# THE POTENTIAL ROLE OF AERIAL CABLE CAR IN PROMOTING SUSTAINABLE MOBILITY IN MOMBASA, KENYA

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## INTRODUCTION

People and freight can be transported from origin to destination by different means such as cars, buses, bicycles, ferries, trains and planes. However, over the last few decades, urban areas and/or cities throughout the world have experienced exponential growth both in population size and in urban sprawl. This has led to the need for providing mass urban transit due to the rapidly growing population and increasing distances travelled. (Tubei 2018)

Besides, rapid growth of motorised transport has led to major socio-economic and urban sustainability externalities, such as traffic congestion and road traffic accidents (RTAs) (Elrayies. 2017). The externalities adversely affect the quality of life of urban residents as well as environmental impacts resulting from pollution caused by fossil fuel combustion, global warming/boiling and noise pollution (Elrayies. 2017).

Rapid urban growth coupled with widening income inequality condemn the poor to living in crowded informal settlements on the periphery of large cities. As Cervero (2000) states, it is difficult to serve these areas with conventional public transit systems such as buses or trains. As a result, the urban poor either forgo trips or endure long and costly travel times to get to their jobs or carry out less paying menial tasks near home, which exacerbate existing social inequalities (Ardila-Gomez, 2012). Affordability of transport is another challenge, as travel expenditures account for 30 percent or more of income of the poor in informal settlements (Kaltheier 2002).

To address mobility problems facing rapidly growing cities around the world, aerial cable cars have been developed to supplement existing public transport systems. Although aerial cable cars were primarily developed for rugged terrain (Sever, 2002; Alshalalfah, et al. 2012; Detter, 2015) they can be used for all types of natural barriers such as rivers, lakes, ports, and railways, as well as informal settlements (Carlet, 2016).

*Photo credit: Stuart Price, Ministry of East African Affairs, Commerce and Tourism (MEAACT), Mombasa Port, 2015.* [https://www.flickr.com/photos/meaact/20316460356](https://www.flickr.com/photos/meaact/20316460356)

Today, aerial cable cars are increasingly used as low-carbon means of transport in congested cities and at touristic sites. They have also been used to serve crowded low-income informal settlements such as in Medellin (Colombia) (Davila and Daste, 2011).

Aerial cable cars have also been proposed for Mombasa City (Kenya) due to its unique morphology, inadequate capacity of the ferry service linking Likoni on the south coast with the Island and traffic congestion caused by increased use of private vehicles, boda bodas and three wheelers(Tuk-tuks)[1] (Figure1). Despite the growing trends in recent years towards the use of aerial cable cars in urban areas (Detter, 2015), their use in urban areas as a public transit system has not been adequately studied (Težak et al., 2016; Elrayies, 2017).

*Fig. 1: Author, Traffic Jam in the CBD in Mombasa City caused by three wheelers (Tuk Tuk), 2023.*

This paper examines the potential role of aerial cable car in promoting sustainable mobility in Mombasa City. The paper set out to achieve three major objectives. These were to: a) discuss the potential role the proposed aerial cable car will play in reducing traffic congestion between Likoni on South coast and Mombasa Island; b) examine potential environmental impacts of installing the proposed aerial cable car in Likoni Channel; and c) examine any barriers that may hinder the effective implementation of the proposed Likoni Channel aerial cable car. The research findings may assist policy makers in the City and the country as a whole in designing more innovative and sustainable urban mass transit strategies in the future.

[1] Kenya mulls first aerial cable car system in Sub-Saharan Africa. Available from: https://cceonlinenews.com/2018/07/06/kenya-mulls-first-aerial-cable-car-system-in-sub-saharan-africa/.

## HISTORY OF AERIAL CABLE CARS

### Global overview of the emergence of aerial cable cars

In recent years, aerial cable cars have become popular worldwide as attractive and cost-effective transit routes for the urban areas (Elrayies, 2017; Premanand et al., 2021). Aerial cable cars are conventionally used in areas of difficult terrain such as mountains due to their ability to bridge steep sections and avoid areas that are difficult to construct on. They are commonly used at ski resorts throughout Europe (Doppelmayr, 2021a). As Williams (2019) observes, today, a number of cities around the world use aerial cable cars as their public transport mode. Some examples include cities like Rio de Janeiro (Brazil), La Paz (Bolivia), Medellin (Columbia), London (United Kingdom) and New York (USA).

The integration of aerial cable cars with the existing public transport system in these cities has conferred numerous benefits. As Sengupta (2021) has observed, aerial cable cars have provided working-class communities living on difficult and inaccessible hills with a reliable, cheap and quick transport to Bogotá (Colombia). Medellin City (Colombia) has also experienced reduced road traffic accidents (RTAs), greater social inclusion, and fewer respiratory diseases resulting from improved air quality after installing aerial cable cars (Abinal, 2019;World Bank, 2020; Sengupta, 2021). In almost all the cities, they also serve as major tourist attractions (Williams, 2019). Given Mombasa's topography, distribution of urban economic centres and share of the tourism in the national economy, it is important to consider introducing aerial cable car technology to take advantage of some of its benefits.

