

**KWAME NKURUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY  
KUMASI, GHANA**

**Assessment Of Bicycling Transportation On The Kwame Nkrumah University Of  
Science And Technology (K.N.U.S.T) Campus**

by

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**A Thesis Submitted to the Department of Civil Engineering,  
Kwame Nkrumah University of Science and Technology**

**In Partial Fulfilment of the Requirements for the Award of the Degree of**

**MASTER OF SCIENCE ROAD AND TRANSPORTATION ENGINEERING**

**NOVEMBER 2016**

## DECLARATION

I hereby declare that this submission is my own work towards the MSc and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in text.

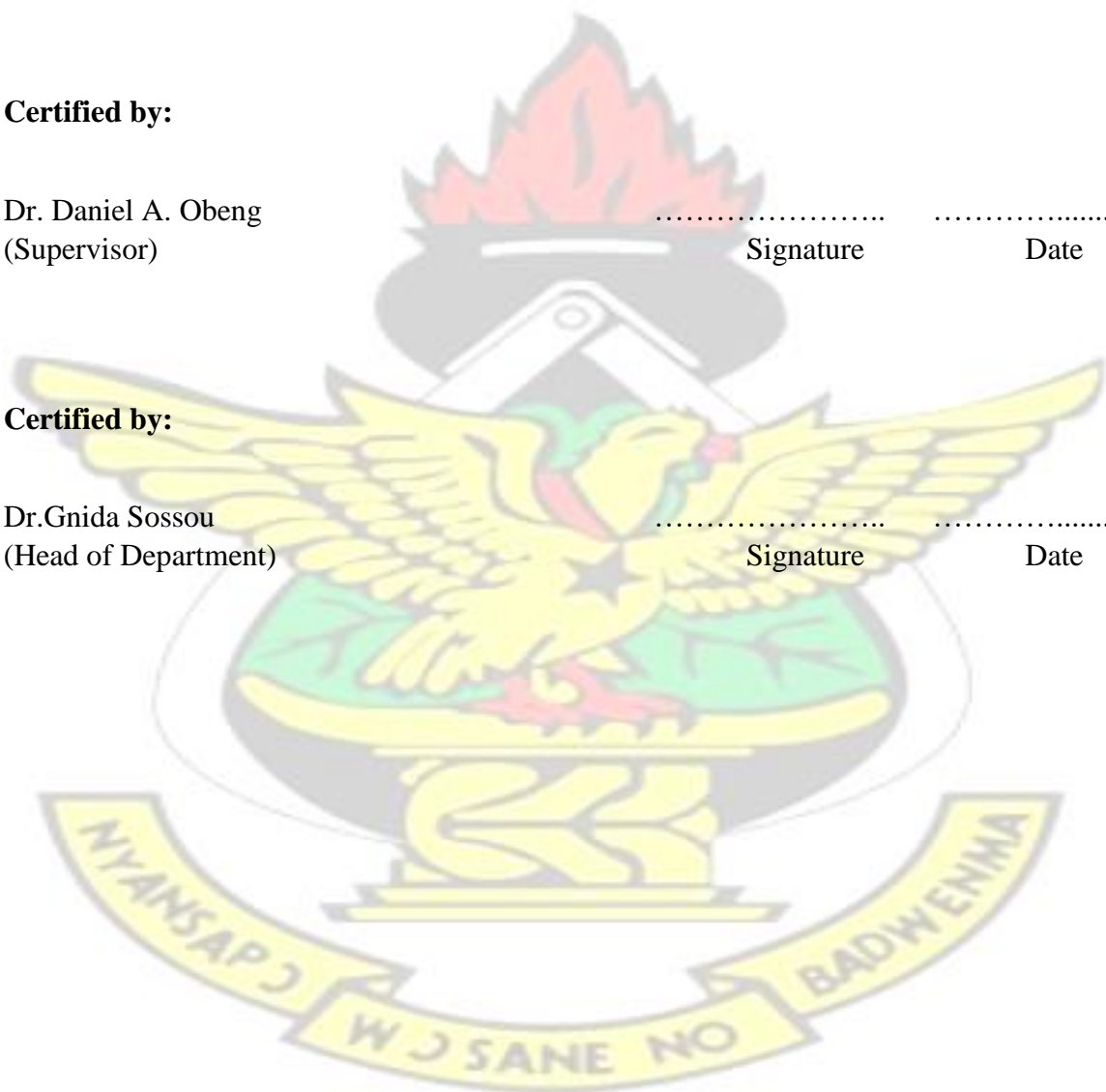
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# KNUST

## ABSTRACT

Over the last decade or so, there has been an increased awareness of the need for sustainable transportation especially in developing countries. Cycling is one of such means of transportation that offers a unique opportunity, by facilitating the contribution of cyclists to the sustainability goal, while they enjoy benefits in the form of improved health, shorter journey times etc. Previous studies have indicated that cycling is often conducive on campuses and more easily accepted because of the neo-traditional town setting of these environments. In Ghana, a developing country in Africa very little cycling culture exists and attitudes to this means of transportation is not well reported especially on tertiary campus environments. This study investigates the feasibility of introducing cycling on the Kwame Nkrumah University of Science and Technology (KNUST) Campus for staff and students; with greater focus on the current limitations, bicycling inducing factors and specific infrastructural challenges. Surveys, both, online and ride-along were employed in the data collection, and the results obtained was analysed through descriptive and exploratory factor analyses. The results infer that there is a high potential for increasing bicycle use among respondents on the KNUST campus, although this may only materialize into actual ridership when potential users feel an overall improvement in safety. Strategic investments in the provision of required infrastructure, could go a long way to encourage cycling culture on campus, and help it join the league of elite colleges worldwide championing the course of environmentally friendly transportation.

## ACKNOWLEDGEMENTS

*“When eating bamboo sprouts, remember the man who planted them”-Chinese Proverb*

This thesis owes its existence to the help, support and inspiration of several people. I wish to express my gratitude to the following;

Ing. Sir F. A. Akwaboah

Dr. Daniel A. Obeng

Rev. Dr. Charles Adams

Prof. Y.A. Tuffuor

Mr. Magnus Quarshie

Dr. Emmanuel Donkor

Dr. Emmanuel De-Graft Johnson

Ing. Paul Yaw Adanse-Pipim Duah

Dr. Kofi Owusu-Daaku

Volunteers of the ride-along and online surveys

Mr. Kingsley Arhin-Acquaah

The entire RTEP 11 class

My dear family

Ms. Tracey Lugada

All the effort and support you individually and collectively offered me, is immensely appreciated. I wish you all, the absolute best.

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# 1 INTRODUCTION

The adverse impact of green house gas emissions on the environment, climate change and human health has been a subject of global concern and discussion over the past twenty years and more.

In 1992, a number of countries came together at the Rio Earth Summit to adopt a framework to address the effect of greenhouse gases on the climate and the environment. This has been followed by a series of similar international fora. In September 2015, the United Nations (UN) again gave expression to this concern by adopting as one of its seventeen (17) Sustainable Development Goals (SDGs), the goal to make cities and human settlements, safe, resilient and sustainable, under the initiative 'Transforming Our World the 2030 Agenda for Sustainable Development' (United Nations, 2015).

A major source of greenhouse gas emissions is vehicular emissions. In 2013, greenhouse gas emissions from transportation accounted for about 27% of total U.S. greenhouse gas (GHG) emissions, making it the second largest contributor of U.S. greenhouse gas emissions after the electricity sector. Overall, greenhouse gas emissions from transportation have increased by about 16% since 1990.

In Ghana, according to the World Resource Institute (2012) almost 28.23 metric tons of carbon dioxide equivalents (MtCO<sub>2e</sub>) is emitted annually making the country the 99th highest ranked GHG emitter in the world (World Resources Institute, 2012).

Previous studies have identified active transportation, such as walking and bicycling, as more appropriate alternatives to motor vehicles, in addressing the problem of carbon emissions. Indeed, the use of active transport also has been associated with some health benefits. A substantial and convincing body of evidence exists associating regular physical activity (PA) engagement, with the prevention of numerous chronic noncommunicable diseases, such as cardiovascular disease, type II diabetes, certain cancers and obesity. It is thus recommended by Health Agencies that adults should accumulate at least thirty minutes a day of moderate intensity physical activity on all or most days of the week to gain these associated health benefits (Badland & Schofield, 2007).

Non-motorised transports (NMTs) have minimal emissions, they are considered low carbon modes that deserve greater focus when it comes to reducing the levels of carbon

emissions while helping people lead healthier lifestyles. It is therefore, vital to encourage the use of these modes of travel. This must however begin within local environments and requires research into the various parameters likely to encourage people to opt for NMTs. It is anticipated that such an approach would help fit bicycling into the community more easily and make people more slightly inclined towards its use.

Cycling is a form of non-motorised transportation which provides a useful and feasible option for travel especially when conditions are favourable. On University campuses in particular, cycling can be more easily adopted because of the greater degree of control which can be ensured on local roads. However, in most Ghanaian Universities, cycling infrastructure and culture are poorly developed, and therefore does not provide an enabling environment for cycling.

This study investigates the feasibility of introducing cycling as an efficient mode of travel within the University community. It considers members' willingness to use the mode and the provision of cycle infrastructure. Attempts were also made to identify operational challenges in the development of a bicycle scheme.

### **1.1 PROBLEM STATEMENT**

KNUST Campus has few bicyclists despite being seemingly favourable for this means of transportation. The use of this mode comes with enormous benefits but the possible disinterest by members of the university could be varied. There is the inherent cultural perception that cycling is meant for the north (MRH and GSS, 2013, 2007), a general lack of infrastructure to support its use and the lack of knowledge on the numerous benefits associated with bicycling (United Nations Human Settlements Programme, 2011). This study investigated all these issues among others.

Some of the possible factors that may make the use of bikes on campus less attractive could be;

1. The lack of a well-planned bicycle transportation scheme and infrastructure for cycling.
2. The inherent fact that the bicycling culture in itself is not very popular within the southern parts of Ghana as compared to the Northern regions where almost everyone cycles.

3. The lack of education on the subject of bicycle transportation.
4. The non-existence of a bike sharing scheme which would allow individuals hire bikes for use on campus.

## **1.2 RESEARCH AIM AND OBJECTIVES**

The aim of this study is to determine the factors which could influence the feasibility of introducing a bicycle scheme on KNUST campus as an efficient mode for travel. Specifically, these objectives were pursued;

1. To determine community members' perceptions and willingness to use bicycle as a mode of travel.
2. To establish the main challenges to the use of bicycles within the study area.
3. To develop the layout of a suitable bicycle network for the study area.
4. To make recommendations for the establishment of appropriate bicycle schemes on similar campuses.

## **1.3 JUSTIFICATION OF THE STUDY**

Many studies have identified the need for improvement of non-motorised transport modes (Tiwari and Jain, 2013; United Nations Human Settlements Programme, 2011). This may be vital in massively reducing the dependence on motorised transportation. Across many parts of the world, efforts continue to be made to improve the situation of travel for these vulnerable road users. In Africa and Ghana for that matter, few studies have been conducted on bicycling (Nkurunziza, van Maarseveen, & Zuidgeest, 2013; Quarshie, 2004). This may be due to a variety of reasons ranging from the perceptions that people have of cycling, issues with weather and terrain, lack of well-designed bicycling infrastructure, to mention a few. University campuses in particular are most attractive for NMT modes, suggesting whether KNUST could also join the league of elite colleges leading the way in the development of eco-friendly learning environments. Ultimately, the implications of this study include the reduction of carbon emissions, improved health of users, shorter travel times for cyclists, improved safety of cycling and the identification of major design constraints for cycle network design. Recommendations for the development of similar schemes on campuses in Ghana were also made.



#### **1.4 OUTLINE OF THESIS REPORT**

The first chapter of the thesis is the introductory chapter. The second chapter presents a review of available and relevant literature. The third chapter shows the methodology used in the study and the approaches for data collection. Chapter four also focuses on the results obtained after analyzing the data collected. Finally, chapter five concludes on the work while providing useful recommendations for cycling on the KNUST campus. A list of helpful references and an appendix are also attached.



## 2 LITERATURE REVIEW

### 2.1 BACKGROUND

Situated in Kumasi, the second largest city in Ghana, the Kwame Nkrumah University of Science and Technology (KNUST) has a student population of approximately 35000 persons and covers a total land area of about 2512.96 acres (KNUST Planning Department, 2014). Based on its general layout, the campus has clearly identifiable trip generation and attraction centres. These include Academic/Teaching areas, Residential areas, Recreational zones, areas for commercial activities among others. Higher frequency of travel is experienced mostly along routes linking these locations as compared to other roads on campus. It is worthy to note also that, the average distance travelled between locations can be described as short with the terrain being generally flat and therefore, favourable for cycling.

From the work of Tiwari (2013) in the Indian cities of Delhi, Pune and Patna, it was deduced that there was an increase in risk for NMT users with deteriorating quality of infrastructure. In spite of these apparent challenges however, NMTs dominated modal shares in developing cities, with bicycle ownership being generally high since the majority of trips made were short (<5km). There also existed a significant number of potential users who may opt for this mode of travel given improved quality of infrastructure (Tiwari and Jain, 2013).

Quarshie (2004), in a study conducted in over 22 suburbs of Accra, Ghana established that bike ownership was highest among students, followed by business and technical persons which included masons, carpenters and other artisans in general. The study further noted that cycling was generally less patronized and represented a meagre 8.6% of all modes for commuting.

Furthermore, it was found that bike ownership and ability to cycle was highest among the age group below 20 years and between the 20-30 years cohort. This suggests cycling is generally more accepted by people within this category and age groups. In stark contrast, older age cohorts, recorded lesser bike ownership. There was a higher composition of male cyclists as compared to their female counterparts in Accra based on the study. This situation is attributed to the fact that cycling was seen in the past as a male preserve. Combined, the findings infer that bicycling is found as a more attractive mode of

transportation when used for shorter trips (<5km) (Tiwari and Jain, 2013) and also, could be popular among a younger active population of students (Quarshie, 2004) such as can be found on the KNUST campus.

Currently, the modes of transportation common on the university campus include walking, the use of commercially run shuttle bus services, few private vehicles, some bicycles and motorbikes. Walking however, seems to be the most patronized mode of transportation among the student population. Gradients can also be said to range between three (3) to seven (7) percent on most roads, and this attribute of the campus may be partly responsible for the proportion of walk trips experienced.

## **2.2 BICYCLING CULTURE IN AFRICA**

### ***2.2.1 A case for sustainable transport***

Across Africa, the development of bicycle transportation has encountered numerous constraints. Challenges include unavailability of funds to develop much needed transportation infrastructure, overall safety of cyclists, and the perceptions and general apathy of people towards cycling as a whole (Batista, 2010; Handy, van Wee, & Kroesen, 2014; Nkurunziza et al., 2013).

As Africa positions itself towards the development agenda, it is essential that greater focus is directed towards ensuring sustainable means of transportation (UNEP, 2010) within the bigger framework of sustainable development. The Brundtland Commission defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. This approach would be appropriate to solve some of the age old problems that are common to most states and as well, more complex ones such as the incorporation of bicycles and bicycling schemes into already developing cities across the continent. Achieving this would require concerted efforts by Governments, Road Agencies, as well as other relevant stakeholders.

According to Batista (2010), two main factors can influence efforts being made in the attainment of sustainable development, and these are (a) human behavioural changes, i.e. a decrease in consumption of unsustainable forms of transportation plus a change in habit, and (b) the development of new sustainable technology. These parameters apply to the African scenario. Human behavioural changes could well ensure the increase in modal share of cycling especially in urban and rural areas. On the other hand, a greater interest in

the development of sustainable technology expressed through, for example, the electric bicycle (McLoughlin, 2012) or bamboo bicycle (Ukoba, Ogunkoya, & Soboyejo, 2011) currently being used as a cheap alternative in rural parts of Ghana, could provide options and encourage technological creativity.

Mobility in most developing cities is characterised by travel demand that far exceeds travel supply (Gebeyehu & Takano, 2007). African cities are by no means an exception to this reality. Demand for public transport has been on the ascendency steadily over several years with increasing urban populations and unavailable corresponding investments causing rather severe travel problems (Amer, 2007). This cocktail of conditions has pushed the vast majority of individuals to continually use the rather dilapidated (poor) public transportation or opt for walking as a chosen alternative to meet their travel needs (Carruthers, Krishnamani, & Murray, 2008).

Although they are not a sustainable mode of transport, the high patronage recorded for “boda bodas” in Uganda for example, demonstrates how travellers across the continent prefer public transportation that is cheap, fast and easily manoeuvrable especially in locations without highly connected networks.

Likewise Nigeria, Burkina Faso, Cameroon and more recently Ghana, motorcycles offer rides to passengers for a fee. The high demand for cheap transportation, the goal of pursuing transportation in a more sustainable way and vastly reducing problems such as congestion, air pollution, etc. all point to the general need for an alternative that serves both needs.

In South Africa, the eventual adoption of the Pedestrian and Bicycle Facility Guidelines Manual was meant to address the serious marginalization of non-motorized transport systems. It was examined that more than five thousand (5,000) non-motorized transport users were killed annually in the country with another thirty thousand (30,000) sustaining some form of injury. These situations were attributed majorly to the lack of integration in transport and land use planning, and the new guidelines were proposed to serve as a guiding tool for road authorities, government departments and the private sector (consulting engineers) in providing appropriate facilities in the different areas (Macozoma & Ribbens, 2004).



### 2.2.2 Foreign situation

Currently, the highest bicycle mode share in the world is 27% in the Netherlands, 18% in Denmark, 10% in Germany and 10% in Sweden (Pucher & Buehler, 2008a). It must be noted, however that all these countries have a very high standard of living, a growing auto ownership and rising income. This notwithstanding, cycling has been thriving, primarily due to long term commitment to enhance safety, speed and convenience of the green mode, while making auto use difficult (Nkurunziza et al., 2013; Pucher & Buehler, 2008a).

City Count	Region	>300k Cities		<300k Cities		Weighted City Mode Share	Years to 2015	2015 Mode Share
		Percent Coverage	Mode Share	Percent Coverage	Mode Share			
12	Denmark	100%	0.45	61%	0.18	0.23	9	0.25
40	France	95%	0.04	15%	0.02	0.02	9	0.04
68	Germany	100%	0.13	19%	0.14	0.12	8	0.13
18	Italy	39%	0.09	7%	0.16	0.10	11	0.12
31	Netherlands	100%	0.28	44%	0.26	0.23	8	0.25
24	Nordic	100%	0.13	29%	0.18	0.14	8	0.16
33	United Kingdom	61%	0.03	14%	0.05	0.03	7	0.04
108	Other OECD Europe	55%	0.06	15%	0.08	0.06	7	0.07
52	Japan	100%	0.17	14%	0.15	0.17	17	0.16
23	Other OECD Pacific	27%	0.02	18%	0.02	0.02	3	0.02
347	United States	95%	0.011	60%	0.012	0.01	5	0.02
14	Canada	56%	0.03	13%	0.01	0.02	5	0.03
14	Mexico	27%	0.02	0%	0.00	0.02	1	0.02
5	Brazil	9%	0.03	0%	0.00	0.02	1	0.02
33	Other LAC	25%	0.03	2%	0.05	0.03	5	0.02
10	Africa	5%	0.06	0%	0.00	0.05	9	0.03
29	Non-OECD Europe/Russia	9%	0.03	4%	0.04	0.03	5	0.02
2	Middle East	1%	0.08	0%	0.02	0.04	9	0.03
24	China	6%	0.25	0%	0.00	0.19	10	0.10
29	India	16%	0.17	0%	0.01	0.08	7	0.07
2	Other Asia	3%	0.03	0%	0.00	0.02	3	0.02

Table 1. Development of baseline cycling modes data by country/region.

