GENDER IMPACTS ON RURAL CYCLING DECISIONS: A CASE STUDY OF BUGESERA DISTRICT, RWANDA

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ABSTRACT

In recent years, cycling mobility has attracted increasing interest from researchers. However, most available data on bicycling has focused on transport planning and policy development to address urban-related issues related. Only some studies have sought to understand rural cyclists' daily mobility decisions. The Global Positioning System (GPS) is an innovative tool that addresses spatial differences, even from a gender perspective. The study, therefore, assesses the impact of men's and women's cycling decisions in rural communities of low-income countries. The study targeted bike taxi customers and owners. Fifty participants of different gender, social background and occupation were recruited and handed a GPS device to collect their travel tracks in Nyamata and Mayange, Bugesera, Rwanda. Tracks collected contained road network data, distance (Origin-Destination), Elevation and Speed. Additional information was obtained through a survey, Focus Group Discussions and mapping of participants' daily activities. Limited gender inequality between male and female cyclists confirms that travelling speed has no impact on cycling decisions, reinforcing the notion that cultural norms and the lack of bicycle education, among many others, are the main barriers to more female cycling in Sub-Saharan Africa. Creating policies that encourage bicycle education at the school level, and teaching the value of cycling use for health and the environment, will help destigmatize cycling and remove cultural norms and restrictions.

Keywords: Cycling mobility, Daily mobility decisions, Global Positioning System, QGIS, MATLAB, Bugesera.

1. INTRODUCTION

In recent years, cycling mobility has attracted increasing interest from researchers. In light of rising gas prices, the recent covid pandemic and concerns over climate change, bicycling is seeing a resurgence of popularity. In many countries, bicycle stores are experiencing higher bicycle sales than usual. However, most of the available data on bicycle use has focused on transport planning and policy development to address related urban-related issues such as increasing traffic or growing effects of urbanization. There is, however, a shortage of available data on cycling mobility culture (Barberan et al., 2017) seeking to understand rural cyclists' daily mobility decisions. With most existing routing

engines being also limited to car travel routes (Silbernagl et al., 2016), a modal shift towards soft modes such as cycling appears relevant for continued progress towards a sustainable urban mobility paradigm (Barberan et al., 2017).

According Hortelano et al. (2021), women have specific mobility characteristics regarding cycling decisions, time of travel, trip purpose, route, or travel distance (Briscoe et al., 2019; Pojani et al., 2017 & Singh, 2020). For Duchene (2011), there is also a variation in daily activities between men and women, with the latter undertaking more complex activities than men. For instance, the European Union policy note for smart choices for cities believes that gender differences in travel patterns reflect the division of roles in the family and affect women's employment conditions, income levels, and mobility (Civitas, 2014; Sola, 2016). Other women mobility complexities in Sub-Saharan Africa include human efforts and cultural norms associated with cycling, especially in male-dominated environments. In order to understand the gender impact on rural bicycle decisions, especially in the region with already limited infrastructures and existing transportation modes, the study recruited fifty participants with the objectives of: (1) assessing men's and women's daily activities and their impacts on their decision to cycle; (2) collecting spatial data on participants' daily travel activities, time and length using Global Positioning System (GPS) Trackers; (3) analyzing the impacts of gender and age on the travelling decision; (4) Finally, conducting Focus Group Discussions (FGDs) targeting decision makers, Bicycle riders and students. The three FGDs intended to identify the gender challenges and the lever of actions were elaborated.

2. LITERATURE REVIEW

Traditionally, modelling mobility decisions in bicycle was conducted in synergy with other modes of transport, as it was understood to observe different factors. However, besides the traditional utility maximization approaches that influence transport decisions, other approaches such as psychological, socio economic and cultural norms could constitute prevalent when discussing cycling mobility decisions. Utility maximization approaches are mainly summarised to the time and cost for the travel demand. Meanwhile, the psychological approaches focus on identifying and defining critical psychological and social variables to determine behaviour (Barberan et al., 2017). Further approaches considered include the socio-economic approach and cultural norms. Black (2000) identifies four benefits of assessing the social and economic impacts of transportation projects:

- Contributing to the general well-being by allowing a sustainable, liveable communities.
- Ensuring that transportation policies that integrate communities' concerns.
- Assisting in coordinating and integrating independent plans for land use, local economies and transportation to achieve common goals.
- Fulfilling the legal obligations of environmental justice by maintaining non-discriminatory principles and practices.

Porter (2010) emphasises the widespread failure of transport planners in sub-Saharan Africa to integrate women's physical mobility, transport use, and needs. For Willis et al. (2015), this is primarily due to the perceptions, attitudes, habits, and social environment influences women are subjected to when dealing with transport decisions. According to Agboola (2021), the heterogeneity of sub-Saharan Africa implies that socio-cultural norms significantly impact logistics and mobility. However, limited studies specifically analyse the cultural norms' impacts on gender in a rural context.