Aerial cable cars are now increasingly being used as a form of public transit system in urban areas (Winter et al, 2016; Carlet, 2016). Although they have primarily been used in developed countries, recent projects in the Global South such as in Colombia, Bolivia, and Nigeria have proven successful in reducing traffic congestion (Detter,2015), and in improving accessibility in informal settlements (Heinrichs and Bernet; 2014) such as in the Metrocable in Colombia. Medellin was one of the first cities in the world to link vulnerable communities to the city's public transport system and central city (Carlet, 2016).

Figure 2 shows an aerial cable car in Medellin (Colombia). Construction of a new road network in densely populated areas such as informal settlements may lead to massive displacement of poor urban residents. However, the provision of an aerial cable car system adds capacity to the transport network without any further pressure on the existing road network or displacement of populations (Winter, 2016).

Aerial cable cars are divided into two types, namely the aerial tramways and gondolas. Aerial tramways (reversible aerial ropeways) transport passengers using one or two cabins that move back and forth on cables. With only two cabins, aerial tramways can overcome greater gradients than gondolas (Brand and Davila, 2011).

***Fig. 2:*** *Julio Davila, Aerial cable car in Medellin, Colombia. 2010.* *https://www.flickr.com/photos/uclnews/7256239732/*

Gondolas are uni-directional aerial cable cars with circulating cabins that can arrive with short headways in between each cabin. They consist of several cabins that can carry up to 30 persons each and thus have greater capacities than aerial cable cars, up to 4,000 persons per hour. Dwell times are shorter than aerial cable cars since their cabins are smaller. Gondolas are ideal for public passenger transport, which requires maximum capacity (Alshalalfah et al, 2012).

**Development of Aerial cable cars in African cities**

To-date, aerial cable cars have been installed in a number of cities in Africa. Aerial cable cars in Africa began as a transport mode for freight. The Italians built the Massawa-Asmara Cableway in Eritrea in the 1930s to carry freight from the Red Sea up to the Eritrean and Ethiopian highlands, where roads were already distributing goods into the hinterland. The aerial cable car was built to prepare for the Italian invasion of Ethiopia. The cableway was over 75 Kilometres in length and linked the two towns of Massawa and Asmara. It had over 1400 gondolas, 13 Stations and moved about 30 tons of goods per hour in each direction (Nuessgen, 2015).

After the introduction of cable transit for goods on the African continent, the French built a first urban aerial cable car in Algiers in Algeria in 1956. After independence, Algeria continued developing urban aerial cable cars. In the 1980s, three aerial cable cars were built to facilitate easy access to three popular destinations in Algiers. In 2008, Constantine, the third largest city in Algeria, was the first in Algeria to construct an aerial cable cars connecting the upper and the lower parts of the city. Constantine is located on difficult terrain, has large elevation differences and natural barriers to overcome (Nuessgen, 2015). The aerial cable car drastically reduced trip duration by bus from over 2 hours to about half an hour on completion. Almost concurrently, three more new generation aerial cable car systems were installed in Algeria, in Algiers, Tlemcen, and Oran. All the aerial cable car systems were entirely integrated into the public transport system leading to significant improvement in mobility and accessibility within the cities. Algeria now has multiple aerial cable car systems including three gondolas systems and several short-haul aerial trams. The gondolas are all multi-station systems. The Skikda gondola system connects two hillside communities to the city's downtown, located in the valley. In Tlemcen, the gondola is a seemingly tourist-oriented attraction, connecting the city's south end elevated park to an amusement park in the north. (Tubei, 2018).

South Africa boasts of two cableways. The first is the famous Table Mountain Aerial Cableway located in the Table Mountain National Park and World Heritage Site (Figure 3). It commenced its operations in 1929 and today, approximately 1 million travellers use it annually.


Before the construction of the aerial cable car, the only way of climbing the Cape Town's iconic mountain was by foot, usually by adventurous people. Aerial cable cars take about five minutes to reach the top of the Table Mountains.

The aerial cable car rotates to offer travellers a 360° views (According to Peterson (1983), the visitor impact of the huge traffic flow on the fauna and flora of the area is enormous. Another also well-known cableway is the Harties Cableway in Hartbeespoort in the North West province. This is the longest mono-cableway in Africa, about 1.2 km long. It was built in 1973 but fell into disuse between 2005 and 2010, but it is now operational.


***Fig. 3:*** *George M. Groutas, Table Mountains aerial cable car, South Africa, 2010. https://www.flickr.com/photos/jorge-11/4787173724*

*Photo credit: Fazielah Williams, Table Mountain Aerial Cableway, 2016. https://commons.wikimedia.org/wiki/File:Table_Mountain_Aerial_Cableway_2016.jpg*

In Nigeria, an aerial cable car was constructed in the Obudu Ranch Resort in 2005. It was built over the Obudu Plateau. The aerial cable car brings travellers from the base of the mountain to the summit of the Obudu Ranch Resort. When it was built, it was the world's longest aerial cable car system. The resort is located on the Obudu Plateau, close to the Cameroon border in the northeastern part of Cross River State. Recently, the Resort has seen an influx of both domestic and international tourists because of the development of tourist facilities by the State Government. This has transformed the ranch into a renowned holiday and tourist resort centre in Nigeria.