Notes: "City count" = number of cities for which data was obtained. "Percent coverage" = percentage of cities within size class for which data was obtained. "Weighted city mode share" includes adjustments for both large/small city weights, and for percentage of cities without data, as described in the text. "Years to 2015" = number of years from average year of data until 2015, used in adjusting data to base year.

### Figure 2.1 Baseline Cycling Modal Data(McDonald, Fulton, & Mason, 2015, p. 11)

Figure 2.1 shows the ranking of countries based on bike mode share data from all over the world. The wide ranging data search focused on cycling levels per capita, average urban mode shares, bike sales and stocks, extent of infrastructure (such as bike lanes and bike sharing systems), and bike-related costs (including bicycle purchase and maintenance costs as well as infrastructure construction and maintenance costs). These underlying factors were used as the basis for the rankings (McDonald et al., 2015).

The ranking considered in all cases, representative cities with populations in excess of 300,000 inhabitants, as well as cities with 300,000 or less inhabitants. The percentage of bicycling in the modal shares was derived for both cases, as well as an aggregated Weighted City Modal Share. African cities had a low bicycle share, although one may argue that the entire continent was poorly represented with the study covering just 10 cities.

It however does not dispel the fact that European cities are more cycle friendly and ready to meet the needs of cyclists as compared to those in Africa.

## **2.3 BICYCLING IN GHANA**

### ***2.3.1 Current Infrastructure and modes of travel***

In most developing countries, bus commuters, pedestrians and non-motorized vehicles (NMVs) form the largest group of road users (Tiwari, 2002). Likewise in Ghana, these aforementioned modes of transport constitute the means of travel for the majority of citizens. Despite having high numbers and requiring the most attention because of their vulnerability, the needs of NMT users for safe and convenient infrastructure remain largely ignored.

From a study conducted in Accra, it was discovered that the percentage of travellers that use public transport comprising buses and trotros to get to work were thirty-six percent (36%), taxi users were three percent (3%), private car users were thirteen percent (13%), bicycles were eight per cent (8.6%) while people who resorted to walking were thirty-four per cent (34%) (Quarshie, 2004). Put together, NMT users represented forty-two per cent (42.6%) with public transport users coming a close second.

According to the Ministry of Roads and Transport, Ghana's road transport infrastructure is made up of 63,122 km of roads as at the end of 2006. The network consisted of 12,786 km of trunk roads, 40,671 km of feeder roads and 9,764 km of urban roads (GIPC, 2016). Traffic densities are relatively low except in the large cities of Accra and Kumasi, where peak hour densities are relatively high (GIPC, 2016). During such periods, heavy pressure is placed on the roads as well as the public transport system, leaving many stranded or in congestion.

In the name of development, cities continue to invest in infrastructure which makes the environment for pedestrian and cyclists even more hostile than the present (Tiwari, 2002).

The network size continues to grow on an annual basis with Governments investing large amounts of capital particularly in the provision of new infrastructure. In the case of Ghana, this was demonstrated in the increase to 13,367km of trunk roads, 42,100 km of feeder roads and 12,600 km of urban roads as at the end of December 2011 (GIPC, 2016).

Bicyclists and pedestrians have been largely ignored, although improvements in these modes of travel could have positive implications for transportation in the two largest cities of Ghana. Bicyclists also require a complete network, which may consist of bicycle tracks (physically segregated from motorised traffic), bicycle lanes (painted segregation on lower speed roads), and mixed facilities where speeds can be kept below 30 km/hr by traffic-calming measures (Tiwari and Jain, 2013). In these instances, cyclists feel safer and are more willing to explore the option of riding a bicycle. This however means that there would be need for re-directed focus by road administrations to accommodate these improvements within their rather tight budgets.

### **2.3.2 Perceptions of cycling**

Economic constraints make it essential to make daily travel easier and cheaper for the urban population through the use of bicycles (Nkurunziza et al., 2013). It must however be noted that this does not imply that bicycling should be reserved for the poor as perceived in most places. Álvaro Fernández-Heredia (2014) and Dill & Voros, (2008) stated that, perception and response of the masses towards bicycling plays a key part in the increase in its mode share. Studies have showed that, indeed, in many places the bicycle is considered a vehicle only for the poor (Batista, 2010).

Mobility is thought to have a strong correlation with wealth such that higher income groups have a higher level of car ownership, travel further, use their cars more often and as a result have a higher level of access to economic opportunities (Gebeyehu & Takano, 2007; Geurs and Wee, 2000). In the same vein, people who experience a better financial situation are more likely to change to public transportation or an individual motorized vehicle (Batista, 2010).

Also, Grieco, Turner, & Kwakye, (1994) in their study of Nima and Jamestown concluded that, although both locations were considered densely populated low income areas of Accra, there were significant differences in the culture of cycling witnessed. It was realized that young people in Nima were more inclined to the use of bicycles while their colleagues



in Jamestown were dissuaded from using bicycles through punishments, etc. This was mainly attributed to the fact that inhabitants of Nima were considered to be largely migrants of the Northern regions where there was higher ridership and bicycle ownership among people. These migrants were therefore considered as carriers of the non-motorized transport culture as a result, whereas the culture was associated with hooliganism in Jamestown.

### ***2.3.3 Number of bicycles in good condition owned per household***

It was found that just a little over thirty percent (30 %) of households in the country owned one or more bicycles in a 2013 National Survey. The proportion of households who owned one bicycle was relatively higher in the three northern regions; Upper West (39.5%), Northern (38%) and Upper East (31.2%). Ownership of bicycle was lowest in the Central Region (5.5%), followed by Western Region (10.2%) (Mrh & Ghana Statistical Service, 2013).

Overall, these figures represented an increase from the twenty per cent (20%) of households in the country who owned one or more bicycles in 2007. However, bicycle ownership suffered a bit of a decline in the Upper West, Northern, and Upper East regions where they had previously recorded fifty-four percent (54 %), forty percent (40%) and forty-onepercent (41%) respectively.

In the Ashanti and Greater Accra regions, bicycle ownership witnessed an increment from tenpercent (10%) and nine percent (9.3%) to fifteen percent (15%) and fourteen percent (14%) respectively (Mrh & Ghana Statistical Service, 2007, 2013).The growing cyclist population calls for attention, and the increasing and obvious need to integrate cycling facilities into the existing road network and public transport system has not been greater (Okoye, Sands, & Debrah, 2010; Quarshie, 2007).

On the average, the price of a bicycle can range anything between one hundred and fifty Ghana cedis (GH¢150.00) and four hundred Ghana cedis (GH¢400.00), with most selling for about two hundred and fifty Ghana cedis (GH¢250.00). Most of these bicycles are also second hand vehicles imported mainly from Europe and other parts of the world.

Footnote : 1 US Dollar equals 4.03 Ghanaian Cedi (Bloomberg.com, 1 Feb 2016)



#### **2.3.4 Safety of Ghanaian cyclists**

Afukaar, Antwi, & Ofosu-Amaah (2003) examined the pattern of road injuries in Ghana taking into account the implications for control. They found that majority of road traffic fatalities (61.2%) and injuries (52.3%) occurred on roads in rural areas. Of these accidents, bicyclists alone accounted for 3.7% of all road traffic fatalities, with the fatality incident for pedestrians being the highest, at forty-six percent (46.2%). It was discovered that, young adults, between the ages of 16 and 25 years were at greatest risk as cyclists.

Research again suggested that the four regions in the north (Northern, Upper West, Upper East and Brong Ahafo) recorded the most fatalities through bicycle related incidents. This could be attributed to the fact that these NMT modes were the affordable and most commonly used, particularly in these parts of the country.

Where there are such apparent dangers to safety of cyclists, Tiwari and Jain (2013) suggest the provision of bicycle tracks, biking lanes, and traffic calmed mixed facilities, which have been associated with improved feeling of safety for cyclists. These may potentially reduce the number of cycling injuries annually recorded.

#### **2.4 FACTORS INFLUENCING THE USE OF BICYCLES**

In an attempt to understand the issues that influence the use of bicycles, some researchers base their studies on qualitative parameters which entails primarily, determining the effects of existing factors on cyclists, while others also adopt a more quantitative approach involving drawing up of conclusions and links between these factors and eventual bicycle use. More recent studies however have adopted the approach of Li et al. (2013) which is based on a combination of the two perspectives of identifying influencing factors.

The factors influencing bicycle use can be grouped into demographic characteristics, environment for cycling and latent variables. Individual or demographic characteristics deal with socio-demographic items. Environment related choice factors are those that can be observed and measured directly within the environment, and subjective factors deal with perceptions and attitudes (Álvaro Fernández-Heredia, 2014). Previous studies such as Álvaro Fernández-Heredia (2014) & Dill and Voros (2008) have all identified the various psycho-social factors that play a role in the adoption of cycling as a mode of transportation. These factors were uniquely identified as;

- i. Individual or demographic characteristics;
  - ii. Environment for cycling; and iii.
- Subjective factors/latent variables.

Individual or demographic characteristics relate to the various socio-demographic characteristics influencing the decision of an individual to ride a bicycle. Some of these include, economic situation, the age of individuals, the size of their families (this would determine the number of car trips), as well as, the availability of a bicycle in the first place (Álvaro Fernández-Heredia, 2014; Dill & Voros, 2008).

The environment within which cyclists travel is identified as a key influencer in the decision of many to cycle. Recent research efforts in land use planning have revealed that built environments and design policies can influence human behaviour and mode choices (Cervero, 2002; Targa & Clifton, 2005). Fortunately, this parameter can be measured directly. Environmental factors are inclusive of *natural environmental conditions* in the form of the weather, topography and urban form which can be said to play a role in the decision to cycle. Bad weather for instance was witnessed to reduce incidence of cycling drastically (Ahmed, Rose, & Jacob, 2010). Likewise, topography or gradient for bicycling has a correlation with the use of cycles. In a stated preference survey, Sener, Eluru, & Bhat (2009) found that cyclists preferred flat ground and moderate hills over very steep hills;

Secondly, the availability of *bicycle infrastructure* within the environs can impact on cycling. In fact, Hunt & Abraham (2007) suggested that, available planning and the infrastructure for bicycling have an influence on the frequency of cycling; Also, *subjective bicycling factors*, such as matters associated with bicycles themselves for instance, the perception of risk and exercise opportunity as seen by potential cyclists can influence bicycle ownership and use (Hunt & Abraham, 2007). Their study further concluded that, there was a general feeling that riding on a roadway in mixed traffic is much less desirable than riding in a designated bike lane. It is expected that this feeling is in part due to the perception that riding in mixed traffic is more dangerous, which is consistent with the evidence of safety effects found elsewhere; *trip factors*, which deals with the duration of journeys with bicycles, flexibility in using them in an environment, etc. (Akar & Clifton, 2009) were represented as the last of the natural environmental conditions influencing bicycle use.

Finally, subjective factors also concern the underlying and more subjective indicators and concepts which although may not be measurable, are indicative of the intention to use bicycles. This implies that the attitudes towards bicycling and perception of people towards it can be essential in the promotion of its usage. Some latent variables related to perception include; sensitivity to time, comfort in usage (including the potential of sweating), the desire for more economical travel and environmental awareness among others (Álvaro Fernández-Heredia, 2014; Dill & Voros, 2008).

## **2.5 BICYCLING ON CAMPUSES**

Balsas (2003) described campuses as ‘places where people of different backgrounds, incomes, lifestyles and attitudes do come together to live, study, work, and recreate. College campuses build societies that are at once transitory and lasting, and have an ideal human scale’.

Colleges and universities have unique transportation needs. Educational institutions value a walkable, green campus where buildings are in close proximity, to foster academic collaboration (Bond & Steiner, 2006). The traditional campus behaves like a neo traditional town where various key locations are within the reach of pedestrians.

This neo traditional town structure of most campuses makes them seemingly more suitable for implementation of bicycling developments since the campuses are considered often as very distinct communities (Huang et al., 2012; Balsas, 2002) with many young people to whom the activity of cycling is more attractive (Dill & Voros, 2008; Quarshie, 2004). On most campuses, key attraction zones are within reach of each other and are often no more than 5 kilometers (km) apart, which makes travelling by bicycles a great alternative (Tiwari and Jain, 2013).

Researchers argue that, the implementation of policies encouraging non-motorized transport on campus is beneficial to the sustainable development of the whole society (Huang et al., 2012). While walking is an attractive option for many reasons, bicycling offers many benefits and warrants further research (United Nations Human Settlements Programme, 2011).

Just like in many parts of Africa, awareness creation seems crucial to gaining recognition of the benefits of cycling in Ghana, especially on university campuses. The message that



needs to be carried on should not be anti-car, but rather pro-cycling and pro other non-motorised transport means (United Nations Human Settlements Programme, 2011).

Large universities have highly mixed daily activities and travel patterns, resulting in complicated transport situations (Huang et al., 2012). Creating a modal shift away from automobiles is an important goal for many institutions of higher learning today. Universities are in an excellent position to experiment with and implement transportation policy changes. This is especially because, universities have complete control over the road network, parking facilities, and land uses on their campuses (Bond & Steiner, 2006).

In the introduction of bicycling on a campus such as KNUST, public policy can play a crucial role in encouraging the use of bikes. Substantial increases in bicycling require an integrated package of many different, complementary interventions, including infrastructure provision and pro-bicycle programs, supportive land use planning, and restrictions on car use (Pucher, Dill, & Handy, 2010).

Management of the university and other key stakeholders may need to make special provisions for bicycling since the current land use plan for the next 10 years has stated no such intentions. Land use planning should be closely tied to the encouragement of physical activity. In fact, Krizek, Barnes, & Thompson (2009) remark that, ‘a central theme in recent planning and public health policy discussions aims to spur bicycle and pedestrian travel and overall levels of physical activity’. Making such provisions would only therefore bring the university at par with current international practice in land use planning.

Since a disproportionate share of bicycling occurs on streets with bicycle lanes, separate paths, or bicycle boulevards (Dill, 2009), the need for these improvements cannot be stated enough. Connectivity of biking facilities also plays a vital role in the modal shift to bicycle use. A well connected bicycle network is the backbone of a successful bicycle program (Akar & Clifton, 2009). Good connectivity of street systems can be accomplished through comprehensive planning, regulation, and funding (Dill, 2009).

### ***2.5.1 Psychology of biking on campuses***

Another interesting characteristic of university campuses is the spill over effect that cyclists have on non-cyclists. Bicycle culture is best described as a social interaction or phenomenon, where a higher bicycle mode share makes it more likely that some other



person will also ride a bike (Goetzke & Rave, 2011). This could be due to the fact that most people enjoy cycling in the company of others, although this can also be a result of improved general feeling of safety, leading to more cyclists being visible in traffic, a crucial factor in bicycling safety (Pucher et al., 2010).

Aside this, there is the issue of conformity to a social norm. For instance, if there is the view of bicycles being ‘cool’ or considered a practical means of travel among students, it is expected that more people will bike (Goetzke & Rave, 2011).

### **2.5.2 Methods used in bike studies**

There has been a lot of research on the factors that influence bicycling. These attempts have been geared at understanding the underlying ‘trigger points’ which could get more people to cycle.

Available literature suggests that most studies on bicycling are carried out by employing the use of qualitative methods i.e unstructured or semi-structured techniques in the form of surveys, group discussions/focus groups, individual interviews, and participation/observations. A few studies also opt for a more quantitative perspective however; some of which entail the drawing of correlations between factors affecting cyclists and the activity of cycling itself. Furthermore, quantitative models are able to infer statistically significant weights on the different influencing factors on cycle mode and route choice, and have the important ability to forecast future changes (Parkin, Ryley, & Jones, 2007). Qualitative and quasi-qualitative methods on the other hand, are usually employed as precursor to the implementation of quantitative models and help in the selection of the appropriate parameters for analysis.

#### **2.5.2.1 Surveys**

In an attempt to gain a better understanding of users’ behaviour towards riding a bicycle as well as suggest appropriate actions to encourage bicycle use, Álvaro FernándezHeredia (2013) designed and administered an internet based survey on the Ciudad Universitaria Madrid Campus. The survey, collected data initially through the creation of focus groups. These groups involved a number of active cyclists on the campus, who helped to detect some of the significant challenges and true requirements for potential cyclists. Using the gathered information, a sample questionnaire was tested, followed by the internet based survey which reached out to 3048 people. Some incentives were

promised early participants of the survey, which could have encouraged responses to the survey.

Similarly, a web-based survey was conducted by Akar & Clifton (2009) so as to understand issues concerning travel patterns and specific difficulties peculiar to bicyclists. The survey included questions about the possible bicycle infrastructure improvements, policy and program innovations to assess the perceptions of the campus community on these changes. The study concluded by stating that both non-bicycle commuters and bicycle commuters agreed improvements such as biking lanes, trails and paths on the campus and its environs would make them cycle more often.

Since there is a clear difference between the perceptions of users that have cycling experience and those that do not have the habit of riding a bicycle (Rondinella, Fernandez-Heredia, & Monzón, 2012) ,one major criticism of these studies is the fact that they did not test the responses of cyclists and potential cyclists in real time situations (or while they cycled). It is believed these perceptions could have been slightly different since some difficulties may best be identified when cycling. It seems logical that an adequate direction to follow should involve measures that allow people to experience cycling in real situations (Broach, Gliebe, & Dill, 2012).

Another criticism of most of these surveys was the fact that the studies present questionnaires that were accompanied by a visual representation of the final product (whether it was a bike sharing scheme, improved biking infrastructure, etc.) The diversity of inexperienced users' evaluations corresponds to assessments of something that is unknown to them, and it contrasts with the clear data structure shown by experienced users (Gatersleben & Appleton, 2007).

It is presumed the incorporation of some visual representation in these studies could have affected the studies one way or another. It must, however, be said that although this is possible, most of the study areas were based in countries which already have some bicycle infrastructure and practise the culture, making it easier for respondents of the survey to 'visualize' the final product.

A final study examined, sought to determine the feasibility of a bike sharing program on the Bridgewater State University campus. This study involved interviewing staff of proxy

universities firstly, followed by focus groups that were centred around some key individuals for the success of the program. For the last aspect of the study, questionnaires were issued to students of the campus, faculty, administrators and staff. This approach learnt from the successes of the other universities already practising the program, and the focus groups involved policy makers well in advance and would enhance their understanding of the benefits of such a system (Ashley, 2012).

### **2.5.3 *Recording of bike trips***

In addition to these criticisms, much of the literature investigating the link between urban form and travel behaviour from the planning field employ the use of travel or activity diaries (Saelens, Sallis, & Frank, 2003). The self-report technique may not necessarily be ideal for bicycle research. This is because the diaries usually cover only a few days of travel, with most researchers agreeing that respondents underreport trips made, especially those of recreational nature (Dill & Voros, 2008). It may thus be more feasible for the cyclists to ride along in a single trip where the researchers can have a greater degree of control over the data collected, without influencing the results of the study. This may require objectivity on the part of the researchers and may be more preferable for determination of required improvements.

