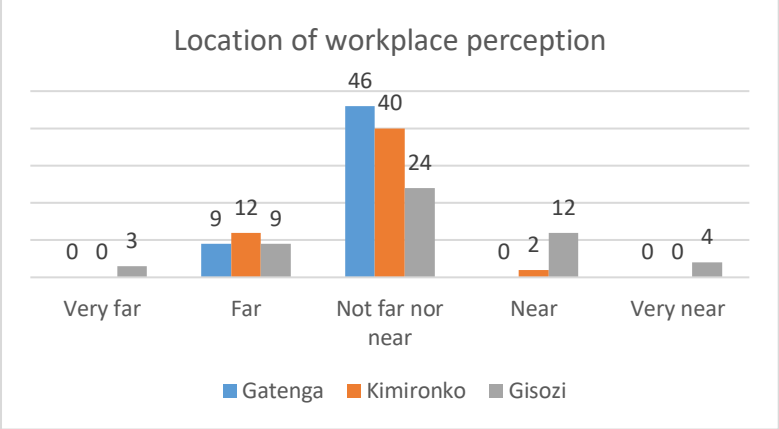
The results from interviews show that workplaces are clustered in the same area named CBD which is comprised of 2 places known as Mumugi and Nyabugogo. 7/11 interviews stated that many working places are there because many businesses are located in the CBD. The other 4/11 interviews said that workplaces in Kigali city are located in a different part of the city. However, 91 out of 161 workers said that they work in a CBD. This means that 56.52% of all workers from the 3 Neighbourhoods commute every day to the CBD. In Gisozi neighbourhood 64.7% of workers work in the CBD, in Kimironko neighbourhood 45.45% of workers work in the CBD, whereas in Gatenga 60% of workers work in the CBD. The figure 7 below shows the location of the workplace for each neighbourhood.

Figure 7: Survey results: workplace location per each neighbourhood



Further 10/11 interview pointed out that the distance from residential area to where people work is quite long. The survey result shows that 68.32% of workers consider the distance from where they work and where they live not far nor near whereas 18.63% consider the distance to be far. Perceptions per each neighbourhood are presented below in figure 8.

Figure 8: Survey results: Workplace location perceptions

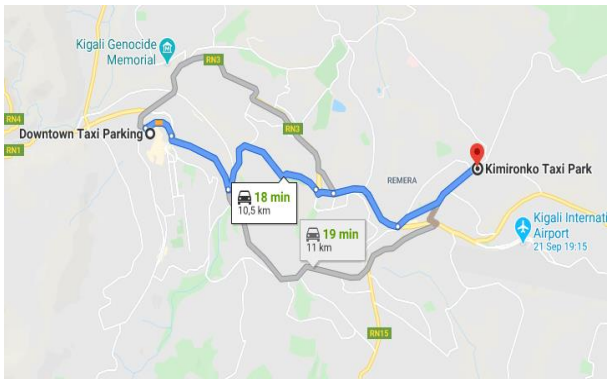


Average commuting distance

The average commuting distance was calculated using Google maps taken in the off-peak period (midnight) to explain the reason why people find where they work near or far. Further explanation of workplace location was explained in mixed land use section 4.4.2.2. According to the above data from the survey, people from Kimironko and Gatenga find their workplace location far compared to workers from Gisozi. The reason why is because there is a short distance from the CBD to Gisozi compared to the other roads (Kimironko-CBD and Nyanza, Kicukiro-CBD) as shown below in figure 9, 10 and 11.

Kimironko-CBD road average commuting distance

Figure 9: Commuting distance Kimironko-CBD road

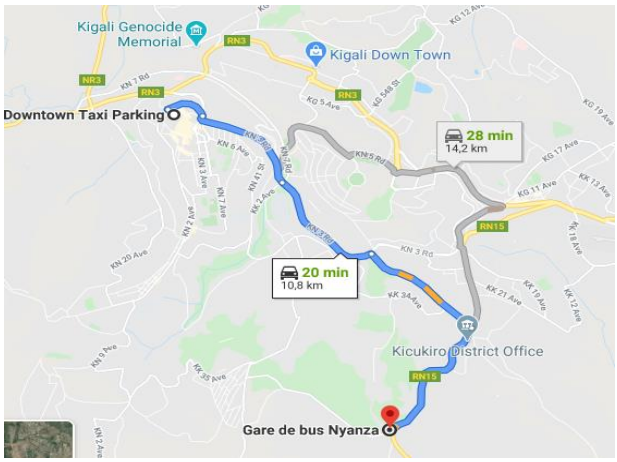


Source: Google maps, 2020

The google maps show the commuting distance from Kimironko taxi park to Downtown taxi parking mostly known as Mumugi. The distance considered in the above map is in line with the road I choose to analyse in this project. Only the distance from the main car park in Kimironko neighbourhood. The distance from each house was not disclosed in this paper. The average commuting distance of Kimironko-CBD road is 10.5 Km

Nyanza, Kicukiro-CBD road average commuting distance

Figure 10: Commuting distance Nyanza, Kicukiro-CBD road

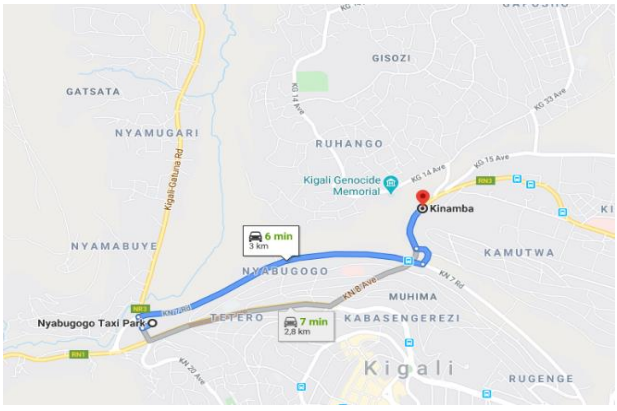


Source: Google maps, 2020

As explained above, the same strategy was used to obtain the average commuting distance of Nyanza, Kicukiro-CBD road. Only the distance from the main car park in Gatenga to CBD was considered, the distance from each household location was not considered. The average commuting distance of this road is 10.8 Km

Gisozi-CBD road average commuting distance

Figure 11: Commuting distance Gisozi-CBD road



Source: Google maps, 2020

Google maps show that the average commuting distance from Gisozi-CBD is 3 Km. This means that 64.7% of workers in Gisozi commute 3 Km every day. Only the distance from Kinamba car park to CBD was considered. Kinamba car park was selected because it is the main car park in Gisozi. This was also applied to the other roads of this study.

The literature about commuting distance and mode of transport that can be used according to each distance showed that people can walk within 1 Km and use bicycles within 5 Km and use vehicles above 5 Km (Rahman et al., 2014). In Kigali city, because of the topography of the country and other cultural factors, cycling is not common. This implies that workers in the 3

neighbourhoods does not walk to their work location rather, they commute using different kinds of vehicles used in Kigali city. This finding was better emphasized by the mode of transport workers use to commute to work that was explained in the other section of travel time where only 3.98% of workers walk in their daily trips. To conclude the commuting distance in terms of location of workplaces and average commuting distance is not far because the longest distance workers from the 3 neighbourhoods use is 11.3 Km but also you cannot say that the distance is near as none of the distance encourages walking as a commuting mode. As concluded in the departure time section, there is the inflexibility of work schedules in terms of when and where people work in Kigali city. This means that more than half of workers who work in the CBD in the 3 selected neighbourhoods cannot walk from workplaces to residential areas moreover they cannot work from home or change the location of their workplaces. This a quite big number which is problematic when it comes to traffic congestion.

Before proceeding to the next Variable, the reliability test of statistical results of this section was carried out where 6 items that are ranged in intervals were tested. The items tested include distance from home to workplace perception, work starting period, departure time for work, work end period, time to reach home from work and working days in a week. The items tested showed good reliability (Cronbach's Alpha= 0.714).

4.4.2. Land use design

This variable has 2 sub-variables which are connectivity and land use mix. The total indicators in this section are 3. Each sub-variable was analysed separately where the results of all indicators from interviews were presented first and then supported by findings from questionnaires, ArcGIS, and secondary sources where necessary. A concluding mark was provided at the end of each indicator.

4.4.2.1. Connectivity

Two indicators were used to explain the connectivity of Kimironko- CBD, Nyanza Kicukiro-CBD, and Gisozi- CBD roads in Kigali city. The results from the interview of those indicators are shown in table 11.

Table 11: Summary of interview responses on connectivity indicators

	Indicators	**Summary of interview responses**	**frequency**
Connectivity	Availability of 3-way and 4-way intersection	We have enough intersections in Kigali, but they increase traffic congestion because the road width is small.	5
		Having many roads that meet at the same point should be avoided and many roads intersect at the same point in Kigali city. That increase also increase traffic	2
		Kigali city roundabout only reduce accidents. They worsen traffic congestion situation.	4
	Roads physical conditions	In Kigali city in general, roads physical conditions are better	1
		Roads are small in width mostly one lane and they are few in Kigali city	10

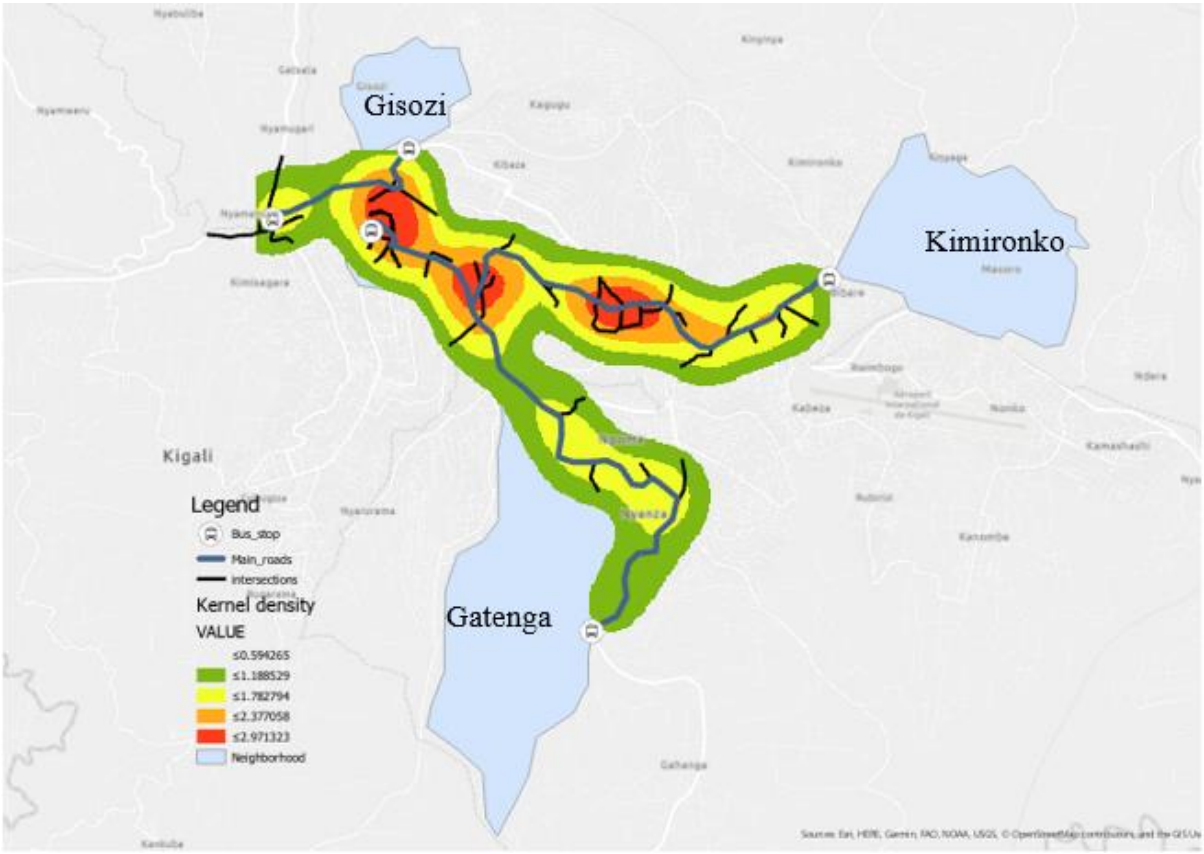
Total number of respondents=11

Availability of 3-way and 4-way intersection

It was impossible for interview respondents to mention the availability of the intersection of roads without mentioning traffic congestion. One thing that all the interviews pointed is that we have enough intersections of roads in Kigali city however, all of them agreed that they increase traffic because the road width in Kigali is small. To support findings from the interview, ArcGIS

pro was used to compute Kernel density that shows the concentration or density of features around a point or a line was used. In this case, the main roads under the study were used together with the road intersections. The following figure 12 shows Kernel density results.