## LITERATURE REVIEW

This section provides a review of previous studies on urban aerial cable car transport. The findings of these studies are relevant to the present study because they would provide insights on the potential benefits and disadvantages of installing aerial cable cars in Mombasa City (Kenya). They would also demonstrate how aerial cable cars could be integrated with the existing urban transport systems and any possible barriers that could prevent their installation. The uses of aerial cable cars in non-urban environments such as in mountainous areas and for tourism are well researched, but, researches on the use of these systems in urban areas and city centres as part of public transport networks are limited (Težak et al., 2016; Elrayies, 2017).

Aerial cable car transport technology has long been associated with highland, rugged, rough or difficult terrains (Joachim et al., 2013; Oluwatuyi, et al., 2018).

Today, aerial cable cars are not only operated in developed but also developing countries. Aerial cable car transport system has many benefits. The system is attractive for urban public transport and is used in some cities such as Medellin (Colombia), La Paz (Bolivia), Rio de Janeiro (Brazil), Ankara (Turkey), and London (UK) (Joachim et al., 2013).

A study by Težak et al., (2016) established that aerial cable cars have several advantages compared with other transport modes (Table 1). Routes for aerial cable cars are not affected by surface configuration such as steepness, infrastructure barriers and need for extra land for transport facilities is limited. This reduces or eliminates the need to remove large amount of vegetation cover on the hillsides and preserves green urban spaces for recreation. Aerial cable cars have lower carbon footprint because they use electricity, especially one derived from renewable energy sources. Noise pollution and traffic accidents are minimised. Aerial cable transportation is also comfortable. Težak, et al. (2016) also found out that despite their positive characteristics, aerial cable cars also have certain disadvantages. Their speed and capacity are limited (when compared with urban passenger transport such as underground metros and modern Light Rail.) The distance covered is about 7km. Rescue operation in aerial cable cars in case of an accident is difficult. However, the most disturbing aspect of aerial cable cars is their negative visual impact on urban landscapes (Težak, et al., (2016).

**Table 1: Advantages and disadvantages of Aerial cable Cars**

| Advantages | Disadvantages |
|---|---|
| Barrier-free transport system | Slow speed (up to 43.2 kph) compared to LRT and trains |
| Eco-friendly: emissions-free, improves air quality, reduces noise pollution | Limited capacity (4,000 persons/hour) |
| Electrically operated and energy saving | Suitable for distances of up to 7 km |
| Congestion free mobility because of dedicated right of way in the air | Extensive maintenance and controls |
| Provide direct and shorter routes, often reducing travel time of alternatives including buses | Weather-sensitive transport system especially strong winds |
| Relatively cheaper to implement than road or rail; Cheaper to operate and maintain than road or rail | Expensive infrastructure especially for faster detachable cable cars, but still much cheaper than rail |
| Safest public transport system | No heating or air conditioning in cabins typically |
| Comfortable transport | Potential negative visual impacts |
| No need of surface for transport | |
| Ideal for tourist sites | |
| Suitable for intermodal transport links | |
| Quick to install | |
| Quick and regular transport system, (low headways) | |
| Source: Modified from Težak et al, 2023. | |

Alshalafah et al., (2013) observed that in recent years, unconventional public transport technologies such as aerial cable cars were increasingly being used in many urban areas around the world. The speed of aerial cable transport systems depends on the speed of the traction cable and on the distance between stations. The capacity of aerial cable transport systems depends primarily on the capacity of the cabins, on the spacing of cabins on the cable and the speed of the traction cable. According to Alshalafah et al., (2013), the advantage of the aerial cable transport systems is that they operate within their own dedicated space and are therefore independent of constraints to which other modes of transport operating on the road network face such as traffic congestion.

Oluwatuyi, et al., (2018) observed that application of aerial cable cars with proper management could be a major source of revenue in developed and developing countries. For example, the Obudu cattle ranch in Calabar Crossriver (Nigeria) provides a source of revenue to the state and attracts tourists worldwide. Oluwatuyi, et al., (2018) established that less than 8% of the world's aerial cable cars are located in Africa. This could point to a possible investment opportunity in aerial cable transport system.

Available literature indicates that aerial cable car transport systems can be integrated with the existing urban public transport systems (Clément-Werny et al, 2011; Mayer, 2013). These studies demonstrate that applications of conventional transport technologies in urban areas might not be always possible due to several factors that may not necessarily be attributed to passenger demand. Some of the factors include high capital outlay of these systems, limited availability of space to expand or create new systems and the presence of geographical and topographical barriers. Aerial cable cars can help reduce traffic congestion and greenhouse gas emissions. Seoul is a good example of a city that was experiencing serious traffic congestion and poor air quality from the mass use of private vehicles, while public transport was in need of a thorough upgrade. Installation of an aerial cable car system helped in easing traffic congestion and improving air quality (Mayer, 2013). Already, several metropolitan areas such as Medellin (Colombia), Caracas( Venezuela), Rio de Janeiro (Brazil), New York (USA), Algiers (Algeria) and others have incorporated aerial cable cars into their public transport systems. This shows that aerial cable car projects can provide an effective urban transport solution (Clément-Werny et al, 2011).