## **2.6 BICYCLE INFRASTRUCTURE AND NETWORK INTEGRATION**

Quite a number of bicycling studies support the notion that providing bicycle infrastructure, particularly lanes and paths, can increase bicycle use (Dill & Carr, 2003). Higher infrastructure availability and greater density of facilities have been positively associated with increased rates of bike commuting.

However, bicycle lanes and paths alone are not likely to increase bicycle commuting. Such infrastructure should connect popular origin and destination zones and must also have adequate and safe parking facilities for travellers (Tiwari and Jain, 2013).

There is therefore the need for well-connected neighbourhood streets and a network of bicycle-specific infrastructure to encourage more bicycling among adults (Dill, 2009).

### **2.6.1 *A review of various cycling infrastructure***

Various types of bicycle infrastructure can be used in different jurisdictions based on how well they fit into landuse patterns and plans. In locations where cycling infrastructure are



incorporated as an after thought, research may play a crucial role in determining the exact kind of infrastructure required prior to introducing the said infrastructure. It is thought also that, the type of bicycling infrastructure can influence preference, and informs an individual's decision whether or not to use bicycles. Bicycles can be used in local environments often, in one of the following three forms;

- a. **Mixed traffic situations-** Under these circumstances, bicyclists share the full roadway with other traffic without any longitudinal separation. Speeds of cars must be kept below 30 km/hr by traffic-calming measures to reduce the chances of collisions and prevent the loss of lives;
- b. **Bicycle Lanes-** These exist where cyclists use the roadway with other traffic but in this case, have a separate lane that is longitudinally separated from the other traffic lanes and is reserved exclusively for cyclists. This sort of separation may also be created in the form of painted segregation on lower speed roads; and
- c. **Bicycle Paths-** Bicycle paths are considered as separate facilities that are typically much narrower than a roadway and physically segregate cyclists and/or other nonmotorised traffic from motorised traffic (Daniels, *et.al.*,2009; Hunt & Abraham, 2007).

Besides these traditional bicycling infrastructural terminologies, some other definitions are available and a few have been tabulated in Table 2.1.

**Table 2.1 Common bicycling terminologies and descriptions**

INFRASTRUCTURE	DESCRIPTION
<b>Bikeway</b>	Bikeway is a generic term for any road, street, path or way, which is in anyway designated for bicycle travel, regardless of whether it is designated for exclusive use by bicycles or shared with other transportation modes (University of Illinois, 2014).
<b>Bicycle Lane</b>	Bicycle Lane is a term often used inreferring to a portion of vehicular streets, which has been designated for exclusive use by bicyclists through the use of pavement markings or signs (University of Illinois, 2014).
<b>Bicycle Route</b>	This is recognized as a street or road noted for <i>higher bicycle volumes</i> and is to be shared by both vehicles and bicycles.



### Shared Use Side Path

These are parallel to but physically separated from a street. They are conventionally separated from motorized vehicular traffic by an open space or barrier. Shared use paths consist of wide paths which can be shared by pedestrians, bicycles, and other non-motorized transportation (NMTs). In some jurisdictions, they may also be referred to as *Off-Road Trails*. They can further be sub-categorised into three forms namely;

- i. Dedicated Bicycle Side Path – This type of facility may be located parallel to but physically separated from a street and is for the exclusive use of bicycles.
- ii. Off-Road Shared Use Path – completely separate from a street, a path intended to be shared by pedestrians, bicycles, and other nonmotorized transportation.
- iii. Off-Road Dedicated Bicycle Path – separate from a street or sidewalk, a path intended for exclusive bicycle use.

Reference; American Association of State Highway and Transportation Officials (AASHTO), (2010); University of Illinois (2014).

Each bike path's design should take note of the following parameters; width, traffic volume, surface, route, speed, crossroad and attractiveness (Khongouan & Sakulrattanakulchai, 2014). Interestingly, some suggest it does not require tremendous amounts of effort to create safer travelways for bicycle traffic. Good examples of simple but efficient changes that can be implemented include the provision of ramps along sidewalks and stairs, creation of cycle paths/lanes and safe places to park bicycles. Specifically, the design of bicycle paths should give special attention to safety, security, way finding system, continuity of bike path, attractive cycling route, quality of flow on bicycle path and universal design. Ultimately, a good design should be one that is tied in with the overall planning of the city. This is one of the sure ways of guaranteeing safe bikeways are provided in all long term plans.

### 2.6.2 Traffic Management and Traffic Calming

*Traffic management* encompasses all the strategies used to control the amount of traffic on streets, and this includes application of turn restrictions to restrict or redirect traffic and regulatory restrictions, conveyed primarily through signs. *Traffic calming* on the other

hand, is defined as the road design strategies, specifically intended to reduce vehicle speeds and improve driver attentiveness.

In achieving traffic calming, the designs and measures implemented on the road should be done in such a way that slowing down seems natural and speeding is made physically more difficult or even impossible. With traffic management measures however, focus is often placed on the application of turn restrictions and other measures to redirect or restrict traffic flows (Massachusetts Department Highway, 2006).

In all, traffic management and traffic calming programs are often a critical component of pedestrian and bicycle planning. Virtually any traffic calming measure enhances the pedestrian environment by reducing traffic speeds and volumes. In fact, traffic calming can be used to create a network of streets that encourage cycling. Consequently, when traffic volumes and speeds are sufficiently reduced, for example, through residential neighborhoods, the need for special bike lanes or separated bicycle trails is reduced (Litman *et al.*, 2002).

Table 2.2 shows some traffic calming and traffic management measures as well as the best circumstances for applying them. Based on a comparison with the Ghana Traffic Calming Design Guideline (2007) it can be said that the following traffic calming measures are more likely to be found on Ghanaian streets; Medians and Crossing Islands, Crossing Islands/Shorts Medians, Roundabouts, Speed Humps, Raised Crosswalks.

**Table 2.2 Traffic Calming and Traffic Management Applicability by Roadway Type (Massachusetts Department Highway, 2006, p. 6).**

### Traffic Calming and Traffic Management Applicability by Roadway Type

	Arterials	Major Collectors	Minor Collectors	Local Roads
<b>Street Narrowing</b>				
Narrow Lanes		△	■	■
Raised Curbs	■	■	■	■
Street Furniture	■	■	■	■
Street Trees	■	■	■	■
Street Lighting	■	■	■	■
Spot Narrowing	△	■	■	■
Medians and Crossing Islands	■	■	■	■
Curb Extensions	■	■	■	■
Road Diets	△	△	■	■
Building Siting	■	■	■	■
<b>Horizontal Deflection</b>				
Chicanes			■	■
Crossing Islands/Short Medians	■	■	■	■
Mid-Block Traffic Circles			△	■
Roundabouts	■	■	■	■
Lane Offsets		△	△	■
<b>Profile Alterations</b>				
Speed Humps		△	△	■
Raised Crosswalks		△	■	■
Raised Intersections		△	■	■
Textured Pavement	■	■	■	■
<b>Traffic Management</b>	△	△	△	△

■ Often used for new design or retrofit programs in traffic calming settings  
△ May be suitable

### 2.6.3 Bicycles and Intersections

Regarding the safety of cyclists on roads, it has been examined that features that separate cyclists from motor vehicles and pedestrians (cycle tracks, local streets, traffic diverters) play a vital role in lowering injury risk to cyclists. These measures should go hand-inhand with lower travel speeds of motor vehicles i.e. below 30 km/h. Additionally, the creation of flatter and more level bikeways can be seen as essential for safer and smoother travel.

Harris et al. (2013) suggested that intersections of two local streets are associated with significantly lesser chances of bicycle collisions that lead to injury. Local-local street intersections were said to experience a fifth the risk of major-major street intersections. It can be inferred then that, the type of intersection has some correlation with injuries experienced.

For cyclists, traffic circles are considered more hazardous than all other intersection types (traffic lights, two-way stops, four-way stops and uncontrolled intersections). Previous



studies of cycling accidents at intersections suggest that, the greatest number of cyclist accidents at traffic circles was with motor vehicles. This could have been a result of the numerous 'conflict points' at these locations (Daniels et al., 2009; Harris et al., 2013).

Despite this, Harris et al. (2013) noted that traffic circles are considered a bit safer at intersections of two local streets, as these streets often experience lower travel speeds. Other studies also have found increased safety with higher ridership (Robinson, 2005), although quite a few opposed this notion by associating higher cycling numbers with increased collisions at roundabouts.

On the subject of the impact of roundabout radii on safety of cyclists, Reynolds et al. (2009) showed that roundabouts with radii greater than 10m were safer than smaller circles. This concept also holds true for larger traffic circles (up to 30m in diameter) which are believed to reduce significantly, the risk of injury among motor vehicles as well. (Daniels et al., 2009) realized that the introduction of physically separated lanes within traffic circles led even further to a reduction of risks for cyclists.

Cyclist collisions at traffic circles were dominated by two main types. The first category of accidents occurring under these circumstances were between cyclists and motor vehicles. These were primarily due to visibility issues such that drivers did not see cyclists. The second category comprised of cyclist-road infrastructure accidents. Here, cyclists may have run into curbs, slid on sharp turns, etc. (Harris et al., 2013) on their own or in reaction to something else. The study therefore suggested major improvements and possible redesign at intersections and traffic circles so that the safety of cyclists would not be compromised.

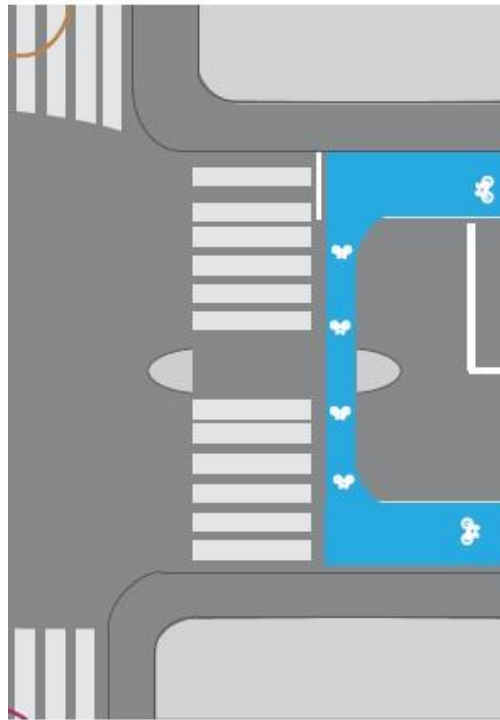
In a study by Colville-Andersen, et al. (2013) in Copenhagen, bicycle users using an intersection within a 12 hour time frame were categorized based on behavior categories. The three categories were: Conformists, Momentumists, and Recklists. The study was conducted in an attempt to document whether or not the persisting perception of bicycle users being "badly behaved" was legitimate. The study highlighted that, of the nearly seventeen thousand (17000) bicyclists, ninety-three percent (93%) were considered conformists who obeyed traffic rules to the latter. Six percent (6%) were Momentumists who only overstepped what was regarded as minor traffic regulations, and the Recklists who broke more serious traffic laws were also only one percent (1%). The study therefore



debunked the persisting myths about bicycle user behaviour. Based on the evidence, improvements such as the ones exhibited in Figure 2.2 and Figure 2.3 were suggested to enhance cyclists' mobility at intersections. Both images suggest that stop lines that are provided for cars at intersections should be least 5 metres from the intersection. It is presumed that this intervention would reduce fears and safety concerns of cyclists at intersections. Secondly, the provision of the U-turn for cyclists would work in tandem with desire lines to settle qualms about potential bicycle/pedestrian interaction, since each user would have their own space.



**Figure 2.2 Stop line for cars pushed back 5 metres (Colville-Andersen, et al. (2013) p.34)**



**Figure 2.3 U-turn for cyclists (Colville-Andersen, et al. (2013) p.34)**

## **2.7 A COMPARISON OF THE KNUST BIKE NETWORK TO BEST PRACTICES FOR BICYCLING**

According to a report published by Mia Birk and Roger Geller in 2005, data collected in Portland(USA) demonstrated a strong correlation between a connected bikeway system, constructed to the highest standards, and increases in bicycle use. Without a modespecific plan for building out this connected network, it is very unlikely that the observed growth in the bicycle mode share would have occurred (Birk et al, 2012). Comparatively, it can be said that the KNUST campus has no cycle tracks, with cyclists forced to exist under mixed traffic situations. These cyclists can often be spotted in vehicular traffic or on some pedestrian sidewalks/paths. In spite of this, the roads are however, fairly well interconnected on the campus, especially for pedestrian travel, with many pedestrian paths being improved into paved sidewalks. This phenomenon in itself is relatively new, and as such, many sections are still shared between pedestrians, vehicles and cyclists.

The Ghana Highway Design Guide (1991) recommends that sidewalks should be a minimum of 1.5m. Mixed sidewalks comprising of bike tracks and sidewalks are to be between the ranges of 1.75m to 3.5m. While bicycle tracks should also be allocated a minimum of 2m to allow for easy manoeuvrability between cyclists. City planners

recommend that bikeways on campuses must be connected with city-owned streets and bikeways to offer true connectivity (University of Illinois, 2014). Future campus bicycle plans could therefore be closely coordinated with bicycle planning for the Kumasi Metropolitan Assembly, to enhance regional connectivity and promote uniformity within the University district.

With regard to safety, it can be said that, poorly marked, inconsistent and unpredictable biking routes may pose difficulties for cyclists trying to navigate campus environments. This commonly leads to unpredictable riding behavior, which not only puts cyclists at risk, but also adversely affects other users of paths and roadways (University of Illinois, 2014). In addition to these problems, other safety issues that are commonplace on the KNUST campus include the many opened side drains, inadequate lighting, and poor placement of electricity posts. Driver behavior in the form of tooting of horns, fast overtaking maneuvers and sometimes, showering of insults are more common in Ghana, and may dissuade potential cyclists from doing so, if they consider that their safety could be jeopardized. Each of the aforementioned problems may consequently result in a lack of user-friendliness for cycling.

### **3 STUDY APPROACH AND METHODOLOGY**

#### **3.1 INTRODUCTION**

In order to assess bicycle transportation on campus, two (2) relevant issues were investigated. Firstly, the study examined the underlying factors to the current low ridership, perceptions and willingness of students to patronize bicycle transportation on campus. This was aimed at understanding the situation on the campus better, in an attempt to develop solutions that meet all the right needs of potential users.

The second aspect of the study considered available infrastructure, in an attempt to determine whether there was an enabling environment for cycling on the campus. This phase established preferences for cycling improvements, by using volunteered users to perform a ride along survey. The ride along survey was to determine whether the infrastructure in place at the time was adequate, safe and cyclist friendly. Based on their preferences, some specific infrastructural improvements were recommended to make cycling safer and more enjoyable.

As a result, two (2) main approaches were adopted for the collection of data in this study. The specific methods employed in assessing the feasibility of bicycle transportation on campus are further discussed under their respective headings.

### **3.2 DESCRIPTION OF THE KNUST CAMPUS**

#### **3.2.1 The Area of Study**

The Kwame Nkrumah University of Science and Technology (KNUST) was founded in 1951 to provide higher education with special reference to science and technology and to act as a catalyst for the technological development of Ghana. The University, one of the largest in Africa, currently has a student population of approximately 35,000. The University campus is located about eight kilometres from the Central Business District of Kumasi. The campus covers an area of about eighteen square kilometres (Niboi, 2013).

The main Campus has been sub-divided into six broad land use categories. These are:

- ☐ Academic/Teaching Area;
- ☐ Commercial Area;
- ☐ Senior Members Housing Area;
- ☐ Senior Staff and Junior Staff Housing Areas;
- ☐ Halls and Hostels Areas; and
- ☐ Administration/Library/Great Hall Area (KNUST Planning Department, 2014).

The map showing the forms of land use on the campus and their locations and has been attached in the Appendix.

##### **3.2.1.1 Transport system of KNUST**

The University campus has about 70 km of road infrastructure presently. The roads comprise of mainly asphalt concrete and bituminous surfaced pavements. During the time of this study, some of the pavements were being overlaid. Despite having a wide expanse of road network, key activity zones that are highly patronized by staff and students are concentrated within a smaller area of the university campus. Majority of the other roads on the campus lead to staff residences, on the eastern and western ends of the campus.

Since most key activity zones are concentrated within a relatively smaller area, travel distances between these zones are usually within 5km, making walking and bicycling attractive options.



As a result, a large majority of students prefer walking between trip attraction zones. This may also be coupled with the fact that many would not be capable of affording private vehicles for their travel on campus. Bus shuttle services are also run on the campus. These shuttles transport few numbers of students (usually about 15) per ride. Students may occasionally alight at their destinations, giving the opportunity for others seeking to patronize the service to get on board the buses. A small fee of seventy (70) pesewas is paid in this case by each student for a ride, with the speculated average distance travelled by shuttle riders being about 2.5km.

The presumptive bicycle infrastructure on campus is shown in Figure 5.1 (pg.68). The network comprises of shared use paths, with virtually no clearly defined on-street bicycle lanes or off-road dedicated bicycle paths. Many of the low volume campus streets are not specifically marked for bicycle traffic, however, using bicycles on all streets are generally allowed. It is also expected that, with some skill and ample patience, cyclists can fairly use pedestrian sidewalks along some roadways, although this may not be advised.

### ***3.2.1.2 Selection of Route for Ride Along Survey***

Based on the six (6) main land use forms available on campus, it was decided that, the route for the ride along survey should pass through some of these key activity zones. Locations that were representative of the various land use forms on campus were randomly selected. The representative locations have been tabulated in **Table 3.1**.

**Table 3.1 Selected locations for Ride-Along Survey**

No.	Type of Facility/Land Use	Location
1	Academic/Teaching Area	College of Architecture and Built Environment
2	Halls and Hostels Areas	University Hall/Brunei
3	Commercial Activity Area	Commercial Area
4	Recreational facility	Swimming Pool
5	Social facility	Catholic Church/Protestant Chapel

Priority was given to sections of the campus which were thought to be highly patronized by students and staff. Accordingly, these areas expected higher volumes of pedestrian and vehicular traffic. Finally, interconnectivity of land uses was also considered in coming up with the route used in this study.

### 3.3 GENERAL QUESTIONNAIRE

The general questionnaire was used in the first aspect of the study, in an attempt to understand the underlying causes of the low ridership on the university campus. This was carried out because, although campuses are considered favourable for cycling in many parts of the world (Balsas, 2003), cycling is still not very popular in KNUST.

It was of interest to understand specifically, why more people did not cycle on campus. The questionnaire therefore inquired from respondents, to what extent factors such as health, weather conditions, terrain, bicycle ownership, lack of adequate bicycling infrastructure, speeds of motor vehicles on campus as well as several other useful parameters, influence their decision to cycle.

These questions were categorized under three (3) main headings;

1. Personal and environmental factors that limit potential cyclists from cycling,
2. Transportation system factors limiting potential cyclists and
3. Other factors that could encourage or induce individuals to cycle more.

The categorization of limiting and encouraging factors is based on previous studies of de Sousa et al. (2014), Álvaro Fernández-Heredia (2013) and Dill & Voros (2008).