Figure 12: Kernel analysis of intersection points



The results from ArcGIS show that there is a high concentration of roads in the CBD, Kacyiru, and where the 2 main roads under this study meet. The overall availability of 3- and 4-way intersections is high because where the main roads meet with the other roads have a high density shown in red colour.

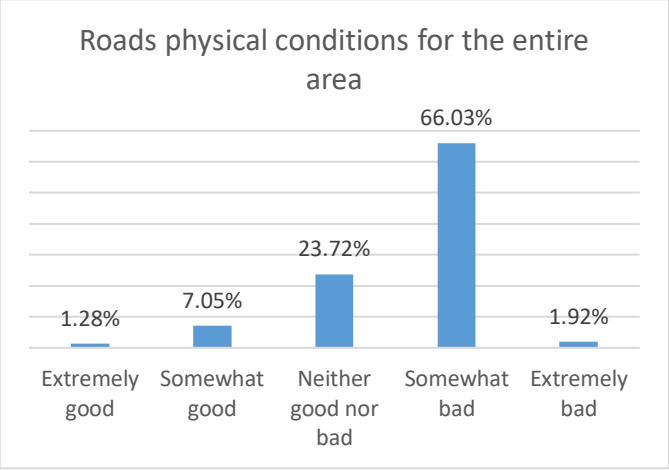
Referencing the literature review, different opinions have emerged in explaining the relationship between road intersections and traffic congestion. The researcher used 3 road topologies from 3 different countries (UK, France and USA) and concluded that traffic congestion is less in roundabouts and the number of traffic accidents is low (Marwan and Ali Al-Sherbaz, 2018). Another study conducted in Nigeria that assessed the relationship between roundabouts and traffic congestion concluded that they reduce traffic congestion depending on the design of the roundabout or presence of traffic lights in the intersection (Atomode, 2012).

In summary, interviews highlighted that the reason why intersections in Kigali city increase traffic is because Kigali roads are small in width. However, combining the results from ArcGIS of road width and road intersections, mainly where the road meets on the 3 selected roads is classified under big width except Gisozi-CBD road. This does not mean that Kimironko-CBD road and Nyanza Kicukiro-CBD road are big in intersections based on international standards, but they are big compared to the other roads in Kigali city. Another reason mentioned by interviewees is that vehicles have to queue or follow traffic light in intersection instead of moving straight to their destination which increase traffic congestion in intersections of roads in Kigali city.

Roads physical conditions(width).

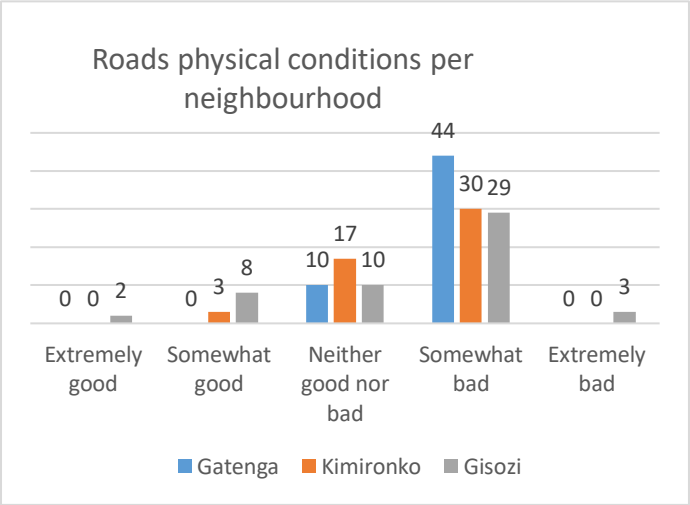
Only 1/11 interview mentioned that "*the roads in Kigali are good compared on the normal standard of the roads".* The other 10/11 interviews stated that roads in Kigali city are small in width where many are one lane. The interviews also mentioned that the roads are few which was also on the top of the causes of traffic congestion in Kigali city. However, those answers were made from 11 interviews out of 16 that were intended to be done. Probably more supporting arguments about having better roads in Kigali city would have appeared. The fact that roads are few was emphasized from the survey findings where only 2 respondents from the entire study area mentioned that in their daily trips to work, they do not use any the of roads disclosed in this study. This means that even if only 56.52% of the respondents work in the CBD, 98.76% of all the workers use the roads connecting Gatenga, Kimironko, and Gisozi neighbourhood to the CBD. The road options available to move from point A to point B in Kigali city are few. The figure 13 below show the survey data about roads physical conditions of the entire area and each neighbourhood on a Likert scale of 5.

Figure 13: Survey results: Roads physical conditions for the study



The survey results about the physical conditions of Kimironko-CBD, Nyanza, Kicukiro CBD, and Gisozi CBD roads shows that the conditions of the roads in terms of width are not good. This is in line with the results from interviews where 10/11 respondents mentioned that roads in Kigali city are small compared with the demand for vehicles that use them. This issue of road width was also pointed out many times as the main cause of traffic congestion in Kigali city.

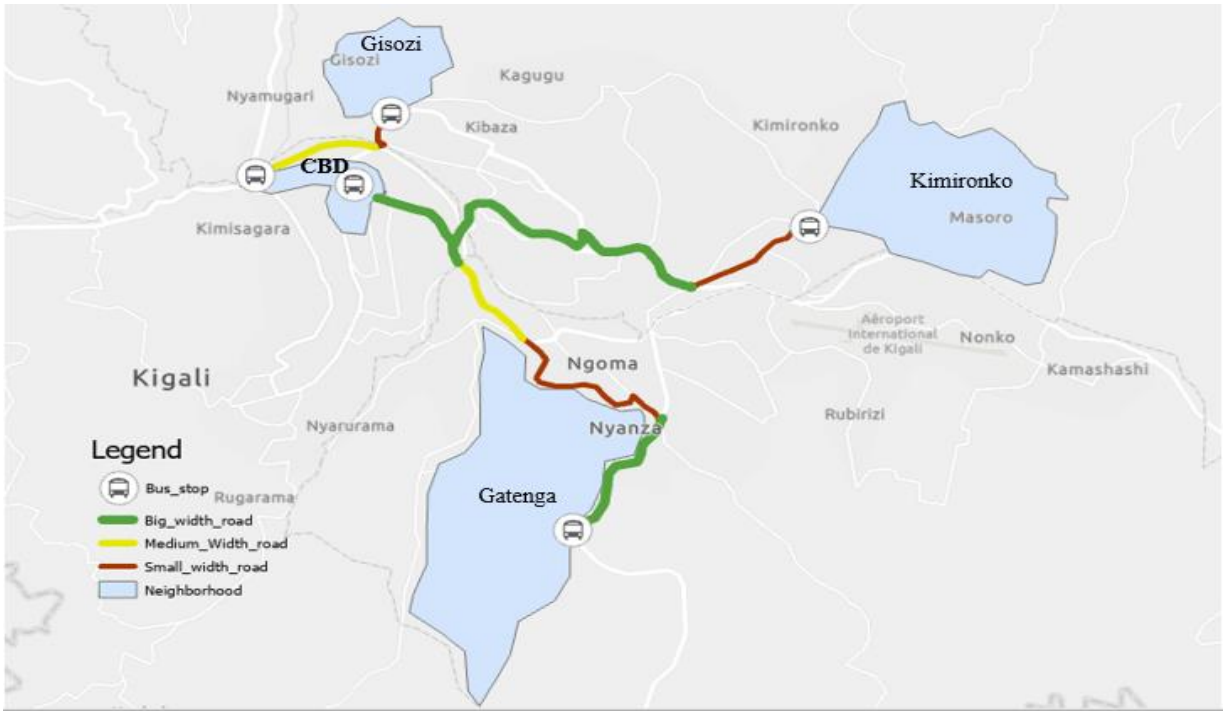
Figure 14: Survey results: Roads physical conditions per Neighbourhood



The survey data corrected on each neighbourhood shows that Kimironko-CBD road is somewhat better compared to the other roads. This assumption was made based on the distribution of responses in figure 14. The road Nyanza, Kicukiro-CBD was considered as the second one which is better among the 3, whereas Gisozi- CBD road was considered as the last one because 66.6% of the respondents said that it is somewhat bad and extremely bad.

To support the data from interviews and questionnaires, a secondary data source was used to know the width of every primary road to the CBD under this study. Open street maps were used where the width of every road was digitized using ArcGIS Pro. The roads were classified into 3 categories named big-width, medium-width, and small-width. Those categories were digitized on every road based on open street maps data. It does not mean that the road width was categorized based on international standards of roads rather done based on categories of roads in Rwanda provided by open street maps. The road width was categorized as shown in figure 15.

Figure 15: Road width categories



Using the information on the road length provided in the attribute table of ArcGIS, the small width road of the entire area occupies 34% of the total road length, medium width is 18% whereas big width road occupies 48%. In general, the entire area roads' physical conditions are good because the large percentage is from a big width road segment. However, the small road width occupies a big percentage too. In terms of road width per each road, Kimironko-CBD road is better than the others because the big part of it is classified under Big width road. Kicukiro-CBD road is the second whereas Gisozi-CBD is the last with no big width road segment on it.

To conclude with the results from interviews, questionnaires, and open street maps, generally Kimironko-CBD, Nyanza, Kicukiro -CBD, and Gisozi-CBD roads physical conditions in terms of width is not bad however the roads are not very good too. I gave the study area a score of 3/5 based on the above data. Ranking each road based on physical conditions, Kimironko-CBD is the first in having better conditions whereas Gisozi-CBD road is the last one.

4.4.2.2. Land use mix

The sub-variable has one indicator which is the availability of land use mix plans that was later supported by the answers collected in a survey about the availability of workplaces in the neighbourhood. The results from interviews were presented first and then compared with results from questionnaires and secondary data.

Table 12: Summary of interview responses on land use mix indicator

Sub-variable	Indicator	Summary of interview responses	frequency
Land use mix	Availability of land use mix plans	Every zoning plan of any district in Kigali city support land use mix of residential area and workplaces	1*
		They are workplaces within the neighbourhoods in Kigali city, but they are not enough to accommodate all the working group residents	1*

		Many workplaces are in the CBD and there are no residential areas there, except hotels and apartments.	7**
		Workplaces are located in different parts of the city within residential areas	4**

*Total number of respondents=2

**Total number of respondents=11

Availability of land use mix plans

Two urban planners that were interviewed agreed that they are workplaces within the residential area. One emphasized that the masterplan of the city support land use mix of residential area and workplaces, however, another one mentioned that even if the workplaces are there, they are not many to accommodate the entire neighbourhood working group. out of curiosity the other question asking whether Kigali city can be considered as a centrally planned city, 7/11 respondents mentioned that the CBD is more developed than the other area and they mentioned that there are more workplaces in the CBD than in the other parts of the city. This can be proved by the survey data presented before showing that 56.52% of all workers work in the CBD. The respondents also added that they are no residential area in the CBD except hotels and apartments.

The survey data was conducted about the availability of workplaces like schools, shopping centres, hospitals, and offices in Gisozi, Kimironko and Gatenga Neighbourhood and as the result shows many agreed that those workplaces are there. The distance from the workplaces to neighbourhood was also asked where many workers said that workplaces are within 2 Km to where they live. The table 13 below summarizes the survey responses of each neighbourhood.