A study carried out by Elrayies (2017) established that traffic congestion and air quality deterioration are major problems in the high- density areas of Greater Cairo (Egypt). This is where the two banks of the Nile River are linked with eight bridges, which, along with the Cairo Metro and other surface transport projects have not been able to solve these problems. Elrayies (2017) highlighted the possibility of applying aerial cable car transport system in Egypt as a means of addressing traffic congestion and air quality problems in Greater Cairo. According to Elrayies (2017), if traffic congestion problem in the Greater Cairo is not addressed, its negative impacts are expected to increase exponentially. The study recommended introduction of aerial cable cars system in the City as well as expanding surface transport networks.

Premanand et al., (2021) carried out a study on aerial cable cars in Mahé (Seychelles). They set out to demonstrate how aerial cable cars could be a solution to Mahé's traffic congestion. They also observed that "operating a successful aerial cable car route demands specific actions from people's representatives, government agencies and investors, apart from wider behavioural changes and acceptance amongst the residents and visitors of the Seychelles'" (Premanand et al., 2021: 77). This implies that certain barriers have to be overcome for the successful installation of aerial cable cars in any given urban centre.

## PROPOSED AERIAL CABLE CAR IN MOMBASA CITY

### Location

Mombasa City is located on the eastern coast of Kenya. In recent times, the City has experienced serious traffic congestion due to increasing private car ownership, inadequate public transport system and large volumes of trucks moving goods to and from landlocked countries of Eastern and Central Africa. The City possesses the biggest seaport in Kenya and serves as the "Gateway" of the Northern Corridor (Irandu, 1982; ITDP, 2020; Watanabe and Opiyo, 2023). Rapid population growth and urban sprawl contribute to an increasing challenge of providing well-organised, high quality public transport (ITDP, 2020).

### Physiographic Features

Relief features are the major determinants in the development of Mombasa. The two large intrusions of the ocean, namely Port Tudor on the east and Port Reitz on the west provide the chief reason for Mombasa's birth and continued development (Figure 4). However, they also present the most significant problem for the development of the City, including transport networks. Port Tudor and Port Reitz divide Mombasa into four physically separate areas, namely, the Island, the North, South and the West Mainlands (Irandu, 1982).

The subsequent rise in sea level led to the submergence of the valleys and the creation of Mombasa Island surrounded by deep natural creeks, ports and harbours such as Kilindini, Tudor, Makupa, and Old Port creeks.

Figure 4 shows Mombasa City; it is apparent that accessibility of Mombasa Island to and from the mainland areas poses major challenges. Given Mombasa's topography, geographical distribution of urban economic activities and contribution of its tourism industry in the national economy, there is need to deploy an aerial cable car technology to help solve some of the perennial transport problems experienced in the rapidly growing urban metropolis.


***Fig. 4:*** *Jasiński, Artur, Satellite Image of Mombasa City. https://www.researchgate.net/publication/332920211_Colour_as_a_tool_in_shaping_the_city_image_-_based_on_the_case_of_Mombasa*

## Socio-demographic Profile

Population distribution and settlement patterns in the City are influenced by proximity to vital social and physical infrastructure networks such as roads, housing, water and electricity. Other factors that influence settlement patterns include accessibility to employment opportunities and security. Its population grew steadily from 0.2M in 1969 to 1.2M in 2019. Between 2009 and 2019, its annual population growth rate averaged 2.5%. (KNBS, 2019: ITDP, 2020).

As per the 2019 census, Likoni area of Mombasa Island, had a population of 21,805. The average age is 40-50 years. Those above 50 years constitute 31.3 % of the Likoni estate residents (KNBS, 2019). About 30.6 % of the Likoni residents are self-employed while 19 % are employed by the County government of Mombasa. The average monthly income of Likoni tenant is about Kshs. 28,000($ 250). Majority of the tenants have little or no income and the installation of aerial cable car at Likoni may offer opportunities for some livelihoods for them and other City residents.

## Transport System

Figure 5 shows that majority of residents (45%) in Mombasa City use walking as their main mode of transport while 36% of the residents use public transport. Although three wheelers (tuk-tuks) account for only 4% of modal split, they are a major cause of traffic congestion in Mombasa City. Mombasa City faces very serious mobility challenges. Residents encounter daily traffic snarl-ups on the roads leading to Mombasa Island, which is the commercial hub of the City. Due to inadequate public transport system and lack of non-motorised infrastructure, the city has witnessed a significant modal shift to private cars and taxi services such as boda bodas and tuk-tuks.