In recent years, GPS tracking has been used to analyse the complexity of transport in Africa, especially with the rise of informal means of transport, such as motorbike transport. For example, Evans et al. (2018) study, with 400 GPS trackers and 532 motorbike taxi drivers and 60 passengers' sample, revealed that this mode of transport is more socio-economically suitable for most of its users and offers short-distance last-mile transport at lower fares. Other studies have used these trackers in conjunction with ethnographic tools to analyse the modus operandi of various transport modes in Accra (Saddier et al., 2016), Cape Town (Coetzee et al., 2018) and Dar es Salaam (Goletz & Ehebrecht, 2018). Jaligot et al. (2017) and Kemajou et al. (2019) evaluated mobility patterns using GPS trackers in Haiti and in Cameroon, respectively. Both authors used a mixed method that included: (1) identifying the conditions that led to the expansion of these practices; (2) understanding in detail the share of mobility demand that is met; and (3) data collection (quantitative, cartographic and socio-economic) on the individual mode of transport. Similarly, Munyaka et al. (2022) used 50 GPS devices and 50 bicycle riders in the Bugesera District to analyse the impact of topography and routes on rural mobility patterns at the level of formal and informal cycle track networks in Rwanda using Digital Elevation Models (DEMs). Munyaka et al. (2022) findings rule out topography as a challenge impacting gender cycling decisions. This study, therefore, intended to analyse rural cyclists' mobility decisions' impact on gender-based on available mobility routes, the speed used, the travelling time, daily activities, socio-economics, or even cultural norms in Bugesera District (Rwanda), targeting Nyamata (more urban sector) and Mayange (more rural sector).

3. MATERIALS AND METHODS

3.1 Study Area

In many parts of the sub-Saharan region, including Rwanda, walking and cycling are considered as the main means of mobility. Despite the recent trends towards urbanization, Rwanda is among the few countries with a pre-dominantly rural population. According to Saddier et al. (2016), approximately 81.55% of the population lives in rural areas. This counter-urbanisation has in turn added a layer of complexity to rural mobility patterns. The study targeted Nyamata and Mayange sectors from Bugesera district, Eastern Province of Rwanda. Bugesera is one of the six districts that make up the Eastern Province. The area is located in the Universal Transverse Mercator (UTM) zone 36 M and surrounded by latitudes -2.231532 (2°13'53.52"S) and longitudes 30.112735 (30°6'45.85"E). The elevation in Bugesera averaged 1417 Meters (4648.9501 Feet). The whole area is estimated to be 1,288 km^2, accounting for 4.9% of the total area of Rwanda (NISR, 2011).

Bugesera district, like most areas in Rwanda, is considered rural. According to the Food and Agriculture Organization of the United Nations (FAO) (accessed in 2022), agriculture is the main economic activity in Rwanda, with over 70% of the population engaged in this sector. About 72% of the working population is employed in agriculture. The map in Figure 1 shows Bugesera district and Nyamata and Mayange locations on Rwanda's map. According to the survey conducted by the National Institute of Statistics (NISR, 2017) (accessed in 2022), Bugesera is the district in Rwanda with the highest number of bicycles, with an estimated 30.5% of households in Bugesera owning a bicycle for mobility. With bicycle ownership more often linked with the social and economic status in Sub-Saharan Africa, analysing the gender perceptions in rural areas will ensure a more practical application of transport policies.

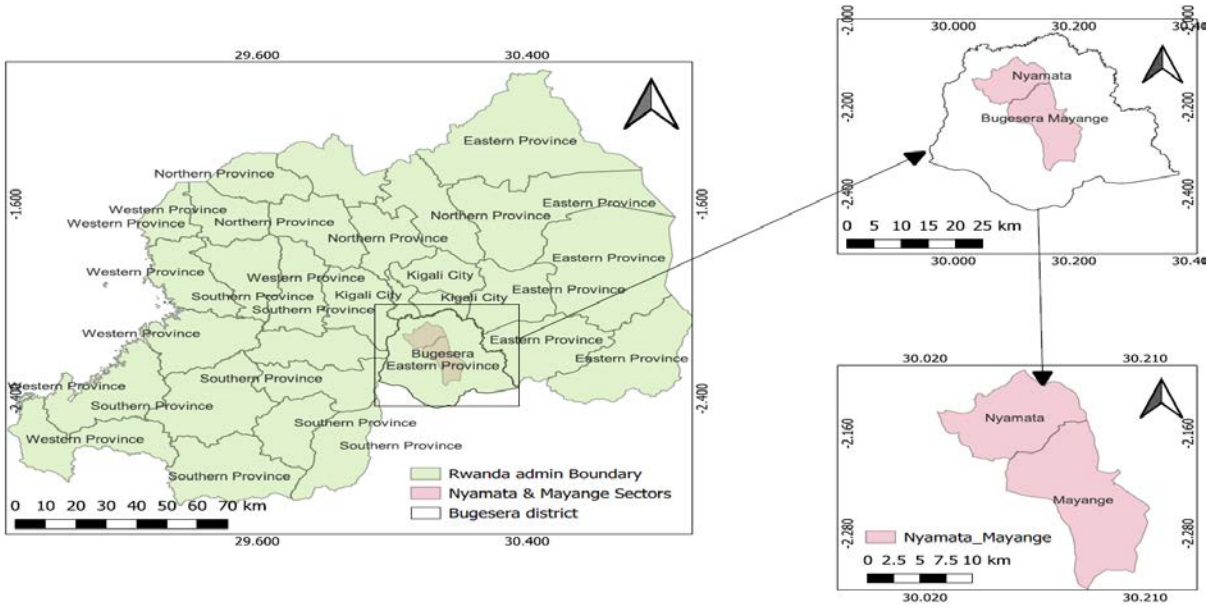

Figure 1: Maps of Nyamata and Mayange sectors, Bugesera District, Eastern Province of Rwanda (Software: QGIS)