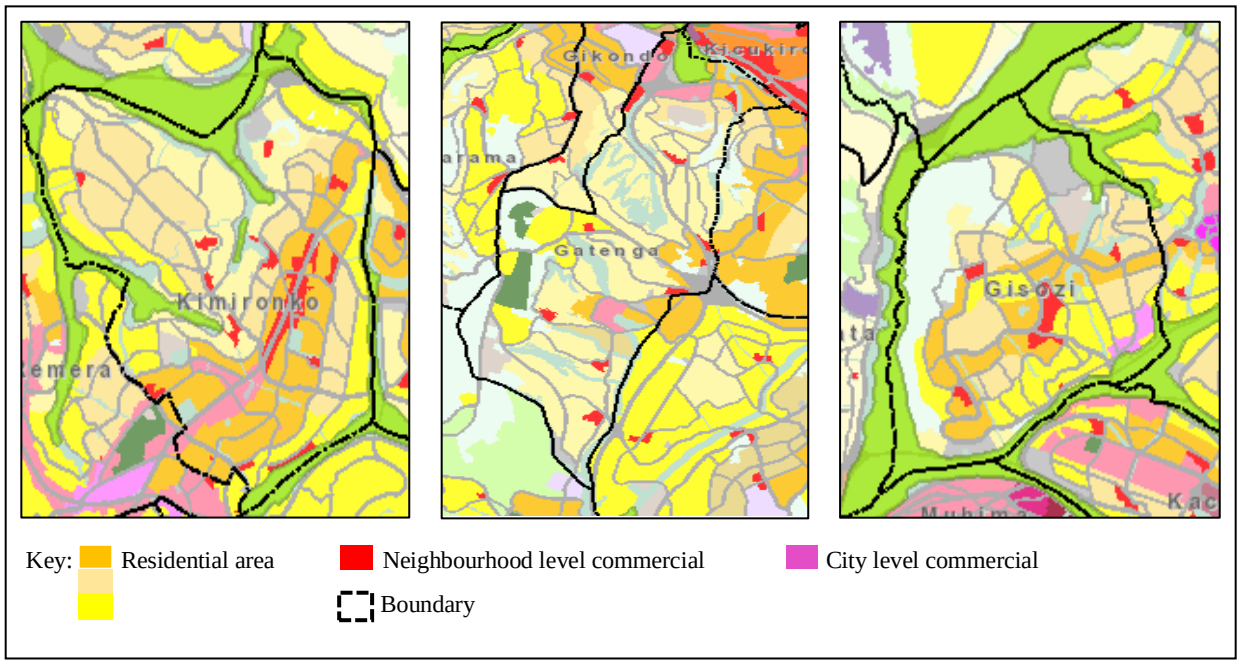
Table 13: Survey results: availability of workplaces within residential area

	Questions	**Summary of responses**	**Kimironko responses in %**	**Gatenga responses in %**	**Gisozi responses in %**
1	Are there offices building in your neighbourhood?	Yes	92.7%	100%	86.5%
		No	7.3%	0%	13.5%
2	Are there schools in your neighbourhood?	Yes	100%	100%	99%
		No	0%	0%	1%
3	Are there hospitals in your neighbourhood?	Yes	100%	100%	90.3%
		No	0%	0%	9.7%
4	Are there shopping centres in your neighbourhood?	Yes	100%	100%	100%
		No	0%	0%	0%

Total number of respondents=161

Comparing the results from the survey and the questionnaires, it is evident that workplaces and residential areas are mixed in Kigali city in general. Gatenga which had the highest number of workers who work in the CBD has a mixed land use of residential and workplaces but not at the same level as the other 2 neighbourhoods. However, many workers go to work in the CBD in general, not in their neighbourhood. 5/11 interviews pointed that they are many workplaces in the CBD that the other part of the city and 1/2 interview stated that workplaces in the residential area are not enough to cope with all working group people within a neighbourhood. To Know the reason why many people, work in the CBD instead of their neighbourhood, a secondary data review of Kigali city master plan 2013 web GIS online version was used for further clarification. The description of land use per neighbourhood is illustrated in figure 16.

Figure 16: Land use of Kimironko, Gatenga and Gisozi



Source: Kigali city master plan, 2013

The figure 16 above shows the land use plan of every neighbourhood where yellow colour represents area designed for residential, red colour represents neighbourhood level commercial, and purple colour represents the city-level commercial district. The lighter and the denser yellow colour represents all residential, they differ according to the level of densification. Based on the data provided above, the plan supports mixed land use of residential with workplaces at the neighbourhood level in General. This is similar to the findings from the interview where R7 said that: *"Every zoning plan of any district of Kigali City supports land use mix of residential areas and workplaces in Kigali city. They are all available online at 2013 Kigali Master Plan online platform".* All the neighbourhoods are mixed at the same level although the city level commercial is slightly more in Kimironko and Gatenga than in Gisozi which is similar to the survey findings presented above. However, this is a master plan. It does not mean that all the land uses have been implemented already but every neighbourhood follows the masterplan in its development.

R8 mentioned that even if residential areas are mixed with workplaces, the workplaces are not enough within residential. This can be proven by the above figure 16 because commercial areas occupy small places compared to the residential area. Additionally, the survey data collected on 161 houses showed that 81.31% of houses have more than 3 workers. The distribution of responses per neighbourhood is somehow the same. The above-mentioned reason can even explain the reason why many people work in the CBD than in their residential area regardless of the mixed land use of residential and workplaces. To gain more insight into why many people work in the CBD rather than any other place, the master plan of the CBD was used as provided Kigali city master plan online version.

Figure 17: CBD land use

CBD of this study, which is composed of Nyabugogo and Mumugi, has many commercial areas than any other neighbourhood under this study. The commercial areas are highlighted in purple colour which differs based on buildings density as shown in figure 17. That explains the reason why more than half of the population works in the CBD. It also emphasizes the fact that 7/11 interviews stated that many workplaces are found in the CBD in Kigali city.

Source: Kigali city masterplan, 2013

To sum up this section of mixed land use availability, they are workplaces within the residential area as supported by Kigali city masterplan. The workplaces are distributed equally in all neighborhoods and they are located not far away from the residential area. However, the available workplaces within neighborhoods are not enough to cope with the number of workers in that neighborhood. That is one of the main reasons that generate working trips in Kigali city. The fact that the CBD is more developed than the other area attracts more than half of the workers in the 3 neighborhoods. The neighborhoods with mixed land use have been debated as the ones that reduce traffic congestion and any other motorized type of transport. However, Mixed land use of this study is low and encourage the use of motorized mode of transport.

Only physical characteristics of roads was considered for statistical analysis that is why at the end of this section there is no reliability test conducted.

4.4.3. Traffic congestion

This variable has two sub-variables which are travel time and level of service. The total number of indicators is 3. Each sub-variable was analysed differently where interview results were presented first then compared and contrasted with the results from questionnaires and secondary data.

4.4.3.1. Travel time

In this study, travel time was measured using the data for the peak period and off-peak period. Findings from interviews were presented first followed with questionnaire findings and secondary data. At the end of this section, a concluding mark was provided. The indicators used are average time travelled in Peak period and average time travelled in off-peak period. The interview findings are presented in table 14.

Table 14: Summary of Interview findings on travel time indicators

Sub-variable	Indicators	Summary of interview responses	frequency
Travel time	Average time travelled in peak period	Time travelled in peak period is high because time spent when commuting and traffic congestion are related	1*
		Time travelled in the morning is higher than time travelled in the evening during peak period because traffic congestion is lower in the evening	3**

		Time travelled in the evening is longer than the time travelled in the morning because traffic congestion is higher in the evening	8**
	Average time travelled in off-peak period	Time travelled in the off-peak period is lower compared to peak period commuting time.	1*

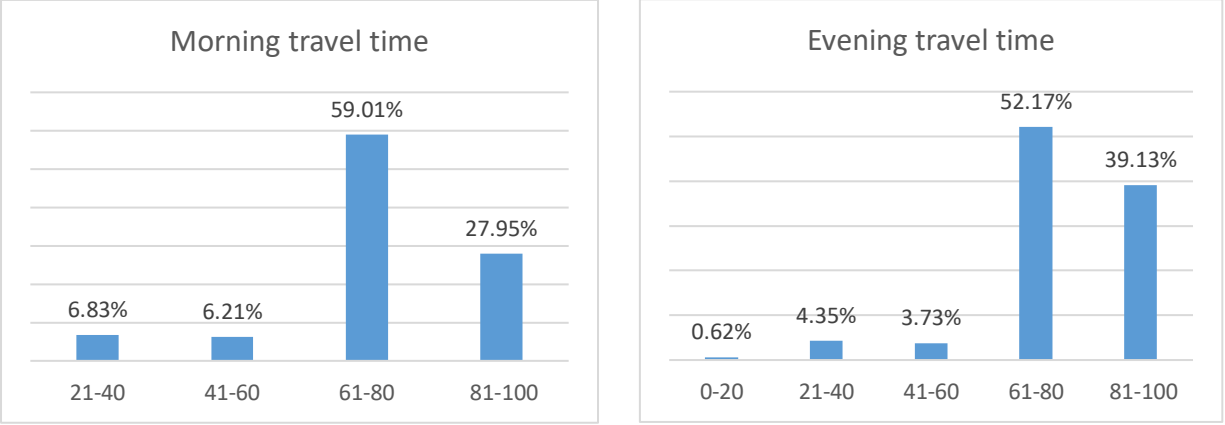
*Total number of respondents=1

**Total number of respondents=11

Average time travelled in Peak-period

The interview response shows that time travelled in peak-period is higher because traffic and travel time are related. However, this is 1 out of the 3 responses I was expecting to correct. When asking respondents when travel time is high comparing morning and evening scenarios, 8/11 said that evening travel time is high that in the morning because traffic congestion is high in the evening. Many pointed that the fact that most of the workers end their work at 5:00 P.M and start their work either at 7 or 8 A.M is the reason because there is a little flexibility of work schedules in the morning than in the evening. This was also proven in section 4.4.1.1 of departure time choice. The time travelled in the morning and in the evening for the study area shows that 27.95% of morning commuters travel between 81-100 minutes whereas 39.13% of commuters travel at the same time in the evening.

Figure 18: Morning and evening travel time



Statistical T-test of paired mean was conducted to support the results from interviews and questionnaires where the mean from work to home is 4.08 which is higher than the mean to commute in the morning which is 4.25 as shown in table 15.

Table 15: Paired sample statistics of evening and morning travel time

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Travel time from home to work	4.08	161	.782	.062
	Travel from work to home	4.25	161	.775	.061

Literature review data from Lundqvist (2003) specified that commuting distance and travel time are related. However, the results from the survey show that even if Gisozi-CBD road is short, the travel time is a bit high. When running a correlation test between commuting distance and travel time using the Spearman coefficient, the correlation was positive, but the correlation is weak at 0.285.

Table 16: Distance and travel time correlation

Correlations

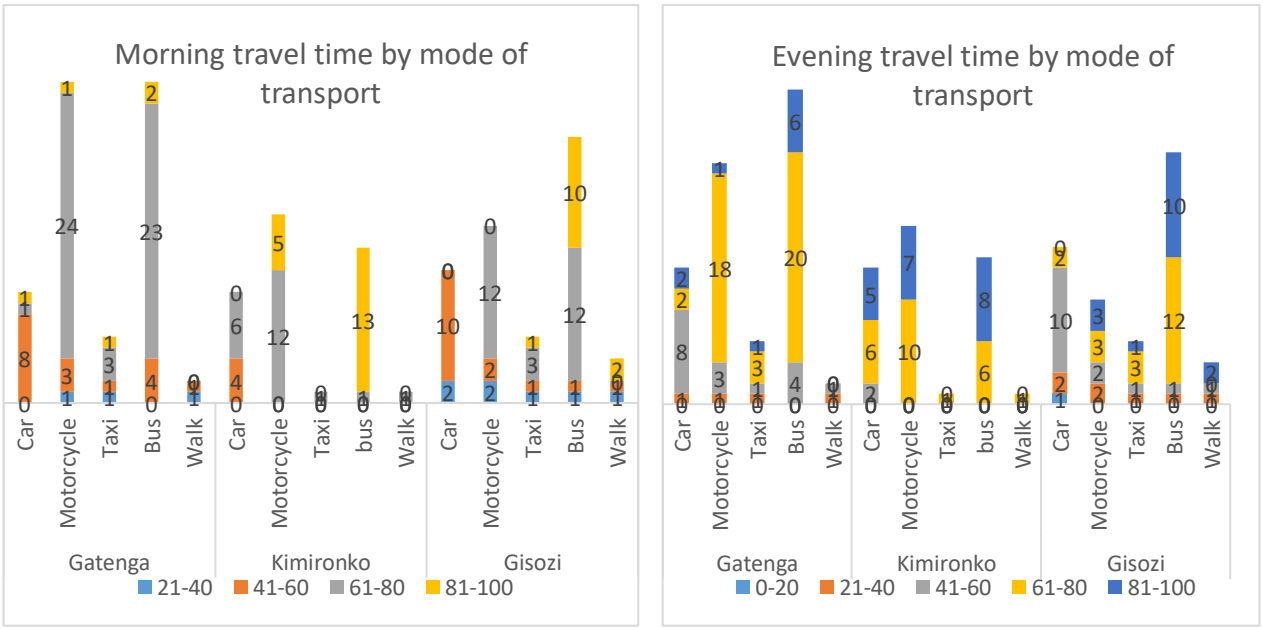
			Travel time	Distance
Spearman's rho	Travel time	Correlation Coefficient	1.000	.285**
		Sig. (2-tailed)	.	.006
		N	91	91
	Distance	Correlation Coefficient	.285**	1.000
		Sig. (2-tailed)	.006	.
		N	91	91

**. Correlation is significant at the 0.01 level (2-tailed).

The reason why there is a weak relationship between the 2 variables is that many respondents said that the commuting distance from home to work is short, but when asking them about travel time many responded that the time is longer. This can be explained by the delay in the roads and lower travel speed in peak-period that affect this relationship.