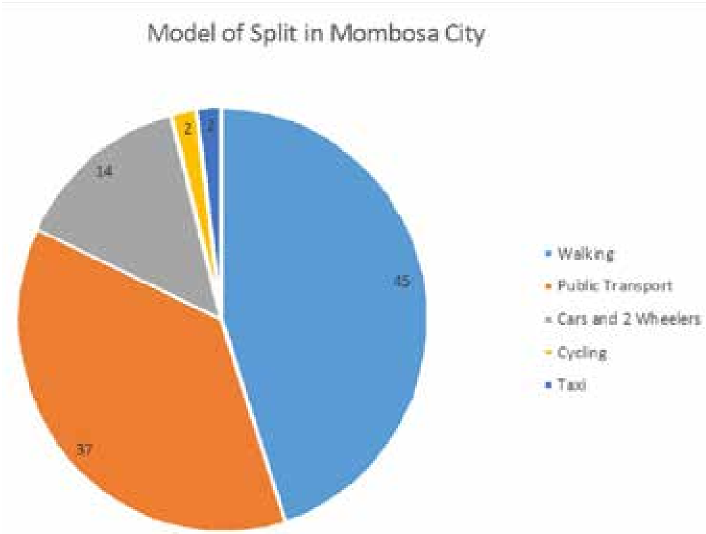


***Fig. 5:*** *Modal Split in Mombasa City, JICA. https://africa.itdp.org/planning-mombasas-public-transport-system/*

The city centre of Mombasa City is situated on the island and separated from its suburbs by various basins and channels (Figure .4).

Whereas bridges connect Mombasa Island to the North coast and West mainland, only ferry service provides transport between Mombasa Island and Likoni on the South coast (Figure 6). About four ferries operated by the Kenya Ferry Services (KFS) transport up to 300,000 passengers and 6,000 vehicles daily across the 500-metre channel. The Likoni ferry service is a very important part of the city's transport system. However, it faces a number of challenges that render it inefficient. For example, pressure is exerted on the existing ferry services especially during peak times, which results in lost person-hours. During this time, long vehicle queues may be experienced. Ramp approaches at the Likoni Ferry are narrow thereby limiting the number of ferries that can load and offload simultaneously. Ships entering and leaving the Kilindini Port pose logistical challenges by disrupting ferry movements across the Likoni channel. Over the years, both human and vehicular traffic using the Ferry service has increased exponentially, putting more strain on the existing facility (ESIA, 2020).

***Fig. 6:*** *Author, Commuters alighting from a ferry at Likoni Channel, Mombasa, 2023.*

**Proposed Aerial Cable Car in Context**

An aerial cable car in Mombasa has been mulled since 2013. The project is estimated to cost KShs 4.1 billion ($40 million) and will be funded by the Kenyan and Australian companies that will run it for 25 years before transferring it to the government in what is known as Build Own Operate Transfer (BOOT) public-private partnership. The project got approval of Cabinet in 2018 and construction was scheduled to begin by the end of 2019.

The plan is to erect a suspended 1.3 km cableway linking Mombasa Island to the South Coast. The proposed aerial cable car will have up to 28 cabins crossing every four minutes carrying about 40 people, thereby facilitating 11,000 commuters per hour to cross the channel. The proposed aerial cable, if constructed, will increase the reliability of the crossing for the passengers. Besides, more commuters will be able to cross at once since the aerial cable car will provide fast passenger crossing with no waiting time (Mair, 2022). Movement within the City and its surrounding areas will be eased following plans to extend the Likoni aerial cable cars project to Moi International Airport, Nyali and Kilifi County. The aerial cable car is not an alternative to road transport but a complement in decongesting the city. Currently, commuters take about 40 minutes from Mwembe Tayari on the Island to Nyali on the North Mainland due to traffic jams. The aerial transport solution will also not conflict with shipping traffic. It will offer a reliable and fast connection in case of emergency.

The proposed Likoni Aerial Cable Car can be integrated with the existing public transport modes such as the Standard Gauge Railway (SGR), the ferry services, mini-buses (matatus) and three wheelers (Tuk tuks). When the SGR is extended to the South Coast, some rail extensions can be built to link with the aerial cable car. This would enable train commuters to catch an aerial cable to and from Mombasa Island. The aerial cable car would be integrated with the railway transport at the railway station built nearby for ease of movement from one mode of transport to the other. The same could be done with minibuses or matatus operating on the Island. Some matatu (minibus) terminals could be built near the Likoni Aerial Cable car to allow faster transfer of travellers from one mode to the other depending on their destinations. Three wheelers (Tuk tuks) could also pick and drop passengers who wish to travel by aerial cable car at the matatu terminals.

A ride in the proposed aerial cable car when complete is estimated to cost between KES20 ($0.14) and KES100 ($0.7) varying between off-peak and peak hours respectively. This may be unaffordable for the poor people, majority of whom are unemployed and live in poor informal neighbourhoods.

The government could make ridership more affordable for poorer residents of the City by subsiding fares. Revenue obtained from tourists who are expected to use aerial cable car can be used to subsidise fares and make its operations financially sustainable. The aerial cable car is also expected to reduce the long queues at Likoni Ferry and open the South Coast for more tourism development.

However, to date, the installation of the proposed aerial cable car has not yet started. With other mega projects being undertaken there are doubts as to whether the proposed Likoni aerial cable car project will ever take off (Mwambingu, 2021). Recently, the Government has embarked on other equally ambitious infrastructure development programs within Mombasa City. These include the construction of the Liwatoni floating bridge and the plan to construct Mombasa Gateway Bridge.

## METHODOLOGY

The research used a descriptive and qualitative analysis design using both primary and secondary data. Secondary data was obtained through literature review of published theses, journal articles, documents from the City County of Mombasa and the State Department of Transport in the Ministry of Roads and Transport Infrastructure of the Republic of Kenya.