In order to distribute the questionnaires across a wide student response, a simple online questionnaire was developed using the Google Forms platform incorporating the above categories of questions. The questionnaire was kept actively online from the 17<sup>th</sup> of March 2016 to the 31<sup>st</sup> of March 2016. Permission was sought from the Dean of Students Office to send a text message that included the web link of the online questionnaire to all students.

This text messaging platform is hosted by the UITs (University Information Technology Service) but required permission from the Dean of Students Office because of confidentiality and ethical issues. The text messages were sent to all undergraduate students on two occasions. These were also supported with Whatsapp messages circulated across various K.N.U.S.T. student pages, encouraging folks to participate in the survey.

About 250 individual responses were obtained using this method. A few additional paper and pencil questionnaires were also issued randomly on the campus, to round up the

number of responses received. Overall, 300 respondents answered the general questionnaire.

Students represent the largest group on the campus, and it was assumed that, if they were particularly targeted for the study, there could be a more significant shift to bicycle transportation when their needs were fully understood and addressed.

The web link for the questionnaire was <https://goo.gl/dwbtpb>. A sample of the questionnaire has been attached at the Appendix.

### **3.4 RIDE ALONG SURVEY**

Besides determining the perceptions of people to cycling, the study assessed how well the infrastructure on campus was also suited for cycling. There was therefore the need to find a way of collecting data on the campus infrastructure.

Literature suggests two probable ways of collecting data on preferred cycling infrastructure. The two main approaches for collecting data from respondents on cycling infrastructure include;

- (i) Stated preference method and
- (ii) Revealed preference method.

Stated preference methods focus on asking participants what they would do given a hypothetical situation, say an improvement in infrastructure, whereas revealed preference methods collect data on how participants actually behave or feel, for instance, with current or improved infrastructure (Basu & Vasudevan, 2013; Dill, 2009). For the purpose of this study, the two probable ways of collecting preference data were merged to seek from respondents, how well the current infrastructure was suited for cycling, in addition to finding out which remedial measures were preferable, where there were problems. This would consequently, require that cyclists who used the campus roads duly expressed their specific impressions of the infrastructural problems.

It has already been established that, the activity diary technique (where cyclists report on their trips) is not preferable for gathering this sort of information when conducting cycling studies. This is because; the technique has been associated with gross under recording and under reporting in times past (Dill & Voros 2008). In trying to avoid the potential challenge



of getting little feedback through the questionnaires, this study adopted a specialized technique to collect the data in real time situations. By this, cyclists on campus were brought together, on a given day, so they could help assess the roads in light of their true needs for cycling. In this respect, they were required to ride along certain routes of the campus, after which they would provide their express opinions through the answering of questionnaires. The approach not only allowed for an instantaneous collection of the data in the form of their opinions on the routes, but also the real time nature of the data collection avoided the problems of relying on participants recollection after not using the route for some time (Dill, 2009). Finally, the approach ensured coordination in terms of the routes on which the data was being collected.

#### **3.4.1 The Participants**

Participants for the ride along survey were all volunteer cyclists. Each of these individuals joined the survey team by responding to social media (*Whatsapp*) invitations that were sent across various K.N.U.S.T. student pages. Some active cyclists were also invited personally when spotted riding on campus. The group comprised of 27 males and 3 females from the various colleges on the University campus.

#### **3.4.2 The Trainings**

Since the participants for the ride along survey were randomly selected, a very brief training session was held to familiarize them with good cycling practices and the basic bicycling infrastructure they were to assess. They were also introduced to the questionnaire and the route for the survey by a trainer, adent cyclist and road design engineer in the person of Mr. Paul Yaw Duah Adanse-Pippim of the Ghana Highway Authority (GHA). Suggestions and concerns of participants were at this stage noted, in the planning of the actual survey. This training is shown in Figure 3.1





**Figure 3.1 Training session with Mr. Duah of GHA**

### **3.4.3 The Survey**

The ride along survey took place on the 12<sup>th</sup> of March, 2016 and involved 30 cyclists, majority of who were students. Between the hours of 8:30am-11:30 am, these cyclists travelled along the selected routes on the campus. This was followed by the answering of questionnaires on the routes. The questionnaire asked various questions on the present infrastructure, challenges for cycling on campus, as well as some preferred improvements. The questions touched on safe parking areas, road markings, adequacy of lighting, mixed traffic situations, among others. Cyclists who already had bicycles used them, while other participants without bicycles also received hired bikes for the period of the study. These bicycles were hired in bulk from local bicycle salesmen at Alaba, Kumasi. The bikes were in fairly good condition and were mainly second-hand bicycles that were meant for sale. Figures 3.2 to 3.7 show the activities involved in the ride along survey.



**Figure 3.2 Cyclists taking delivery of the bikes at the College of Architecture and Built Environment (CABE)**



**Figure 3.3 Cyclists setting off for the survey from CABE**



**Figure 3.4 Cyclists at the Main Administration, KNUST**



**Figure 3.5 Cyclists departing the Commercial Area for the Catholic Church**





**Figure 3.6 Cyclists on the Swimming Pool Road to the Unity Roundabout**

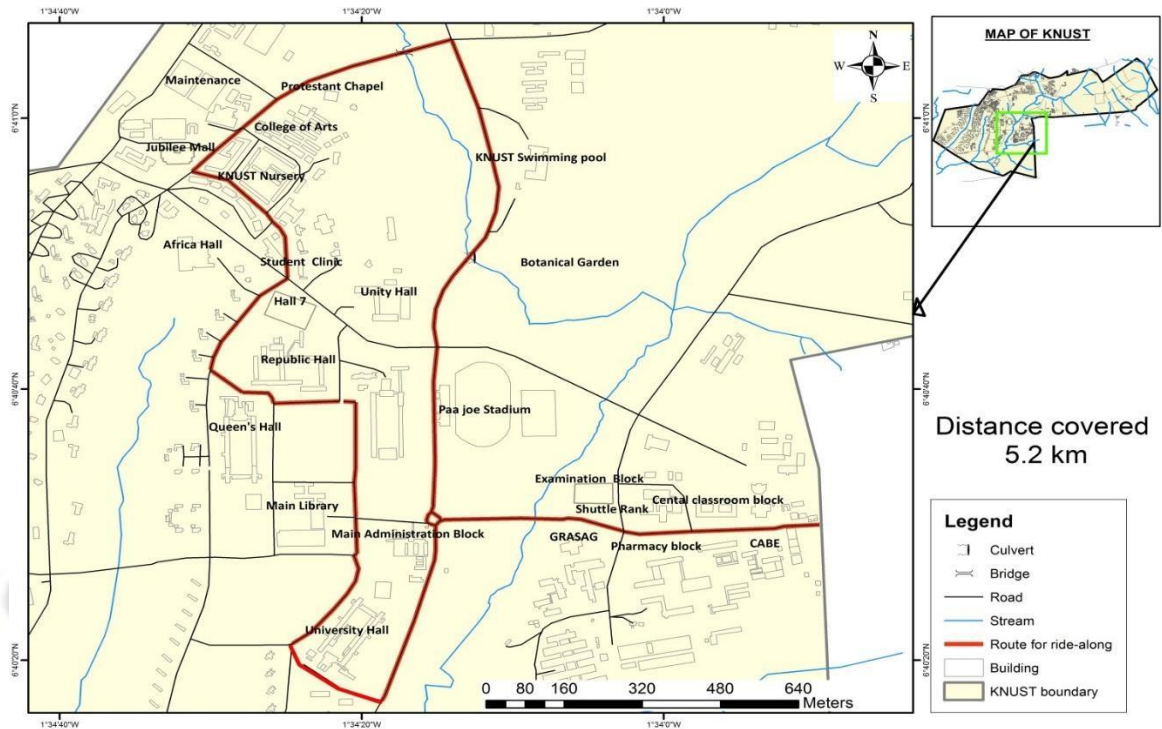


**Figure 3.7 A female cyclist negotiating the roundabout at the Main Administration, KNUST**

#### **3.4.3.1 The Route**

The KNUST campus has a well-developed network of roads linking most parts of the campus to one another. Many of the roads available for cycling are shared streets. A few have pedestrian walkways, but a large number still remain without protected paths for non-motorized travel. Given the various options of routes around the campus, amidst the limited time and other constraints, a few representative roads were selected for the study and subsequent design. Furthermore, Dill and Voros (2008) suggest that, “Higher levels of street connectivity are associated with more cycling for utilitarian trips”. In light of that fact, interconnectivity of the route was prioritized. The route for the survey is represented in Figure 3.8 and covered a total length of about 5.2 km. The route run through the College

of Architecture and Built Environment (CABE) to University hall (Katanga), and then to the Commercial Area through to the Catholic church/Protestant chapel area, to the KNUST Swimming Pool, before returning to the start point at the College of Architecture and Built Environment.



**Figure 3.8 Map with route for ride along survey (in red )**

These locations were regarded as randomly selected key trip attraction and destination zones for students on campus. The route was conveniently broken into four sections to aid in the specificity of data collected per section.

### 3.5 APPROACH FOR ANALYSIS

Based on the nature of the observations, the results would best be represented in descriptive form. As such, descriptive analysis was used in presenting part of the results of the analyzed data. Statistical packages including the Statistical Package for the Social Sciences (SPSS) and Minitab were employed in performing this task. The data analyses undertaken were descriptive statistics and exploratory factor analysis. It is said that, factor analysis is useful for finding clusters of related variables and thus ideal for grouping many variables into fewer ones that can be more easily understood. Factor analysis was therefore performed to observe which factors were the most influential in the low bicycle ridership amongst students, and centred on the specific objectives of this study.



# KNUST



## **4 ANALYSIS AND DISCUSSION OF RESULTS**

### **4.1 INTRODUCTION**

The analysis of primary data collected from both the general questionnaire and ride along survey is documented in this chapter. As earlier mentioned, respondents for both aspects of the study were randomly engaged. A total of 300 responses were received for the general questionnaire, while the ride along survey had the 30 participants answer questionnaires on the 4 routes surveyed.

The chapter discusses key factors underlying the low bicycle ridership on campus, factors which could encourage bicycling, as well as specific infrastructural challenges cyclists encounter while traveling along some selected routes on campus. Two different methods of analysis were employed; namely, descriptive statistics and factor analysis. The analyses centre on the specific objectives of this study. Tables, pie charts, and bar charts aided the discussions of the results.

### **4.2 RESULTS FOR GENERAL QUESTIONNAIRE**

#### **4.2.1 Demographic Data**

This section of the questionnaire sought some basic information on respondents so as to understand the characteristics of these individuals. The demographic data collected included respondents' gender, ability to ride a bicycle, bicycle ownership and present mode of transport. The importance of knowing the profile of respondents is to build confidence in the reliability of the collected data.

##### **4.2.1.1 Gender of Respondents**

For the purpose of this study, students of the KNUST campus were mainly targeted. As such, it was of interest to determine the genders of these respondents so as to have a clearer picture of some of the other ensuing results. Of the 268 respondents, 190 were males representing 70.9% and 78 female, representing 29.1%. Based on these figures, it can be said that more male respondents were recorded from the general survey, as far as this study is concerned.

##### **4.2.1.2 Ability to Ride a Bicycle**

This question was primarily asked to identify whether respondents knew how to ride bicycles. This was part of the attempt to understand whether low ridership was as a result of many people not knowing how to ride bicycles in the first place. The results show that

88.5% of respondents knew how to ride bikes, and only 11.5% stated otherwise. The proportions are illustrated in Table 4.1.

#### 4.2.1.3 Bicycle Ownership

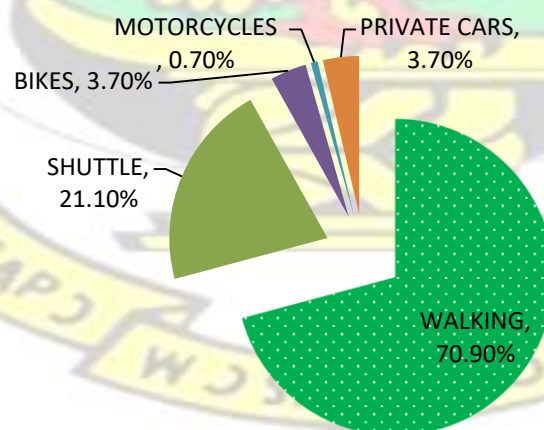
Respondents were also asked whether or not they owned a bicycle on campus. To this question, 92.6% of respondents answered no, with only 7.4% answering in the affirmative. The percentages were computed from 295 responses. The result certainly confirmed the fact that bicycle ownership was low among the student populace. This situation necessitated an inquiry into the primary modes of travel amongst students on campus. Table 4.1 shows a representation of these results in the form of a bar chart. **Table 4.1**

**Demographic Data Table**

	MALE			FEMALE		
	Yes	No	Total	Yes	No	Total
<b>Ability to ride bike</b>	194 (95.1%)	10 (4.9%)	204	61 (73.5%)	22 (26.5%)	83
<b>Bicycle Ownership</b>	20 (9.8%)	185 (90.2%)	205	1 (1.2%)	83 (98.8%)	84

#### 4.2.1.4 Primary mode of transport

The question on the primary means of travel was asked, to ascertain the various modes of travel that are mostly used by respondents. This provided a fair idea of how many of these students already subscribe to active modes of travel (Badland & Schofield, 2007), and also shed some light on the prevailing situation for transport on campus.



**Figure 4.1 Primary mode of transportation currently on campus**

Figure 4.1 shows the general mode of commuting with respect to the survey conducted. The percentage that uses the campus shuttle service as their primary means of getting about campus was 21.1%. Percentage that used private cars was 3.7%. another 3.7% stated that they used bicycles for most of their trips, with motorcyclists accounting for just 0.7%. Walk trips represented 70.9% of the primary modes of travel on campus. Table 4.2 also shows the various modes of transportation on the campus, by their respective gender distributions.

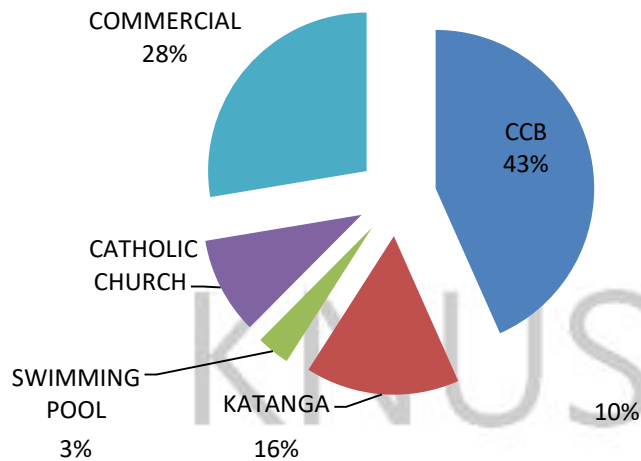
**Table 4.2 Modes of Transport on Campus by gender distribution**

Mode of Transport	Gender				Average
	Male	Percentage	Female	Percentage	Percentage
<b>Walking</b>	155	76.4%	49	59.7%	<b>71%</b>
<b>Bicycle</b>	10	4.9%	-	0%	<b>3.7%</b>
<b>Motorcycle</b>	1	0.5%	1	1.2%	<b>0.7%</b>
<b>Private Car</b>	5	2.5%	4	4.9%	<b>3.5</b>
<b>Shuttle Bus Services</b>	32	15.8%	28	34.1%	<b>21.1%</b>
<b>Total</b>	203	100%	82	100%	<b>100%</b>
<b>285</b>					

#### **4.2.1.5 Frequented locations**

Furthermore, it was also of some interest to identify the primary locations that these respondents frequented most within the campus environment. For this, respondents were asked to select any of the key activity locations identified. These locations were the Central Classroom Block, University Hall/Brunei, Swimming Pool, Catholic Church/Protestant Chapel, and the Commercial Area. The chart in Figure 4.2 presents the result of the inquiry. The Central Classroom Block attracted the most trips with 43% of respondents indicating that this was the one location on campus they frequented the most, Commercial Area ranked second with 28%, and Katanga/Brunei Hostel came third as one of the most frequented locations. The fourth and fifth most frequented areas were the Catholic Church/Protestant Chapel, and the Swimming Pool respectively. Tables showing an impression of most likely mode of Transport that would be used by a person to their most frequented location on the KNUST Campus were also developed and attached in the appendix (Table 7.1).

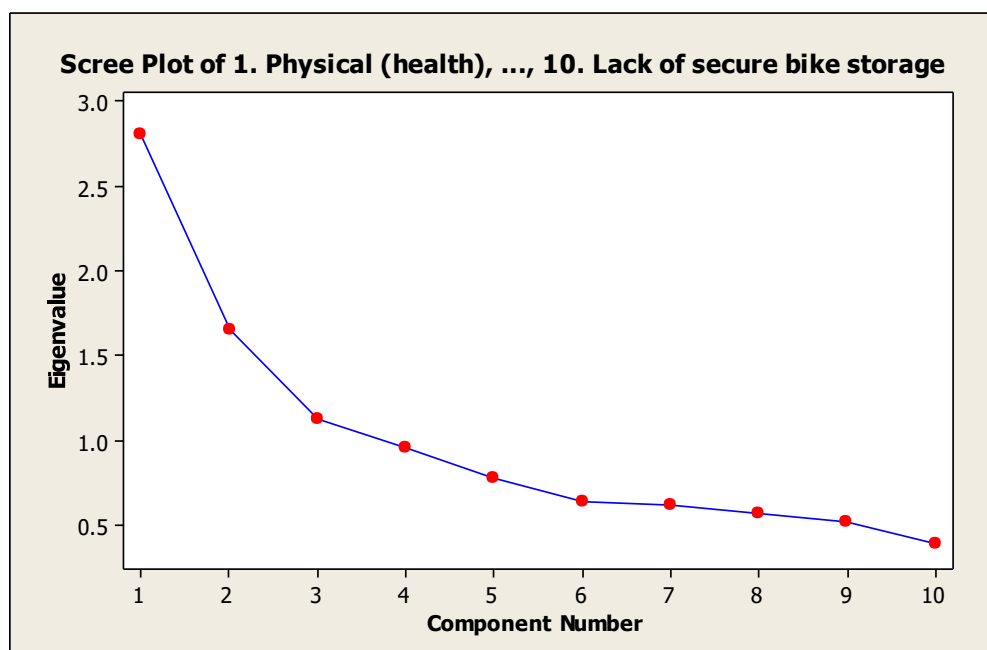




**Figure 4.2** Frequented Locations

#### **4.2.2 Factors Underlying the Low Bicycle Ridership**

The next section of the questionnaire sought to give respondents the opportunity to show by indicating on a five point Likert scale, if the factors identified truly limit them from bicycling on campus. Factors considered for this aspect of the study included; *Physical (health), Weather conditions, Terrain (steep hills) on campus, Access to a bicycle, Lack of parking for bikes and Bicycles are cool*, etc. It was assumed that, given the extensive nature of these variables, there was the possibility that some of these factors would result in effects that were more directly related to the low ridership than others. A reduction technique which would ascertain which of the specific variables was measuring aspects of the underlying facet was therefore required. The results of the factor analysis conducted are presented.