Travel time and mode of transport a commuter use to move from one place to another are related. The survey data collected showed that the modes of transport used to go and come back from work are the same. The data collected shows that some workers use more than 1 transport mode on their daily trips. Only the working trips from 3 residential areas to the CBD were considered and both morning and evening trips were analysed differently as peak period. The figure 19 shows the relationship between travel time in the peak period by different modes of transport.

Figure 19: Survey results: Travel time in peak period (morning and evening) by mode of transport



The Travel time in each neighbourhood by mode of transport (car and bus) was calculated using the frequencies and mid-point of the travel time interval from figure 19 because the data collected for travel time are grouped. The average travel time was obtained by finding the mean of morning peak-period and evening peak-period as shown in table 17.

Table 17: Average travel time per mode of transport in peak period

Roads	**Morning Peak-period**		**Evening peak-period**		**Average travel time**	
	Car	**Bus**	**Car**	**Bus**	**Car**	**Bus**
Kimironko-CBD	62 minutes	76 minutes	61 minutes	82 minutes	62 minutes	79 minutes
Nyanza, Kicukiro-CBD	56 minutes	66 minutes	58 minutes	71 minutes	57 minutes	69 minutes
Gisozi-CBD	47 minutes	70 minutes	51 minutes	75 minutes	49 minutes	73 minutes

Average time travelled in off-peak period

One interviewee from the transportation sector pointed out that travel time in the off-peak period is lower compared to the peak-period. The survey data collected showed that most of the workers travel during peak period. To get off-peak period travel time, secondary data source of google maps was used and off-peak period travel time. The average travel time was obtained by considering the direction of each road towards CBD. Additionally, the data was collected at midnight which is off-peak period under my study. Figure 9,10, and 11 presented on commuting distance were used for car users travel time in off-peak period. The results were presented in table 18 as follow:

Table 18: Average travel time per mode of transport in off-peak period

Road	Off- peak period	
	Car	**Bus**
Kimironko-CBD	18 minutes	47 minutes
Nyanza, Kicukiro-CBD	20 minutes	50 minutes
Gisozi-CBD	6 minutes	10 minutes

Source: Google maps, 2020

Travel time commuted in the off-peak period is lower compared to the peak-period time. Additionally, the average time traveled is associated with distance in the off-peak period which did not show a high correlation during peak period. This means that travel speed in peak period is lower than travel speed in off-peak period as explained in section 4.4.3.2 of level of service.

To close this section, it is evident that the travel time and mode of transport are associated. Only 3.98% of all workers said that the walk from home to workplace. This means that the commuting distance from where they work and where they live is not short. That is why 42.55% of workers use buses, 5.17% of workers use taxi, 31.61% of workers use motorcycle whereas 16.72% of workers use cars. This was explained further in the previous section of land use mix.

4.4.3.2. Level of service

This sub-variable has one indicator which is average vehicle speed. The average vehicle speed was used to determine which level of service belongs to each road using distance and travel time measures presented in the sections above. The level of service ranges from A to F based on different factors. Interview responses were presented before whereas different literature was used to categorize the level of service and to estimate vehicle per capacity ratio of each road under the study.

Table 19: Summary of interview responses of level of service indicators

Sub-variable	indicator	Summary of interview responses	Frequency
Level of service	Average vehicle speed	Average vehicle speed in peak hour is low compared to off-peak vehicle speed	1*
	Vehicle per capacity ratio	Traffic congestion in Kigali city is high because roads are smaller compared to the volume of vehicles that use the roads.	7**
		Traffic congestion in Kigali is not high but it is increasing faster as number of vehicles increase while the roads are still the same	4**

*Total number of respondents=1

**Total number of respondents=11

Average vehicle speed and Vehicle per capacity ratio

The 2 indicators were used together because they complement each other. The interview response corrected on this indicator revealed that the average speed and traffic congestion are related. However, R10 added that " *yeah it is understandable if a road has 2 lanes for going and coming movement and many cars are using one lane it is understandable that congestion will increase but in case of 6 lane highway, means that the vehicle speed increase and vehicle queues reduce in the roads".* The interviewee disclosed how Average vehicle speed and capacity of the road are related. This was also proven by (Ali and Kazemi, 2014; Qi et al., 2015) where the 2 indicators were presented together. 7/11 interview said that the main reason why traffic congestion is high in Kigali city is that the designed capacity of roads is low compared to the increase in car ownership volume. R9 from Ministry of Infrastructure said that: *"the car ownership is increasing because the importation growth is 12%. So as long as the importation increase, the motorization rate also increases. But the roads are still the same".* This reduces the speed the vehicle is supposed to use in general especially in the peak period. The average speed per each mode of transport was calculated below as shown in table 20.

Table 20: Average speed in off-peak period and peak period

Road	**distance**	**Travel time in off-peak period**		**Speed in off-peak period**		**Travel time in peak period**		**Speed in peak-period**	
		Car	**Bus**	**Car**	**Bus**	**Car**	**Bus**	**Car**	**Bus**
Kimironko-CBD	10.5 Km	18 min	47 min	35 Km/h	13.5 km/h	62 min	79 min	10.1 Km/h	8.01 Km/h
Nyanza, Kicukiro-CBD	10.8 Km	20 min	50 min	33 Km/h	13.0 km/h	57 min	69 min	11.3 Km/h	9.39 Km/h
Gisozi-CBD	3Km	6 min	10 min	30 Km/h	19 Km/h	49 min	73 min	3.7 Km/h	2.47 Km/h

The data presented in the off-peak period are basically from google maps. Google maps estimates travel time based on speed limits, current traffic conditions and the distance from the starting and endpoint of your destination (Wallin, 2020). However, the speed in off-peak period for car differ completely with the speed of buses. This was also mentioned by R10 that vehicle speed used by buses is lower compared to the speed used by private vehicles in Kigali city. This can be explained by the fact that bus stops are many where Kimironko-CBD road has 13 bus stops, Kicukiro-CBD road has 12 bus stops, whereas Gisozi-CBD road has 4 bus stops. Another factor that makes buses delay more than cars is that the speed limit Kigali is 40 Km/h for all the urban roads but to reduce fatal accidents, the speed governor device is now mandatory in Public transport vehicles in Kigali city (Times reporter, 2016). Even if the speed is the same in general, bus conductors have to be more careful of not exceeding the maximum speed where the device can trim down the speed up to 25 Km/h.

By comparing the speed of buses and cars in peak-period, the difference is not higher as it is perceived in off peak period. Speed was used in this study to measure the level of service because speed explains the reduction in mobility commuters' experience in traffic congestion. Additionally, traffic congestion was explained before as a function of reduction in speed. The table 21 below summarises the literature review about the comparison of average vehicle speed for the speed limit of 40 Km/h, level of service and vehicle per capacity ratio together with the description of each case.

Table 21: Level of service description

Level of service	Average vehicle speed	Vehicle/ capacity ratio	description
A	≤ 40 Km/h	0-60%	Free flow
B	>32 km/h	61%-70%	Stable vehicle flow
C	>24 Km/h	71%-80%	Stable vehicle flow
D	>16 Km/h	81%-90%	Less stable vehicle flow
E	>8 Km/h	91%-100%	Unstable vehicle flow
F	≤8 km/h	>100%	Forced vehicle flow

Source: (Ali and Kazemi, 2014; Ekardt, 2020; Qi et al., 2015)

Using the level of service described above, the level of service for each road was described as follow:

Level of service Kimironko CBD road

Based on the speed experienced by vehicles in peak period the road is classified under level E. this means that there is an unstable flow of vehicles during peak periods where the average vehicle per capacity is 91%-100%.

Level of service Nyanza, Kicukiro- CBD road

Based on the speed results of buses and cars in peak period the road is classified under level E. this means that there is an unstable flow of vehicles during peak periods where the average vehicle per capacity is 91%-100%.

Level of service Gisozi- CBD road

Based on the speed results of buses and cars in peak period the road is classified under level F. this means that there is forced flow of vehicles during peak periods where the average vehicle per capacity exceeds 100%. This can be emphasized by the fact that physical conditions of this road are not good comparing to the other roads.

However, to compare peak period and off-peak period travel time and speed, the speed reduction index (SRI) was used. SRI means the relative speed change between free-flow and congested conditions which range from 0-10. Congestion occurs when SRI exceeds 5. Values of less than 4 means that there is no congestion (Ekardt, 2020). The Speed Reduction formula is:

SRI= $(1-V_{ac}/V_{ff}) \times 10$, where V_{ac} is the actual travel speed and V_{ff} is the free flow speed or off peak period speed as named by (Ekardt, 2020).

Using the above SRI formula on the results provided in table 21, SRI of Kimironko-CBD road is 6.3, SRI of Nyanza, Kicukiro-CBD road is 5.6 and SRI of Gisozi CBD road is 8.7. The results show that all the roads have SRI which is higher than 5 which means that the roads are congested.

However, the results show that Gisozi-CBD road is the most congested road regardless the fact that this road is the shortest among the others. Based on the above-mentioned indicators in different sections of this chapter, the reasons behind this is because the road physical conditions are bad compared to other roads. Additionally, the road has 4- or 3-way intersections which increases vehicles queues because many cars meet at the small width of the road.

Kimironko-CBD road is the second congested road because this road has many 4- or 3-way intersections compared to the other roads. As explained above, intersections increase travel time because vehicles queues or deviate from their normal movement instead of going straight. Kimironko-CBD road has intersections known for being most congested area in Kigali like chez

rando, Minijust, Gishushu, Convention centre, and Peyage as R1, R8 and R10 mentioned. Nyanza, Kicukiro-CBD road is the least congested among the others even if it is the longest road because it has fewer intersection compared to Kimironko-CBD road.

However, even if only 56.52% of all workers work in the CBD, 98.76 % of all workers said that they use one of the 3 roads in their daily trips that is why the number of workers who work in the CBD per neighbourhood does not affect travel time on the 3 roads. This finding complements with connectivity problems stated in an interview where R4 said that: *"we have few roads options to move from point A to point B in Kigali city"*. Factors that contribute to traffic congestion on each road are not only limited to the indicators of this study because only working trips were considered with limited number of indicators.

To conclude this section, Kimironko-CBD, Nyanza, Kicukiro-CBD and Gisozi-CBD roads are congested in peak periods. However, traffic congestion only lasts for 3 hours in the morning (6:00 A.M-9:00 A.M) and 4 hours in the evening (5:00 P.M-9:00 P.M) from Monday to Friday as indicated in inflexible work schedules section. In the off-peak period, there is a free flow of vehicles on Kimironko-CBD, Nyanza, Kicukiro-CBD and Gisozi-CBD roads. This means that the road capacity only exceeds the number of vehicles trying to use that road in peak period.

For further statistical analysis, the reliability analysis conducted on questionnaire data of Traffic congestion indicators shows a good reliability of Cronbach $\alpha = 0.879$. The indicators tested include travel time from home to work, travel time from home to work perceptions, travel time from work to home and travel time from work to home perceptions.

4.5. Statistical results

This section presents first the Spearman's correlation between dependent variable and independent variables of the entire study. Later an ordinal regression model for the entire study area was performed to test the significance of independent variables in influencing travel time as dependent variable. At the end, correlation and regression results of each neighbourhood was described. Spearman's correlation and ordinal regression model were used since the data used in this paper are ordinal. Finally, a concluding mark was presented at the end of this section.

The table 22 below shows the correlation results for the entire study area between travel time as the dependent variable and independent variables that were statistically significant among the others as presented in Annex 4. Both morning and evening travel time gave the same results hence only morning travel time results were presented to avoid repetition. Only working trips from the 3 residential areas (Gisozi, Gatenga, Kimironko) to the CBD were considered.

Table 22: Spearman's correlation results for the entire study extracted from Annex 4

	Travel Time
Commuting distance	.249*
Time to reach home from work	.285*
Vehicle occupancy	.214*

*Correlation is significant at the 0.05 level (2-tailed)

The spearman's correlation results show that there is a positive correlation only between travel time, commuting distance, vehicle occupancy and time to reach home from work. However, the relationship between commuting distance is weak but as explained above commuting distance and travel time are highly related in off-peak period. Time to reach home from work and travel time are positively correlated but the relationship is weak. This means that as you use few minutes to travel, you will reach your home early. This relationship is true however, the correlation is weak because the data collected are for workers who moves in peak period. This means that workers spend long time in the road which has a little impact on the time they reach

their home. Another correlation observed is between vehicle occupancy and travel time. This means that people who have their own cars or motorcycles travel less than people who use buses. However, the relationship is weak in peak period compared to the off-peak period as the results about travel time in section 4.4.3.1 shows. This means that in Peak-period whether you use a car or bus the difference in travel time is short because all the vehicles are queuing together. The difference in travel time between cars and bus in peak period occurs when a bus stop to pick up passengers.