Primary data was obtained through questionnaire survey of commuters and key informant interviews (KIIs) of Central Government and Mombasa City County officials. Eighty (80) people were interviewed in the study. A questionnaire survey was administered to 20 commuters drawn from each of the three mainland areas (North, West and South) and 10 from the Island, making 70 interviewees. Commuters to interview were randomly selected by being asked to pick a random number from a basket. Once a given random number was picked, it was not returned to the basket. Since the study was qualitative in nature and descriptive statistics were used in analysis, any sample size was considered sufficient (Israel, 1992).

The commuters interviewed were expected to provide views on the advantages and disadvantages of the proposed aerial cable car in Mombasa City. This was important because the 70 commuters interviewed represented the expectations of the travelling public in the City. The ten (10) key informants were not randomly selected but purposefully selected based on their expertise on the new aerial cable car technology. These included two (2) Kenya Ferry Services (KFS) officials, two (2) Kenya Ports Authority officials, two (2) City County officials, two (2) Ministry of Transport officials and two (2) technical experts drawn from the Private sector.

Content analysis was employed in analysing secondary data from published sources. After thorough search and review of published and unpublished data, it was subjected to critical evaluation. Any possible negative environmental impacts likely to result from the installation of commuter aerial cable cars were established after critical review of the existing Environmental and Social Impact Assessment (ESIA) report carried out on the proposed project. These impacts were compared with those experienced in cities where cable cars are already operational. Primary data was obtained such as commuters' opinions on possible benefits of introducing aerial cable car at the Likoni Channel.

To discuss the potential role the proposed Likoni aerial cable car would play in Mombasa City, the ten (10) key informants were all asked the following open-ended questions: a) What do you consider to be the advantages and disadvantages of the Likoni aerial cable car to Mombasa residents? b) What are the likely barriers to the installation of the proposed Likoni aerial cable car?

To discuss the potential role the proposed aerial cable car will play in reducing traffic congestion between Likoni on South coast and Mombasa Island, the 70 commuters were asked the question: 'What are your expectations of the proposed Likoni aerial cable car before construction?' It was expected that the proposed aerial cable car would be useful in reducing traffic congestion in Mombasa City if commuters would be willing to use it. To find out whether commuters in Mombasa City would be willing to use aerial cable car after completion, the 70 commuters were asked the following question. Do you agree with the following statement? 'I would use the proposed aerial cable car when complete.' The responses to this question were on a 5-point Likert scale. Responses to the two questions above were presented through cross tabulation and chart.

## RESULTS AND DISCUSSION

This section presents the results and discussion of the potential role the proposed aerial cable car will play in reducing traffic congestion between Likoni on South coast and Mombasa Island, examination of the potential environmental impacts of installing the proposed aerial cable car in Likoni Channel and examination of the potential environmental impacts and possible barriers to effective installation and operation of aerial cable car at the Likoni Channel in Mombasa City.

### Potential role of the proposed aerial cable car

Literature reviewed revealed that building an aerial cable car in a developing country such as Colombia, Rwanda or Egypt has both advantages and disadvantages (Mayer, 2013; Težak et al., 2016; Elrayies, 2017). Some of the advantages identified in these studies are: reduction of traffic congestion, not affected by topography, have lower carbon footprint and noise pollution. However, the studies also established that installation of aerial cable cars has some disadvantages. Some of the disadvantages identified include loss of biodiversity through clearance of vegetation, invasive species introduced by construction equipment, visual intrusion and high operation and maintenance costs (Težak et al., 2016; Elrayies, 2017).

To discuss the potential role the proposed aerial cable car will play in reducing traffic congestion between Likoni on South coast and Mombasa Island, the 70 randomly selected commuters were asked to give their expectations on the Likoni Channel aerial cable car before its construction. Their expectations were varied as shown in Table 2. The study found out that residents of Mombasa City expected the Likoni Channel aerial cable car to reduce traffic congestion. This was revealed by an overwhelming majority (96%) of the respondents interviewed (Table 2).

**Table 2: Residents' expectations of the Likoni aerial cable car before construction (percentage)**

| Expectation | Percentage |
|---|---|
| Reduction of travel time | 72 |
| Comfortable travel | 76 |
| Reduction of waiting time | 84 |
| Much safer | 90 |
| Reduction of traffic congestion | 96 |
| Reduction of road traffic accidents | 64 |
| Increase accessibility of the South mainland | 80 |
| Increase trips made per day | 48 |
| Improve frequency of service | 60 |
| Affordability | 40 |
| Improvement of air quality | 76 |
| Provide better view of the City | 62 |
| Improving quality of life | 52 |

*Source: Compiled by author, 2023*

The expectation of overwhelming majority (96%) of respondents interviewed is not surprising since Mombasa City faces serious traffic congestion especially at peak times at the Likoni Ferry and the CBD. The ferry service often experiences massive delays and frequent breakdowns. The respondents expect the proposed aerial cable car to complement ferry services at the Likoni Channel. This finding is consistent with what other previous studies established (Irandu, 1982; ITDP, 2020).