3.2 Cycling Data Collection Methodology

Because of its proven record, this study used GPS trackers to collect bicycle mobility patterns in the areas mentioned (Figure 1). The collected data will: 1) Make the often-scarce data available; 2) Assist in understanding rural mobility challenges and the lack thereof, particularly for the most vulnerable members, and finally; 3) Influence policymakers to develop well-thought-of inclusive transportation policies for rural areas. Table 1 below lists the data type and sources the study used for their collection.

Table 1: Data type and sources for Bugesera District, Rwanda

SN	Data Type	Source 1	Source 2	Source 3
1	Road Networks	OSM	Rwanda Transport Development Agency (RTDA)	GPS
2	Point of Interests (POI)	OSM	National Institute of Statistics Rwanda (NISR)	Kobo Collect

The data collected from the GPS coordinates included: 1) the cyclist's speed; 2) cycling time from Origin to Destination; 3) the cycling distance; 4) Elevation, etc. Fifty Columbus V-990s GPS trackers were handed to 50 cyclists in the Nyamata and Mayange areas. Of the participants recruited, 24% were female cyclists, while the remaining 76% were male riders. Meanwhile, the points of interest (POI) targeted were schools, health facilities, government offices, commercial sites, religious sites, sports facilities, financial institutions, etc.

As these areas are predominantly rural, little about their mobility patterns is known. The fifty participants recruited (25 from each sector) were trained on the use of the data collection strategy, ethics and the use of the GPS device. During the collection, the participants switched the GPS device at the start of every cycling trip and switched it off at the end. Data were generated as tracks, and each track contained the participant's cycling speed, distance, time, elevation and other data beyond this research scope. In total, 580 tracks were collected in both areas. Apart from collecting tracks, participants were also

tasked to stop and collect points of interest (POIs), as mentioned in Table 1. Kobo Collect was then used by the research assistants to confirm the location captured by the participants and obtain additional POIs. In addition to POIs, Kobo collected assisted in collecting participants' demographic information that included gender, age category, participant sector (2), cell (9), and villages (27). The demographic data conducted from the participants during the training include the daily activities drafted separately for males and females between 6:00 AM to 8:00 PM. The survey also found that 38 participants cycled for "business and personal" means (76%), seven cycled strictly for business purposes (14%), and 5 for personal purposes (10%). With the data collected, Table 2 below lists the activities targeted by the research:

Table 2: Activities, tools and analysis conducted in this research

SN	Activities	Tools	Description
1	Social economic impact of gender and cycling	Stata	Gender income range, activities in relation to bicycle ownership
2	Gender daily activities analysis	Nvivo	Gender cycling analysis from 6.00 to 8.00
3	Gender Mobility Analysis	QGIS, Excel, Matlab	Gender tracks (speed, time, length) analysis,
4	Challenges vs. Levers of Actions	FGDs	From Decision Makers, Bike riders and Student's perceptions

4. RESULTS

4.1 Socio-Economical Impact of Gender and Cycling

As mentioned in the methodology, the survey conducted by the National Institute of Statistics (NISR, 2017) revealed that 30.5% of participants (1842 participants involved) in the Bugesera district owned a bicycle for either "business and personal", "personal only", or "strictly business", as previously stated. From the 30.5% of bicycle owners, 48.75% were male, while the remaining 51.20% were female. From the females and males owning bicycles, the analysis in Figure 2 targets whether they are from low (Rwf. 300 - 900), lower (Rwf. 1,000 - 9,000), high (Rwf. 10,000 - 99,000) or higher (Rwf. 100,000 and above) income groups (Rwandan Francs). The survey revealed that low-income earners, with incomes between 1,000 and 9,000 Rwandan francs (Rwf), are the most likely to own a bicycle. In addition, the higher the income of participants, the less interest they have in owning a bike in the Bugesera District, Rwanda (Figure 2).