The off-peak period data from secondary sources shows that there is a high correlation between commuting distance and vehicle occupancy even if the results from peak-period prove it different. According to Stangl and Guinn (2011) physical characteristics of the roads influence traffic congestion. Traffic congestion results of this study shows that Gisozi-CBD road is the most congested road among the others. One of the reasons is bad physical conditions of that road as the results from questionnaires and secondary data proved. However, the statistical analysis shows that there is no correlation between physical conditions of the road and travel time. Additionally, socio-economic variables like age, gender, and income level in this paper do not have an association with Travel time as shown in Annex 4 however, it has been correlated positively by other research done by (Daragay, 2003; Ferguson, 2016; Lundqvist, 2003). Moreover, the study conducted by Saleh and Farrell (2005) showed that there is a correlation between departure time and travel time. This was emphasized by the results of peak and off-peak period travel time data of this study where peak-period travel time is higher than off-peak period travel time. But because the survey data collected shows that most workers move in peak-period, there is no relationship between departure time and travel time.

Based on the above-mentioned reasons, the researcher does not agree with these results because the data collected were for workers who commute in peak period hence some indicators that can increase or reduce travel time were not all statistically significant.

The significance test for association of questionnaire data was carried out using ordinal regression since the dependent variable is ordinal and the independent variables are classified under ordinal category. Travel time was analysed as independent variable, whereas commuting distance, vehicle occupancy and time to reach home from work were analysed as independent variables. The results of the regression analysis show that there is a significant fitting in the final modal of ordinal regression between travel time with commuting distance, vehicle occupancy and time to reach home from work as the final significant is 0.000 which is less than P=5%.

Table 23: SPSS Model fitting information

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	96.090			
Final	72.115	23.975	3	.000

Link function: Logit.

The ordinal regression model for the entire study area shows that the 3 independent variables which are commuting distance, time to reach home from work, and vehicle occupancy are statistically significant with travel time as their P value is less than 5%. However, the other indicators which were not statistically significant in correlation test were not included in the modal. Only statistically significant indicators were used to test their influence on travel time as shown in Table 24 below.

Table 24: SPSS ordinal regression model for the entire study results

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Traveltime = 1]	7.008	1.945	12.990	1	.000	3.197	10.820
	[Traveltime = 2]	7.942	1.975	16.165	1	.000	4.070	11.813
	[Traveltime = 3]	11.512	2.205	27.265	1	.000	7.191	15.833
Location	Distance	1.569	.422	13.796	1	.000	.741	2.397
	Time_To_Reach_Home	1.045	.393	7.085	1	.008	.276	1.815
	Vehicle_occupancy	1.366	.432	9.996	1	.002	.519	2.212

Link function: Logit.

However, each study area was analysed separately and the results extracted from Annex 4 shows that Spearman's correlation that was done on all the indicators with travel time for Kimironko neighbourhood data, only time to reach home has a weak positive correlation with travel time at 0.474 where ordinal regression modal was significant at 0.034 between the 2 indicators. In Gatenga neighbourhood Spearman's correlation showed that only departure time has a weak negative correlation with travel time at -0.391 and regression analysis was significant at 0.008 whereas in Gisozi neighbourhood only commuting distance has a weak positive correlation with travel time at 0.363 and the association was significant at 0.015. The statistical results presented for each neighbourhood were significant at the confidence interval of 95% and only working trips from residential area to the CBD were considered.

Based on the results above, the researcher concluded that the statistical results of this study do not explain widely the association and relationships between indicators under this study because of the limited number of respondents that undermine this correlation and the answers provided in questionnaires mainly represent peak-period situation. The statistical test for the entire study shows that there is only a significant relationship between commuting distance, vehicle occupancy, time to reach home from work and travel time while other factors like physical conditions and departure time do not matter in influencing travel time. However, Cronbach α test shows that there is good reliability of indicators within each variable and secondary data sources of off-peak period proved that there is a strong correlation between travel time and different indicators. Additionally, it was presented before in the interview findings and literature that there is a significant relationship between inflexible work schedules, land use design and traffic congestion.

Chapter 5: Conclusions

5.1. Introduction

This chapter presents the main findings presented in chapter 4. This case study research focuses on how inflexible work schedules and land use design influence traffic congestion on Kimironko-CBD, Nyanza, Kicukiro-CDB, and Gisozi-CBD roads in Kigali city. Working trips in Kigali were discussed in different researches as the main causes of traffic congestion in Kigali city (Jean Chrétien, 2017; Vincent, 2019). However, the reason why working trips are problematic is that the schedules are fixed. This means that workers went to the same place every day at the same time which generates trips from Monday to Friday or Saturday. In connection with a fixed place where workers go every day, Joseph (2018) mentioned that Kigali city is a centrally planned city as many as the other African cities. This implies that workers go to work from Monday to Friday or Saturday at the same time in the morning from the residential area to the CBD. This trip is also repeated in the evening from CBD to the residential area. The fact that the connectivity of the roads is not good in Kigali city, in general, was discussed as the main cause that worsens the movement of workers from residential areas to the CBD (Jean Chrétien, 2017). This study, therefore, aims to provide knowledge that will be beneficial to regulate the demand side of traffic congestion in Kigali city by explaining how inflexible work schedules and land use design influence traffic congestion on Kimironko-CBD, Nyanza, Kicukiro-CDB and Gisozi-CBD roads in Kigali city.

The conceptual framework of this study was delivered from the literature of empirical studies in different cities or countries. Inflexible work schedules were explained by signalling theory which seeks to integrate personal needs with the work environment. Inflexibility in work schedules means that your place and time to start work are fixed. Based on this definition, departure time choice and commuting distance were used as sub-variables of inflexible work schedules that influence traffic congestion. The urban form concept was used to explain land use design. Land use design was defined as physical and functional characteristics of place result from human activities based on land use regulation of a certain area for effective use of resources. Land use mix and connectivity were used as sub-variables that explain how land use design influence traffic congestion. This study uses travel time and level of service to explain the situation of traffic congestion on Kimironko-CBD, Nyanza, Kicukiro-CDB, and Gisozi-CBD roads in Kigali city. Understanding how inflexible work schedules and land use design influences traffic congestion can provide less cost-effective measures that can reduce traffic congestion in Kigali city.

In the subsequent section, the main findings gathered from online interviews, questionnaires, ArcGIS Pro, and secondary data sources together with the statistical analysis presented in chapter 4 are highlighted following the order of sub-research questions and the main research question. Finally, recommendations, areas for future research and Author's outlook are highlighted.

5.2. Main findings of the research

The following section presents findings from primary data sources and secondary data sources that answer the main research question and sub-research questions. The conclusion answering the main research question was provided based on the answers of each sub-research question that was presented first.

RQ1: What is the situation of traffic congestion on Kimironko-CBD, Nyanza, Kicukiro-CDB and, Gisozi-CBD roads in Kigali city?

To answer the first sub-research question, travel time and level of service have been used as sub-variables to answer this question since the 2 measures have fewer limitations comparing to the other measures like delay and volume (Mohan and Ramachandra, 2012). The level of service classification and speed reduction index was used to know the magnitude of congestion of each road. The level of service measure uses peak period findings whereas SRI uses both peak-period data and off-peak period data.

The findings of this research to answer the first sub-research question uses both primary data and secondary data sources. Primary data collected from interviews and questionnaires together with secondary data show that the 3 roads of this study are congested. Peak-period data collected through questionnaires were used to find the peak-period speed of each road. Data collected from interviews shows that roads in Kigali city are congested in general where 7/11 respondents said that the capacity of the roads to cope with the number of vehicles that use that road is not enough during peak periods.

Based on the results of travel time from questionnaires and secondary data, the average speed of each road in peak and off-peak period was calculated. Using the speed results, Kimironko-CBD and Nyanza, Kicukiro-CBD roads were classified under level E which means that there is an unstable flow of vehicles during peak period where the capacity of the road is almost equal to the number of vehicles trying to use that road. Gisozi-CDB road was classified under level F which makes it the most congested road under this study. On Gisozi-CBD road there is a forced flow of vehicles during peak period because the vehicles using that road exceeds its capacity during peak period.

Using the SRI formula, also Gisozi-CBD road was the most congested among the others even though all the roads have the SRI which is higher than 5. Kimironko-CBD road was the second congested road whereas Nyanza, Kicukiro-CBD road was the least congested among the others. Both peak-period data and off-peak period data were used and that provided the opportunity to compare the amount of congestion on different roads. Although using the level of service has shown that the roads are congested, using SRI helped to know which one is more congested than another especially between Kimironko-CBD and Nyanza, Kicukiro-CBD roads as they were both classified under level E.

In general, traffic congestion on Kimironko-CBD and Nyanza, Kicukiro-CBD roads is not very high yet like on Gisozi-CBD road, but measures should be taken early because it has many negative effects on people's wellbeing. Traffic congestion is the main challenge to developing cities like Kigali because as the country's level of entrepreneurship increases, cars also increase. However, Monowar et al (2009) said that focusing on the supply side of traffic congestion by increasing road facilities can never solve that problem because the situation will repeat over and over again. The more you increase road facilities also cars will increase, and people will find it easy to live far away from the city which will create urban sprawl. In the case of Kigali city, demand-oriented solutions to reduce unnecessary trips are way more appropriate than supply oriented solutions.

RQ2: How do inflexible work schedules influence traffic congestion on Kimironko-CBD, Nyanza, Kicukiro-CD, and Gisozi-CBD roads in Kigali city?

The inflexible work schedules in this study were discussed in terms of departure time choice and commuting distance. In Kigali city in general, work schedules are inflexible where workers do not have to change when to start their work and where to do their work. Departure time choice and distance findings were discussed below

Departure time choice of the entire study is clustered in the same period which is known as peak-period. Most workers start work at 7 and 8 whereas most workers end their work at 5. The departure time of workers from their home in the morning start from 5 A.M up to 8 A.M whereas in the evening many workers reach their home between 5 P.M up to 9 P.M. Based on the information from secondary data and primary data source, Peak period in Kigali city was classified in the morning between 6 A.M- 9 A.M whereas in the evening is from 5 P.M -9 P.M. Most workers work 5-6 days in a week and more than 80% of workers do not change the start or end period of their work or change the location of their workplaces. This means that the same number of workers travel from their homeplace to their workplace every day from Monday to Friday or Saturday.

This inflexible movement of workers has been mentioned in interviews as the main sources of traffic congestion in Kigali city because many people start their journey at the same time mainly in the peak period. This was also proven by questionnaire results and secondary data where travel time becomes longer in peak-period than in off-peak period. Additionally, the other empirical study done by (Noland and Small, 2006) shows that there is a relationship between departure time and travel time. The inflexibility of work schedules in this study is the same Kimironko-CBD, Nyanza, Kicukiro-CDB and Gisozi-CBD roads in Kigali city because the labour laws that do not favour flexibility of work schedules are applied everywhere in the country with no exception.

The statistical result of this study only shows a weak significant relationship between time to reach home and travel time for the entire study. In Gatenga neighbourhood only departure time has a weak association with travel time among the other indicators whereas in Kimironko neighbourhood only time to reach home has a weak correlation with travel time. This contradicts the above results presented which demonstrate that the time you will start your journey will impact your travel time. However, the researcher did not agree with statistical results because mainly questionnaire data represents only peak period situation and the limited number of respondents that undermine this correlation.

Commuting distance is the second sub-variable of inflexible work schedules. The distance was measured after asking workers where they work. However, more than half (56.52%) of workers work in the CBD. Kimironko-CBD road has 10.5 Km, Nyanza, Kicukiro-CBD road has 10.8 Km whereas Gisozi-CBD road has 3 Km. According to literature from Rahman et al (2014), all those commuting distances do not favour walking. This was emphasized by questionnaire results where only 3.98% of workers walk on their daily trips. Based on the inflexibility results of work schedules more than half of workers commute every day at the same time from their workplaces to the CBD and commute the same distance that does not favour walking from Monday to Friday which contributes a lot to traffic congestion.

This result can be further supported by empirical research done in the Netherlands that shows that flexible work schedules program like telecommuting and compressed workweek are the main reason why vehicle mile travelled has reduced by 4% (van der Loop et al. , 2017). Additionally, the shorter distance that favour walking reduces traffic congestion because car usage reduces. However, statistical analysis for questionnaire data of this research shows that there is a weak correlation between commuting distance and travel time for the entire study area and Gatenga neighbourhood as the data collected are for workers who commute in peak period and the sample size of respondents is limited.