**Figure 4.3 Scree plot**

The scree plot (**Figure 4.3**) was used as the basis for selection of the number of factors to be extracted. The Guttman-Kaiser criterion for selection of factors suggests that only factors with an Eigen value of one and above should be retained. Applying these criteria to the plot helps to choose the required number of principal components. Based on the plot above, there should be **four (4)** components extracted.

### General Survey Eigen values

Eigen analysis of the Correlation Matrix

**Table 4.3 Total variance explained**

Component	Initial Eigenvalues		
	Eigenvalue	Proportion	Cumulative %
1	2.7954	0.280	0.280
2	1.6462	0.165	0.444
3	1.1178	0.112	0.556
4	0.9516	0.095	0.651
5	0.7764	0.078	0.729
6	0.6319	0.063	0.792
7	0.6172	0.062	0.854
8	0.5679	0.057	0.910

9	0.5141	0.051	0.962
10	0.3814	0.038	1.000

From **Table 4.4** the total variance explained by extracted components is as follows: **Component 1 (Transport System Factors)** which was the first principal component accounted for **28.0%** of the total variance. Likewise, **Physical and Natural Environmental factors**, the second principal component contributed **16.5%**. **Component 3 (Perception Factors)** and **4 (Availability of Bicycles)** accounted for **11.2%** and **9.5%** respectively. As a whole, the components extracted cumulatively explained **65.1%** of the variation in the data set. This also passes the cumulative proportion of variance criterion where the extracted components should altogether explain at least 50% of the variation.

**Table 4.4 Rotated Factor Loadings and Communalities**

Varimax Rotation

	Component				Communal ity
	Factor 1	Factor 2	Factor 3	Factor 4	
			-0.254	-0.151	
Physical (health)	-0.067				0.719
Weather conditions	0.077	<b>-0.785</b>	0.094	-0.032	0.631
Terrain (steep hills) on campus	0.303	<b>-0.699</b>	0.159	0.018	0.606
Don't own/have access to a bicycle	0.003	0.139	-0.028	<b>0.921</b>	0.869
Bicycles are cool	0.081	0.032	<b>-0.923</b>	0.030	0.861
Lack of good bicycle routes to my destinations	<b>0.720</b>	-0.075	-0.104	-0.201	0.575
The lack of specially created bicycle paths/lanes(for bicycles only)	<b>0.757</b>	-0.083	-0.283	-0.059	0.663
Speeds of motor vehicles and Inattentive /Aggressive drivers (make it unsafe for me to cycle)	<b>0.672</b>	-0.185	0.145	0.280	0.586
I consider the roadways on campus narrow	<b>0.725</b>	0.005	0.195	-0.061	0.568
Lack of secure bike storage/parking	<b>0.591</b>	-0.089	-0.121	0.247	0.433

Variance	2.7954	1.6462	1.1178	0.9516	6.5111
% Var	0.253	0.181	0.112	0.106	0.651

### Transport System Factors

<sup>1</sup>-ve sign indicates an inverse relationship between factor and variable however, the magnitude tells the actual strength of relationship. e.g. -.8 will have a strong inverse relationship between factor and variable as compared to +0.4. Thus, -0.8 should be considered as the stronger variable.

Component one (Transport system factors) consists of the following factors: *Lack of good bicycle routes to destinations, lack of specially created bicycle paths/lanes(for bicycles only), speeds of motor vehicles and inattentive/aggressive drivers (make it unsafe for me to cycle), narrow roadways on campus and lack of secure bike storage/parking.* All these variables were loaded together under the same component and contributed **25.3%** of total variance.

*Lack of good bicycle routes to destinations* scored an absolute Eigenvalue of **0.720** and was considered a very significant factor to respondents' non-use of bicycles on campus. Presence of good bicycle routes on campus imply that bicyclists can travel easily to many parts of the campus using bicycles, thus impacting the number of potential trips made by this means of transport. A lack of good useable bicycle routes also could consequently hinder promotion of bicycling, as cyclists could feel a sense of restriction in terms of routes available for their use. Respondents perceived that the lack of good bicycle routes was therefore a variable of high value. Availability of routes and ample interconnectivity therefore is of prime concern to respondents if they would consider cycling on campus.

*The lack of specially created bicycle paths/lanes (for bicycles only)* came out as one other important variable which could influence the choice of potential bicyclists. The Eigen value for this variable was **0.757**. Most respondents agreed that the lack of bicycle lanes and paths directly influenced their non-use of bicycles. This is consistent with previous studies where the lack of bicyclist specific infrastructure often is attributed as a major cause of not cycling. This also implies that respondents may be seeking separation from mixed traffic so as to be guaranteed of their personal safety if they have to use bicycles. In fact, Garrard et al. (2008) found that female commuter cyclists in particular preferred to use routes with maximum separation from motorized traffic. Improved cycling infrastructure



in the form of bicycle paths and lanes that provide a high degree of separation from motor traffic is likely to increase cycling amongst under-represented population groups such as women on campus, although this parameter must also be applied with caution because of cost implications.

*Speeds of motor vehicles and inattentive/aggressive drivers (make it unsafe to cycle)* had an Eigen value of **0.672** and can also be regarded as another noteworthy element that discourages potential cyclists from opting for bicycling. This factor takes into consideration, the safety of cyclists if they are to use roads in mixed traffic. Majority of respondents strongly agreed (47%), with 22.3% also agreeing that speed of cars and inattentive drivers were an inhibiting factor for them to safely cycle on campus. This pointed to the lack of encouraging transport system factors in providing potential cyclists adequate protection if they decided to commute by bike.

The next variable reflected was *narrow roadways on campus*, which had an Eigen value of **0.725**. The question was asked to find out whether respondents found the widths of campus roads to be too narrow to safely cycle. Majority of responses were affirmative. Here also, the presence of this parameter in component 1 indicated that this was another vital parameter which would influence respondents' decision to cycle in the future or not.

Finally, the *lack of secure bike storage/parking* also scored an Eigen value of **0.591**. Incorporation of secure parking areas for bicycles can be seen as an integral part of making campus more cycle friendly. In some jurisdictions, private developers and building owners are required by local ordinances to provide specified minimum levels of bike parking both within and adjacent to their buildings (Pucher & Buehler, 2008a). More potential cyclists may be encouraged to make trips by bicycle if they have some guarantee that there would be safe and secure places to park their bicycles at the trip attraction/destination zones. This question attracted a response of *strongly agree* from 50.2% of respondents with 23.2% also showing some agreement. The present lack of adequate safe parking facilities is therefore another important variable which potential cyclists felt limited them from cycling on campus and reflects the last of the perceived transport system challenges for non-cyclists.

### **Physical and Natural Environmental factors**

The second principal component constituted **18.1%** of the total variance recorded. This component was made up of 3 main factors; *physical (health)*, *weather conditions* and *terrain on campus*. These variables also had Eigen values of **-0.792, -0.785 and -0.699** respectively. There was consistency in the loadings with all variables loading negatively. The negative Eigenvalues in this case tell the story of a generally opposite/inverse relationship between factor and variable.

*Physical (health)* is a factor that was aimed at understanding whether the health of respondents was the reason for their non-use of bicycles. Health can be an essential determinant in whether or not a person cycles. On a University campus such as KNUST where there are many young, energetic and healthy people, one would expect that this would potentially not be a limiting factor, however, because of the general low ridership, it was of interest to consider this variable. Based on the responses received, nearly 50.8% of respondents strongly agreed that they were not held back by their health. Another 13.6% also agreed that health was not the factor limiting them from cycling on campus. It can again be said that, the Eigenvalue of **-0.792** is also reflective of the fact that it was an important issue, but generally had an inverse relationship with the use of bicycles or in other words, was not a major excuse for individuals non-use of bikes.

*Weather conditions* were also identified as the second of the **Physical and Natural Environmental factors** that could impact on respondents' choice to cycle. Bad weather restricts how much cycling can be done even when there is willingness. Here, there was the attempt to understand if perhaps the weather condition on campus was that which limited individuals from cycling. The better the weather conditions are, the less likely people would find it a hindrance to cycling. Results in this study show that of 295 respondents, 33.6% were completely unhindered by the weather on campus even though it still should be considered as one that has a direct effect on cycling.

*Terrain on campus* attracted an Eigen value of **-0.699** based on the responses gathered. It implies that for majority of respondents, the terrain plays a considerable role in their choice to cycle. It also confirms the assumption as stated by Goetzke and Rave that a city's physical and social environment (i.e. topography, infrastructure and socioeconomic composition) plays a dominant role in determining how many people use their bicycles (Goetzke & Rave, 2011). The results from this study imply that many potential cyclists

perceive that the terrain on campus is not a hindrance for them to commute by bicycle, although it would nonetheless be a key factor influencing their choice to cycle or otherwise.

### **Perception Factors**

Perception related factors were the third principal component identified in this study. Under this component, the variable *bicycles are cool* was the only factor present and also had a variance of **11.2%**. Perception plays a pivotal role in everyday choices. The perception that potential cyclists have about cycling is therefore essential in understanding the challenges for cycling. Perception can either be positive or negative.

Where perception is positive, promotion of bicycling for instance could require less effort, as the people already are willing or inclined towards the activity being promoted. The statement *bicycles are cool* was included in the questionnaire to understand the current perception of individuals and also to find out how much perception was a key factor to their potential use of bikes. Given the Eigen value of **-0.923**, it appears that indeed, on the KNUST campus, perception is a key parameter that could affect cycling. Additionally, the results suggest that there was a 76.9% agreement (49.3% strongly agree, 27.6% agree) that bicycles were cool. This implies that there generally is a positive perception of bicycles among students, making it also not much of a limiting factor for the use of bikes. This can therefore be seen as a positive in terms of overall bicycling promotion as pointed out by Alvaro-Fernandes-Heredia (2013) .

### **Availability of Bicycles**

The fourth most significant component was the **availability of bicycles** which contributed **10.6%** of total variance. Under this component also, just one factor was present, and this factor was identified as *do not own/have access to a bicycle*. This factor had an Eigen value of **0.921**. The availability of a bicycle in the first place must therefore be considered a key determinant of whether or not people opt for cycling as a means of transport. The results also go to confirm findings by Dill & Voros (2008) and Álvaro Fernández-Heredia (2013) who classified the availability of bicycles under the various socio-demographic characteristics influencing the decision of an individual to ride a bicycle. The results suggest that for this study, majority of student respondents stated that they were not riding bicycles on campus mainly because they did not have access to the bikes. This is in spite of bikes being cheaper to travel with as compared to shuttle services on campus. The initial



cost of purchasing a bike may be a deterrent as the average price of a bike in Kumasi is about GH¢250. Coupled with this cost factor is the challenge of actually transporting the bikes to campus from town, a situation which many students may find cumbersome. Also, the non-existence of a hiring service that makes it possible for students to use bikes on campus for a fee could be considered another reason.

The unavailability of bicycles as well as the perceptions that people had of bicycles certainly were very important components in determining whether individuals would use bicycles for their trips or not. The respective Eigen values that these variables attracted are indicative of how much they should be given attention in the promotion of bicycle culture on campus.

#### **4.2.3 *Bicycling Inductive Factors***

After identifying the limiting factors for low ridership on campus, there was some interest in testing a few potentially encouraging factors. This was aimed at outlining some meaningful interventions and observing responses of individuals to them.

Respondents were asked 'What factors would encourage you to use a bicycle on campus?' Some of the proposed encouraging factors were '*creation of new off-street bicycle paths/lanes, provision of safer bicycle parking facilities and other infrastructure, I would cycle more if more of my friends cycled*' etc. Responses were indicated once again on a five point Likert scale. On the Likert scale, 1 was regarded as not important, 2 was less important, 3 was moderately important, 4 was important and 5 was very important.

Some descriptive analysis in the form of bar charts and pie charts as well as a ranking of the factors was done to determine the order of priority of the factors. Rankings were based on mean values for these questions. For each variable, the null hypothesis was that this variable was not significant ( $H_0: U=U_0$ ). The  $U_0$  is the critical rating above which the variable is considered important. The higher ratings of 4 and 5 were chosen for the rating scale as important and very important respectively while the  $U_0$  was set at 3.5. These responses and results are discussed briefly below;

##### **4.2.3.1 *Creation of off street bicycle lanes***

The response of individuals to the creation of off-street paths and bicycle lanes was needed to understand how they would react to having this infrastructure in place. From below, 188



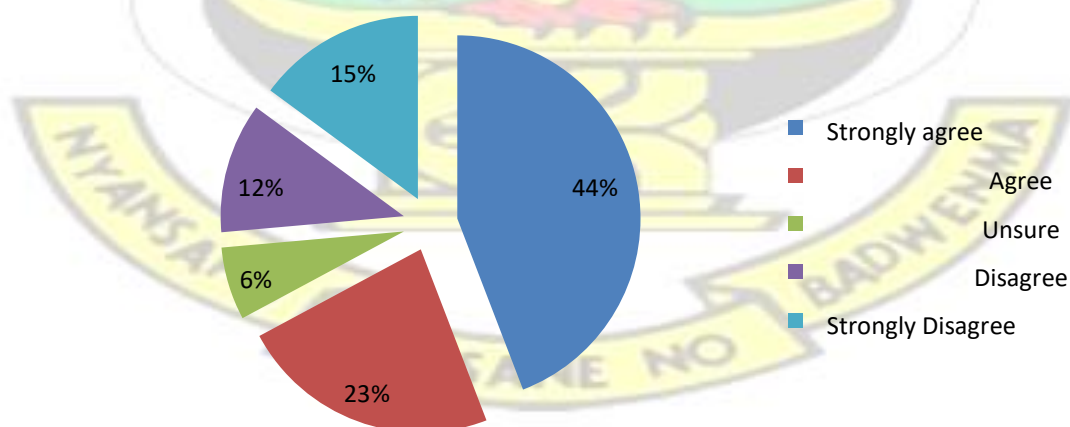
people, representing 63.5% stated strongly that they would be more inclined to cycle if there were off-street bicycle lanes/paths to separate them from traffic.

**Table 4.5 Creation of off-street paths**

Rating	Frequency	Percentage	Cumulative Percentage
1 (Strongly disagree)	15	5.1%	5.1%
2(Disagree)	11	3.7%	8.8%
3 (Neutral)	25	8.4%	17.2%
4(Agree)	57	19.3%	36.5%
5(Strongly Agree)	188	63.5%	100%
Total	296	100.0	

#### 4.2.3.2 Education on bicycle safety

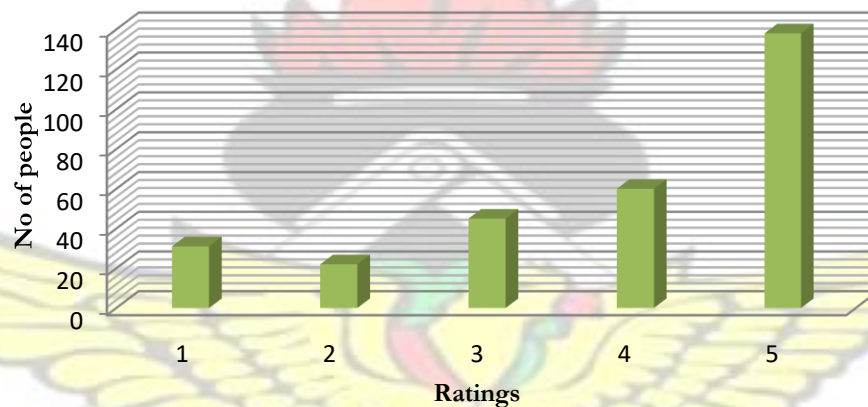
**Figure 4.4** shows what respondents thought about the role of education in encouraging their use of bicycles. 44% strongly agreed that some education on bike safety would encourage them cycle. 23% also agreed. However, 12.5% showed some disagreement to the fact that education would play any special role in encouraging their use of bikes. 6.2% were uncertain about the role education could play in getting them to cycle.



**Figure 4.4 Education on bicycle safety**

#### 4.2.3.3 Peer influence

This question was asked to identify the extent of peer influence on the individual's decision to cycle on campus since previous research has already suggested that people enjoy cycling in groups as a result of peer influence. A close look at the bar chart (**Figure 4.5**) reveals that 138 respondents, representing 46.6% strongly agreed. Another 60 representing 20.3% showed agreement. There were also some disagreements recorded. 10.5% strongly disagreed that peer influence was a factor in informing their decision to ride bicycles, while 22 people representing 7.4% also disagreed. This infers that most respondents in this study would be more inclined to cycling through peer influence. It is therefore imperative that the peer influence and group perceptions are factored into any interventions or measures to encourage biking culture.



**Figure 4.5 Peer influence**

#### 4.2.4 Inductive Factors

From Table 4.6, all five factors had a standard deviation greater than one (1). Three of the factors had means greater than 4 (agree) these were: *creation of new off-street bicycle paths/lanes*, *education on bicycle safety* and *provision of safe bicycle parking facilities/racks and others*. The means of each of these have been displayed in the table below. Rankings were based on the mean; with higher mean values being ranked higher/ top priority. Worthy of mention is the fact that, all the factors had standard error means that were close to zero, which also indicates a great consistency in responses especially whenever respondents showed agreement.

#### 4.2.4.1 Ranking of Inductive factors

*Creation of new off-street bicycle paths/lanes* was ranked as the first most important factor that could encourage cycling (Table 4.6). *Provision of safe bicycle parking facilities/racks and others* was ranked by the respondents as the second most important factor while *education on bicycle safety* and *I would cycle more if more of my friends and colleagues cycled* were ranked as the third and fourth most important factors respectively. Drawing from the table, *higher shuttle prices* was not a factor which would draw respondents to ride bicycles, as it was ranked fifth. Higher shuttle prices could rather discourage biking, especially if prices of shuttle rides are increased specifically to get people to cycle more.

**Table 4.6 Ranking of Inductive factors**

	Ranking	Mean	Std. Deviation	Error Mean	95% Std. CI	N
<i>Creation of new off-street bicycle paths/lanes</i>	1 <sup>st</sup>	4.3276	1.1019	0.0644	(4.2009,4.4543)	296
<i>Provision of safe bicycle parking facilities/racks and others</i>	2 <sup>nd</sup>	4.2260	1.1108	0.0650	(4.0981,4.3540)	296
<i>Education on bicycle safety</i>	3 <sup>rd</sup>	4.0068	1.2021	0.0702	(3.8686,4.1450)	296
<i>I would cycle more if more of my friends and colleagues cycled more</i>	4 <sup>th</sup>	3.8567	1.3573	0.0793	(3.7006,4.0127)	296
<i>Higher shuttle prices</i>	5 <sup>th</sup>	2.6041	1.6027	0.0936	(2.4198,2.7884)	296

#### 4.2.5 Additional Descriptive Questions

Besides the ranked questions, some additional questions were asked to which respondents were required to reply in the affirmative or otherwise. The questions were geared at understanding and anticipating the respondents' choices if their needs for bicycling were fully addressed.

#### ***4.2.5.1 Have you ever considered using a bicycle on campus?***

The responses to this question provided insight on whether respondents had considered the use of bicycles prior to the research. Rather surprisingly, 213 respondents representing 71.7% of all participants indicated they had previously considered the use of bicycles on campus. Only 28.3% (84 people) disagreed that they had not considered the use of bikes as an alternative means of transport.