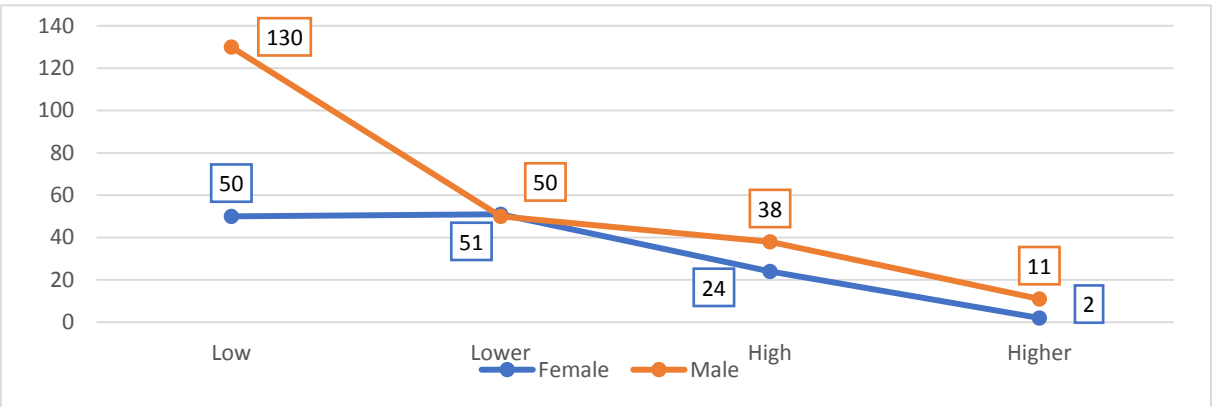

Figure 2: Bugesera income category in relation to household bicycle ownership (%) (NISR, 2017) (Modelling method: histogram, Software: Stata)

Figure 3 shows the result of the cross-tabulation of the "female and male" participants' income and their type of work category as shown from the survey data list. The result revealed that most low and lower (Rwf 300-900) income earners (Female and male) are involved in private businesses (Private/VUT), with more women being dominant. The “private/VUT” activities in Bugesera imply subsistence activities. This confirms Akinboade's (2005) statement that women are increasingly playing a decisive role in the fight against poverty in many developing countries.

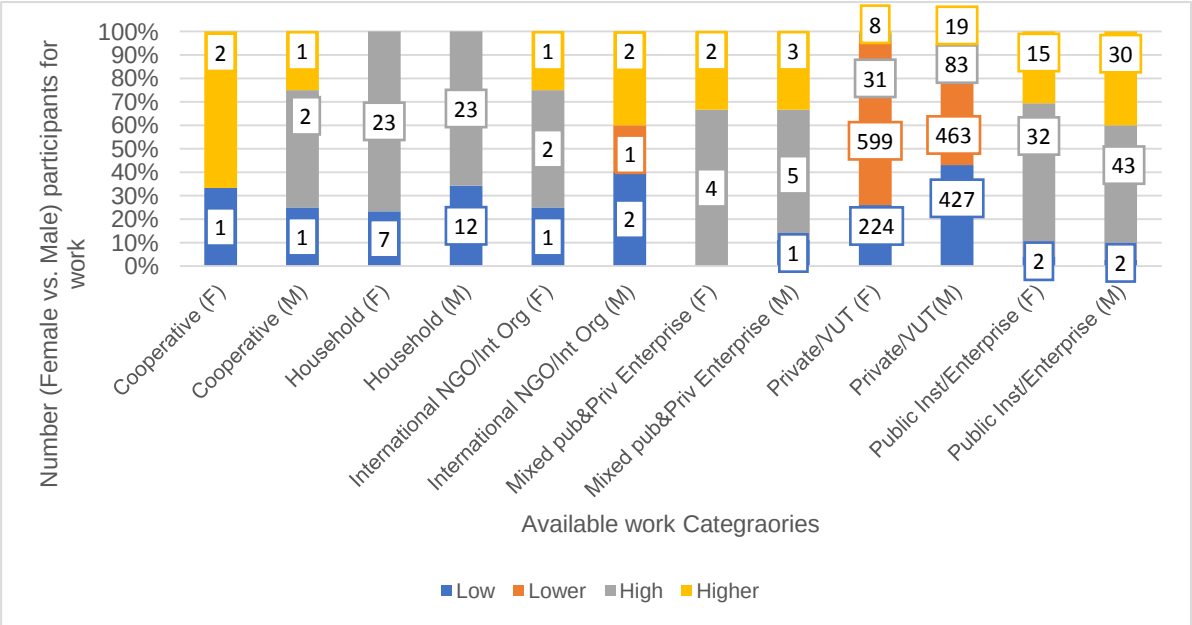

Figure 3: Bugesera income in relation to available work category (female vs. male) (modelling method: Cross-Tabulation, Software: Stata) (NISR, 2017)

4.2 Gender Activities for Mobility

The frequency of trips and the multitude of tasks performed daily by women testify to their strong contribution in the formation of economic and family structures (agriculture, trade, crafts, and liberal professions). A comparative census of the reasons for traveling by bicycle indicates that men and women travel for almost similar reasons, but with totally different interests and frequencies. To do this, we measured the activities carried out over a period ranging from 6:00 a.m. to 8:00 p.m. and according to identical time slots of two hours apart. “Based on a literal transcription of the speeches, the information collected was subjected to a thematic content analysis assisted by Nvivo” (Blanchet & Gotman, 1992). The study has therefore identified 37 bicycle trips for women and 29 for men, based on that, the following themes were developed: 1) trips related to Agro-pastoral activities; 2) for commercial activities; 3) for commuting and 4) for public transport (Figure 4).