To sum up with the above findings, the researcher concluded that inflexible work schedules have significantly influenced traffic congestion on Kimironko-CBD, Nyanza, Kicukiro-CDB and Gisozi-CBD roads in Kigali city because most of the workers do not change their workplace and when to start their work in general and traffic congestion occurs in peak period when

workers are commuting. Additionally, telecommuting was like a dream before COVID 19 as R11 stated however, there the researcher believes that different organizations will consider flexible work schedules even after COVID 19 because traffic congestion reduced significantly during COVID 19 in Kigali city.

RQ3: How does land use design influence traffic congestion on Kimironko-CBD, Nyanza, Kicukiro-CDB, and Gisozi-CBD roads in Kigali city?

Land use design in this study is divided into connectivity and land use mix plan. Connectivity was explained by physical conditions of roads and availability of 3 and 4-way intersections of the roads whereas land use mix was explained by the availability of workplaces within residential areas.

Physical conditions of the roads under this study in terms of width in general are neither good nor bad. Data from interviews shows that roads in Kigali city, in general, are small in width where 10/11 interviews said that. However, data from questionnaires and secondary sources shows that Kimironko-CBD, Nyanza, Kicukiro-CBD, and Gisozi-CBD roads are not very bad in width. In terms of the physical conditions of the road, Gisozi-CBD road has very bad conditions compared to the other 2 roads under this study. Nyanza, Kicukiro- CBD road is the second one which has bad conditions whereas Kimironko-CBD road is better in width compared to the others. The small width of the roads has been pointed out by interviews as the main source of traffic congestion in Kigali city.

The intersection of roads also was cited as the main cause of traffic congestion where interviews said that where many roads meet, there is a high chance of being congested because the volume of vehicles is high at that point. The data from secondary sources shows that Kimironko-CBD road has many intersections than the other roads, but the width of the road is big in intersections. However, on Gisozi-CBD roads the width is medium in intersections of the roads.

An empirical study done in Madrid, Spain proved that neighbourhoods with good road connectivity are more sustainable because they encourage sustainable transport and reduce traffic congestion (Lamíquiz and López-Domínguez, 2015). This was proven by the fact that Gisozi-CBD road is the most congested road among the others because of its bad physical conditions although this is the smallest road among the others (only 3 Km). According to Atomode (2012) where roads intersect traffic congestion is inevitable where congestion is higher in intersections than the other parts of the road segments. This was proven by Gisozi-CBD road through being the most congested road among the others where this road has intersections on medium width road. Additionally, Kimironko-CBD road is more congested than Nyanza, Kicukiro-road because Kimironko-CBD road has many intersections that are known for being the most congested places in Kigali as explained in chapter 4.

Land use mix was discussed by assessing the availability of workplaces within residential area. In general, there is a mixed land use of workplaces and residential area within the 3 neighbourhood which are Gisozi, Gatenga, and Kimironko to an equal extent. However, the level of mixed land use is low because workplaces within residential areas are not enough to cope with the working group population of each neighbourhood.

There are many workplaces in the CBD compared to the neighbourhood which can be further explained by the fact that 56.52% of all workers work in the CBD. However, 96.02% of all workers use the motorized mode of transport in their daily trips which means that they do not work within their neighbourhood or near their residential area. Additionally, travel mode correlated with traffic congestion where commuters who use single cars contribute to traffic congestion than commuters who use buses. In Kimironko neighbourhood 48.1% of workers use cars in their daily trips, in Gatenga neighbourhood 28% of workers use cars whereas in Gisozi

neighbourhood 37.8% of workers use cars in their daily trips. Vehicle occupancy positively correlates with income level and age. High vehicle occupancy in Kimironko neighbourhood explains the reason why Kimironko-CBD road is more congested than Nyanza, Kicukiro-CBD road because many workers use their cars to travel instead of public transport which increases traffic congestion.

Mixed use neighbourhoods where all compatible activities are integrated within a short distance promote the use of non-motorised transport like walking and cycling (Health space and places, 2009). But land use mix in Gisozi, Gatenga and Kimironko neighbourhood is low and does not favour sustainable mode of transport which increases traffic congestion.

Notwithstanding the above, correlation and regression tests done on questionnaire data did not show any significant relationship between land use design and traffic congestion. But there was a weak significant correlation between vehicle occupancy and travel time. This can be explained by inadequate sample size representation and the fact that questionnaire data collected are for workers who commute in peak-period where the other factors affect less travel time.

However, the researcher did not agree with statistical test results because as explained above using data from questionnaires, interviews, and secondary sources land use design has significantly influenced traffic congestion on Kimironko-CBD, Nyanza, Kicukiro-CBD, and Gisozi-CBD roads. Almost all workers use motorized mode of transport in their daily trips because the distance between where they work and where they live is long and the roads options to use are limited because of connectivity issues which cause traffic congestion during peak-period.

Main RQ: How do inflexible work schedules and land use design influence traffic congestion on Kimironko-CBD, Nyanza, Kicukiro-CBD, and Gisozi-CBD roads in Kigali city?

The above section answers each sub-research question where how inflexible work schedules and land use design influenced traffic congestion were explained. This section summarizes how the 2 independent variables influenced traffic congestion as the dependent variable with a note stating which level the 2 independent variables influenced the dependent variable.

As mentioned above, inflexible work schedules have significantly influenced traffic congestion because traffic congestion happens during peak-period where most workers commute. However, the statistical results of this study did not show any strong relationship between inflexible work schedules and traffic congestion because of the reasons explained in section 4.5 and the above answers of each sub-research question. But the study shows that almost all workers do not change the location or time to do their work. The movement of workers from Monday to Friday every day at the same time increased travel time in peak periods which reduce travel speed hence congestion. Moreover, commuting distance of working trips does not favour walking because many workers use motorized mode of transport on their daily trips. This means that workers commute the same distance every day at the same time known as peak-period. The researcher would like to highlight that work schedules in Kigali are inflexible which significantly influences traffic congestion on Kimironko-CBD, Nyanza, Kicukiro-CBD, and Gatenga-CBD roads at the same level.

As also mentioned, land use design significantly influenced traffic congestion because almost all the workers use motorized mode of transport in their daily trips as where they live and where they work is not near. Additionally, connectivity of the roads influenced traffic congestion in different ways. However, not all the roads were affected equally as in the above section because Gisozi-CBD road is the most congested road among the 3 roads as it has bad physical characteristics of the roads, intersections at small road width, and high number of a single-car usage. Kimironko-CBD road is the second congested road as it has many intersections than the

other roads and the highest number of single-vehicle usage among the other roads. Nyanza, Kicukiro-CBD road is the least congested because it has few intersections, a smaller number of single-car usage and the physical characteristics of the roads are better. Single car usage was used because the distance between workplaces and residential area does not favour motorized mode of transport and land use mix is lower as many workers do not walk in their daily trips.

To conclude the findings from this study, independent variables inflexible work schedules and land use design have influenced significantly the dependent variable traffic congestion. Traffic congestion only occurs in the peak period when workers are going or coming from work because of inflexible work schedules in Kigali city. Also, roads under this study are congested at different levels due to land use design measurements like connectivity and land use mix. While the results are statistically insignificant due to the small sample size and the representation of the peak period situation only, they match with the findings from secondary data, questionnaires, ArcGIS, and interviews.

5.3. Recommendations

From the results of this study, it is recommended that to solve traffic congestion problem on Kimironko-CBD, Nyanza, Kicukiro-CBD, and Gatenga-CBD roads, the flexibility of work schedules like telecommuting, working in shifts, working in the nearby office or compressed work week where workers can work less than 5 or 6 days in a week can be introduced. This will reduce the number of daily commuters which will shorten travel time.

On land use design side, Kigali city masterplan is already made, and it supports mixing residential areas and workplaces. Even if the level of mixing is still low it will be improved in the future. Further, connectivity of roads is being improved every day in Kigali city. By regulating inflexibility of work schedules, land use design will have little impact on traffic because if a greater number of workers are working from home, go or leave work at different time or work at nearby offices, road conditions and where workplaces are located will impact less traffic congestion. This was also emphasized by the off-peak period results of this study where the speed of vehicles was higher when fewer commuters are in the roads.

Therefore, it is recommended that the Ministry of workers in Rwanda collaborates with urban planners, transport sectors, and health sectors to improve mobility in Kigali city which will improve its liveability. Additionally, the collaboration of these sectors is necessary for the development of secondary cities in Rwanda.

5.4. Areas of future research

In Kigali, there are no academic studies about how either inflexible work schedules or land use design influence traffic congestion. Mainly traffic congestion studies in Kigali focused on the supply side of the problem where population increase, and poor road conditions are the main causes. So, there is a need to address the demand side of the problem to find cost-effective solutions for urban areas. Besides alternative work schedules and land use design, improving public transport, car sharing, and parking pricing are among the other travel demand management strategies that can reduce traffic congestion and boost liveability in cities.

There is a significant increase in single-car ownership in Kigali city where in this study 47.02% of all workers said that they have cars and one of the main reasons is the inefficiency of public transport. By improving public transport and promoting car sharing, single vehicle occupancy can be reduced moreover, by increasing parking prices in Kigali city, commuters will be discouraged to buy cars. For further studies, a case study addressing the questions about: “How does parking management influence traffic congestion in Kigali city” or “how does public transport inefficiency influence traffic congestion in Kigali city” can be carried out.

Furthermore, a survey study with a mixed method that combines both public transport and parking management can be carried out by answering the following question: “How do public transport inefficiency and parking management influence traffic congestion in Kigali city? Generalization of the results from that survey study can be supportive for the future planning of Kigali city.

5.5. Author’s Outlook

Traffic congestion in Kigali city is mainly caused by population increase, inflexible work schedules, land use design, roads physical conditions, single occupancy vehicle (SOV) increases, and inadequacy of public transport. The results from this study show that inflexible work schedules and land use design significantly influence traffic congestion where flexibility of work schedules was highly recommended to resolve that issue. However, Kigali city population is increasing and that is inevitable. The inefficiency of public transport attracts people to buy their cars since the level of development and entrepreneurship is also increasing in the city.

Resolving traffic congestion by regulating the supply side will not stop the problem from emerging that is why traffic congestion in Kigali city will continue to increase in the future if the demand side is not controlled. Some of the travel demand management that can help Kigali city to fight traffic includes alternative work schedules and land use design as this study proved. Parking management, public transport efficiency, and promoting car sharing or carpooling also can improve urban mobility. To sum up, boosting urban liveability entails “focusing on the movement of people and goods rather than the movement of vehicles” (Ferguson, 2016,p.9).

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Annex 1: Questionnaire for road users.

Influence of inflexible work schedules and land use design on traffic congestion in Kigali city. (Questionnaire for workers)

Hello! I am a master student in Urban Management and development at Erasmus University, Rotterdam and I would like you to help me fill this questionnaire. This questionnaire aims to investigate how inflexible work schedules and land use design influence traffic congestion in Kigali city, and the information will be confidential and will be used for study purpose only.