#### ***4.2.5.2 Bike use in the case of improved safety***

Respondents were asked, “Would you cycle if bike safety was improved?” at the end of the study, to ascertain from potential users whether or not they would opt for cycling as an alternative means of travel in the case of improved overall safety. Here, 252 (84.8%) responded in the affirmative with 45 people (15.2%) saying they would not. The results suggest that most people are likely to cycle in the case of improved and safer situations for bicycling.

#### ***4.2.5.3 Bike use in the case of secure parking areas***

In this study, the scope consisted of people who were active bicyclists as well as potential cyclists. Both sets of respondents were targeted, however, from Figure 4.1 it can be seen that majority of individuals stated they did not use bikes presently on campus. As such, the question, “Would you cycle if there were secure parking areas for bikes?” was asked, to determine whether an improvement of security of parking places would consequently result in more people riding bikes on the campus. **Table 4.7** demonstrates the responses obtained. 83.5% of respondents stated they would cycle if there were secure parking areas for bikes. 16.5% also stated they would not cycle even if there were secure parking for bikes.

Table 4.7 Would you cycle if there were secure parking areas for bikes?

<b><i>Response</i></b>	<b><i>Yes</i></b>	<b><i>No</i></b>	<b><i>Total</i></b>
<i>% response</i>	83.5	16.5	100
<i>Number</i>	248	49	297



### 4.3 RESULTS FOR RIDE ALONG SURVEY

#### 4.3.1 Road Infrastructure

For this aspect of the study, another set of questionnaires were issued to individuals to seek their opinions on the road infrastructure on campus after the ride along survey. The objective was to determine how potential cyclists felt about the present infrastructure and their thoughts on some possible improvements. The route for the survey was broken into four sections with the aim of addressing the specific challenges for each particular section. These subsections were identified as stretches from College of Architecture and Built Environment (CABE) to Katanga (University Hall), Katanga to Commercial Area, Commercial Area to KNUST Swimming Pool and finally from the Swimming Pool Area back to CABE. Responses were indicated on a 5 point Likert scale questionnaire where ratings ranked from *1, strongly agree* to *5, strongly disagree*.

Use of Descriptive statistics was considered as a fitting approach for analyzing this portion of the work because it helped bring to light the most significant infrastructural problems for discussion.

In performing this task, factors such as *creation of cycle routes and crossings at intersections, safe parking places, landscaping (Aesthetics), feeling of safety among other traffic, unpleasant hilliness, need to slow down speeds of vehicles* among others, which were being considered for this study, were ranked based on their means. The eight (8) topmost infrastructural challenges were highlighted for discussion.

Furthermore, mean score plots were generated for each question as part of the results to illustrate and aid in comparing the relative importance/prevalence of a given factor along respective corridors of the route. Bar charts also elucidate the extent to which participants responded to the questions and help better understand the results.

##### 4.3.1.1 Ranking of Infrastructural challenges

From Table 4.8, it is evident that most factors had a standard deviation slightly greater than one, indicating that there were a few discrepancies in respondents' interpretations. This probably also occurred because the majority of respondents were potential cyclists and might not have had a long term observation of the factors. It is anticipated that, an increased familiarity with the facility amongst cyclists could therefore generate even lower values for the Standard Deviation values. However, three of the factorsnamely; *Required off-*

*street bicycle paths to improve safety, Creation of routes & crossings through intersection and Drainage coverings and Ramps* had standard deviations of 0.8311, 0.7425 and 0.9917 respectively, showing a strong consistency in respondents' interpretations of these factors.

Again, on the same table, a ranking of the factors was conducted based on their means. This placed *creation of routes and crossings through intersections*, as the most important infrastructural concern. *Cyclists require an off street bicycle path/lane* was ranked by the respondents as the second most important factor while *drainage coverings and ramps* as well as *need to slow down speeds of vehicles on this road* were ranked as the third and fourth most important infrastructural considerations respectively. Drawing from the table, all the respondents agreed that *adequacy of lighting along route* and *unpleasant hilliness* are the least important infrastructural considerations since they were ranked fourteenth and fifteenth respectively.

**Table 4.8 Ranking of Infrastructural challenges**

	Mean	Std. Deviation	Difference from Upper/Lower bound	Rank
<i>Creation of routes, crossings through intersection</i>	1.4336	0.7425	0.4336	1 <sup>st</sup>
<i>Cyclists require an off street bicycle path/lane</i>	1.4957	.83113	0.4957	2 <sup>nd</sup>
<i>Drainage coverings and ramps should be provided along this route</i>	1.7544	.99166	0.7544	3 <sup>rd</sup>
<i>There is the need to slow down speeds of vehicles on this road</i>	1.8609	1.00775	0.8609	4 <sup>th</sup>
<i>Roads narrow for cycling</i>	1.9739	1.21005	0.9739	5 <sup>th</sup>
<i>The road markings and signage at the intersection are inadequate</i>	1.9912	1.09298	0.9912	6 <sup>th</sup>
<i>Safe parking places are unavailable</i>	2.243	1.089	1.2435	7 <sup>th</sup>
<i>I am unable to ride my bicycle safely on the pedestrian sidewalks along this route</i>	2.351	1.15966	1.3509	8 <sup>th</sup>
<i>Landscaping (Aesthetics)</i>	2.4783	1.0542	1.4783	9 <sup>th</sup>
<i>I felt safe among other traffic</i>	2.487	1.293	1.4870	10 <sup>th</sup>

<i>Ease of cycling around roundabout</i>	2.618	1.181	1.6182	11 <sup>th</sup>
<i>Locations are too far for cycling</i>	2.626	1.274	1.6261	12 <sup>th</sup>
<i>I felt safe negotiating the intersection</i>	2.679	1.289	1.6786	13 <sup>th</sup>
<i>Adequacy of lighting along route</i>	2.783	1.234	1.7826	14 <sup>th</sup>
<i>Unpleasant hilliness</i>	2.982	1.344	1.9825	15 <sup>th</sup>

Based on the rankings, the eight (8) most prominent infrastructural issues that cyclists faced on the routes were; *creation of routes & crossings through intersections; cyclists require an off street bicycle path/lane; drainage coverings and ramps should be provided along this route; need to slow down speeds of vehicles on this road; narrow roadway for cycling; adequacy of road markings and signage at intersections; safe parking places; and pedestrian sidewalks along this route.*

#### **4.3.1.2 Most Prominent Infrastructural Challenges**

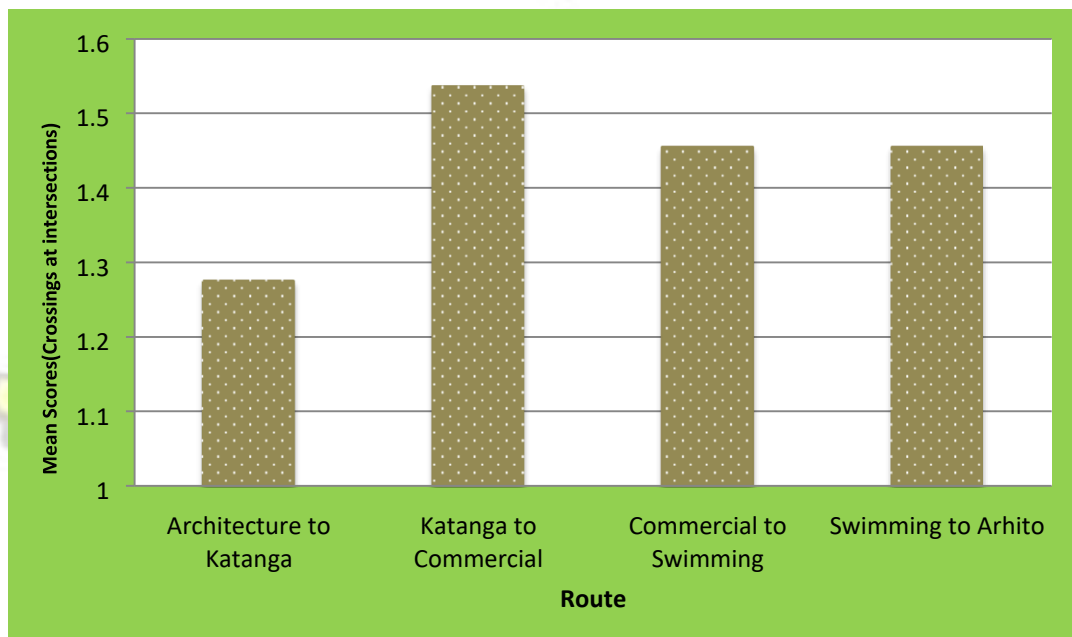
Given the responses and the resulting rankings, the following challenges were identified as key for discussion; *creation of crossings through intersections, required off-street bicycle paths to improve safety, need for drainage coverings and ramps, need to slow down speeds of vehicles, narrowness of road for cycling, adequacy of road markings and signage, availability of safe parking places* and finally *cycling on pedestrian sidewalks*.

The variables have been discussed according to their rankings. Charts of the mean scores have been included to show the variations in the responses when travelling on different sections of the route.

1. ***Creation of routes and crossings through intersections***- ranked first among the prominent infrastructural issues and proposes the creation of designated routes for bicycles through intersections. Intersection safety is very important in making the campus very cyclist friendly. It has been determined that, at intersections, higher vehicle volumes and turning lanes were associated with higher risks for cyclists (Harris et al., 2013). Cyclists in this study agreed that the provision of cycle routes through intersections could help allay some of the safety concerns they expressed with the present infrastructure and could make them feel more at ease in mixed traffic. The intervention attracted an SD lower than 1, and



as such shows there was significant consistency in the responses received on all sections. It also implies that in most cases, cyclists felt the creation of cycle routes and better crossings could improve manoeuvrability at intersections. From Figure 4.6, it can be seen that the mean values to this question also ranged between **1.536** and **1.276** and suggest the high demand for the intervention. Respondents however felt the crossings were most required at the Shuttle rank intersection on the **Architecture to Katanga** route where the mean was approximately **1.276**. Figure 4.6, which is the mean chart for the question reflects the responses on the various sections.

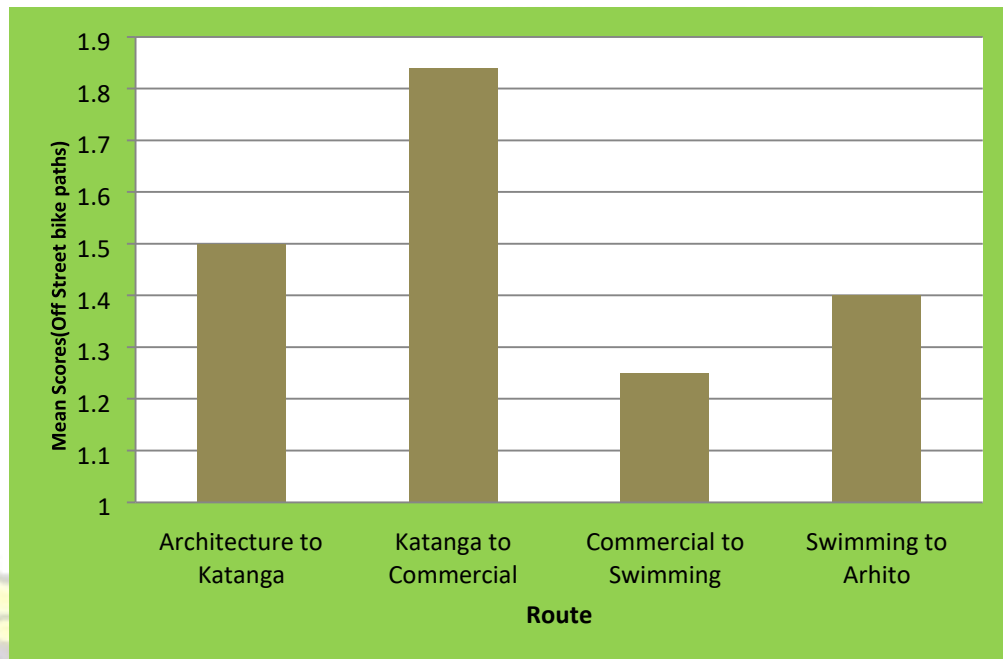


**Figure 4.6 Mean responses to creation of routes & crossings through intersections**

2. ***Required off-street bicycle paths to improve safety-*** Off-street bicycle paths are often seen to be a one off solution to encouraging bicycling. However, this is not necessarily true. The provision of bicycle paths must be closely tied to the safety requirements of the community. In this research, participants in both aspects showed through their responses that safety is one of their main concerns when it comes to getting them to cycle. As such, the provision of off-street bicycle paths should be seen as a warranted infrastructural improvement. On all four sections of the route, participants indicated that off-street paths were essential. In spite of this, there were some slight differences in how much the intervention was required on some routes as compared to others. These respondents called for the off-street bicycle paths especially on the **Commercial to Swimming Pool through to Architecture** routes. Given how much



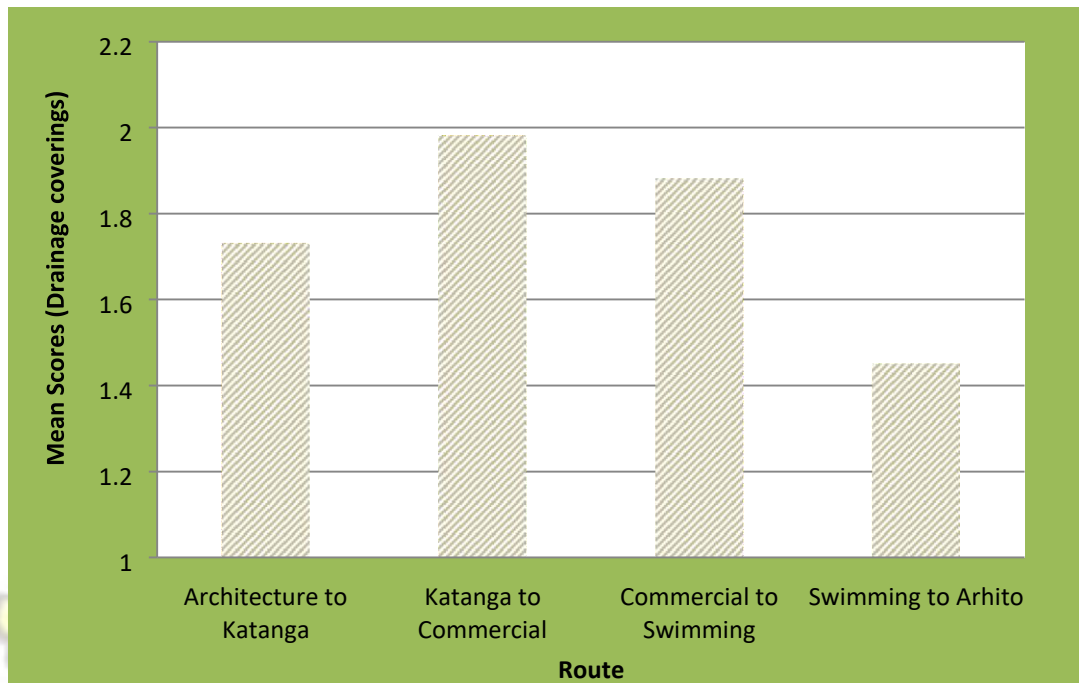
individuals prioritize safety as a whole in their use of bicycles, making provision for such infrastructure can tremendously reduce the potential of injury and increase the feeling of safety among cyclists and even potential cyclists who would then be encouraged to cycle. Figure 4.7 shows the mean responses for the question and reflects the perception on the various sections.



**Figure 4.7 Mean responses to required off-street bicycle paths**

3. ***Drainage coverings and Ramps***- Provision of *drainage coverings and ramps* also come in as an essential factor which could aid bicyclists' travel. Typically, drainage coverings may not be considered much of an important parameter for cycling, however, on the KNUST campus; there are many open drains which are situated on either side of most roads. As a result, cyclists in mixed traffic situations have to be extra cautious to avoid falling into these open drains, especially when they ride along the shoulders of the roads. The open drains also influence interconnectivity between routes at given locations and require that cyclists first carry their bicycles over certain portions which makes cycling more cumbersome. The mean scores suggest cyclists felt there was a greater need for this intervention mostly on the **Swimming Pool to Architecture road**, followed by the **Architecture to Katanga** stretch. These sections scored mean values of **1.45** and **1.73** respectively. The mean score chart (Figure 4.8) also shows that the **Commercial to Swimming Pool** section, and the **Katanga to Commercial Area** section, must receive

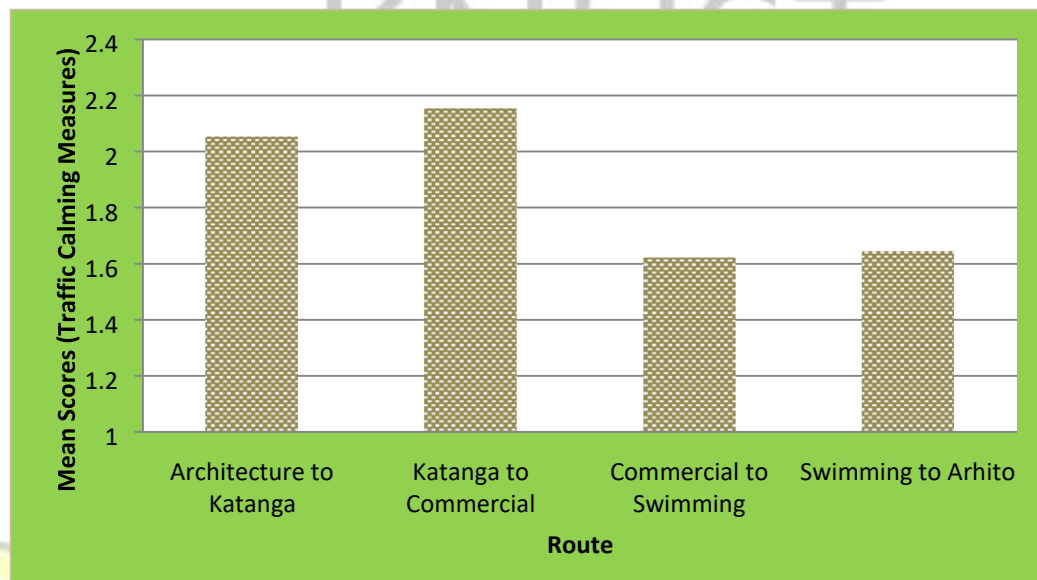
attention, in terms of drainage coverings and ramps. Based on the overall mean value of **1.754**, it can be said there was however, a general consensus on the need for drain coverings on all roads. Consequently, it ranked third among the prominent infrastructural challenges.



**Figure 4.8 Mean responses to Drainage coverings & Ramps**

4. ***Need to slow down speeds of vehicles using traffic calming measures-*** It has already been determined that cyclists place a high value on their personal safety especially in mixed traffic. As such, any factor which may perhaps make the use of bicycles in mixed traffic unsafe can be seen naturally as one in opposition to the goal of promoting bicycling. Cars travelling at high speeds can be seen as one such opposing factor. The speeds of cars were of concern particularly on the **Commercial Area road** passing through **the Swimming Pool section back to CAFE**. This is demonstrated in Figure 4.9 where both these sections had means of **1.621** and **1.643** respectively. Speed reduction may be seen as a solution which can be achieved through policies and a host of other innovative measures. Traffic calming of all residential neighbourhoods via speed limit (30 km/hr) and physical infrastructure deterrents for cars may possibly be implemented in such cases (Pucher & Buehler, 2008b). In the case of campus, the implementation of policies on speed could be appropriate. Also, some past traffic calming interventions such as speed bumps and humps

used previously could be revisited and more appropriately implemented if need be, to calm traffic. At the same time, special consideration should be given to bicyclists when providing these traffic calming measures so that they do not end up impeding or inhibiting cycling. This may very well create the perception of safety needed to encourage potential cyclists to cycle.