Among men, the main reason for cycling is related to public transport activities (12), which allow them to earn money by transporting people (pupils and workers in the public and private sector) and goods. Essentially limited to minor activities, daily trips (9) are then linked to personal tasks such as visiting relatives and returning to their households. Travel related to Agro-pastoral activities (5) consists mainly of transporting fodder for animals from the fields. Finally, commercial activities (3) consist of transporting goods to market. Among women, on the other hand, the reasons are primarily daily activities in nature (14). More diversified, their purpose is to transport children going to or returning from school,

supply households with drinking water and consumable food, strengthening social ties through visits to families and relatives, and participating in socio-economic activities, Cultural and religious. Then, they move to carry out Agro-pastoral activities (10) through which they provide and guarantee most of their household resources. These include going back and forth in the fields for pastoral activities and transporting fodder for livestock. In addition, there are trips related to commercial activities (8) that aim to sell products from Agro-pastoral activities for which men are less concerned. Finally, there are journeys relating to public transport (5). Women desire to diversify the financial resources of households by carrying out parallel economic activities in transporting people and goods.

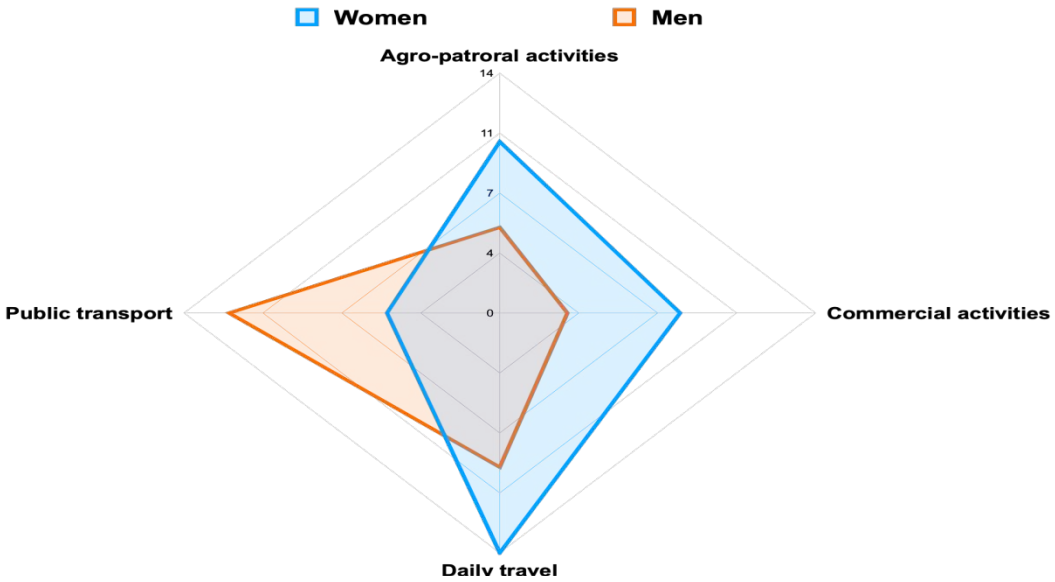

Figure 4: Women's and men's cycling activities from 6:00 to 20:00 (Software: Nvivo)

4.3 Gender Mobility Analysis

In total, 2050 GPS tracks were collected in both Mayange and Nyamata sectors. Those GPS tracks were extracted from the Columbus V-990 in the csv format, cleaned the data with Jupyter analysis. The cleaned csv data were then geo-processed on QGIS. In Figure 5 below, Map A revealed the track used by males and females during the data collection exercise. Map B shows the areas cycled on the bike for a longer time (minute) before stopping. Comparing Map B to A, areas cycled by women are revealed. Furthermore, Map C revealed each participant's cycling speed (meter per minute), while Map D revealed the cycling length (meter) per participant during the study period.

Further analysis was conducted to understand the gender mobility decisions (Figure 6). The finding revealed that over 50% of male participants cycle for a short period (Figure 7). In line with the male daily activities in Figure 4, this finding shows that "bicycle taxi" transport is mainly valuable for last miles transportation. As for the cycling speed in Figure 8 the travelling 'length' in Figure 9 shows a relatively constant rate between men and women.