Part A. socio-economic factors

1	Area of residence	☐ Gatenga	☐ Kimironko	☐ Gisozi		
2	Gender	☐ Female	☐ Male			
3	Age	☐ 18- 25 years	☐ 26-35 years	☐ 36-45 years	☐ 46- 55 years	☐ Above 55 years
4	Highest education level	☐ Less than high school	☐ High school	☐ Bachelor	☐ Postgraduate	
5	Income level	☐ Lower income	☐ Middle income	☐ Higher income		
6	What type of vehicle do you have in your home? (tick all applicable choices)	☐ Car	☐ Motorcycle	☐ Bicycle	☐ None	

Part B. Inflexible work schedules

7	Where do you work?	☐ Mumugi	☐ Nyabugogo	☐ Kacyiru	☐ Other	
8	How do you consider the distance from home to workplace	☐ Very far	☐ Far	☐ Not far nor near	☐ Near	☐ Very near
9	What time do you start work?	☐ 6.A.M	☐ 7 A.M	☐ 8 A.M	☐ 9 A.M	☐ later than 9 A.M
10	What time do you leave home for work?	☐ Before 6 A.M	☐ 6A.M-7A.M	☐ 7A.M-8A.M	☐ 8 A.M-9 A.M	☐ Later than 9A.M
11	What time do you close work?	☐ 3 P.M	☐ 4 P.M	☐ 5 P.M	☐ 6 P.M	☐ Later than 6 P.M
12.	When do you reach home from work?	☐ Before 4 P.M	☐ 4P.M-5P.M	☐ 5P.M-6P.M	☐ 6 P.M-7 P.M	☐ Later than 7 P.M
13	How many days do you work in a week	☐ Less than 5 days	☐ 5 days	☐ 6 days	☐ 7 days	
14	Do you change the location of your workplace in a week?	☐ Yes	☐ No			
15	Do you change the start period of your work in a week?	☐ Yes	☐ No			
16	Do you change the end period of your work in a week?	☐ Yes	☐ No			
17	Do you telecommute in a week?	☐ Yes	☐ No			
18	If yes, how many days to you telecommute in a week?	☐ 1 day	☐ 2 days	☐ 3 days	☐ More than 3 days	

Part C. Land use design

19	How many people living in this house go to work?	☐ 1	☐ 2	☐ 3	☐ More than 3
20	Are there offices building in your neighbourhood?	☐ Yes	☐ No		
21	If yes in 16 above, how far are the offices building to your neighbourhood?	☐ Less than 0.5 Km	☐ 0.5km-1km	☐ 1km-2km	☐ 2km-3km ☐ Above 3 km
22	Are there schools in your neighbourhood?	☐ Yes	☐ No		
23	If yes in 18 above, how far are the schools to your neighbourhood?	☐ Less than 0.5 Km	☐ 0.5km-1km	☐ 1km-2km	☐ 2km-3km ☐ Above 3 km
24	Are there hospitals in your neighbourhood?	☐ yes	☐ No		
25	If yes in 20 above, how far are the hospitals to your neighbourhood?	☐ Less than 0.5 Km	☐ 0.5km-1km	☐ 1km-2km	☐ 2km-3km ☐ Above 3 km
26	Are there shopping centre in your neighbourhood?	☐ yes	☐ No		
27	If yes in 22 above, how far are the shopping centre to your neighbourhood?	☐ Less than 0.5 Km	☐ 0.5km-1km	☐ 1km-2km	☐ 2km-3km ☐ Above 2 km
28	In your daily trip to work, do you use Kimironko-CBD, Nyanza Kicukiro- CBD, or Gisozi- CBD road?	☐ yes	☐ No		
29	If yes, how are the physical conditions of the roads from your home to your destination?	☐ extremely good	☐ somewhat good	☐ Neither good nor bad	☐ somewhat bad ☐ extremely bad

Part D. Traffic congestion

30	Which mode of transport do you use when you go to work?	☐ Car	☐ Motorcycle	☐ Taxi	☐ Bus	☐ Walk
31	Which mode of transport do you use when you go back home	☐ Car	☐ Motorcycle	☐ Taxi	☐ Bus	☐ Walk
32	How many minutes do you travel from home to work?	☐ 0-20	☐ 21-40	☐ 41-60	☐ 61-80	☐ 81-100
33	What do you consider this time to be?	☐ Very short	☐ short	☐ Not long nor Short	☐ Long	☐ Vey Long
34	How many minutes do you travel from work to home?	☐ 0-20	☐ 21-40	☐ 41-60	☐ 61-80	☐ 81-100
35	What do you consider this time to be?	☐ Very short	☐ short	☐ Not long nor Short	☐ Long	☐ Vey long

Thank you for your cooperation!

Annex 2. Semi-structured Interview

Semi-structured interview for key informants: Influence of inflexible work schedules and land use design on traffic congestion in Kigali city.

June-July 2020

Number of the interview: _____

Position of interviewee: _____

Location of the interviewee: _____

Date: _____

Objective:

To describe traffic congestion situation in Kigali city.

To describe how inflexible work schedules influence traffic congestion in Kigali city.

To describe how land use design influences traffic congestion in Kigali city.

(Introduction applied to all respondents)

Introduction

Good morning/ afternoon! Thank you for allowing me to do this interview about inflexible work schedules, land use design and traffic congestion in Kigali city. The objective of this interview is to describe how inflexible work schedules and land use design influence traffic congestion as well as understanding traffic congestion situation in Kigali city.

The results from interview will be confidential and will be used for the academic purpose only and if it is okay with you, the interview will be recorded.

Interview guide 1: MININFRA (Ministry of Infrastructure)

Questions:

1. What do you think is the situation of traffic congestion (level of service) in Kigali city?
2. What do you think are the main causes of traffic congestion in Kigali city?
3. What time do you consider as peak period?
4. How do you think the departure time for work affects traffic congestion in Kigali city roads?
5. How influential do you consider the separation of workplaces and residential areas on traffic congestion?
6. How do you think the characteristics of the roads (width of the road, number of road lanes) influence vehicle speed in Kigali city?
7. How do you think connectivity of the roads (4-way or 3-way intersection) influences traffic congestion?
8. What do you this is the preferred mode of transport in Kigali city?
9. How do you think time travelled and traffic congestion are related?
10. What do you think is the preferred mode of transport in Kigali city?
11. Do you have any comment?

Interview guide 2: MIFOTRA (Ministry of public service and labour)

1. Do you know if there are plans that support alternative work schedules in Kigali city?
2. What do you think is the situation of traffic congestion in Kigali city?
3. How many days do you think most workers go to work in a week?
4. How influential do you consider the number of working days on traffic congestion in Kigali city?
5. Do you know whether there are workers who telecommute (working from home) or work in shifts, in Kigali city?
6. What time do you consider as peak period or rush hour?
7. How do you think the departure time for work affects traffic congestion in Kigali city?
8. How influential do you consider the separation of workplaces and residential areas on traffic congestion?
9. Do you have any comment?

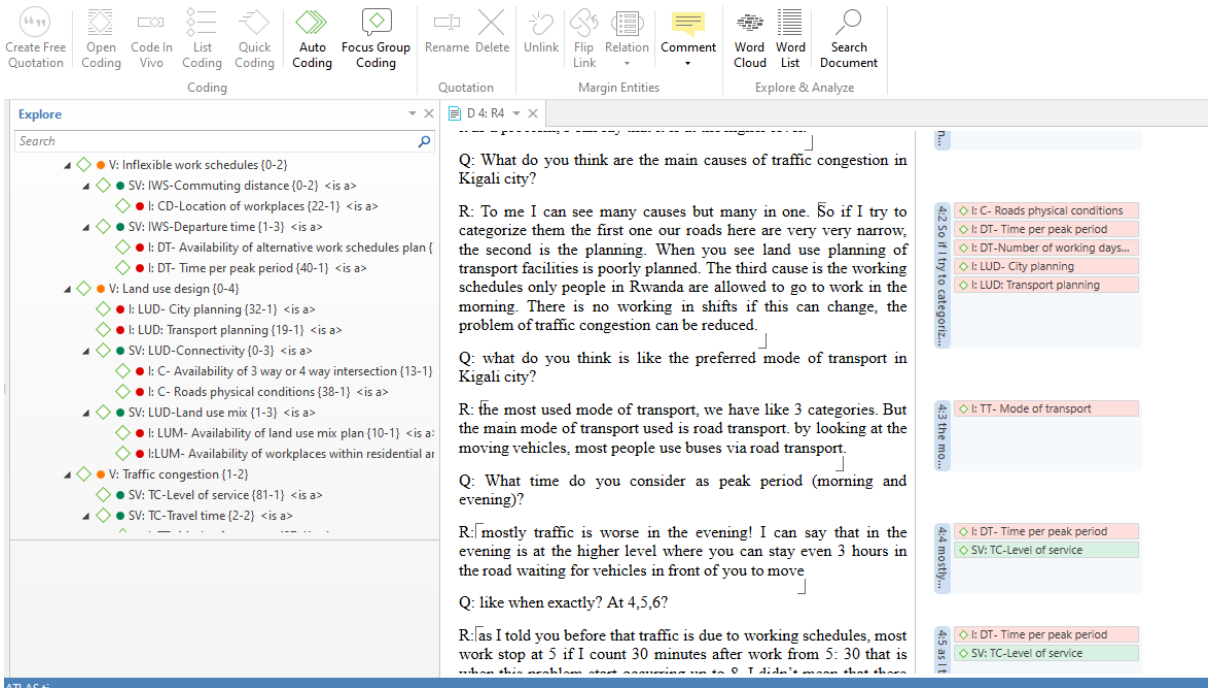
Interview guide 3: urban planners and civil engineers.

1. Do you consider Kigali city as a centrally planned city? Explain your answer
2. Do you know if there are development plans that support land use mix of residential areas and workplaces in Kigali city?
3. What do you think is the situation of traffic congestion (level of service) in Kigali city?
4. What do you think are the main causes of traffic congestion in Kigali city?
5. How influential do you consider the separation of workplaces and residential areas on traffic congestion?
6. What is the preferred mode of transport in Kigali city?
7. How do you think connectivity of the roads (4-way or 3-way intersection) influences traffic congestion?
8. Do you have any comment?

Interview guide 4: Academics

1. What do you think is the situation of traffic congestion in Kigali city?
2. What do you think are the main causes of traffic congestion in Kigali city?
3. What time do you consider as peak period?
4. How many days do you think most workers go to work in a week?
5. How do you think the departure time for work affects traffic congestion in Kigali city roads?
6. What do you think is the preferred mode of transport in Kigali city?
7. Can you consider Kigali city as a centrally planned city? Explain your answer
8. How influential do you consider the separation of workplaces and residential areas on traffic congestion?
9. How do you think connectivity of the roads (4-way or 3-way intersection) influences traffic congestion?
10. Do you have any comment?

Annex 3: Atlas ti coding



Annex 4: Statistical results

Correlation between travel time with independent variables and socio-economic variables for the entire study.

Correlations

			Gender	Travel time	Distance	Physical conditions of the road	Departure time	Age	Education	Income level	Vehicle	Workplaceloc ation	Return time
Spearman's rho	Gender	Correlation Coefficient	1.000	-.075	-.054	.028	-.122	-.071	-.051	-.136	-.091	-.076	-.166
		Sig. (2-tailed)	.	.481	.613	.793	.250	.505	.629	.200	.403	.473	.115
		N	91	91	91	89	91	91	91	91	86	91	91
	Travel time	Correlation Coefficient	-.075	1.000	.285**	.062	-.018	.090	.077	.024	.214*	.117	.249*
		Sig. (2-tailed)	.481	.	.006	.563	.866	.395	.466	.825	.048	.271	.017
		N	91	91	91	89	91	91	91	91	86	91	91
	Distance	Correlation Coefficient	-.054	.285**	1.000	.141	-.204	-.092	.012	-.100	-.228*	-.067	-.057
		Sig. (2-tailed)	.613	.006	.	.189	.053	.388	.910	.345	.035	.530	.594
		N	91	91	91	89	91	91	91	91	86	91	91
	Physical conditions of the road	Correlation Coefficient	.028	.062	.141	1.000	-.165	-.064	.154	.041	.021	-.183	-.136
		Sig. (2-tailed)	.793	.563	.189	.	.121	.550	.151	.704	.850	.085	.203
		N	89	89	89	89	89	89	89	89	84	89	89
	Departure time	Correlation Coefficient	-.122	-.018	-.204	-.165	1.000	-.071	.027	.044	.095	.139	.274**
		Sig. (2-tailed)	.250	.866	.053	.121	.	.505	.797	.676	.382	.188	.009
		N	91	91	91	89	91	91	91	91	86	91	91
	Age	Correlation Coefficient	-.071	.090	-.092	-.064	-.071	1.000	.002	.399**	.280**	.016	-.134
		Sig. (2-tailed)	.505	.395	.388	.550	.505	.	.988	.000	.009	.880	.205
		N	91	91	91	89	91	91	91	91	86	91	91
	Education	Correlation Coefficient	-.051	.077	.012	.154	.027	.002	1.000	.245*	.103	.177	-.147
		Sig. (2-tailed)	.629	.466	.910	.151	.797	.988	.	.019	.347	.093	.164
		N	91	91	91	89	91	91	91	91	86	91	91
	Income level	Correlation Coefficient	-.136	.024	-.100	.041	.044	.399**	.245*	1.000	.216*	.131	-.260*
		Sig. (2-tailed)	.200	.825	.345	.704	.676	.000	.019	.	.046	.215	.013
		N	91	91	91	89	91	91	91	91	86	91	91
	Vehicle	Correlation Coefficient	-.091	.214*	-.228*	.021	.095	.280**	.103	.216*	1.000	.187	-.086
		Sig. (2-tailed)	.403	.048	.035	.850	.382	.009	.347	.046	.	.085	.431
		N	86	86	86	84	86	86	86	86	86	86	86
	Workplacelocation	Correlation Coefficient	-.076	.117	-.067	-.183	.139	.016	.177	.131	.187	1.000	-.244*
		Sig. (2-tailed)	.473	.271	.530	.085	.188	.880	.093	.215	.085	.	.020
		N	91	91	91	89	91	91	91	91	86	91	91
	Return time	Correlation Coefficient	-.166	.249*	-.057	-.136	.274**	-.134	-.147	-.260*	-.086	-.244*	1.000
		Sig. (2-tailed)	.115	.017	.594	.203	.009	.205	.164	.013	.431	.020	.
		N	91	91	91	89	91	91	91	91	86	91	91

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlation between travel time with independent variables and socio-economic variables for Kimironko Neighbourhood.