The cost of building a bridge across the Likoni Channel would be prohibitive due to topographical, land use and height challenges. (African City Planner, 2015) Therefore, installation of aerial cable car would ease traffic congestion at the Likoni Ferry crossing, as some of the commuters would very likely prefer to use the aerial cable car (Figure 7). If the aerial cable car were integrated with public transport system and non-motorised transport infrastructure, there would be a great improvement in reduction of traffic congestion in the City.

**Potential environmental impacts of the proposed aerial cable car**

To examine the potential environmental impacts of installing the proposed aerial cable car in Likoni Channel, an in-depth review of the available literature was undertaken. The study established that an aerial cable car is an environmentally sound transport system when compared with private cars and buses (Težak, et al., 2016; Elrayies, 2017; Premanand et al., 2021). Besides, critical review of the Environmental and Social Impact Assessment (ESIA) report prepared by experts licenced by National Environment Management Agency (NEMA) revealed that construction of aerial cable car across the Likoni Channel would have no serious and irreversible environmental impacts in the area it will pass. It was also revealed that generation of noise and exhaust fume emissions was negligible (ESIA Report, 2020). Aerial cable car operated by electricity in Mombasa City is feasible since about 68% of Kenya's energy generation is from green or renewable energy (MoEP, 2018).

**Barriers likely to hinder implementation of the proposed aerial cable car**

To examine the likely barriers that may hinder effective implementation of the Likoni Channel aerial cable car, thorough review of available literature was undertaken and questionnaire survey and key informant interviews carefully analysed. The information obtained from in-depth literature review, questionnaire survey and key informants revealed that installation of aerial cable cars in the Likoni Channel would face some barriers.

Literature review established that technical barriers are a major limitation of aerial cable car connection or route (Premanand et al., 2021). It was established that integrating aerial cable cars with other modes of public transport such as roads and railways networks might be difficult and expensive especially in an urban area facing spatial constraints such Mombasa City (Clement-Werny, 2011; Davila, 2013; Premanand et al., 2021). Mombasa's physiographic features may hinder further extension of aerial cable car in the future even after completion of the Likoni Channel project. Construction of aerial cable cars is subject to very stringent requirements for alignment. It is much easier to alter road or rail alignment or expand it as need arises than an aerial cable car.

Key informant interview (KII) with the Kenya Ferry Services and Ministry of Transport officials revealed that financial barriers would also hinder the installation of the proposed aerial cable car. It was established through discussion with key informants that proposed Likoni aerial cable car would require a whopping $40 million to install. This is a huge amount for a poor developing country such as Kenya. The local City County Government of Mombasa cannot be able to raise such a colossal sum. Therefore, financing has to be sourced from Central Government and/or external sources. The proposed aerial cable car is to be financed through a public-private partnership (PPP) model. When the aerial cable car is built, it may be unaffordable to the poorer members of the City and tourists may be the ones able to use it.

Another financial barrier identified by the key informants was that residents in neighbourhoods where the proposed aerial cable car would pass were concerned about possible intrusion and loss of their privacy. This is a genuine fear because aerial cable cars would be passing overhead (100 metres). The residents also feared that their property values would plummet because of loss of privacy. Some of the likely barriers identified through literature review and key informant interviews are summarised in Table 3.

**Table 3: Barriers to the implementation of aerial cable cars in Likoni Channel, Mombasa**

| Type of Barrier | Description |
|---|---|
| Technical barrier | a. Post-construction changes may be difficult due to proximity of port facilities.<br>b. Inefficient over distances greater than 7 kms.<br>c. May be used mostly by tourists, locals may be reluctant to use them.<br>d. Slower travel speed compared to cars, buses or trains (but not necessarily slower on a point to point basis)<br>e. Lack of technical expertise to operate and maintain the cable cars. |
| Economic/financial barrier | a. Integrating aerial cable cars with other modes of public transport may be difficult and expensive.<br>b. Charges for ridership may be high.<br>c. Reduction of property values |
| Social barriers | a. Visual impact and intrusion (loss of privacy).<br>b. Commuters may prefer to be picked and dropped at convenient points.<br>c. Preference of private cars for prestige. |
| Political barriers | a. Difficult to get public consent<br>b. Lack of political good will from local (county) authorities |

Source: Compiled by author, 2023

The 70 randomly selected commuters were asked to choose from a 5-point Likert scale, whether they would be willing to use the aerial cable car when completed. As shown in Figure 7, it is apparent that about two-thirds (66%) of the respondents agreed, to varying degrees, that they would use the aerial cable car when completed. However, a significant proportion (34%) of the commuters disagreed to varying degrees. Possibly some of the commuters fear height or felt the aerial cable car would be for tourists. This finding is consistent with the findings of Premanand et al., (2021) in their study of the impact of aerial cable car in Mahe City in Seychelles.