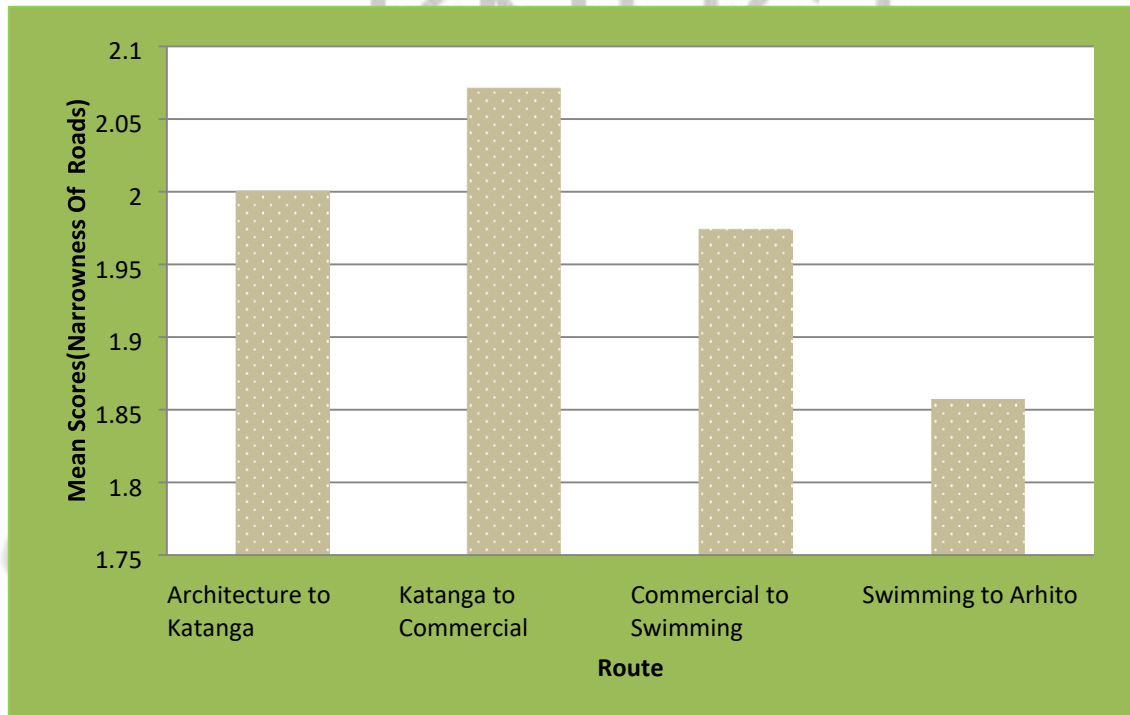
**Figure 4.9 Mean responses to traffic calming measures**

5. ***Roads are narrow for cycling*** was asked to ascertain whether cyclists felt the width of roads allowed them ample space to cycle safely on the shoulders in mixed traffic. The challenge was considered prevalent mostly on the **Swimming Pool to CAFE** section followed by the **Commercial Area to Swimming Pool** route. The results implied that cyclists perceive roads in these locations to be narrow for cycling. One may find it interesting that, on these roads, *speeds of vehicles* was also considered an important issue, suggesting cyclists must have been even more concerned about the width of the carriageway where they had to travel with excessively speeding vehicles. It is also fair to assume that, challenges with the width of the road may be made even more prominent where there are opened side drains which in turn constrain cyclists to balance between the narrow road widths and the drains.

The Katanga to Commercial area stretch attracted the highest mean value of **2.071**, while the lowest mean of **1.857** was estimated for the Pool to Architecture section; both of which can be seen on the mean graph (Figure 4.10). The results also are suggestive of the fact



that the Swimming Pool to Architecture route was considered most narrow in this regard, while the Katanga to Commercial section is considered the least narrow. Overall, the question scored a mean of **1.974** from the computations with a SD of **1.210**. It implies there was not much significant difference in the responses to this question and suggests that, generally the road widths on campus were considered narrow in the opinion of cyclists.



**Figure 4.10 Mean responses to narrowness of campus roads for cycling**

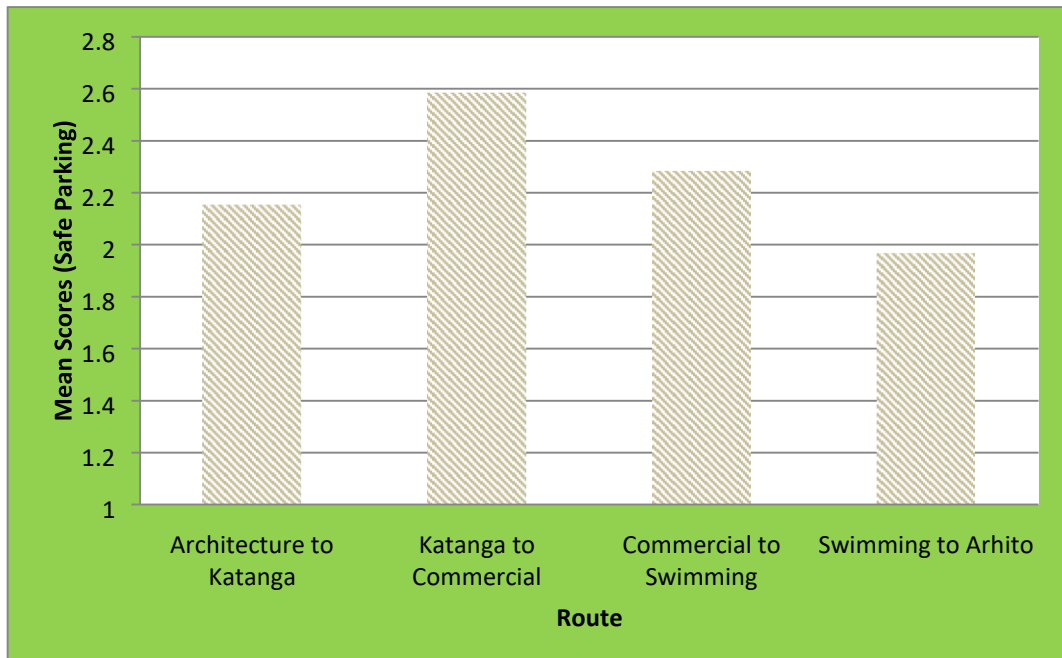
6. ***Inadequacy of road marking and signage at intersections*** also was a major challenge identified at the time of the ride along survey by cyclists. The issue was of prime concern firstly on the **University Hall (Katanga) to Commercial** route and secondly, the **Commercial Area to Swimming Pool** road based on their mean scores of **1.679** and **1.931** respectively. The specific intersections which needed to be addressed were the Hall 7 intersection on the first route, and the intersections at both the filling station and the former College of Art leading to the UITS intersection for the second route.

Signage and markings at intersections can help alleviate some of the challenges presently faced at intersections when cyclists have to join mixed traffic. Cyclists felt that there was not adequate or advance notice of signage or road markings at intersections which would help them move safely through to their destinations. In fact, the KNUST Land Use Plan

(2014-2024) attests to this by stating that, “there currently exists a major problem of vehicle-pedestrian conflicts at many locations on campus. This has been attributed mainly to the lack of pedestrian walkways and inadequate road markings on most roads on campus. The Farm Road, the Ayeduase- Paa Joe Roundabout Road and the College of Architecture and Planning section of the Duncanson Road were some of the places that this occurrence was seen to be most prevalent” (KNUST Planning Department, 2014).

Once again, respondents gravitated towards responses that showed an agreement on the Likert scale. The averaged mean deduced from all legs of the route for this question was **1.991** which also supposes that cyclists thought there were generally poor road marking and signage at all intersections they encountered during the ride along survey.

7. *Need for safe parking places* came up as one of the key factors for cycling on campus. Based on the results, it can be said there were some differences in responses to the question depending on the route being travelled. The question attracted an overall mean of **2.243** and a SD value of **1.089**. The fact that safe parking places ranked highly (**7<sup>th</sup>**) among the top concerns for biking on campus, also reflects the need to make available, infrastructure such as bicycle racks and more secure parking facilities on campus. The responses suggest that there was generally a lack of safe places to park one’s bicycle between nodal points along the route for the ride-along survey. This would result in cyclists having to park their bicycles by locking them to street light posts or any other available unmovable structures instead of having designated parking facilities. The severity of the problem was most felt on the **Swimming Pool to Architecture section** where this road attracted a mean value of **1.964**. A comparison of the situation on the various routes is made evident in Figure 4.11.

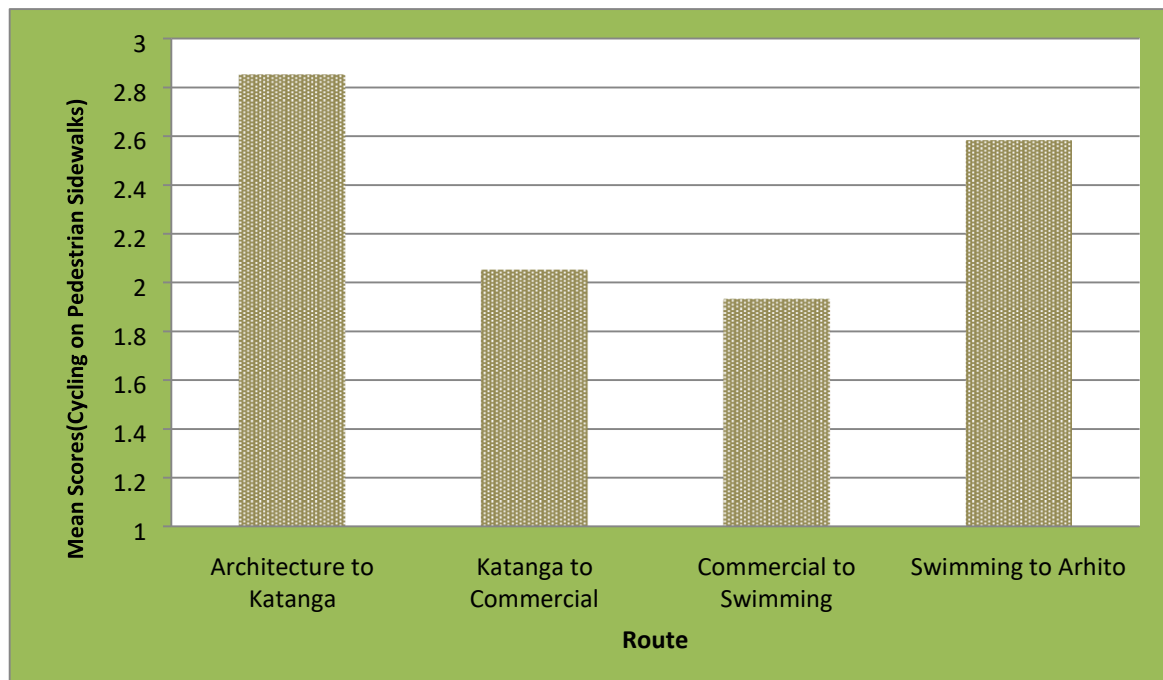


**Figure 4.11 Mean responses to Safe parking places**

8. *Cycling on pedestrian sidewalks-* Finally, *cycling on pedestrian sidewalks* has several implications for both cyclists and pedestrians. Harris et al (Harris et al., 2013) found evidence that bicycle-specific infrastructure (eg, bike routes, painted bike lanes and offroad bike paths) were associated with the lowest injury risks, and also that sidewalks and multi-use trails were associated with higher risks of injuries for both cyclists and pedestrians. This may explain why cyclists in many cases have disagreed that it was safe using pedestrian sidewalks. The question was asked to understand whether cyclists could use the pedestrian sidewalks available on campus comfortably. However, it turns out that respondents thought cycling with pedestrian traffic would require greater effort and restraint on the part of cyclists in order to avoid possible collisions.

The lowest mean recorded for this question was **1.931** on the Commercial to Swimming Pool section which was just slightly lower than the group mean of **2.351**. This was closely followed by cycling on pedestrian sidewalks on the Katanga to Commercial Area section which came in second. Cycling on pedestrian sidewalks on the **Swimming Pool to CAFE** and the **CAFE to Katanga** sections were even more unacceptable, as can be seen from the mean graph in Figure 4.12.





**Figure 4.12 Mean responses to cycling on Pedestrian Sidewalks**

On the **Swimming Pool to Architecture** section, respondents could have given such responses because even the pedestrian path along the road was not well developed at the time of the study, whereas in the case of the **Architecture to Katanga** section, the disagreement may have bordered on the fact that high pedestrian traffic on the sidewalks would cause discomfort to users and require extra caution from cyclists. Ultimately, it makes this one of the most difficult if not impossible sections to ride one's bicycle on the pedestrian sidewalks.

## 5 CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

The main objective of the study was to determine the feasibility of introducing a bicycle scheme on KNUST campus as an efficient mode of travel. Specifically, the study also sought to establish community members' perceptions and willingness to use bicycles, in addition to the main challenges of using of bicycles within the study area. These findings were to serve as the basis for the development of a suitable bicycle network for the campus. Accordingly, the following conclusions were drawn based on the results of the study.

#### 1. *Infrastructural challenges-*

Based on the available infrastructure on KNUST campus, it can be said that there is still a substantial amount of ground to cover in terms of becoming truly cycling friendly. The most prominent infrastructural challenges identified were; (i) issues with crossing intersections, (ii) lack of off-street bicycle paths along road sections, (iii) need for drainage coverings and ramps on roads, (iv) inadequate traffic calming, (v) issues with current width of roads, (vi) road marking and signage problems, (vii) unavailable safe parking places, and (viii) inability to share pedestrian sidewalks.

#### 2. *Perceptions and willingness-*

Generally, it does appear that most individuals are interested or would be interested in riding bicycles despite the relatively low ownership. In fact, 71.7% of respondents stated they had previously considered using bicycles on campus prior to the survey and 84.8% of respondents also expressed interest in riding bicycles on campus, if safety was improved.

#### 3. *Factors underlying low ridership-*

The main factors currently underlying low ridership on campus are categorised under; (a) Transport system factors, which include the speed of vehicles on campus, lack of off-street bicycle paths, among others; (b) Physical and Natural Environmental factors consist of weather, terrain and health of cyclists; (c) Perception related factors which relate to the impressions and attitudes of people towards bicycling and (iv) Unavailability of bicycles.

#### 4. *Bicycling Inductive factors-*

The creation of off-street bicycle lanes, education on bicycle safety and to some degree, peer influence could help induce the bicycling culture on campus. Higher shuttle prices were however not seen to be an inducing factor, especially if the measure is to be instituted specifically to get more people to cycle. Given the fact that 88.5% of individuals expressed their ability to ride bicycles, it would make sense to take advantage of the right inductive factors to encourage cycling on campus.

## 5.2 **Recommendations**

The recommendations provided seek to address the major problems identified in Chapter 4. By implementing the following recommendations, safety, maintenance, connectivity, and user-friendliness will be improved.

### 5.2.1 *General recommendations*

1. Firstly, it is recommended that policies should be established aimed specifically at the prioritization of non-motorized transportation. Taking this step would empower users of non-motorized transportation on campus, and ensure respect among all road users. In this respect, personal cars must give recognition and priority to bicycle users and pedestrians, while bicycles also give priority to pedestrians on all roads on campus.
2. Also, ample education on the use of bicycles is required. Drivers in particular, must be educated to be more tolerant towards cyclists and pedestrians. Students and staff must also be educated on the possible benefits of cycling and on defensive cycling.
3. Furthermore, it is recommended that the University establishes a bicycle scheme on campus on a pilot basis. The University could partner with the private sector in the acquisition of bicycles, which may be hired out to students interested in using them on semester basis. This could help those interested in cycling but cannot afford to purchase their own bikes, and would at the same time be convenient to others who may have personal bikes at home but cannot convey them to school.



4. Again, it is recommended that all open drains on campus be well covered. This measure should be taken seriously to prevent accidents. Placement of ramps should also be considered at several locations to allow for smoother transition from off-street facilities unto the main roads.

### **5.2.2 *Infrastructural recommendations***

With regard to specific infrastructural recommendations on campus, the following measures may be considered:

1. There is the need to provide cycle routes and crossings at intersections of most roads on campus to allow cyclists to cross streets safely and with greater ease. Specifically, these interventions are recommended for the Shuttle rank intersection, the former College of Art leading to UITS intersection, the Fuel service station to Catholic Church intersection, the Hall 7 intersection, and finally, the Unity roundabout.
2. The provision of safe and adequate parking places is recommended at key trip attraction and destination zones, such as the central classroom block area, the various halls of residence, the commercial area and other social venues, to allow cyclists use their bicycles more easily and frequently.
3. Thirdly, there is the need to incorporate appropriate traffic calming measures on campus roads, as a safety measure that can encourage cyclists to use their bicycles more confidently in mixed traffic situations. The measures adopted must centre on slowing down vehicles without necessarily impeding the travel of cyclists. The use for instance, of speed cushions may be considered in this case, with all traffic calming measures ultimately maintaining a speed limit of 30km/h on all roads.
4. It is further recommended that, in the provision of new road infrastructure on campus, roads of wider width should be constructed to incorporate on-street bicycle lanes. In the case also where on-street lanes are not created, wider widths would imply there could still be enough space on the roads to be shared by both vehicles and non-motorized users.