Correlations

			Gender	Age	Education	Income	Car ownership	Workplace location	Commuting distance	Roads conditions	Morning travel time	Departure time	time to reach home
pearman's rho	Gender	Correlation Coefficient	1.000	.074	.221	.000	.241	-.210	-.343	.119	.221	-.193	.035
		Sig. (2-tailed)	.	.726	.288	1.000	.279	.314	.093	.588	.288	.356	.868
		N	25	25	25	25	22	25	25	23	25	25	25
	Age	Correlation Coefficient	.074	1.000	.209	.366	.321	.182	.302	.552**	.187	-.142	-.293
		Sig. (2-tailed)	.726	.	.316	.072	.145	.384	.143	.006	.370	.499	.155
		N	25	25	25	25	22	25	25	23	25	25	25
	Education	Correlation Coefficient	.221	.209	1.000	.274	.270	-.356	.016	-.132	-.229	-.087	-.343
		Sig. (2-tailed)	.288	.316	.	.185	.225	.081	.939	.547	.270	.680	.094
		N	25	25	25	25	22	25	25	23	25	25	25
	Income	Correlation Coefficient	.000	.366	.274	1.000	.279	.000	.000	.000	.000	.392	-.289
		Sig. (2-tailed)	1.000	.072	.185	.	.209	1.000	1.000	1.000	1.000	.052	.162
		N	25	25	25	25	22	25	25	23	25	25	25
	Car ownership	Correlation Coefficient	.241	.321	.270	.279	1.000	-.311	.000	.042	.341	.214	.000
		Sig. (2-tailed)	.279	.145	.225	.209	.	.158	1.000	.860	.120	.339	1.000
		N	22	22	22	22	22	22	22	20	22	22	22
	Workplace location	Correlation Coefficient	-.210	.182	-.356	.000	-.311	1.000	.408*	.174	.264	-.073	.500*
		Sig. (2-tailed)	.314	.384	.081	1.000	.158	.	.043	.426	.203	.727	.011
		N	25	25	25	25	22	25	25	23	25	25	25
	Commuting distance	Correlation Coefficient	-.343	.302	.016	.000	.000	.408*	1.000	.075	.065	.030	.000
		Sig. (2-tailed)	.093	.143	.939	1.000	1.000	.043	.	.734	.759	.887	1.000
		N	25	25	25	25	22	25	25	23	25	25	25
	Roads conditions	Correlation Coefficient	.119	.552**	-.132	.000	.042	.174	.075	1.000	.002	-.157	-.116
		Sig. (2-tailed)	.588	.006	.547	1.000	.860	.426	.734	.	.991	.474	.597
		N	23	23	23	23	20	23	23	23	23	23	23
	Morning travel time	Correlation Coefficient	.221	.187	-.229	.000	.341	.264	.065	.002	1.000	.037	.474*
		Sig. (2-tailed)	.288	.370	.270	1.000	.120	.203	.759	.991	.	.861	.017
		N	25	25	25	25	22	25	25	23	25	25	25
	Departure time	Correlation Coefficient	-.193	-.142	-.087	.392	.214	-.073	.030	-.157	.037	1.000	.178
		Sig. (2-tailed)	.356	.499	.680	.052	.339	.727	.887	.474	.861	.	.396
		N	25	25	25	25	22	25	25	23	25	25	25
	time to reach home	Correlation Coefficient	.035	-.293	-.343	-.289	.000	.500*	.000	-.116	.474*	.178	1.000
		Sig. (2-tailed)	.868	.155	.094	.162	1.000	.011	1.000	.597	.017	.396	.
		N	25	25	25	25	22	25	25	23	25	25	25

*. Correlation is significant at the 0.01 level (2-tailed).

. Correlation is significant at the 0.05 level (2-tailed).

Kimironko Neighbourhood ordinal regression analysis model

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Morningtraveltime = 2]	2.626	2.749	.912	1	.339	-2.762	8.013
	[Morningtraveltime = 4]	7.282	3.311	4.837	1	.028	.792	13.772
Location	timetoreachhome	2.477	1.165	4.519	1	.034	.193	4.761

Link function: Logit.

Correlation between travel time with independent variables and socio-economic variables for Gatenga Neighbourhood

Correlations

			gender	age	education	Income	car ownership	workplace location	distance	departure time	Time to reach home	Roads conditions	travel time moning
Spearman's rho	gender	Correlation Coefficient	1.000	-.059	-.317	.084	-.016	.365*	.155	.036	-.163	.037	-.113
		Sig. (2-tailed)	.	.746	.072	.642	.932	.037	.389	.843	.366	.842	.532
		N	33	33	33	33	32	33	33	33	33	32	33
	age	Correlation Coefficient	-.059	1.000	-.113	.248	.127	-.017	.036	-.033	-.056	.021	-.121
		Sig. (2-tailed)	.746	.	.530	.164	.490	.924	.844	.853	.756	.909	.502
		N	33	33	33	33	32	33	33	33	33	32	33
	education	Correlation Coefficient	-.317	-.113	1.000	.072	-.008	-.227	.007	-.134	-.052	.075	.342
		Sig. (2-tailed)	.072	.530	.	.692	.964	.204	.970	.458	.772	.682	.052
		N	33	33	33	33	32	33	33	33	33	32	33
	Income	Correlation Coefficient	.084	.248	.072	1.000	.024	-.090	.033	.125	-.398*	-.294	-.278
		Sig. (2-tailed)	.642	.164	.692	.	.897	.617	.854	.488	.022	.103	.117
		N	33	33	33	33	32	33	33	33	33	32	33
	car ownership	Correlation Coefficient	-.016	.127	-.008	.024	1.000	-.225	-.132	-.244	-.333	.255	.221
		Sig. (2-tailed)	.932	.490	.964	.897	.	.216	.471	.179	.062	.166	.224
		N	32	32	32	32	32	32	32	32	32	31	32
	workplace location	Correlation Coefficient	.365*	-.017	-.227	-.090	-.225	1.000	-.155	.301	.387*	.073	-.171
		Sig. (2-tailed)	.037	.924	.204	.617	.216	.	.389	.089	.026	.692	.340
		N	33	33	33	33	32	33	33	33	33	32	33
	distance	Correlation Coefficient	.155	.036	.007	.033	-.132	-.155	1.000	-.080	-.242	-.062	-.163
		Sig. (2-tailed)	.389	.844	.970	.854	.471	.389	.	.658	.174	.736	.365
		N	33	33	33	33	32	33	33	33	33	32	33
	departure time	Correlation Coefficient	.036	-.033	-.134	.125	-.244	.301	-.080	1.000	.020	-.341	-.391*
		Sig. (2-tailed)	.843	.853	.458	.488	.179	.089	.658	.	.910	.056	.024
		N	33	33	33	33	32	33	33	33	33	32	33
	Time to reach home	Correlation Coefficient	-.163	-.056	-.052	-.398*	-.333	.387*	-.242	.020	1.000	.105	.244
		Sig. (2-tailed)	.366	.756	.772	.022	.062	.026	.174	.910	.	.566	.171
		N	33	33	33	33	32	33	33	33	33	32	33
	Roads conditions	Correlation Coefficient	.037	.021	.075	-.294	.255	.073	-.062	-.341	.105	1.000	.211
		Sig. (2-tailed)	.842	.909	.682	.103	.166	.692	.736	.056	.566	.	.246
		N	32	32	32	32	31	32	32	32	32	32	32
	travel time moning	Correlation Coefficient	-.113	-.121	.342	-.278	.221	-.171	-.163	-.391*	.244	.211	1.000
		Sig. (2-tailed)	.532	.502	.052	.117	.224	.340	.365	.024	.171	.246	.
		N	33	33	33	33	32	33	33	33	33	32	33

*. Correlation is significant at the 0.05 level (2-tailed).

Gatenga Neighbourhood ordinal regression analysis Modal

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[traveltimemoning = 2]	-7.045	2.014	12.241	1	.000	-10.991	-3.098
	[traveltimemoning = 3]	-4.756	1.374	11.988	1	.001	-7.448	-2.064
	[traveltimemoning = 4]	.477	1.061	.202	1	.653	-1.602	2.556
Location	departuretime	-1.403	.530	7.003	1	.008	-2.441	-.364

Link function: Logit.

Correlation between travel time with independent variables and socio-economic variables for Gisozi Neighbourhood

Correlations

			Gender	Age	Education	Income	car ownership	workplace location	Commuting distance	departure time	time to reach home	roads conditions	Mornig TT
Spearman's rho	Gender	Correlation Coefficient	1.000	-.246	.071	-.286	-.341	-.026	.069	-.119	-.266	.143	.014
		Sig. (2-tailed)	.	.168	.695	.106	.056	.886	.701	.510	.135	.428	.939
		N	33	33	33	33	32	33	33	33	33	33	33
	Age	Correlation Coefficient	-.246	1.000	.011	.504**	.414*	-.161	-.271	.029	-.080	-.308	.221
		Sig. (2-tailed)	.168	.	.951	.003	.019	.371	.128	.873	.658	.081	.215
		N	33	33	33	33	32	33	33	33	33	33	33
	Education	Correlation Coefficient	.071	.011	1.000	.336	.068	-.056	-.024	.050	-.119	.059	.043
		Sig. (2-tailed)	.695	.951	.	.056	.711	.756	.894	.782	.509	.744	.811
		N	33	33	33	33	32	33	33	33	33	33	33
	Income	Correlation Coefficient	-.286	.504**	.336	1.000	.316	-.209	-.166	.040	-.224	.028	.060
		Sig. (2-tailed)	.106	.003	.056	.	.078	.244	.357	.824	.211	.877	.742
		N	33	33	33	33	32	33	33	33	33	33	33
	car ownership	Correlation Coefficient	-.341	.414*	.068	.316	1.000	-.031	-.426*	.278	.058	-.168	.082
		Sig. (2-tailed)	.056	.019	.711	.078	.	.867	.015	.124	.751	.358	.656
		N	32	32	32	32	32	32	32	32	32	32	32
	workplace location	Correlation Coefficient	-.026	-.161	-.056	-.209	-.031	1.000	.027	-.474**	.000	.044	-.261
		Sig. (2-tailed)	.886	.371	.756	.244	.867	.	.879	.005	1.000	.809	.143
		N	33	33	33	33	32	33	33	33	33	33	33
	Commuting distance	Correlation Coefficient	.069	-.271	-.024	-.166	-.426*	.027	1.000	-.407*	-.043	.402*	.363*
		Sig. (2-tailed)	.701	.128	.894	.357	.015	.879	.	.019	.813	.021	.038
		N	33	33	33	33	32	33	33	33	33	33	33
	departure time	Correlation Coefficient	-.119	.029	.050	.040	.278	-.474**	-.407*	1.000	.393*	-.175	-.001
		Sig. (2-tailed)	.510	.873	.782	.824	.124	.005	.019	.	.024	.329	.995
		N	33	33	33	33	32	33	33	33	33	33	33
	time to reach home	Correlation Coefficient	-.266	-.080	-.119	-.224	.058	.000	-.043	.393*	1.000	-.244	.109
		Sig. (2-tailed)	.135	.658	.509	.211	.751	1.000	.813	.024	.	.172	.545
		N	33	33	33	33	32	33	33	33	33	33	33
	roads conditions	Correlation Coefficient	.143	-.308	.059	.028	-.168	.044	.402*	-.175	-.244	1.000	.323
		Sig. (2-tailed)	.428	.081	.744	.877	.358	.809	.021	.329	.172	.	.067
		N	33	33	33	33	32	33	33	33	33	33	33
	Mornig TT	Correlation Coefficient	.014	.221	.043	.060	.082	-.261	.363*	-.001	.109	.323	1.000
		Sig. (2-tailed)	.939	.215	.811	.742	.656	.143	.038	.995	.545	.067	.
		N	33	33	33	33	32	33	33	33	33	33	33

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Gisozi Neighborhood ordinal regression model

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Morningperception = 2]	1.687	1.276	1.749	1	.186	-.813	4.187
	[Morningperception = 3]	3.427	1.376	6.207	1	.013	.731	6.123
	[Morningperception = 4]	7.033	1.877	14.037	1	.000	3.354	10.713
Location	distance	1.108	.454	5.968	1	.015	.219	1.998

Link function: Logit.

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