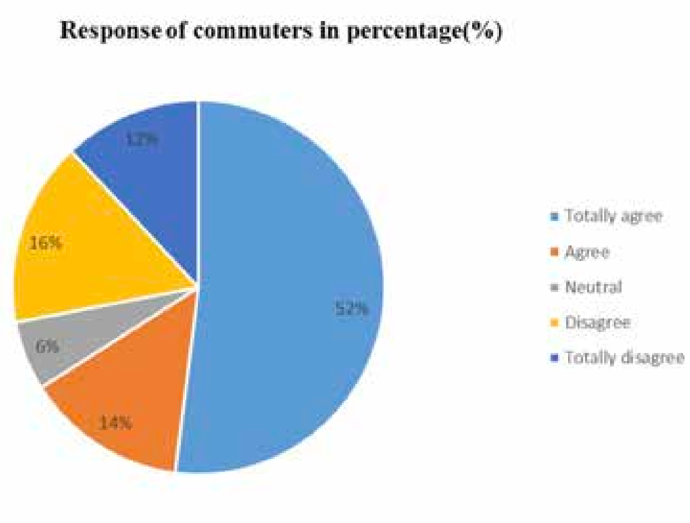


***Fig. 7:** Author, Responses of commuters on a 5-point Likert scale,*

Generally, a major project such as the Likoni Aerial Cable Project would face some financial barriers such as poor residents' ridership due to high fares charged.

However, discussions with experts from the State Department of Transport of the Ministry of Roads and Transport of the Republic of Kenya revealed that the proposed aerial cable car project could cater for the needs of residents who travel daily from Likoni Ferry to Mombasa Island for work and other trip purposes by providing affordable, safe and comfortable transport. The experts from the State Department of Transport also indicated that the Likoni Ferry Aerial Cable Car Project could generate revenue from both residents and tourists and that stable residents' ridership could help fill the gap during off-peak season, which corresponds with Northern Hemisphere Summer.

*Photo credit: Tumo Maokisa, Colorful Matatu in Mombasa, 2020. https://commons.wikimedia.org/wiki/File:Colorful_Matatu_in_Mombasa.jpg*

## CONCLUSION

**This section provides a summary of the key findings, lessons learned and recommendations based on in-depth literature review and analysis of questionnaire survey and key informant interviews. Some recommendations have been made to guide policy makers in designing integrated and sustainable public transport system in Mombasa City and in other rapidly growing urban areas in the country, which also incorporates aerial cable cars.**

A key finding of the study was that the construction of aerial cable car at the Likoni Channel in the Mombasa City is expected to reduce traffic congestion. This was the expectation of the majority (96%) of the respondents (commuters) interviewed. As already discussed, Mombasa City experiences serious traffic congestion especially at peak times at the Likoni Ferry and the CBD. To ease traffic congestion and overcrowding in public transport vehicles, aerial cable car transport system should be developed in many parts of Mombasa City. There is need to provide adequate connectivity between the Island, which is the core of the City with the mainland areas. Aerial cable cars can be integrated into the existing public transit system in Mombasa City. Terminals can be located near bus stations and taxi lanes to allow for easy interchanges and thus ensure seamless transport. This is what has been done in La Paz (Bolivia) (Winter, 2016). As studies have shown elsewhere (Carlet, 2016), the integration of aerial cable car into the existing transport infrastructure is cheaper when compared to the costs of bus transport or commuter rail. Therefore, it can be concluded that aerial cable car is a promising technology and one worth considering as Mombasa City continues to evaluate its approach to an integrated public transit system.

Another key finding was that aerial cable cars have less carbon footprint than other public transport modes. In-depth literature review including the Environmental and Social Impact Assessment (ESIA) report for the Likoni Channel aerial cable car project, it was established that aerial cable car systems have low carbon footprint because of using electricity and generate zero emissions. This is the type of transport system ideal for assisting the City in combating climate change. Mombasa City would develop a more sustainable transport system by integrating aerial cable car technology with other public transport modes such as the BRT and the Standard Gauge Railway (SGR).

Review of available literature on aerial cable cars in Medellin (Colombia), La Paz (Bolivia), Rio Janeiro (Brazil), Cape Town (South Africa), Cairo (Egypt) and Kigali (Rwanda) among others, offers valuable lessons for cities that plan to adopt the new technology (Joachim et al., 2013; Oluwatuyi, et al., 2018; Davila, 2021). It has been proven that aerial cable cars are a sustainable mode of urban transport especially where topography and informal settlements pose challenges to the development of other modes of public transport. Therefore, introduction of aerial cable cars may improve accessibility, mobility and reduce poverty in a city.

Another important lesson is that aerial cable car transit system alone may not automatically lead to greater integration of informal settlements (slums) with the rest of the city and to poverty reduction. Other necessary elements are improving mobility, making public transport affordable and reducing traffic congestion.

Thus, when designing, planning and installing aerial cable cars the expectations and lifestyles of the inhabitants of the affected area should be prioritised. This is important because it may influence the use or not of the new technology by residents.

However, as a long-term solution to the mobility problems faced daily by commuters in Mombasa City, there is need to promote a well-integrated public transport system. This would involve developing a reliable, efficient, affordable and environmentally-friendly public transport system such as the Bus Rapid Transport (BRT) and integrating it with Non-motorised transport (NMT) infrastructure and aerial cable car technology. The Ministry of Roads and Transport of the Republic of Kenya should formulate a policy framework to guide the construction, operation and integration of aerial cable cars with the existing transport system in urban areas throughout the country. Efforts should be made by the Central government to develop requisite expertise for successful operation of aerial cable cars once installed in urban areas such as Mombasa City.

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