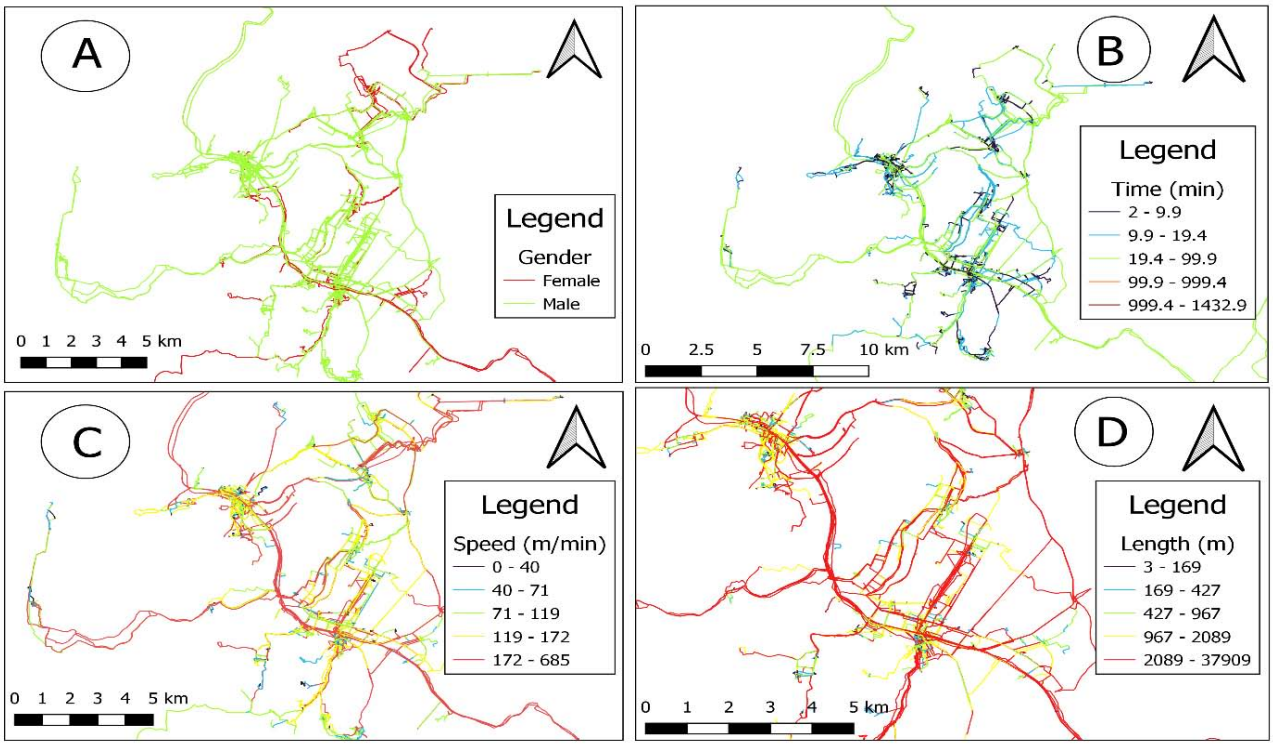

Figure 5: Female vs. male track collected in Nyamata and Mayange (Map A: Tracks per gender, Map B: Travel time (minute) per track, Map C: Travel speed (m/min) per track, Map D: Travel length (m) per track) (Software: QGIS)

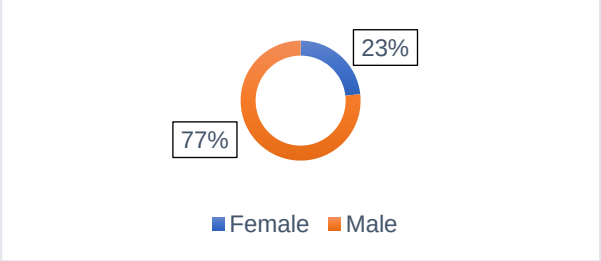

Figure 6: Male vs. female GPS tracks collected (Software: Excel)

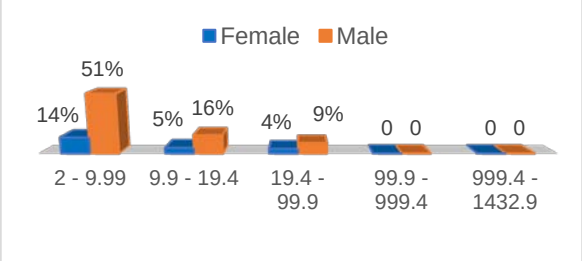

Figure 7: Male vs. female travelling 'time' (min) per GPS track (Software: Excel)

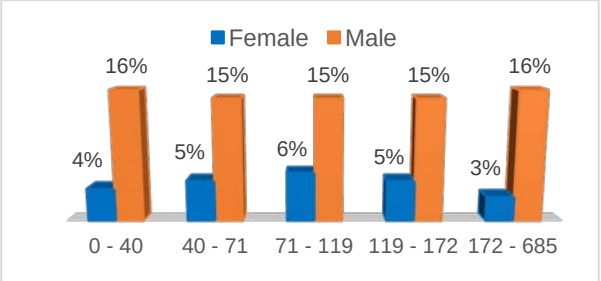

Figure 8: Male vs. female travelling 'speed' (m/min) per GPS track (Software: Excel)

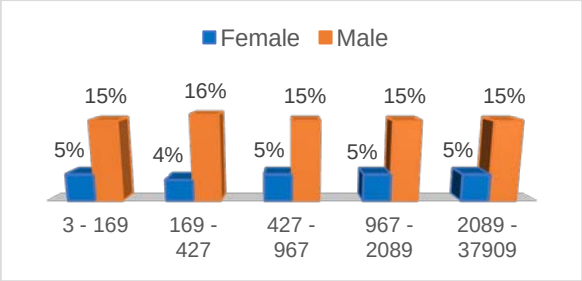

Figure 9: Male vs. female travelling 'length' (m) per GPS track (Software: Excel)

Another decision that could potentially impact the decision to cycle is the cyclist's age. At that end, participants from age categories beginning at 18 years older were recruited, and a comparison was conducted between the travelling speed (meters/min) of participants (females (F), males (M)) and their age categories. Figure 10 revealed that the age categories of female participants were even more diverse than the male participants in Mayange while cycling at a similar speed to males. Therefore, the travelling speed (meters/min) of Female participants in Mayange was higher than that of males while in Nyamata, the speed for both genders were relatively constant.