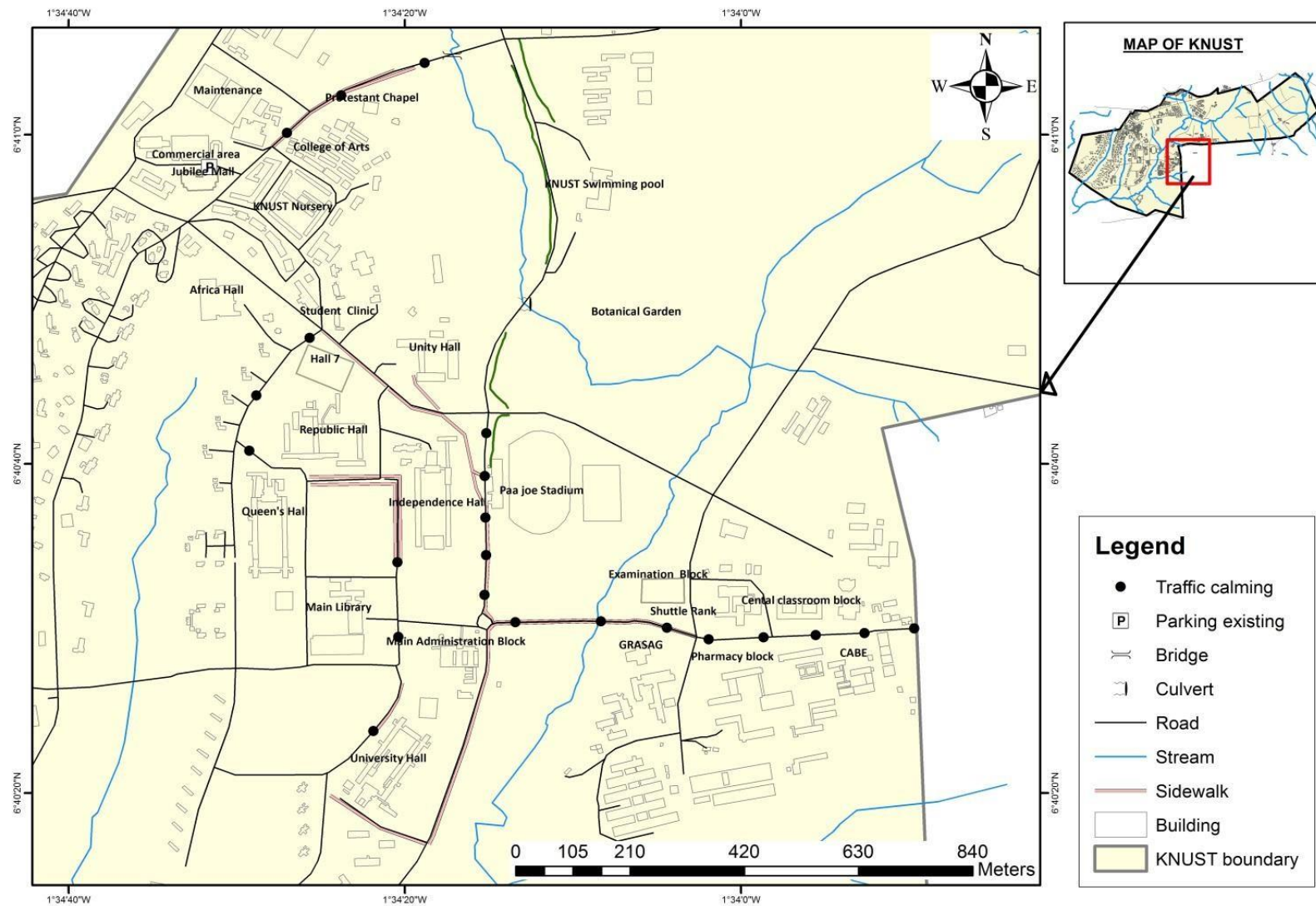
5. It is recommended that some campus streets are simply marked as a Bicycle Route using way finding signs. Bicycle Routes should be implemented on streets that have lower traffic volumes or are too narrow for bicycle lanes. These are helpful pieces of the full bicycle network which provide continuity when the street is not suitable for engineered bicycle lanes (University of Illinois, 2014).
6. Road markings and signage are also suggested at intersections, particularly, on the University Hall to Commercial Area, and the Commercial Area to Swimming Pool sections. This measure would complement the cycle routes and crossings proposed at these places, to allow for easier crossing at intersections.
7. Other infrastructural enhancements such as cycle maps can be created and placed at advantageous places on campus, to help cyclists plan their trips and select the best alternative routes for their journeys. Bicycle repair stations must also be created on or near the campus to facilitate the maintenance and repair of broken down bicycles.
8. Also, future infrastructural developments must direct greater focus on the provision of off-street bicycle paths, especially when the campus begins to register higher levels of ridership. This would improve the feeling of safety for cyclists and also allow cars to use certain roads without being obstructed by cyclist traffic. Ideally, these off-street bicycle paths should be created near canopies of trees to take advantage of the vegetation on campus and provide some shade to cyclists.
9. Again, there would be the need to ensure there are adequate security measures on campus in the form of street lighting, to enhance the safety of cyclists at night, and the installation of security cameras and locking systems to prevent bicycle theft.
10. Regular maintenance of bikeways on campus is recommended as a critical measure to ensuring the safety of cyclists and others. The continuous maintenance of the current network as well as the incorporation of new fixtures would be essential to the success of the goal of improving cycling (University of Illinois, 2014).

### **5.2.3 Proposal for infrastructural interventions**

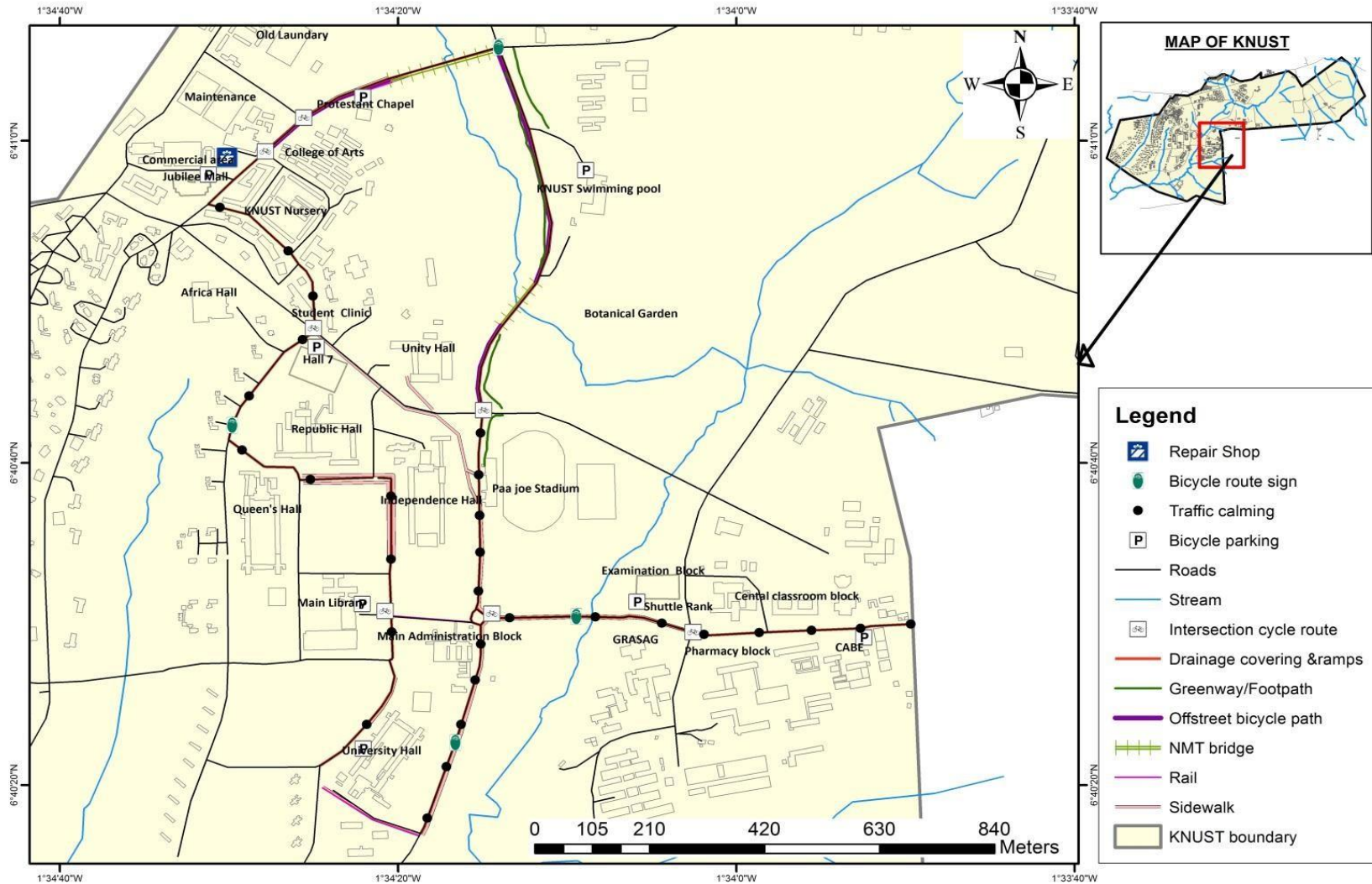
Based on the infrastructural challenges identified, and recommendations made, as a further step, the following proposed infrastructural improvements are suggested, to improve cycling on the current network. Figure 5.1 shows a map of the existing infrastructure for bicycling, presently on the route. Figure 5.2 also shows the proposed cycle route developed through the results of the study.







**Figure 5.1 Existing infrastructure on the route**



# KNUST

Figure 5.2 Proposed cycle route

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### 5.3 Recommendations for further research

The following recommendations are offered as possible ways of furthering this study.

1. Further examination of latent variables that underlie the present low ridership on campus, and the region in general. Latent variables could be further delved into, so as to enhance the knowledge base, and also guide decision makers in the promotion of cycling.
2. Responses of individuals could be also be determined in response to a fully designed network covering all aspects of the campus. This may be tested by accompanying questionnaires with a visual representation of the final product instead of assessing something that is unknown to them (Gatersleben & Appleton, 2007). Focus could also be placed on providing best alternative routes, as part of the preparation for the implementation of the bicycle scheme.
3. Lastly, it would also be also be good to determine whether individuals who find themselves in a cyclist friendly environment, such as a college campus with many bicyclists, would ultimately become more tolerant towards cyclists when they leave the campus environment.

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### Feasibility of Bicycle Transportation on the KNUST campus

Most university campuses the world over are gradually becoming hubs for more green/eco-friendly modes of travel such as bicycling. This is because, universities are perceived to have excellent environment for cycling i.e. low vehicular traffic and good road network, among others. In Ghana however, this has not been the observed trend. This questionnaire is part of a larger study which is assessing the feasibility of bicycle transportation on the Kwame Nkrumah University of Science and Technology campus. The candid views of participants would be appreciated to understand the underlying challenges to cycling and also the needed improvements.

a. Name:

b. Gender: MALE/FEMALE

c. Frequented location:

#### **Choice factors**

**Kindly rate, on a scale of strongly agree to strongly disagree the following factors which influence your using of bicycles on campus.** Complete this section with a CROSS in the appropriate box

What personal and environmental factors limit you from bicycling (more often)

? ☒

	strongly agree Agree
--	----------------------------

1. Physical (health)	<input type="checkbox"/>	<input type="checkbox"/>
2. Weather conditions	<input type="checkbox"/>	<input type="checkbox"/>
3. Terrain (steep hills) on campus	<input type="checkbox"/>	<input type="checkbox"/>
Don't own/have access to a bicycle		
Bicycles are cool		

What transportation system factors limit you from bicycling?

6. Lack of good bicycle routes to my destinations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. The lack of specially created bicycle paths/lanes (for bicycles only)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Speeds of motor vehicles and Inattentive or aggressive drivers (make it unsafe for me to cycle)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. I consider the roadways on campus to be narrow for cycling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Lack of secure bike storage/parking	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

What factors would encourage you to use a bicycle on campus?

11. Creation of new off-street bicycle paths/lanes (created exclusively for bikes along the main roads) as well as more	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. roadway shoulders	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Education on bicycle safety and how to ride a					
13. bicycle effectively	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Higher shuttle prices					

14. Provision of safer bicycle parking facilities/racks and other infrastructure like bicycling maps
15. I would cycle more if more of my friends and colleagues cycled more.

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

#### ADDITIONAL DETAILS

16. DO YOU HAVE/OWN A BICYCLE ON CAMPUS?

a. Yes      b. No

17. DO YOU KNOW HOW TO RIDE A BICYCLE?

a. Yes      b. No

18. If ..... no,  
why?.....  
.....

19. WHAT IS YOUR PRIMARY MEANS OF TRANSPORT CURRENTLY?

a. Walking      b. Bicycle      c. Motorcycle      d. Shuttle      e. Private Car

20. HAVE YOU EVER CONSIDERED USING A BICYCLE ON CAMPUS?

a. Yes      b. No

21. WOULD YOU CYCLE IF BIKE SAFETY WAS IMPROVED?

a. Yes      b. No

22. WOULD YOU CYCLE IF THERE WERE SECURE PARKING AREAS FOR BIKES?

a. Yes      b. No

23. WOULD YOU PREFER A BIKE HIRE SCHEME SO YOU COULD HIRE BIKES FOR EACH SEMESTER ON CAMPUS?

a. Yes      b. No





## QUESTIONNAIRE FOR RIDE ALONG SURVEY

Name:

Gender: MALE/FEMALE

Route name:

**Kindly rate, on a scale of strongly agree to strongly disagree the following factors which influence your using of bicycles on campus.** Complete this section with a CROSS in the appropriate box

**Options of Routes: a.**

**b.**

**c.**

**Preferred choice:**

	strongly agree	Agree	not applicable	disagree	strongly disagree
1. There are safe places to park your bicycle	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I felt generally safe among other forms of traffic (i.e. cars, pedestrians, etc.) when travelling on my bike	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I consider the roadways to be narrow for cycling. This could be improved with wider outside lanes of roadways	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. I think the hilliness of this road is unpleasant for cycling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. I felt safe when negotiating the intersection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. The road markings and signage at this intersection are adequate (in directing or helping cyclists move safely through to their destination)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. I can ride my bicycle safely on the pedestrian walkways along this route	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Cyclists require an off-street bicycle path/lane along this route to improve safety	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. There is adequate lighting along this route (for night travel)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

10. Cycling around this roundabout is relatively easy and safe

11.

The creation of bicycle routes, bicycle crossings/Zebra crossings through the intersection would significantly improve safety of cyclists/pedestrians

12.

There is the need to slow down speeds of vehicles on this road using eg. speed humps, speed cushions, etc. since speeds of motor vehicles make it unsafe for me to cycle.

13. Drain coverings and ramps should be provided along routes

14. Landscaping along this route is beautiful

(Aesthetics) with adequate shade available for bicyclists.

15. Most locations are too far

(in terms of distance for bicycling)

☐ ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ ☐

16. Would you rather....

a. ride a bike everyday on this route

b. use a shuttle

c. walk

d.

personal vehicle Did you have other peculiar challenges?

Kindly state them

.....

.....

.....

.....

.....

.....

17. How long do you usually travel on this route by your current mode of transport? a. 0-5 mins

b. 5-10 mins

c.10-15 mins

d. 15+ mins

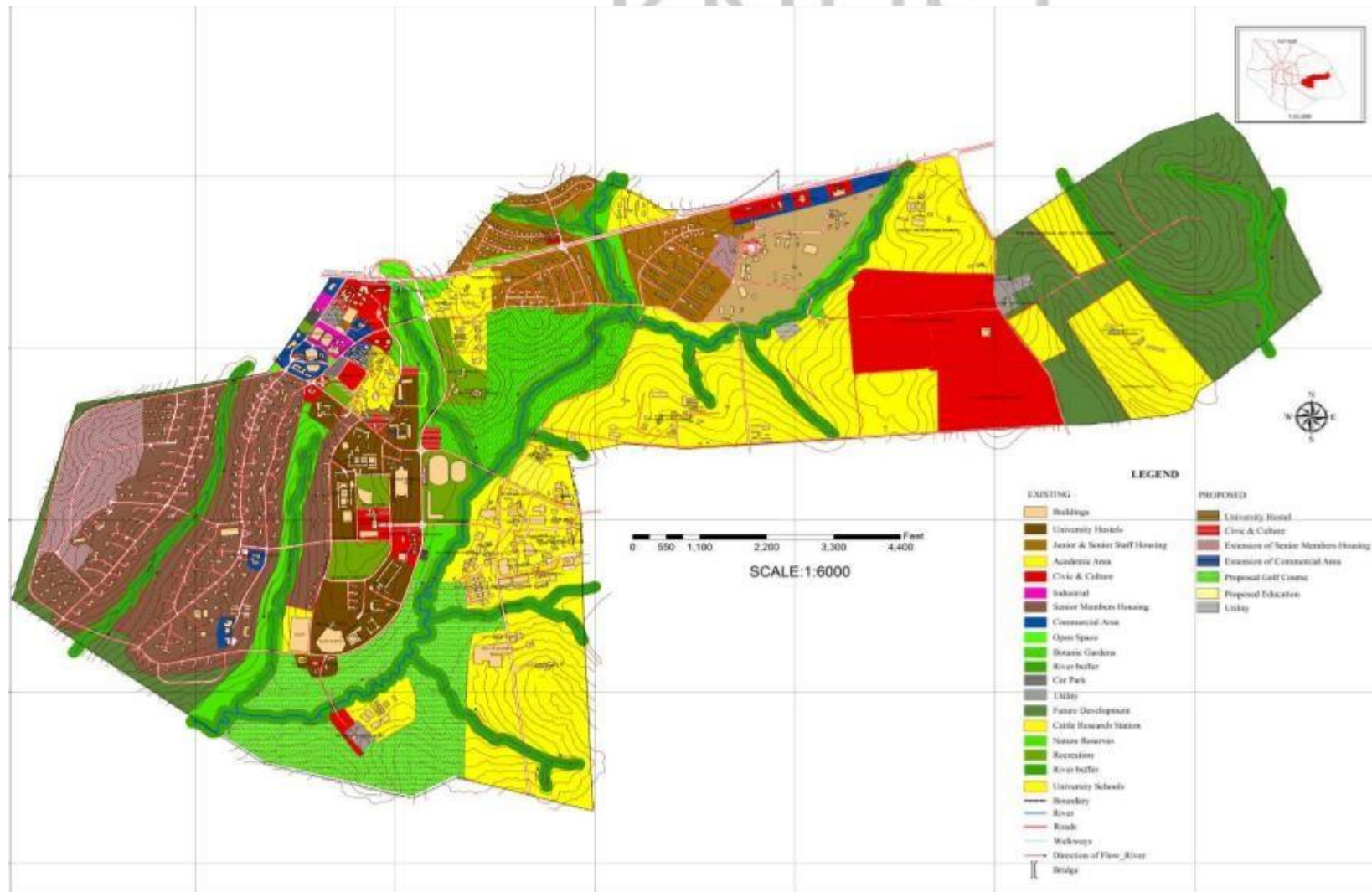


Figure 3.1 Land Use Map of KNUST



# KNUST



**Table 7.1 Tables showing an impression of most likely mode of Transport that would be used by a person to their most frequented location on the KNUST Campus.**

Gender	Location	Mode of Transport	No.	Per. Total Trips (%)
MALE	Swimming Pool	Walking	5	1.86
		Bike	1	0.37
		Private Car	2	0.75
		Shuttle	1	0.37
	Catholic Church	Walking	9	3.36
		Bike	1	0.37
		Shuttle	4	1.49
	CCB	Walking	67	25
		Bike	1	0.37
		Private Car	2	0.75
		Shuttle	12	4.48
	Commercial Area	Walking	41	15.3
		Bike	4	1.49
		Motorcycle	1	0.37
		Private Car	2	0.75
		Shuttle	6	2.24
	Katanga/Brunei	Walking	21	7.84
		Bike	4	1.49
		Shuttle	7	2.61

Gender	Location	Mode of Transport	No.	Per. Total Trips (%)
FEMALE	Swimming Pool	Shuttle	1	0.37
	Catholic Church	Walking	6	2.24
		Shuttle	6	2.24
	CCB	Walking	23	8.58
		Private Car	3	1.12
		Shuttle	6	2.24
	Commercial Area	Walking	12	4.48
		Motorcycle	1	0.37
		Shuttle	7	2.61
	Katanga/Brunei	Walking	4	1.49
		Private Car	2	0.75
		Shuttle	5	1.86

A

# KNUST