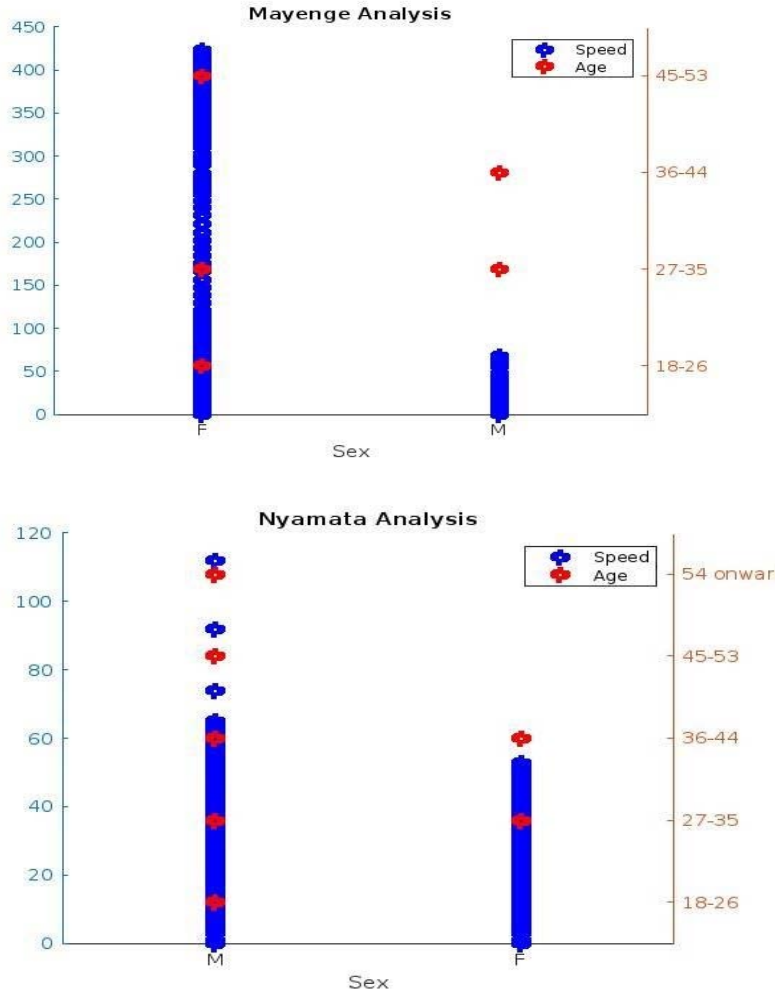

Figure 10: Scatter analysis of Mayange and Nyamata speed (meters/min) used by female and male as per age categories (Software: Matlab)

4.4 Challenges vs. Lever of Actions

The findings have revealed little to no difference between male and female cyclists in their respective activities. FGDs were then organized with students, decision-makers and bicycle riders in order to understand the challenges faced by women regarding cycling as well the lever of actions needed to make cycling accessible to all gender. Among many actions revealed in Figure 11 includes creating policies that encourage bicycle education at the school level and teaching the value of bicycle use for health and the environment.

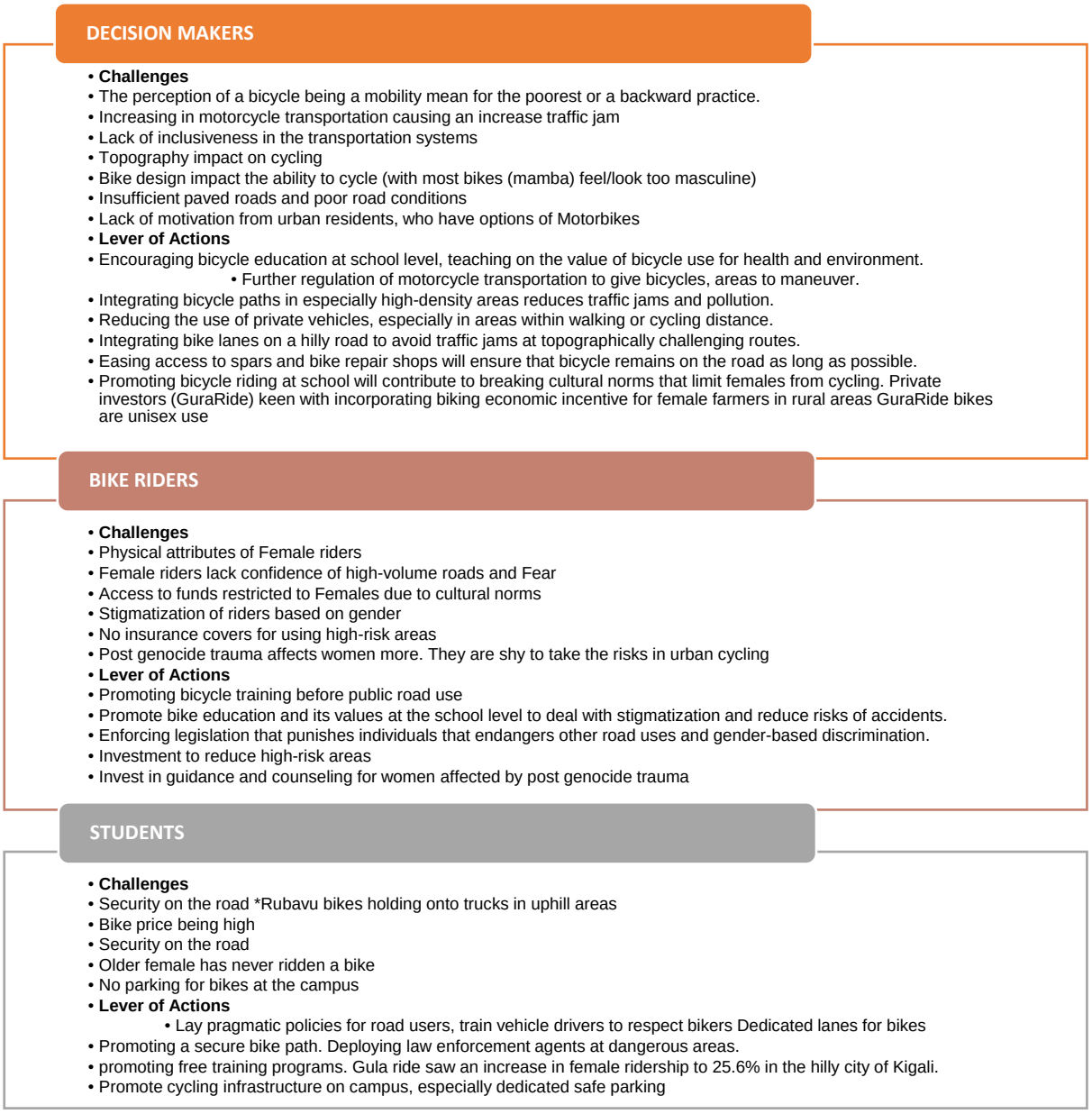

Figure 11: Feedback of FGDs with students, decision-makers and bicycle riders

5. DISCUSSIONS

With already limited infrastructures and existing transportation modes, cycling in the Sub-Saharan region is, more often than not, perceived as the cheapest and the poor people's transportation means. To understand the gender impacts on rural cycling decisions, the following activities and analyses were conducted. First, the researchers analyzed the socio-economic impact of gender in cycling. These research findings revealed that the population with low income (Rwf. 300 -900), living on subsistence activities such as farming, are most likely to own a bicycle. Looking at the gender balance, the survey revealed that a third of women in Bugesera own bicycles. This finding could be due to the relatively flat surface and culturally tolerant environment to cycle. Second, the study looked at the daily activities of males and females to understand cycling decisions. Moreover, those four activities were analyzed; the results in Figure 4 showed that women are more involved in daily activities in nature, such as taking children to school, going to the market, farming, etc. Most use of the bicycle is linked to the mentioned activities. Third, the research intended to understand if cycling speed, travel length, and time impact cycling.

With the use of GPS devices, the study revealed that, apart from the travelling "time" where male participants have shown a considerable gap, mainly due to the last miles transportation nature of their usage, the travelling speed and length have remained constant for both genders.

Further finding from MATLAB revealed that there is no gender inequality between male and female cyclists, confirming, therefore, that travelling speed has no impact on cycling decisions. Finally, FGDs were organized with students, decision-makers and bicycle riders to understand women's challenges regarding cycling and the lever of actions needed to make cycling accessible to all gender. Among many actions proposed was the creation of policies that encourage bicycle education at the school level, teaching the value of bicycle use for health and the environment. Such will destigmatize cycling, removing cultural norms and restrictions.

6. CONCLUSIONS AND RECOMMENDATIONS

As stated by World Bicycle Relief (Le temp, accessed on 2023), an organization active in Sub-Saharan Africa, having distributed nearly 460,000 bicycles since its creation in 2005, with 70% of them with women being the beneficiaries, believe that cycling is a way out of poverty in black Africa (Christinaz, 2019). This research activity and analysis has chosen that the multitude of women's journeys contributes to ensuring community life and the production of goods. Cycling is an essential element that only some activities in rural areas halt. This research has revealed little to no difference between the male and female ability to cycle to their respective activities. However, women's efforts are only recognized partially due to patriarchal traditions (Blidon, 2017). Thus, guaranteeing and ensuring women's movement by bicycle is the sine qua non for guaranteeing diversity and fighting poverty in communities and homes (Olvera et al., 2013). In line with the actions mentioned by the participants during the FGDs, Policymakers should promote the use of bicycles as a utility regardless of the individual gender. There is also a need to ensure bicycle users are safe and comfortable on the road. Therefore, bicycle training is more necessary, specifically for the younger at education facilities and older users at designated training centres. Furthermore, future research on the topic could apply male and female participants to the same roads and road conditions to optimize the results. Applying a similar methodology on hilly surfaces will assist in determining the gender impact on the cycling length, speed and time.

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